Hazus Flood Model User Guidance

Hazus 5.1

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FEMA

Table of Contents

Table of Contents ii

List of Figures v

List of Tables v

Acronyms and Abbreviations xiv

Section 1. Introduction 1-1

1.1 Background 1-1

1.2 Hazus Users and Applications 1-2

1.3 Assumed User Expertise 1-3

1.4 When to Seek Help 1-3

1.5 Technical Support 1-4

1.6 Uncertainties in Loss Estimates 1-4

Section 2. Overview of the Flood Model 2-1

2.1 Flood Hazards in the Flood Model 2-3

2.2 Definitions of Structures 2-3

2.3 Levels of Analysis 2-4

Section 3. Getting Started Part 1: Hazus Startup Screen 3-1

3.1 Hazus Startup 3-1

3.2 Create New Region 3-1

3.3 Open Region 3-7

3.4 Delete Region 3-9

3.5 Duplicate Region 3-11

3.6 Export/Backup a Region 3-14

3.7 Import a Region 3-16

Section 4. Getting Started Part 2: Basic Hazus Analysis 4-1

Section 5. Model Menu: Inventory 5-1

5.1 General Building Stock 5-1

5.2 Essential Facilities 5-11

5.3 User-Defined Facilities 5-13

5.4 Transportation Systems 5-14

5.5 Utility Systems 5-15
5.6 Demographics 5-16
5.7 Vehicles 5-17
5.8 View Classifications 5-18
Section 6. Model Menu: Hazard 6-1
6.1 Flood Hazard Type 6-1
6.2 User Data 6-2
6.3 Develop Stream Network 6-8
6.4 Scenario 6-11
6.5 Riverine 6-30
6.6 Coastal 6-46
Section 7. Model Menu: Analysis 7-1
7.1 Damage Functions 7-1
7.2 Restoration Functions 7-9
7.3 Parameters 7-11
7.4 Annualized Loss 7-15
7.5 Combined Wind and Flood 7-18
7.6 Run 7-18
Section 8. Model Menu: Results 8-1
8.1 View Current Scenario Results By 8-1
8.2 Flood Hazard Map 8-3
8.3 General Building Stock Damage 8-3
8.4 Combined Wind and Flood Loss 8-10
8.5 Essential Facilities 8-12
8.6 User-Defined Facilities 8-14
8.7 Transportation Systems 8-15
8.8 Utility Systems 8-17
8.9 Vehicles 8-19
8.10 Debris 8-20
8.11 Shelter 8-22

8.12 Summary Reports 8-23

Section 9. Model Menu: Other Items 9-1

9.1 File Menu 9-1

9.2 Help Menu 9-3

9.3 Customize Menu 9-4

Section 10. Advanced Hazus Analysis: User-Defined Inventory Data 10-8

10.1 UDF Required Attributes 10-8

10.2 UDF User-Supplied Inventory 10-15

Section 11. Advanced Hazus Analysis: Hurricane Surge Scenario 11-1

11.1 Storm Surge Scenario Options 11-1

11.2 Run Storm Surge Analysis 11-5

11.3 Storm Surge 11-9

11.4 User-supplied Storm Surge Depth Grid Analysis 11-21

Section 12. Advanced Hazus Analysis: Import User-Defined Data 12-1

12.1 Import Flood Depth Grid Results (preferred method for importing flood hazard information) 12-1

12.2 Import HEC-RAS .FLT Grid Results (preferred method for importing flood hazard information) 12-6

List of Figures

Figure 2-1 Hazus Flood Model Methodology Schematic 2-2
Figure 2-2 Levels of Hazus Analysis 2-4
Figure 3-1 Select Create a New Region in Hazus Startup 3-2
Figure 3-2 Select Create New Region in Wizard 3-2
Figure 3-3 Create a Study Region Name 3-3
Figure 3-4 Select Hazard Type for New Region 3-3
Figure 3-5 Select Desired Aggregation Level 3-4
Figure 3-6 Select Appropriate State for the New Region 3-5
Figure 3-7 Select County for the New Region 3-5
Figure 3-8 Create New Region Wizard Completion 3-6
Figure 3-9 Create New Region Progress 3-6
Figure 3-10 Create New Region Acknowledgement 3-7
Figure 3-11 Select Open a Region 3-7
Figure 3-12 Open Region Wizard 3-8
Figure 3-13 Select the Region to Open 3-8
Figure 3-14 Open Region Wizard Completion 3-9
Figure 3-15 Select Delete a Region 3-10
Figure 3-16 Select Region to Delete 3-10
Figure 3-17 Delete Region Confirmation 3-11
Figure 3-18 Select Duplicate a Region 3-12
Figure 3-19 Select a Region to Duplicate 3-12
Figure 3-20 Duplicate Region Confirmation 3-13
Figure 3-21 Provide Duplicate Region Name 3-13
Figure 3-22 Duplicate Region Progress 3-13
Figure 3-23 Duplicate Region Completed 3-13
Figure 3-24 Select Export/Backup a Region 3-14
Figure 3-25 Select a Region to Export or Backup 3-15
Figure 3-26 Export/Backup Region Progress 3-15
Figure 3-27 Export/Backup Region Completed 3-15
Figure 3-28 Select Import a Region 3-16
Figure 3-29 Provide the Name for the Imported Region 3-17
Figure 3-30 Import Region Progress 3-17
Figure 3-31 Region Import Completed 3-17
Figure 4-1 Open a Region 4-1
Figure 4-2 Open Region Wizard 4-2
Figure 4-3 Select the Region to Open 4-3
Figure 4-4 Confirm the Selected Region 4-3
Figure 4-5 Example – Flood Model in ArcMap 4-4

Figure 4-6 Select Flood Hazard Type in Hazard Menu 4-4
Figure 4-7 Select Flood Hazard Type 4-5
Figure 4-8 Select User Data in Hazard Menu 4-5
Figure 4-9 Select Determine Required DEM Extent 4-6
Figure 4-10 Select Download required DEM 4-7
Figure 4-11 DEM Downloaded and Saved 4-7
Figure 4-12 Automatically Load DEM 4-8
Figure 4-13 Import DEM Files into Hazus 4-8
Figure 4-14 DEM Import Progress 4-9
Figure 4-15 DEM Import Completed 4-9
Figure 4-16 Example – Flood Model after DEM Import 4-10
Figure 4-17 Select Develop Stream Network in Hazard Menu 4-10
Figure 4-18 Enter Drainage Area for Develop Stream Network 4-11
Figure 4-19 Develop Stream Network Progress 4-11
Figure 4-20 Develop Stream Network Completed 4-11
Figure 4-21 Example – Flood Model after Developing Stream Network 4-12
Figure 4-22 Select Scenario and New in Hazard Menu 4-12
Figure 4-23 Provide Name for New Scenario 4-13
Figure 4-24 Select Add to Selection for River Reaches 4-14
Figure 4-25 Example – Flood Model after Stream Selection 4-15
Figure 4-26 Select Save Selection to Finalize Selected River Reaches 4-16
Figure 4-27 Example – Flood Model after Stream Reaches Chosen for a Scenario 4-17
Figure 4-28 Select Riverine and Hydrology in Hazard Menu 4-17
Figure 4-29 Select Yes to Start Hydrologic Analysis 4-18
Figure 4-30 Hydrologic Analysis Progress 4-18
Figure 4-31 Hydrologic Analysis Completed 4-18
Figure 4-32 Example – Flood Model after Hydrologic Analysis 4-19
Figure 4-33 Select Riverine and Delineate Floodplain in Hazard Menu 4-19
Figure 4-34 Delineate Floodplain for a Single Return Period 4-20
Figure 4-35 Delineate Floodplain Progress 4-21
Figure 4-36 Delineate Floodplain Completed 4-21
Figure 4-37 Example – Flood Model after Delineate Floodplain 4-22
Figure 4-38 Select Run in Analysis Menu 4-22
Figure 4-39 Select General Building Stock Damage and Loss from Analysis Options 4-23
Figure 4-40 Flood Losses Progress 4-24
Figure 4-41 Flood Losses Completed 4-24
Figure 5-1 Inventory Menu 5-1
Figure 5-2 Inventory > General Building Stock Menu 5-1
Figure 5-3 Square Footage Table 5-2

Figure 5-4 Building Count (by Occupancy) Table 5-3
Figure 5-5 Valuation Parameters Table 5-4
Figure 5-6 Dollar Exposure Table 5-5
Figure 5-7 Depreciation Parameters Table 5-6
Figure 5-8 Depreciated Exposure Table 5-7
Figure 5-9 General Occupancy Mapping Schemes 5-8
Figure 5-10 Flood-Specific Occupancy Mapping Schemes 5-9
Figure 5-11 Flood Building Characteristics Distribution 5-10
Figure 5-12 First Floor Elevations 5-11
Figure 5-13 Inventory / Essential Facilities Menu 5-12
Figure 5-14 Essential Facilities (Medical Care Facilities) Table 5-12
Figure 5-15 Inventory / User-Defined Facilities Menu 5-13
Figure 5-16 User-Defined Facilities Table 5-13
Figure 5-17 Inventory > Transportation Systems Menu 5-14
Figure 5-18 Transportation Systems Table 5-14
Figure 5-19 Inventory / Utility Systems Menu 5-15
Figure 5-20 Utility Systems Table 5-15
Figure 5-21 Inventory / Demographics Menu 5-16
Figure 5-22 Demographics Table 5-16
Figure 5-23 Inventory / Vehicles Menu 5-17
Figure 5-24 Vehicles (Vehicle Count) Table 5-17
Figure 5-25 Inventory / View Classifications Menu 5-18
Figure 5-26 Buildings Classifications Table 5-19
Figure 5-27 Essential Facilities Classification Table 5-20
Figure 5-28 Transportation Systems Classification Table 5-21
Figure 5-29 Utility Classifications Table 5-22
Figure 6-1 Hazard Menu 6-1
Figure 6-2 Select Flood Hazard Type 6-1
Figure 6-3 Flood Hazard Type Dialog 6-2
Figure 6-4 Select User Data 6-2
Figure 6-5 User Data Options Window 6-3
Figure 6-6 DEM Extent Window 6-4
Figure 6-7 DEM Downloaded, Unzipped, and Saved 6-5
Figure 6-9 Import DEM Files into Hazus 6-6
Figure 6-10 DEM Import Progress 6-7
Figure 6-11 DEM Import Completed 6-7
Figure 6-12 Select Develop Stream Network 6-8
Figure 6-13 Develop Stream Network Dialog 6-8
Figure 6-14 Example – Flood Model after Developing Stream Network 6-9

Figure 6-15 Example Discontinuous Synthetic Stream 6-10
Figure 6-16 Example Continuous Synthetic Stream 6-10
Figure 6-17 Select New Scenario (Prior to Defining First Scenario) 6-11
Figure 6-18 Select New Scenario (After Defining First Scenario) 6-11
Figure 6-19 Enter a Name for the New Scenario 6-12
Figure 6-20 Select Map Features 6-13
Figure 6-21 Select River Reaches for a Scenario 6-13
Figure 6-22 Select User-Defined Depth Grids for a Scenario 6-14
Figure 6-23 Enter a New Scenario (Coastal) 6-15
Figure 6-24 Select a Shoreline for a New Coastal Scenario 6-16
Figure 6-25 Select Shoreline 6-17
Figure 6-26 Input Shoreline Limits 6-18
Figure 6-27 Example – Setting Shoreline Limits 6-19
Figure 6-28 Example – Resetting the Shoreline Startline 6-20
Figure 6-29 Example – Resetting the Shoreline Endline 6-20
Figure 6-30 Example – Adding a Breakline to the Selected Shoreline 6-21
Figure 6-31 Shoreline Characterization – Stillwater Flood Conditions Window 6-22
Figure 6-32 Select River Reaches and Coastal Shorelines 6-24
Figure 6-33 Select Open Scenario 6-24
Figure 6-34 Open Scenario Dialog 6-25
Figure 6-35 Select Save As 6-26
Figure 6-36 Enter a New Name for the Scenario 6-26
Figure 6-37 Select Edit 6-28
Figure 6-38 Select Close 6-28
Figure 6-39 Select Delete 6-29
Figure 6-40 Delete Scenario Dialog 6-29
Figure 6-41 Select Hydrology 6-30
Figure 6-42 Select Yes to Start Hydrologic Analysis 6-30
Figure 6-43 Hydrologic Analysis Progress 6-31
Figure 6-44 Hydrologic Analysis Completed 6-31
Figure 6-45 Select Streams for Hydrology 6-32
Figure 6-46 Edit Scenario Dialog to Add Streams 6-33
Figure 6-47 Select Hydrology 6-33
Figure 6-48 Hydrology Processing Dialog 6-34
Figure 6-49 Overwrite Hydrology Dialog 6-34
Figure 6-50 Flood Options, Check Automatically Remove Problem Reach(es) 6-35
Figure 6-51 Notification and Option to Remove Problem Reaches 6-36
Figure 6-52 Edit Scenario Window 6-36
Figure 6-53 Edit Scenario Dialog to Remove Problem Reaches 6-37

Figure 6-54 Example Edited Scenario with Problem Reaches Removed 6-37
Figure 6-55 Select Delineate Floodplain 6-38
Figure 6-56 Riverine Hydraulic Analysis Dialog 6-39
Figure 6-57 Example Riverine Hydraulic Analysis Results 6-40
Figure 6-58 Chosen Reaches Attribute Table, Zoom to Selected Reach 6-44
Figure 6-59 Example Selected Chosen Reach (highlighted), Zoomed Out 6-45
Figure 6-60 Example Failed Reaches (purple) on Map after Hydraulics Completed 6-46
Figure 6-61 Select Delineate Floodplain 6-47
Figure 6-62 Coastal Hazard Analysis Dialog 6-47
Figure 6-63 Required Shoreline Inputs 6-49
Figure 6-64 Overview of Hazus Coastal Flood Hazard Modeling Process 6-50
Figure 7-1 Analysis Menu 7-1
Figure 7-2 Analysis > Damage Functions Menu 7-1
Figure 7-3 Building Depth-Damage Functions by Occupancy (Riverine) Table 7-2
Figure 7-4 Building Depth-Damage Function Library 7-3
Figure 7-5 Building Depth-Damage Function Library User-Defined Option 7-5
Figure 7-6 Editing Dialog for User-Defined Function Development 7-5
Figure 7-7 Building Depth-Damage Function Dialog with a User-Defined Damage Function 7-6
Figure 7-8 Analysis > Damage Functions Menu 7-6
Figure 7-9 Transportation Damage Function Table 7-7
Figure 7-10 Utility Facility Damage Function Table 7-8
Figure 7-11 Vehicle Damage Functions Table 7-9
Figure 7-12 Analysis > Restoration Functions Menu 7-10
Figure 7-13 Essential Facilities Restoration Functions Table 7-10
Figure 7-14 Analysis > Parameters Menu 7-11
Figure 7-15 Debris Analysis Parameters Table 7-12
Figure 7-16 Direct Economic Loss – Business Inventory Table 7-13
Figure 7-17 Direct Economic Loss –Restoration Time Table 7-14
Figure 7-18 Direct Economic Loss – Rental, Owner-Occupied, Wages and Capital, and Recapture Features Table 7-15
Figure 7-19 Analysis > Average Annualized Loss Menu 7-16
Figure 7-20 Riverine Flood Full Suite of Return Periods Analysis 7-16
Figure 7-21 Coastal Flood Full Suite of Return Periods Analysis 7-16
Figure 7-22 Average Annualized Loss Analysis Dialog 7-17
Figure 7-23 Average Annualized Loss GBS Error Dialog 7-17
Figure 7-24 Average Annualized Loss UDF Error Dialog 7-17
Figure 7-25 Analysis > Combined Wind and Flood Menu 7-18
Figure 7-26 Analysis > Run Menu 7-18
Figure 7-27 Select Analysis Options 7-19
Figure 7-28 Customize > Flood Options Menu 7-20

Figure 7-29 Check Show Redo Analyses Warning Message Box(es) 7-21
Figure 8-1 Results Menu 8-1
Figure 8-2 Results > View Current Scenario Results By Menu 8-2
Figure 8-3 Select Available Results 8-2
Figure 8-4 Results > Flood Hazard Maps Menu 8-3
Figure 8-5 Results > General Building Stock Menu 8-4
Figure 8-6 General Building Stock Damage Results Table 8-5
Figure 8-7 Building Stock Damage by Building Type Table 8-6
Figure 8-8 General Building Stock Damage Count Table 8-7
Figure 8-9 General Building Stock Direct Economic Losses for Full Replacement Value (By General Occupancy) Table 8-8
Figure 8-10 General Building Stock Direct Economic Losses for Full Replacement Value (Total) Results 8-9
Figure 8-11 Export General Building Stock Direct Economic Losses for Full Replacement Value (By Occupancy) Results 8-10
Figure 8-12 Results > Combined Wind and Flood Loss Menu 8-11
Figure 8-13 Combined FL/HU Surge Direct Economic Losses for Full Replacement Value (By General Occupancy) Table 8-12
Figure 8-14 Results > Essential Facilities Menu 8-13
Figure 8-15 Essential Facilities (Medical Care Facilities) Table 8-13
Figure 8-16 Results > User-Defined Facilities Menu 8-14
Figure 8-17 User-Defined Facilities Loss Table 8-15
Figure 8-18 Results > Transportation Systems Menu 8-16
Figure 8-19 Transportation Systems Damage/Economic Loss (Highway) Table 8-17
Figure 8-20 Results > Utility Systems Menu 8-18
Figure 8-21 Utility Systems Damage/Economic Loss (Waste Water Treatment Plants) Table 8-18
Figure 8-22 Results > Vehicles Menu 8-19
Figure 8-23 Vehicle Damage and Loss (Damage) Table 8-20
Figure 8-24 Results > Debris Menu 8-21
Figure 8-25 Debris Generation Table 8-21
Figure 8-26 Results > Shelter Menu 8-22
Figure 8-27 Shelter Table 8-23
Figure 8-28 Results > Summary Reports Menu 8-24
Figure 8-29 Summary Reports (Inventory) Window 8-25
Figure 8-30 Example – Transportation Systems Exposure Summary Report 8-26
Figure 8-31 Example – Building Damage By General Occupancy Summary Report 8-27
Figure 8-32 Report Export 8-28
Figure 9-1 Hazus File Menu 9-1
Figure 9-2 Select Hazard Dialog 9-2
Figure 9-3 Study Region Wizard 9-2
Figure 9-4 Hazus Help Menu 9-3

Figure 9-5 Technical Support Window 9-3
Figure 9-6 About Hazus Window 9-4
Figure 9-7 Hazus Customize Menu 9-4
Figure 9-8 Flood Options (Startup Options) Window 9-5
Figure 9-9 Flood Options (Raster Options) Window 9-5
Figure 9-10 Flood Options (Automation) Window 9-6
Figure 9-11 Flood Options (Repository) Window 9-7
Figure 10-1 Hazus Comprehensive Data Management System 10-8
Figure 11-1 Select Hazards for New Region 11-2
Figure 11-2 Select Hurricane Model First in Study Region 11-3
Figure 11-3 Ensure Optimized Analysis Mode is Off 11-4
Figure 11-4 Review Scenario in Hazard > Show Current 11-4
Figure 11-5 Scenario Management Wizard 11-5
Figure 11-6 Analysis Run Storm Surge Menu 11-6
Figure 11-7 Analysis Options for Storm Surge 11-6
Figure 11-8 Provide Initial Water Level 11-7
Figure 11-9 Run Analysis Progress Status Window 11-8
Figure 11-10 Run Storm Surge Progress Status Window 11-8
Figure 11-11 Coastal Surge Status Window 11-8
Figure 11-12 Select Flood Model in Study Region 11-9
Figure 11-13 Select Flood Hazard Type 11-9
Figure 11-14 Select Storm Surge 11-10
Figure 11-15 Select User Data to Import DEM 11-10
Figure 11-16 Add User Data DEM to Model 11-11
Figure 11-17 Review User Data in Storm Surge Tab 11-12
Figure 11-18 Select New Scenario in Hazard Menu 11-13
Figure 11-19 Provide Name for New Scenario 11-13
Figure 11-20 Input Shoreline Limits 11-14
Figure 11-21 Select Shoreline Characteristics 11-14
Figure 11-22 Select Coastal to Delineate Floodplain 11-15
Figure 11-23 Delineate Floodplain Completion Status Window 11-16
Figure 11-24 Example – Coastal Surge Floodplain Delineation 11-16
Figure 11-25 Select Run in Analysis Menu 11-17
Figure 11-26 Select Preferred Analysis Options 11-17
Figure 11-27 Select Combined Wind and Flood to Calculate Losses 11-18
Figure 11-28 Combined Coastal Surge Status Window 11-18
Figure 11-29 Select View Current Scenario Results 11-19
Figure 11-30 Select Available Results for Surge Analysis 11-19
Figure 11-31 Select Combined Wind and Flood Loss Results (Flood Model) 11-20

Figure 11-32 Select Combined Wind and Surge Loss (Hurricane Model) 11-20
Figure 11-33 Example – Combined Surge Result Table 11-21
Figure 11-34 User Supplied Coastal Surge Grid Set to YES 11-22
Figure 11-35 Flood Hazard Type Storm Surge 11-22
Figure 11-36 Storm Surge Data Import Dialog Box 11-23
Figure 11-37 Overwrite and Process User-Supplied Storm Surge Data 11-24
Figure 11-38 New Scenario Window 11-24
Figure 11-39 Delineate Floodplain 11-25
Figure 11-40 Coastal Hazard Analysis 11-25
Figure 11-41 Process Coastal Hazard 11-26
Figure 11-42 Successfully Completed Coastal Flood Hazard 11-26
Figure 12-1 Select FIT Tab to Import FIT Data 12-1
Figure 12-2 FEMA Map Service Center 12-2
Figure 12-3 Map Service Center Search Options 12-3
Figure 12-4 Jurisdiction Search Results 12-3
Figure 12-5 Geotiff Data from Map Service Center 12-4
Figure 12-6 Select Depth Grid Tab to Import Depth Grid Data 12-5
Figure 12-7 Set Parameters for Depth Grid Dialog 12-5
Figure 12-8 Select the HEC-RAS Tab to Import .FLT Grid Data 12-7
Figure 12-9 Set Parameters for .FLT Grid Dialog 12-7

List of Tables

Table 8-1: List of Summary Reports 8-28
Table 10-1 UDF Attribute Descriptions 10-9
Table 10-2 NumStories Field Description 10-13
Table 10-3 DesignLevel Field Description 10-14
Table 10-4 FoundationType Field and FirstFloorHt Field Description 10-14
Table 11-1 Workflow to Build Multi-Hazard Study Region 11-1

Acronyms and Abbreviations

Acronym/ Abbreviation	Definition
.dat	hurricane surface wind file
.fGDB	file geodatabase file
.FLT	floating-point binary
.hpr	Hazus Packaged Region, file extension used for exported Hazus study regions
.IMG	IMAGINE file
.mdb	geodatabase file
.TIF	tagged image file
DEM	Digital elevation model
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
FIT	Flood Information Tool
GBS	General Building Stock
GIS	geographic information system
HEC-RAS	Hydrologic Engineering Center's River Analysis System
Hurrevac	hurricane evacuation tool
NAVD	North American Vertical Datum
NOAA	National Oceanic and Atmospheric Administration
RES1	Single-Family
SLOSH	Sea, Lake, and Overland Surges from Hurricanes (model)
SWAN	Simulating WAves Nearshore (model)
SWEL	stillwater elevation
UDFs	User-Defined Facilities
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
WHAFIS	Wave Height Analysis for Flood Insurance Studies

Section 1. Introduction

1.1 Background

The Hazus Flood Loss Estimation Methodology provides state, local, tribal, and territorial (SLTT) officials with a decision support software for estimating potential losses from flood events. This loss estimation capability enables users to anticipate the consequences of floods and develop plans and strategies for reducing risk. The Geographic Information System (GIS) based software can be applied to study geographic areas of varying scale with diverse population characteristics and can be implemented by users with a wide range of technical and subject matter expertise.

This Methodology has been developed, enhanced, and maintained by the Federal Emergency Management Agency (FEMA) to provide a tool for developing flood loss estimates for use in:

- Anticipating the possible nature and scope of the emergency response needed to cope with a flood-related disaster.
- Developing plans for recovery and reconstruction following a disaster.
- Mitigating the possible consequences of floods.

The Hazus Flood Model provides the capability to quantify potential building impacts and losses, and social parameters such as shelter needs. The model analyzes flood hazards from a variety of inputs or can develop a flood hazard using probabilistic parameters set by the user.

The current capability addresses all fifty states and Caribbean territories and includes both riverine and coastal models. This flood methodology was developed by FEMA in the early 2000s and is updated with ongoing modifications based on newer methodology or software development. It is intended to help guide the allocation of federal resources to stimulate risk mitigation efforts and to plan for a flood-related disaster response at all levels of government.

This Hazus Flood Model User Guidance outlines the background and instructions for developing a Study Region and defining a scenario to complete a flood loss estimation analysis using Hazus. It also provides information on how to modify inventory, improve hazard data and analysis parameters for advanced applications, and guidance on calculating and interpreting loss results.

The Hazus Flood Model Technical Manual (FEMA, 2021) documents the methods used in calculating losses. A companion document, the Hazus Inventory Technical Manual (FEMA, 2021), provides more detailed methodology and data descriptions for the inventory shared by each hazard model. Together, these documents provide a comprehensive overview of this nationally applicable loss estimation methodology across Hazus.

1.2 Hazus Users and Applications

Hazus can be used by various types of users with a wide range of informational needs. A SLTT government official may be interested in the costs and benefits of specific mitigation strategies, and thus may want to know the expected losses if mitigation strategies have (or have not) been applied. Health officials may want information regarding the demands on medical care facilities and may be interested in social impacts for different flood scenarios. Emergency response teams may use the results of a loss study in planning and performing emergency response exercises. They might be interested in the operating capacity of emergency facilities such as fire stations, emergency operations centers, and police stations. Emergency planners may want estimates of temporary shelter requirements for different flood scenario events. Federal and state government agencies may conduct a loss analysis to obtain quick estimates of impacts immediately following a flood to best direct resources to the disaster area. Insurance companies may be interested in the estimated monetary losses so they can determine asset vulnerability.

Flood loss estimation analyses have a variety of uses for various departments, agencies, and community officials. As users become familiar with the loss estimation methodology, they can determine how to use it to best suit their needs, and how to appropriately interpret the study results.

The products of Hazus analyses have several pre- and post-flood applications in addition to estimating the scale and extent of damage and disruption. Examples of pre-flood applications of the outputs include:

- Development of flood hazard mitigation strategies that outline policies and programs for reducing flood losses and disruptions indicated in the initial loss estimation study. Strategies can involve rehabilitation of hazardous existing buildings (e.g., unreinforced structures in a high-risk flood zone), building code enforcement, development of appropriate zoning ordinances for land use planning in flood inundation zones, and the adoption of advanced building codes.

- Development of preparedness (contingency) planning measures that identify alternate transportation routes, social preparedness, and public education.

- Anticipation of the nature and extent of response and recovery efforts including the identification of alternative housing; the location, availability, and scope of required medical services; and the establishment of a priority ranking for restoration of water and power resources.

Post-flood applications of the outputs include:

- Projection of immediate economic impact assessments for state and federal resource allocation, and support for state and/or federal disaster declarations by calculating direct economic impact on public and private resources, local governments, and the functionality of facilities in the area.

- Activation of immediate emergency recovery efforts including search and rescue operations, rapid identification and treatment of casualties, provision of emergency housing shelters, and rapid repair and availability of essential utility systems.

- Application of long-term reconstruction plans that include the identification of long-term reconstruction goals, implementation of appropriate wide-range economic development plans for the impacted area, allocation of permanent housing needs, and the assessment of land use planning principles and practices.

1.3 Assumed User Expertise

Users can be divided into two groups: those who perform the analysis and those who use the analysis results. For some analyses, these two groups occasionally consist of the same people. The more interaction that occurs between these two groups, the better the analysis will be. End users of the loss estimation analysis need to be involved from the beginning to make results more usable.

Any risk modeling effort can be complex and would benefit from input from an interdisciplinary group of experts. A flood loss analysis could be performed by a representative team consisting of the following:

- Floodplain managers
- Structural engineers or architects
- GIS professionals
- Economists
- Sociologists
- Emergency planners
- Loss analysts

The individuals needed to perform the study can provide valuable insight into the risk assessment process and will depend on the desired level of analysis, explained in greater detail in Section 2.3. In addition to subject matter expert involvement, at least one GIS specialist should participate on the team.

If a SLTT agency is performing the analysis, some of the expertise may be found in-house. Experts are generally found in several departments: building permits, public works, planning, public health, engineering, information technologies, finance, historical preservation, natural resources, and land records. Although internal expertise may be most readily available, the importance of the external participation of individuals from academic institutions, citizen organizations, and private industry cannot be underestimated.

1.4 When to Seek Help

The results of a loss estimation study should be interpreted with caution because default input values have a great deal of uncertainty.

If the loss estimation team does not include individuals with expertise in the areas described in Section 1.3, one or more consultants will likely be needed to help interpret the results. It is also advisable to retain objective reviewers with relevant expertise to evaluate the map and tabular data outputs. A floodplain manager, hydrologist, or hydraulic engineer may be needed to provide deterministic or probabilistic scenario data or review the software parameters.

If the user intends to modify the default inventory data or parameters, assistance will be required from an individual with relevant expertise. For example, if the user wishes to change the default percentages of foundation types in a region, a structural engineer with knowledge of regional design and construction practices would be helpful. Modifications to defaults in the economic loss models will require input from an economist.

1.5 Technical Support

Technical Support contact information is provided in the Hazus application at **Help > Obtaining Technical Support**; technical assistance is available via the Hazus Help Desk by email at FEMA-Hazus-support@fema.dhs.gov (preferred) or by phone at 1-877-FEMA-MAP (1-877-336-2627). The FEMA Hazus website also provides answers to Frequently Asked Questions, and information on software updates and training opportunities.

FEMA-provided resources also include the Hazus Virtual Training Library, a series of short videos arranged into playlists that cover various Hazus topics, from an introduction to Hazus methodologies, to targeted tutorials on running Hazus analyses, to best practices when sharing results with decision makers. This easily accessible learning material provides quick topic-refreshers, free troubleshooting resources, and engaging guides to further Hazus exploration.

The application's **Help** menu references the help files for ArcGIS. Since Hazus was built as an extension to ArcGIS functionality, knowing how to use ArcGIS and ArcGIS Help Desk will help Hazus users.

Technical support on any of the four hazards is available in the contacts shown via **Help > Obtaining Technical Support**.

1.6 Uncertainties in Loss Estimates

Although the software offers users the opportunity to prepare comprehensive loss estimates, even with state-of-the-art techniques, uncertainties are inherent in any estimation methodology. The Flood Model is only a tool for loss estimation from modeled flood events. Hazus does not compute uncertainties in the loss estimates, provide ranges for possible losses, or offer any confidence levels. The output of hard numbers is tied to the input data. Uncertainties may be estimated, but Hazus does not output such statistics.

Section 2. Overview of the Flood Model

This brief overview of the Flood Methodology is intended for SLTT officials contemplating a flood analysis.

The Flood Model will generate an estimate of the consequences to a county or region of a scenario flood (i.e., a flood of a specified magnitude). The resulting "loss estimate" will generally describe the scale and extent of damage and disruption that may result from the modeled flood event. The following information can be obtained:

- *Quantitative estimates of structural damage* based on specific building and occupancy types that delineate how and to what extent a structure can be damaged by varying flood water depths.
- *Quantitative estimates of losses* in terms of direct costs for repair and replacement of damaged buildings, direct costs associated with loss of function (e.g., loss of business revenue or relocation costs).
- *Estimates of social and infrastructure impacts.*

To generate this information, the Methodology includes:

- Classification systems used in assembling inventory and compiling information on the General Building Stock (GBS), demographic, and economic data.
- Standard calculations for estimating type and extent of damage, and for summarizing losses.
- National and regional databases containing information for use as baseline (built-in) data useable in the calculation of losses if there is an absence of user-supplied data.

These systems, methods, and data have been combined in a user-friendly GIS software for this loss estimation application.

The Hazus software uses GIS technologies for performing analyses with inventory data and displaying losses and consequences on applicable tables and maps. The Methodology permits estimates to be made at several levels of complexity, based on the level of inventory data entered for the analysis (i.e., baseline data versus locally enhanced data). The more concise and complete the inventory information, the more accurate the results.

The following figure provides a graphic representation of the modules that the Hazus Flood Model Methodology is comprised of, and their interrelation in deriving estimates.

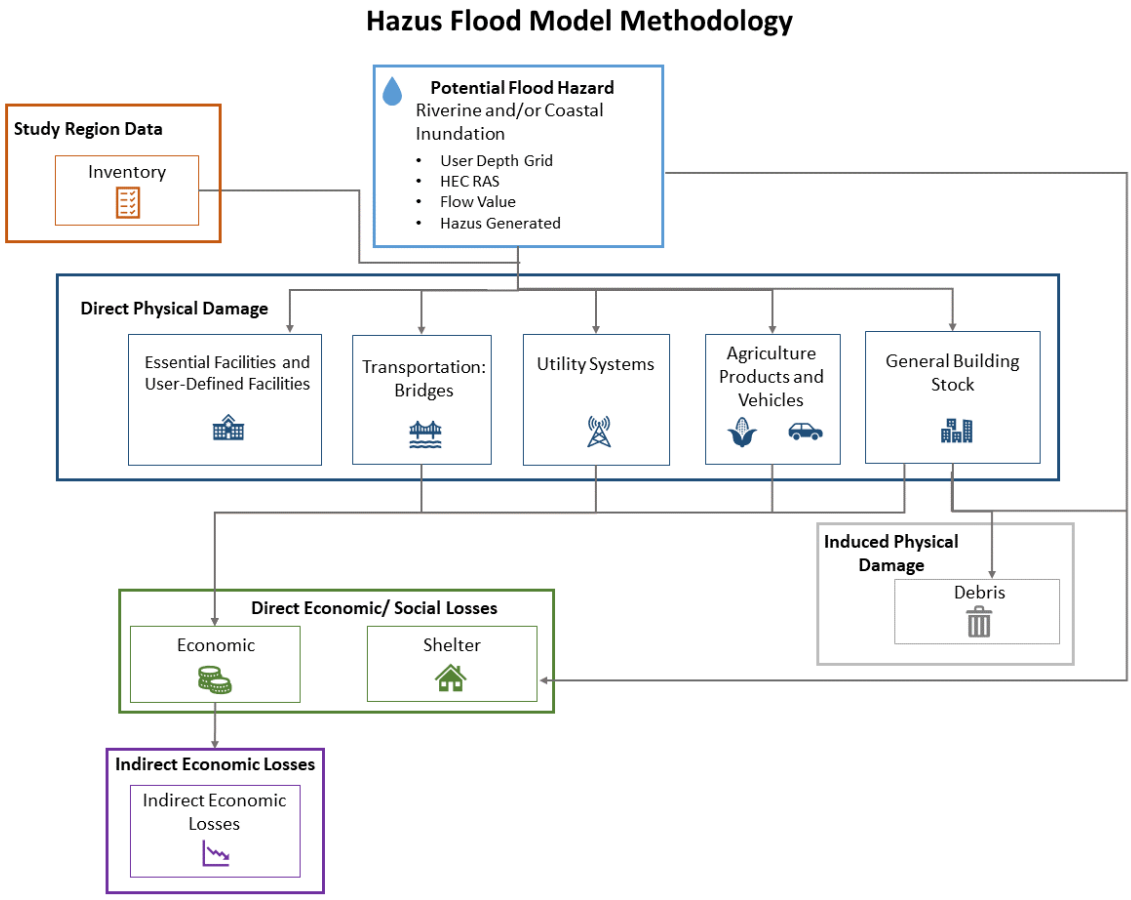


Figure 2-1 Hazus Flood Model Methodology Schematic

While Figure 2-1 shows the conceptual relationships, the steps used in the Hazus Flood Model are as follows:

- Select the area to be studied: The Hazus Study Region (the region of interest) is created based on Census block, tract, or county level aggregation of data. The area generally includes a city, county, or group of municipalities. It is generally desirable to select an area that is under the jurisdiction of an existing regional planning group.

- Specify the Flood hazard scenario: In developing the scenario, flood consideration should be given to the availability of data including depth grids or elevation models from HEC-RAS or lidar-derived sources

- Integrate local inventory data: Include user-defined facilities and updates to GBS characteristics.

- Use the formulas embedded in Hazus: Compute probability distributions for damage to different classes of buildings, facilities, and infrastructure system components.

- Compute estimates of direct economic loss, infrastructure, and social impacts using the damage and functionality information.

The user plays a major role in selecting the scope and nature of the output of a loss estimation analysis. A variety of maps can be generated for visualizing the extent of the losses. Generated reports provide numerical results that may be examined at the level of the Census block, tract, or aggregated by county or region.

2.1 Flood Hazards in the Flood Model

The Hazus Flood Model analyzes both riverine and coastal flood hazards. Flood hazard is defined by a relationship between depth of flooding and the annual chance of inundation to that depth.

Depth, duration, and velocity of water in the floodplain are the primary factors contributing to flood losses. Other hazards associated with flooding that contribute to flood losses include channel erosion and migration, sediment deposition, bridge scour, and the impact of flood-borne debris. The Hazus Flood Model allows users to estimate flood losses from depth of flooding. The Flood Model does not estimate the losses due to high-velocity flash floods.

In different contexts, flood hazard may have different meanings. Hazard can mean risk in some contexts, and it can mean a source of danger in others. The hazard may be that an area is inundated about once every 10 years (risk), or it may be that an area is subject to flood depths ranging from 5 to 10 feet (source of danger). Flood frequency studies combine these ideas and define flood hazard in terms of the chance that a certain magnitude of flooding is exceeded in any given year.

Flood magnitude is usually measured as a discharge value, flood elevation, or depth. For example, flood magnitude may be referred to as the 100-year flood elevation, which is the elevation, at the point of interest, that has a 1% annual chance of being exceeded by floodwater. Using the flood frequency convention, flood hazard is defined by a relation between depth of flooding and the annual chance of inundation greater than that depth. The relation is called a depth-frequency curve.

2.2 Definitions of Structures

There are differences between terminology used to designate distinctions between types or categories of structures. The term “structure” refers to all constructions, such as a building, bridge, water tank, shed, carport, or other man-made thing that is at least semi-permanent. A building is a structure with a roof and walls that is intended for use by people and/or inventory and contents, such as a house, school, office, or commercial storefront. A facility corresponds to a particular place, generally a building, with an intended purpose such as a school, hospital, electric power station, or water treatment facility. Some facilities are defined as ‘essential facilities’ meaning the facility is critical to maintaining services and functions vital to a community, especially during disaster events. The buildings, essential facilities, and transportation and utility systems considered by the Methodology are as follows:

- *General Building Stock:* The key General Building Stock (GBS) databases in Hazus include square footage by occupancy and building type, building count by occupancy, and building type, building and content valuation by occupancy and building type, and general occupancy mapping. The GBS commercial, industrial, and residential buildings in a region are not considered individually when calculating losses. These buildings within each Census block are aggregated and categorized. Building information derived from Census and employment data are used to form groups of 33 specific occupancy classes, seven foundation types, and five general building types (additional information on the Hazus baseline GBS inventory data is provided in the *Hazus Inventory Technical Manual* (FEMA, 2021). Degree of damage is computed for each grouped combination of model building type and occupancy class.

- *User-Defined Facilities (UDFs):* A template database is available in Hazus to enter individual accurate results. structures to be analyzed, instead of or in addition to the aggregated GBS. Template databases are available in Hazus if the user is comfortable working with SQL Server. More information on how to set up a UDF database can be found in Section 9 of this document, the *Hazus Inventory Technical Manual* (FEMA, 2021) or in the documentation and sample databases accompanying the Hazus FAST tool. Use of individual, site-specific data is highly encouraged for more

2.3 Levels of Analysis

Hazus is designed to support two general types of analysis (Basic and Advanced), split into three levels of data updates (Levels 1, 2, and 3). Figure 2-2 provides a graphic representation of the various levels of analysis.

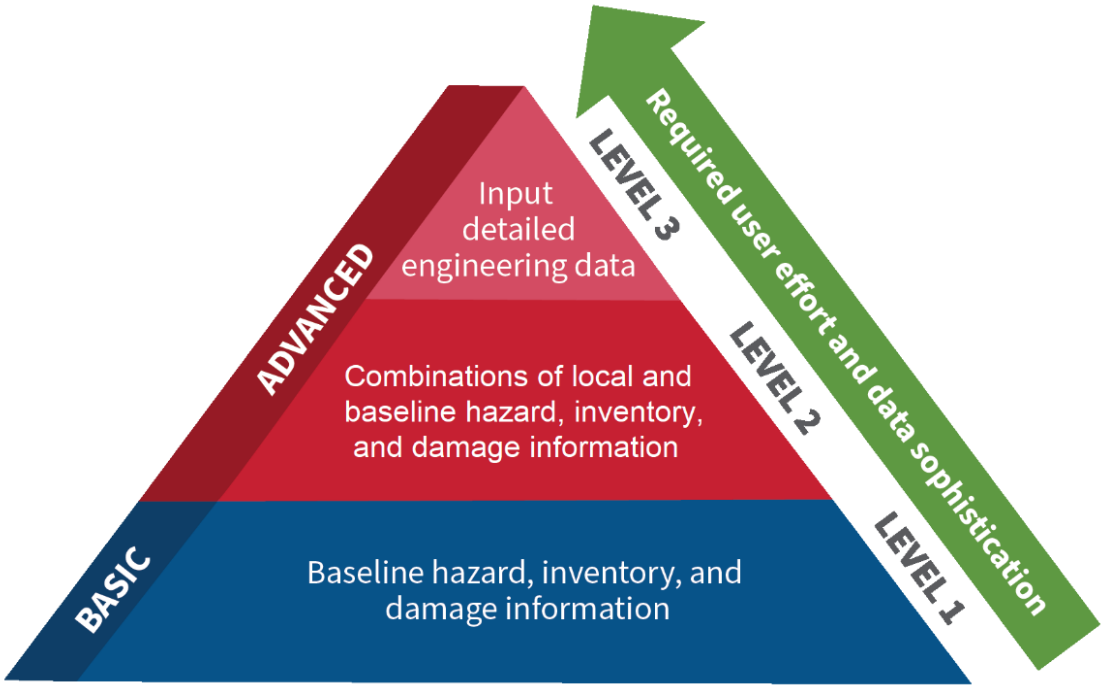


Figure 2-2 Levels of Hazus Analysis

2.3.1 Analysis Based on Baseline Information

The basic level of analysis uses only the baseline databases built into the Hazus software and Methodology on building square footage and value, population characteristics, costs of building repair, and certain basic economic data. This level of analysis is commonly referred to as a Level 1 analysis. In a basic analysis (Level 1), the user must specify a drainage area for stream network delineation, and Hazus will use these inputs to estimate a depth grid for the study region. Direct economic and social losses associated with the GBS, and essential facilities are computed. Baseline data for transportation and utility systems are included; thus, these systems are considered in the basic level of analysis. However, there is a significant level of uncertainty pertaining to the estimates.

Other than defining the Study Region, selecting the scenario flood(s), and making decisions concerning the extent and format of the output, an analysis based on baseline data requires minimal effort from the user. As indicated, the estimates involve large uncertainties when inventories are limited to the baseline data. This level of analysis is suitable primarily for preliminary evaluations and comparisons among different Study Regions. A basic Level 1 analysis could be used for comparisons and preliminary evaluations to assist in identifying potential mitigation actions within a community, which could be useful if evaluating funding priority for projects.

2.3.2 Analysis with User Supplied Inventory

Results from an analysis using only baseline inventory data can be improved greatly with at least a minimum amount of locally developed input. Improved results are highly dependent on the quality and quantity of improved inventory data. The significance of the improved results also relies on the user's analysis priorities. This level of advanced analysis is commonly referred to as a Level 2/Level 3 analysis. The following inventory improvements impact the accuracy of Level 2/Level 3 Advanced Analysis results:

- Use of locally available data or estimates of the square footage of buildings in different occupancy classes.
- Use of local expertise to modify the mapping scheme databases that determine the percentages of specific building types associated with different occupancy classes.
- Preparation of a detailed inventory of all essential facilities and infrastructure.
- Use of locally available data concerning construction costs or other economic parameters.
- Level 2 or 3 hazard data can also be incorporated in the form of independently generated depth grids. Sources for these grids may include local engineering offices, state water departments with access to lidar products, adapted DFIRMs from FEMA, or the HEC-RAS tool.

Section 3. Getting Started Part 1: Hazus Startup Screen

The **Hazus Startup** screen is the first screen users will see after launching Hazus.

3.1 Hazus Startup

Before running a loss estimation analysis, users must define a Study Region. The Study Region in Hazus is the geographic unit for which data are aggregated, the flood hazard is defined, and the analysis is carried out. Before starting, make sure that the appropriate state(s)'s Hazus data have been downloaded and extracted here: C:\HazusData\Inventory.

Hazus will prompt users to create a new region or import a previously created region. Users can also open, delete, duplicate, backup, or export an existing region.

3.2 Create New Region

In the **Hazus Startup** screen (Figure 3-1), users will take the first step in defining the Study Region. In Figure 3-1, **Create a new region** has been selected. Click **OK** to activate the window shown in Figure 3-2.

Click **Next** to open the window shown in Figure 3-3 and name the region in the first box (up to 18 characters, no spaces, and must not begin with a number). Enter a description of the region in the second box. This is especially helpful if multiple users will be accessing this region in the future. Click **Next**, which will open the window shown in Figure 3-4. Select **Flood** from the **Hazard Types** and click **Next**. This selection cannot be altered later.

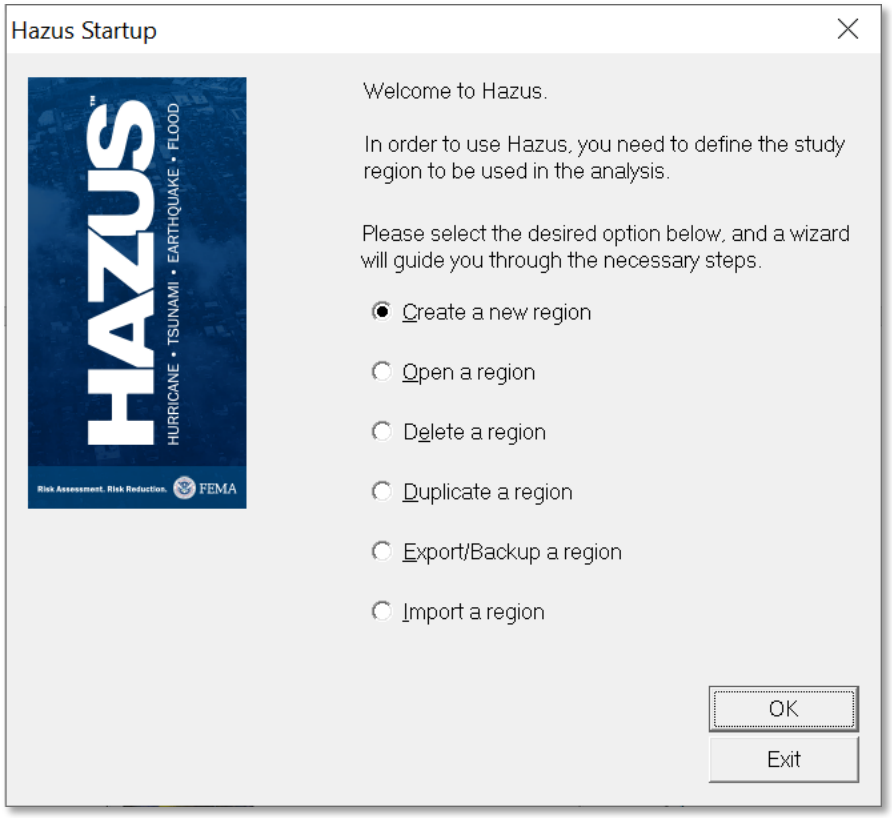


Figure 3-1 Select Create a New Region in Hazus Startup

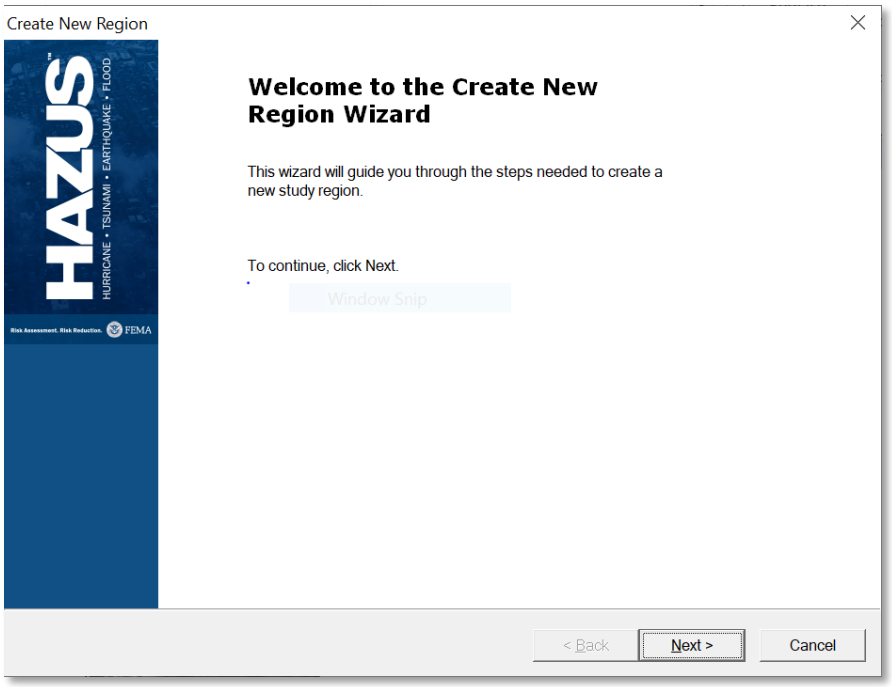


Figure 3-2 Select Create New Region in Wizard

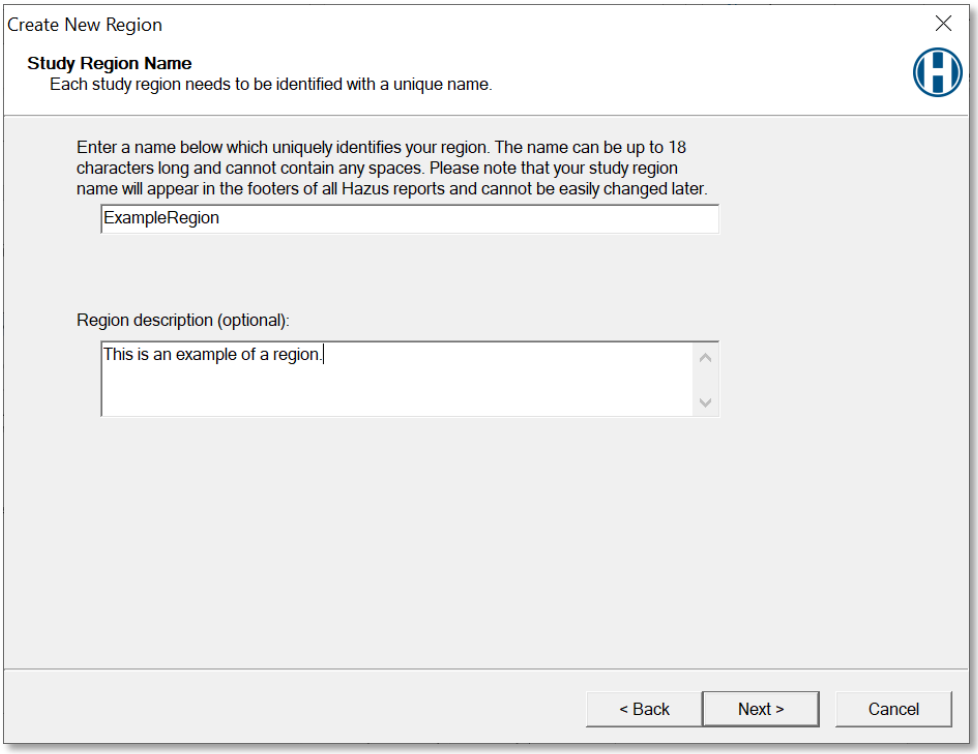


Figure 3-3 Create a Study Region Name

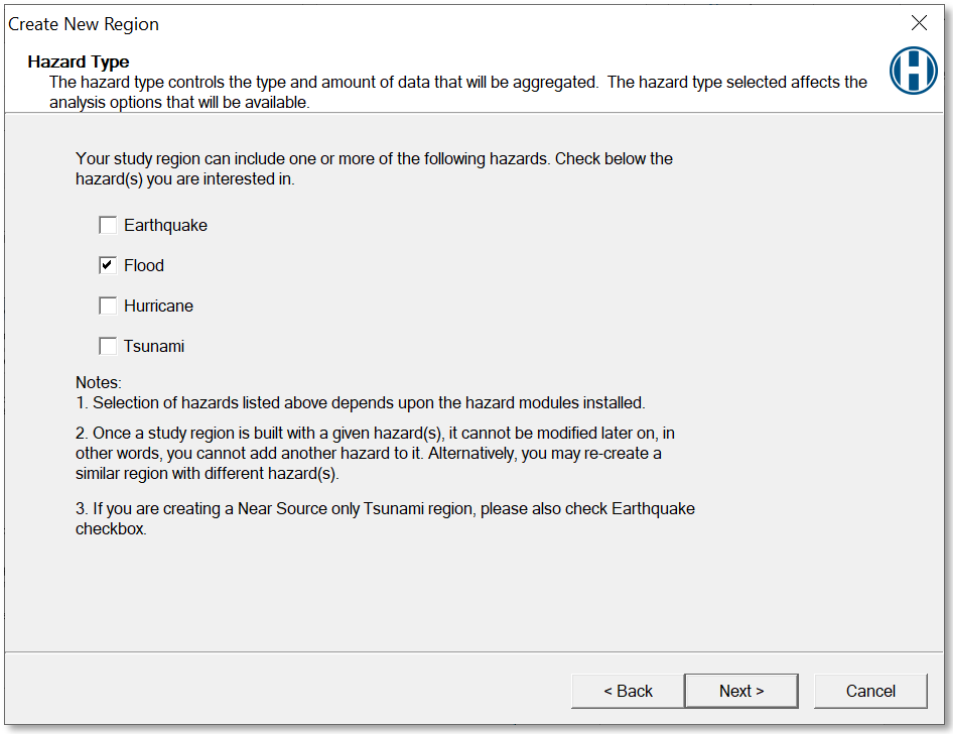


Figure 3-4 Select Hazard Type for New Region

From the window shown in Figure 3-5, select one of the six aggregation levels. Click **Next** to open the window shown in Figure 3-6. Select the state(s) covered by the Study Region. To select multiple states, hold the Shift key while making selections. Click **Next** to open the window in Figure 3-7. Select the county or counties covered by the Study Region.

Click **Next** to open the **Region Wizard Completion** notification shown in Figure 3-8. Click **Finish**. The status window shown in Figure 3-9 will appear. It may take several minutes for the region to be created. Once the process is finished, click **OK** to acknowledge the Study Region has successfully been created (Figure 3-10). The **Start Menu** will reappear.

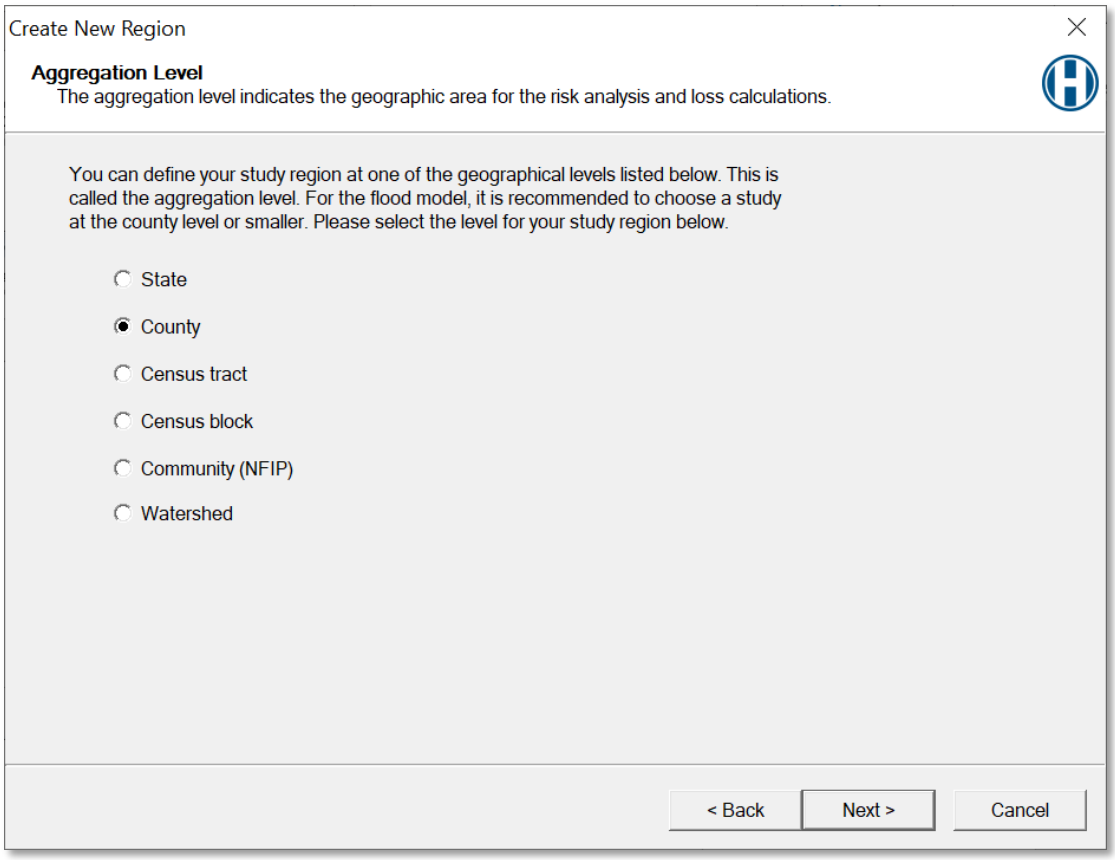


Figure 3-5 Select Desired Aggregation Level

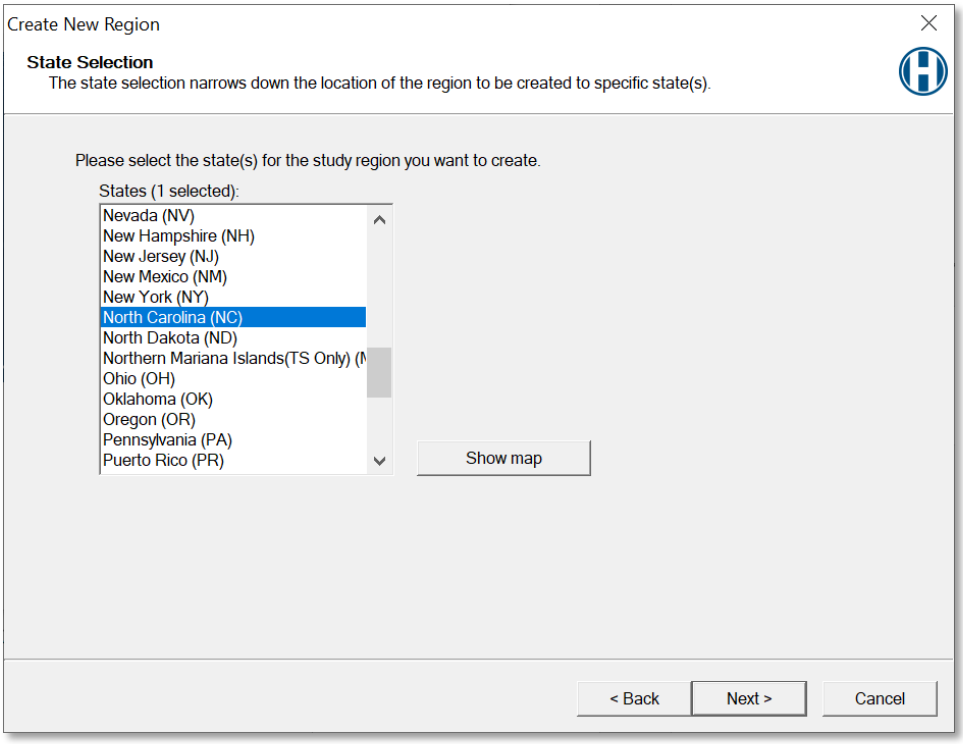


Figure 3-6 Select Appropriate State for the New Region

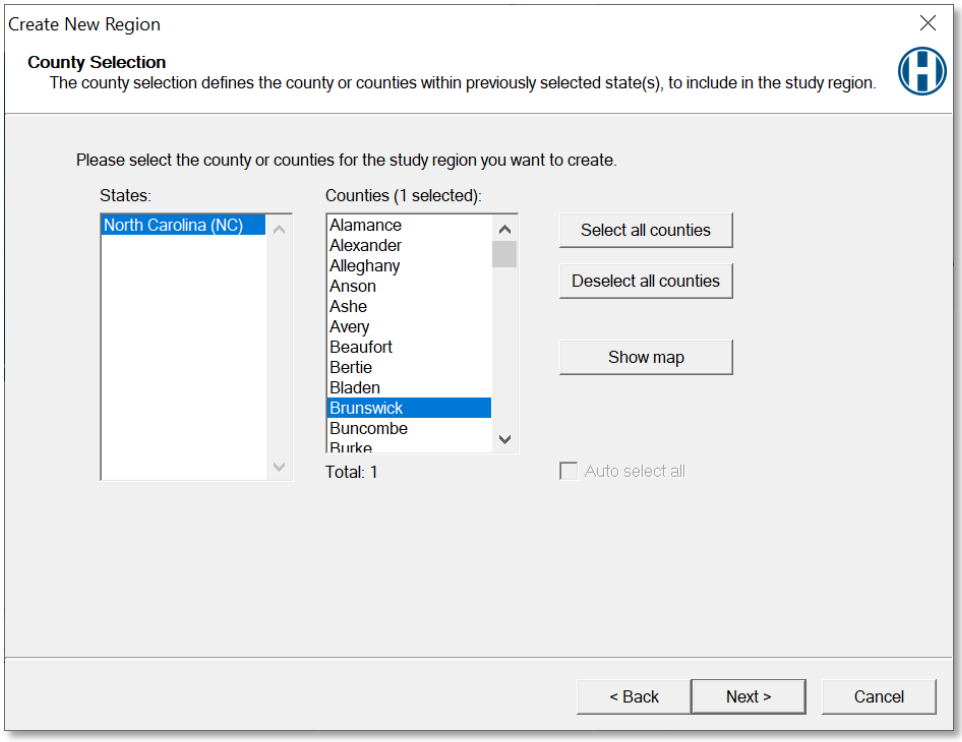


Figure 3-7 Select County for the New Region

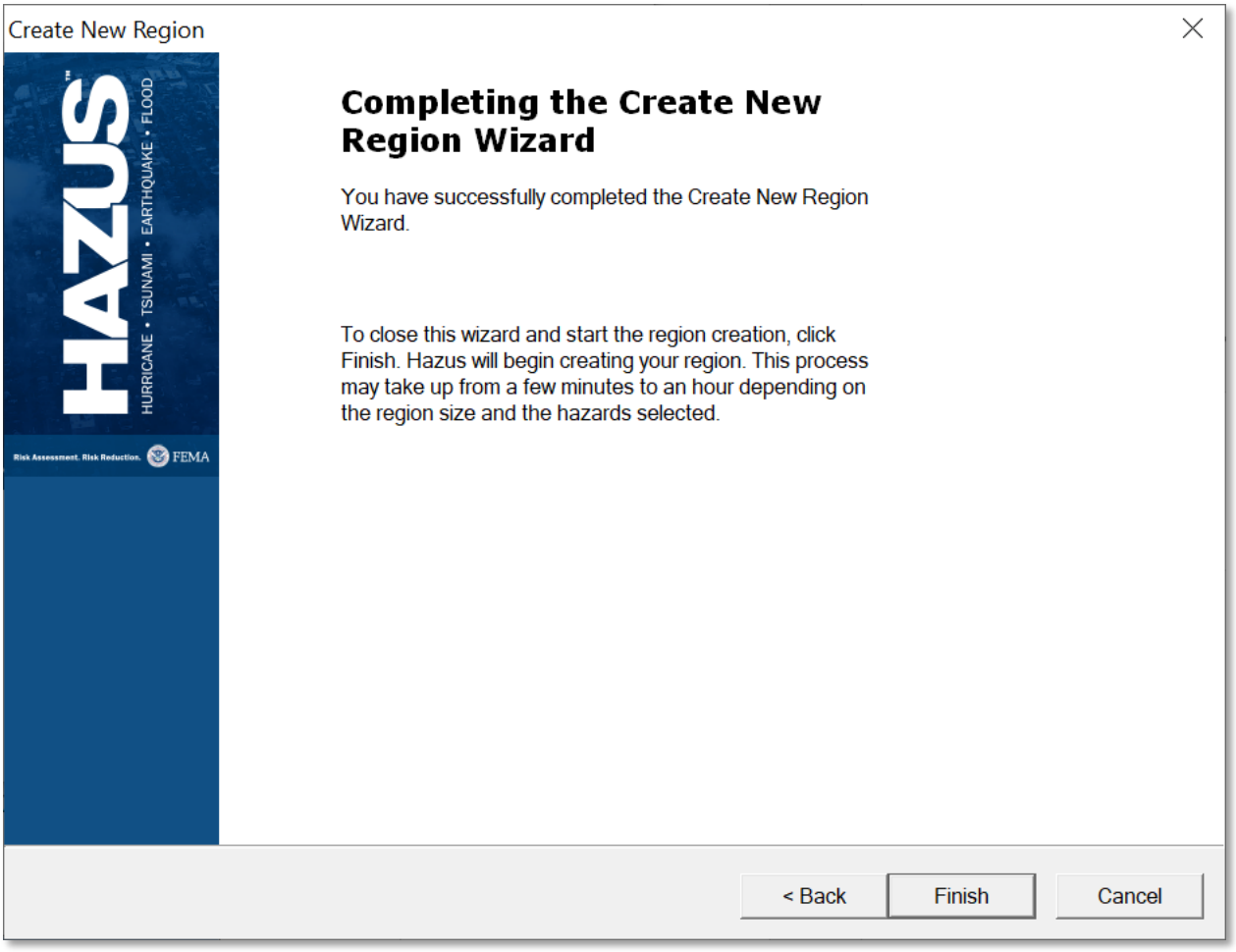


Figure 3-8 Create New Region Wizard Completion

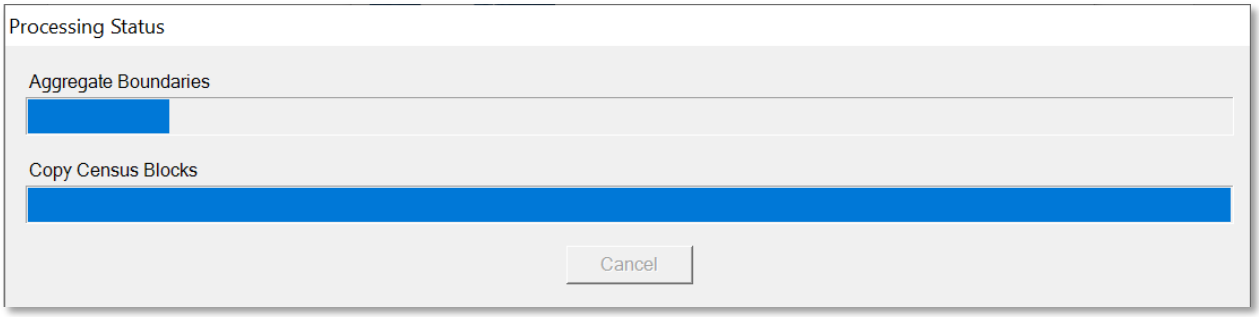


Figure 3-9 Create New Region Progress

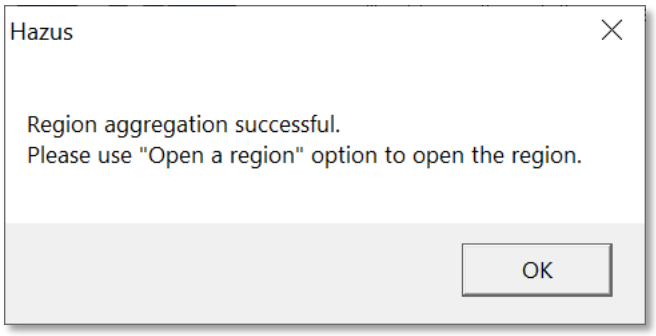


Figure 3-10 Create New Region Acknowledgement

3.3 Open Region

The **Open a region** option will not be available in the **Hazus Startup** screen in Figure 3-11 until a region has been created or imported. Select **Open a region** and click **OK**. The **Open Region Wizard** will appear (Figure 3-12). Click **Next**. An **Open Region** list will appear (Figure 3-13). Select which region should be opened. Click **Next**. Verify that the region name and hazard type are correct (Figure 3-14). Click **Finish**. Clicking **Finish** will launch ArcMap. Refer to the additional Hazus User Manuals for guidance.

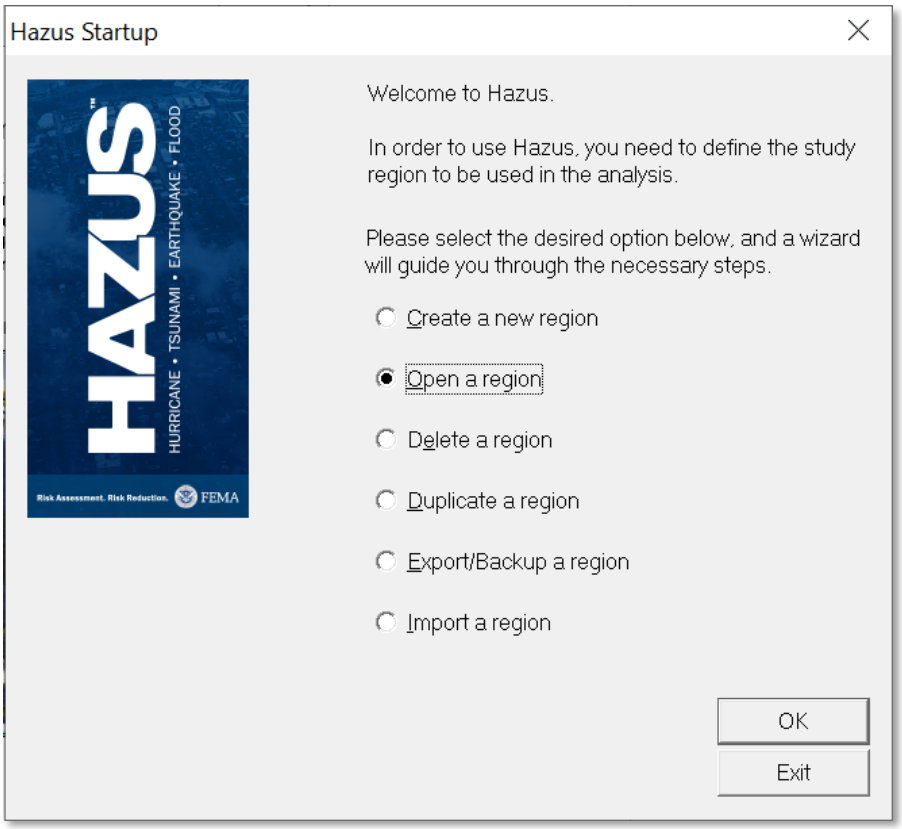


Figure 3-11 Select Open a Region

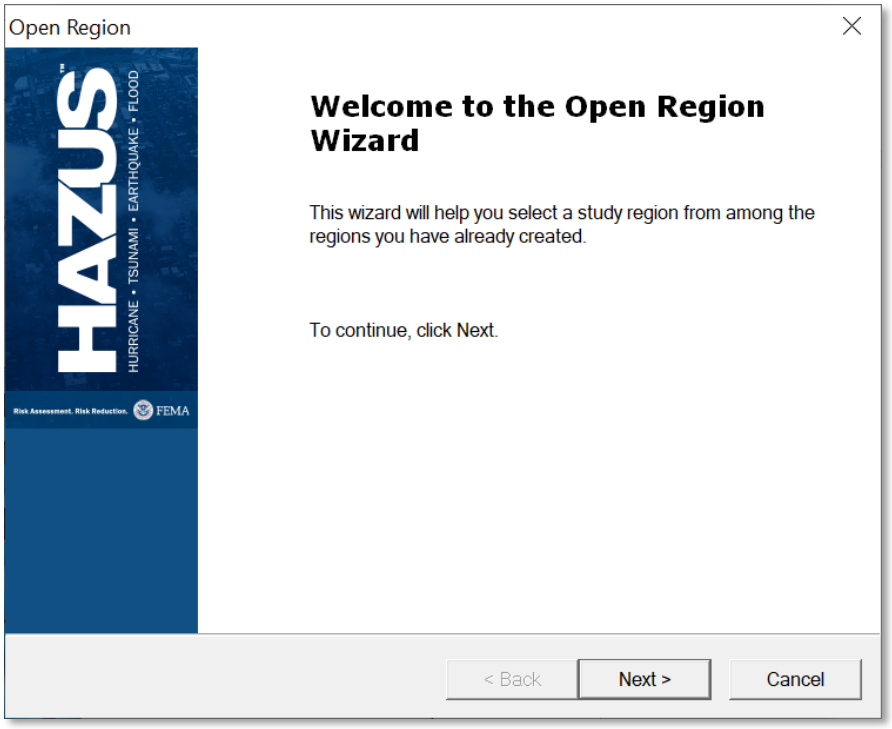


Figure 3-12 Open Region Wizard

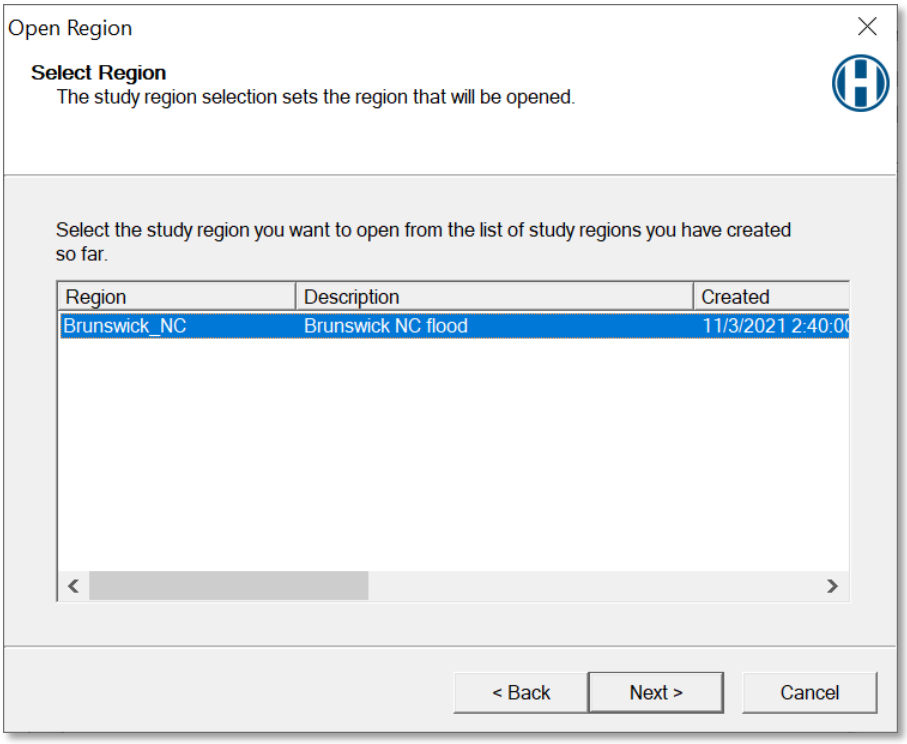


Figure 3-13 Select the Region to Open

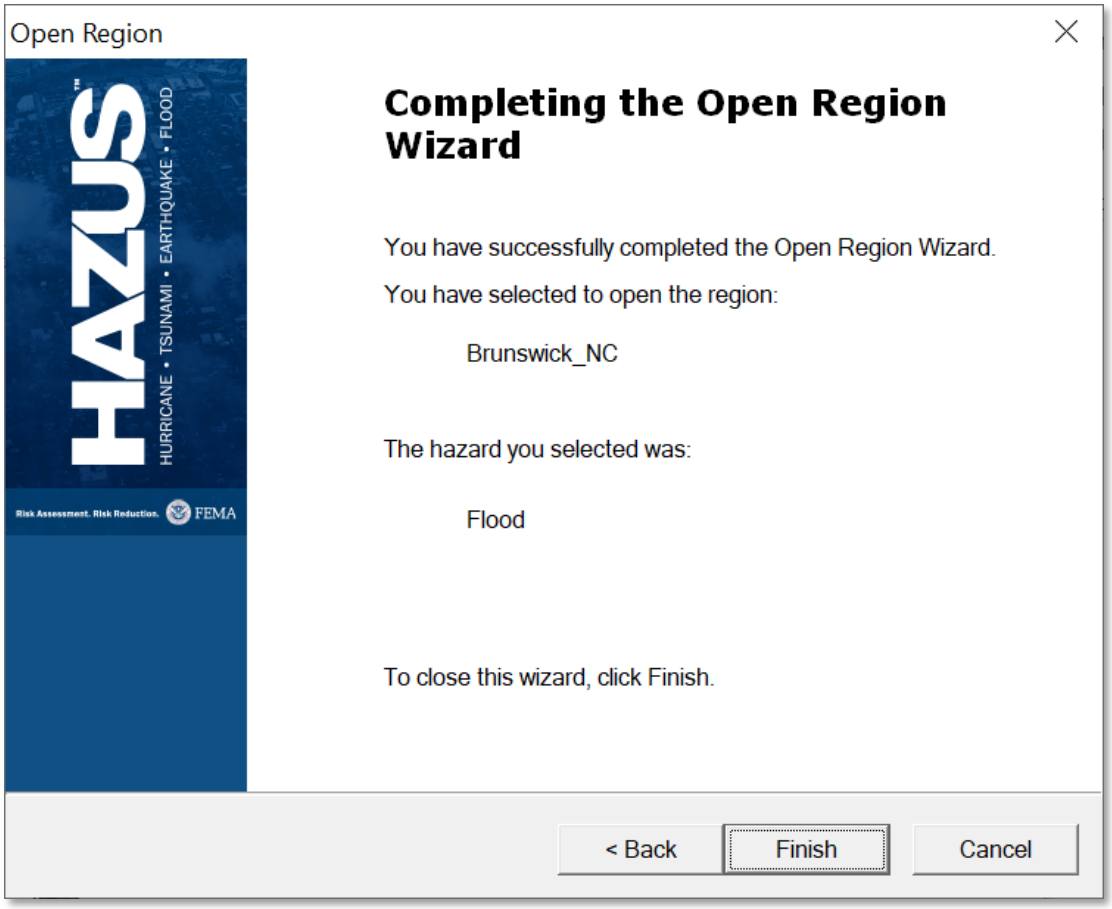


Figure 3-14 Open Region Wizard Completion

3.4 Delete Region

The **Delete a region** option will not be available in the **Hazus Startup** screen in Figure 3-15 until a region has been created or imported. Select **Delete a region** and click **OK**. A **Delete Region** list will appear (Figure 3-16). Select a region from the list and click **Delete** to permanently delete the region. The **Delete Region Confirmation** window will appear (Figure 3-17). Click **Yes** to delete or **No** to return to the **Delete Region** window (Figure 3-16). Click **Done** to close the window and return to the **Hazus Startup** screen.

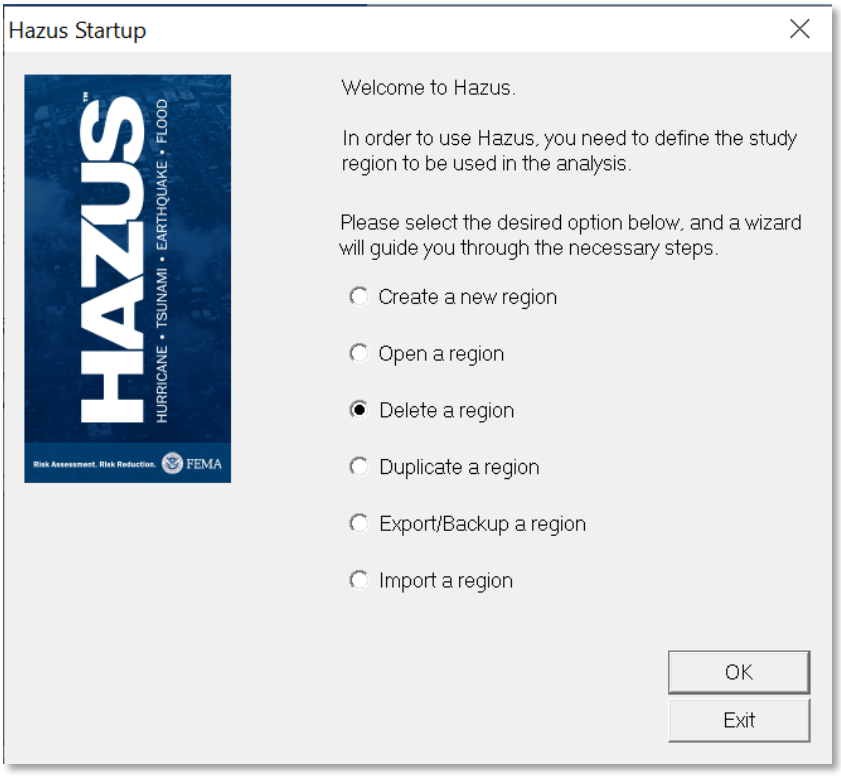


Figure 3-15 Select Delete a Region

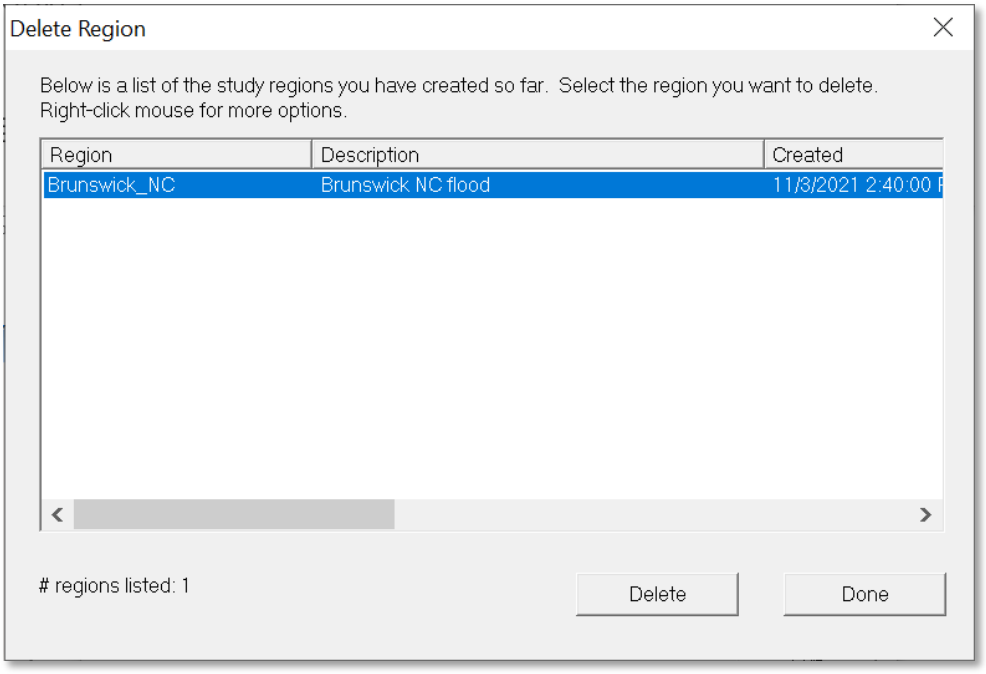


Figure 3-16 Select Region to Delete

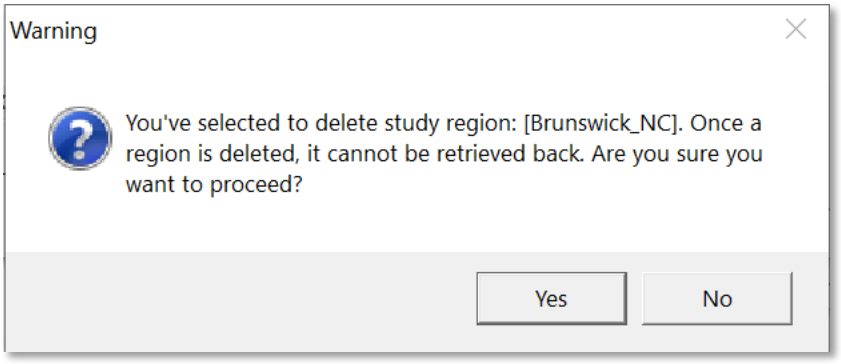


Figure 3-17 Delete Region Confirmation

3.5 Duplicate Region

The **Duplicate a region** option will not be available in the **Hazus Startup** screen in Figure 3-18 until a region has been created or imported. Select **Duplicate a region** and click **OK**. A **Duplicate Region** list will appear (Figure 3-19). Select the region from the list to be duplicated. Click **Duplicate**. A duplicate region confirmation window will appear (Figure 3-20). Click **Yes** to duplicate or **No** to return to the **Hazus Startup** screen (Figure 3-18). The **Duplicate Region Name** dialog will appear (Figure 3-21). Enter the name of the new region (18 characters and no spaces) and a brief description. Click **OK**. A progress bar will appear (Figure 3-22). It will close once the region has been successfully duplicated. This may take several minutes depending on the size of the region and the speed of the computer. A duplicate region completion notification (Figure 3-23) will appear to notify the user that the region has been duplicated. Click **OK** to return to the **Duplicate Region** list (Figure 3-19). Click **Done** to return to the **Hazus Startup** screen.

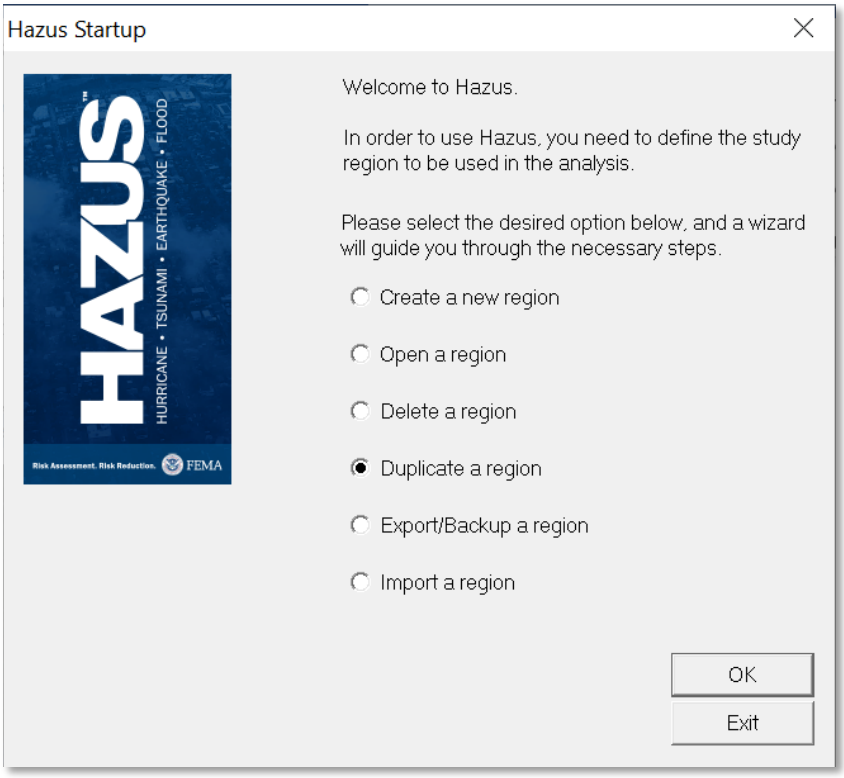


Figure 3-18 Select Duplicate a Region

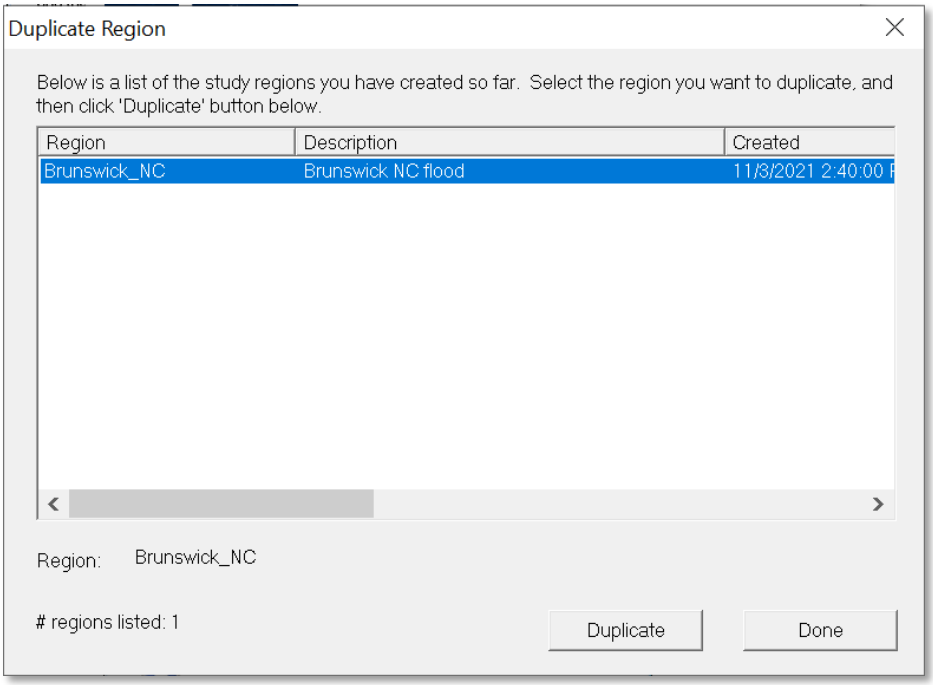


Figure 3-19 Select a Region to Duplicate

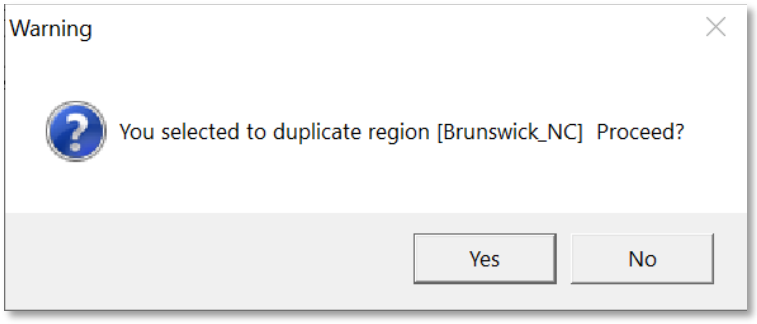


Figure 3-20 Duplicate Region Confirmation

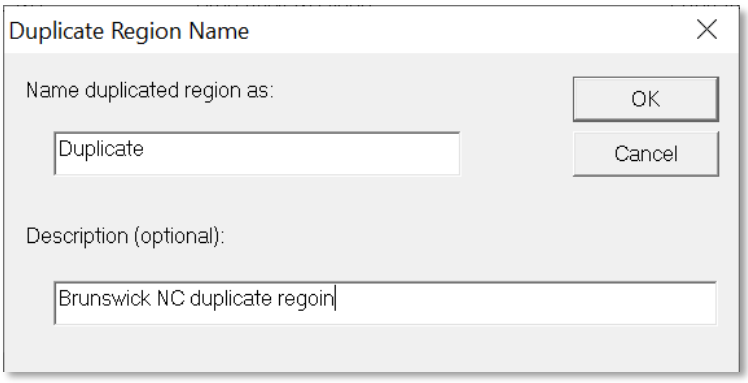


Figure 3-21 Provide Duplicate Region Name

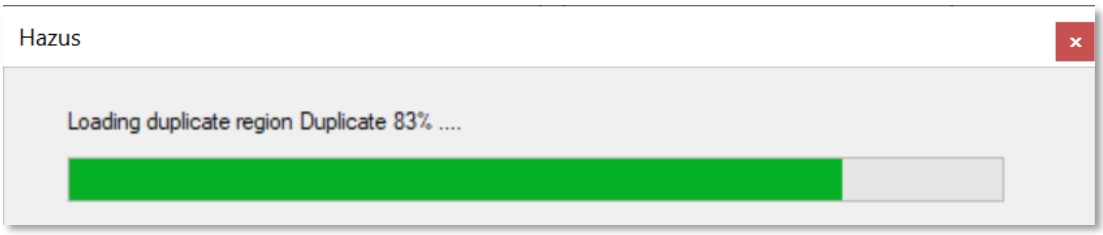


Figure 3-22 Duplicate Region Progress

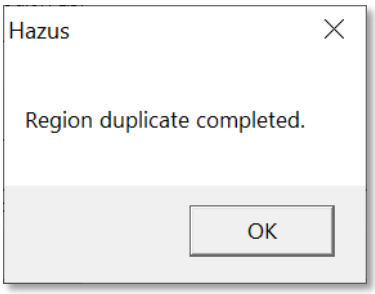


Figure 3-23 Duplicate Region Completed

3.6 Export/Backup a Region

The **Export/Backup a region** option will not be available in the **Hazus Startup** screen in Figure 3-24 until a region has been created or imported. Select **Export/Backup a region** and click **OK**. An **Export/Backup Region** list will appear (Figure 3-25). Select the region to export or backup from the list. Click **Browse** to select a file location to save the export/backup. Click **Export/Backup**. A progress bar (Figure 3-26) will appear. It will close once the region has been successfully exported. This may take several minutes depending on the size of the region and the speed of the computer. An **Export/Backup Region Completion** notification (Figure 3-27) will appear once the export has completed. Click **OK**.

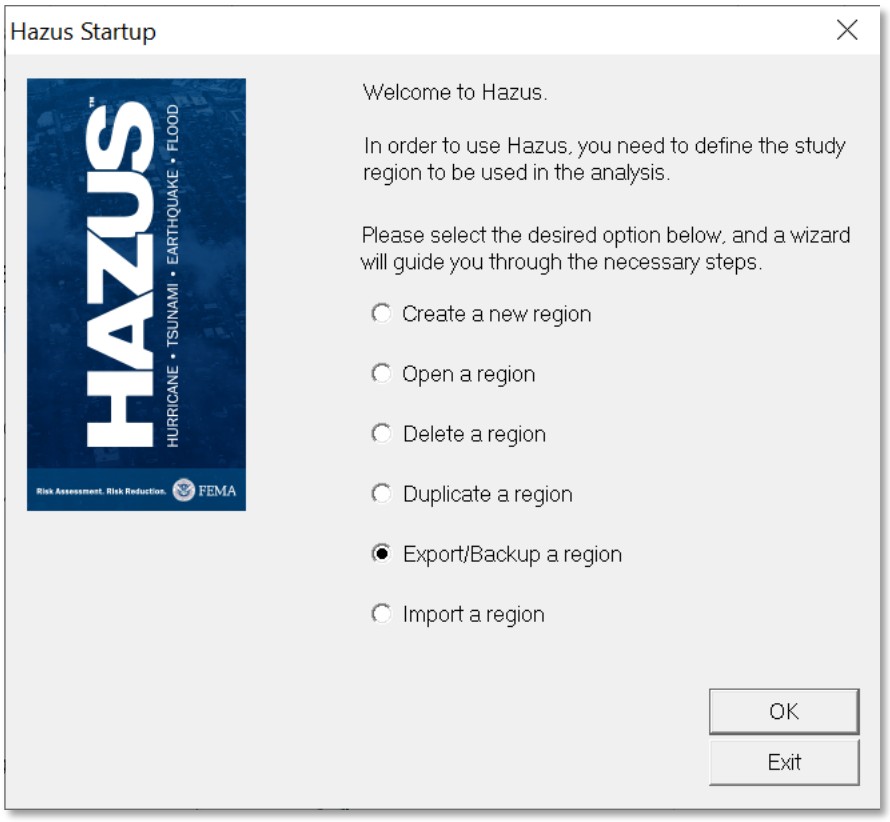


Figure 3-24 Select Export/Backup a Region

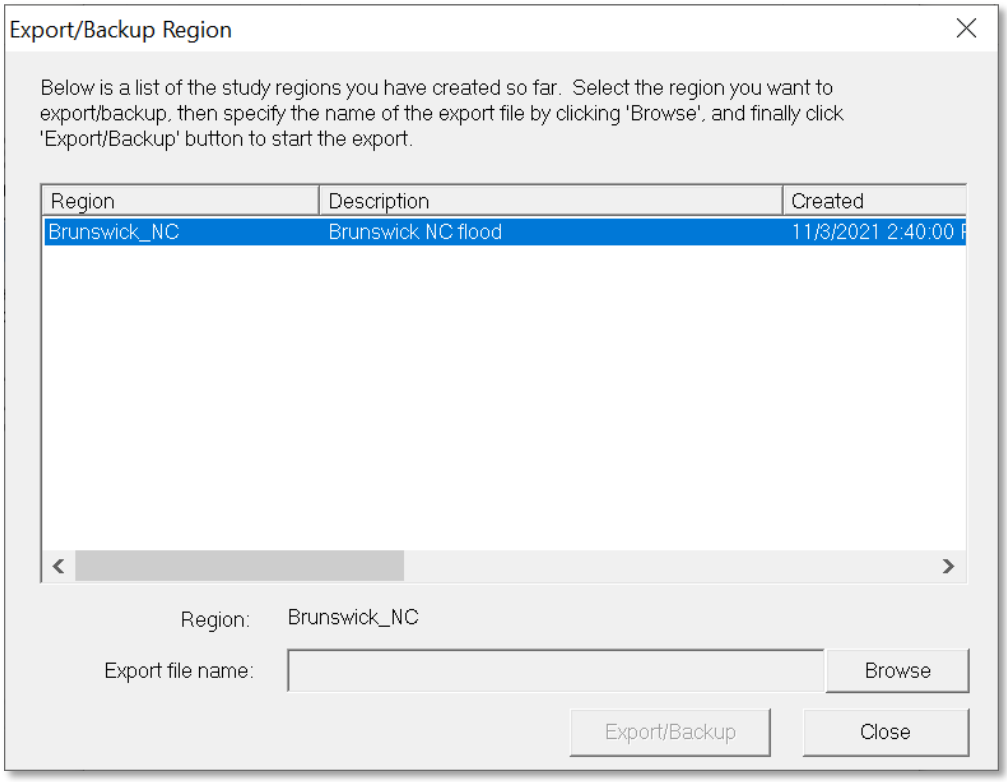


Figure 3-25 Select a Region to Export or Backup

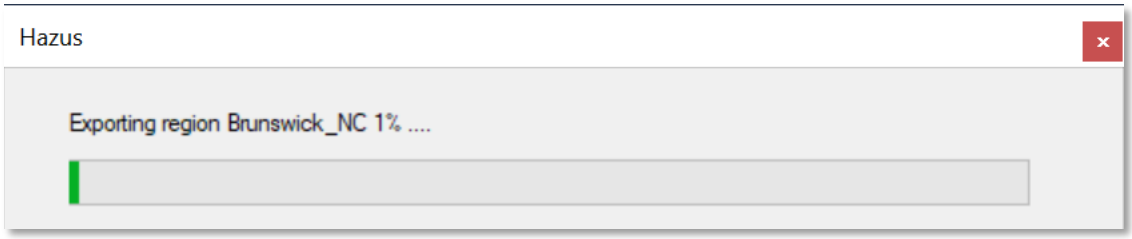


Figure 3-26 Export/Backup Region Progress

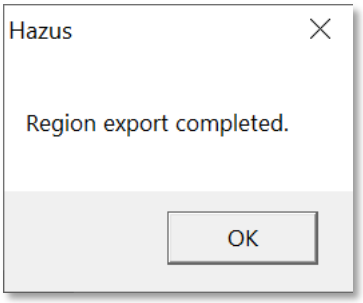


Figure 3-27 Export/Backup Region Completed

3.7 Import a Region

Select **Import a region** from the **Hazus Startup** screen in Figure 3-28 and click **OK**. Check the latest Hazus version release notes for limitations on importing from previous versions. Hazus is backwards compatible by one version. A file explorer will open. Select an export Hazus Packaged Region (.hpr) file. In the **Imported Region Name** dialog (Figure 3-29), enter the name of the region (18 characters and no spaces) and a brief description. The name must be different than the imported .hpr file name. Click **OK**. A progress bar (Figure 3-30) will appear. It will close once the region has been successfully imported. This may take several minutes depending on the size of the region and the speed of the computer. A **Region Import Completion** notification will appear once the export has completed. Click **OK.**

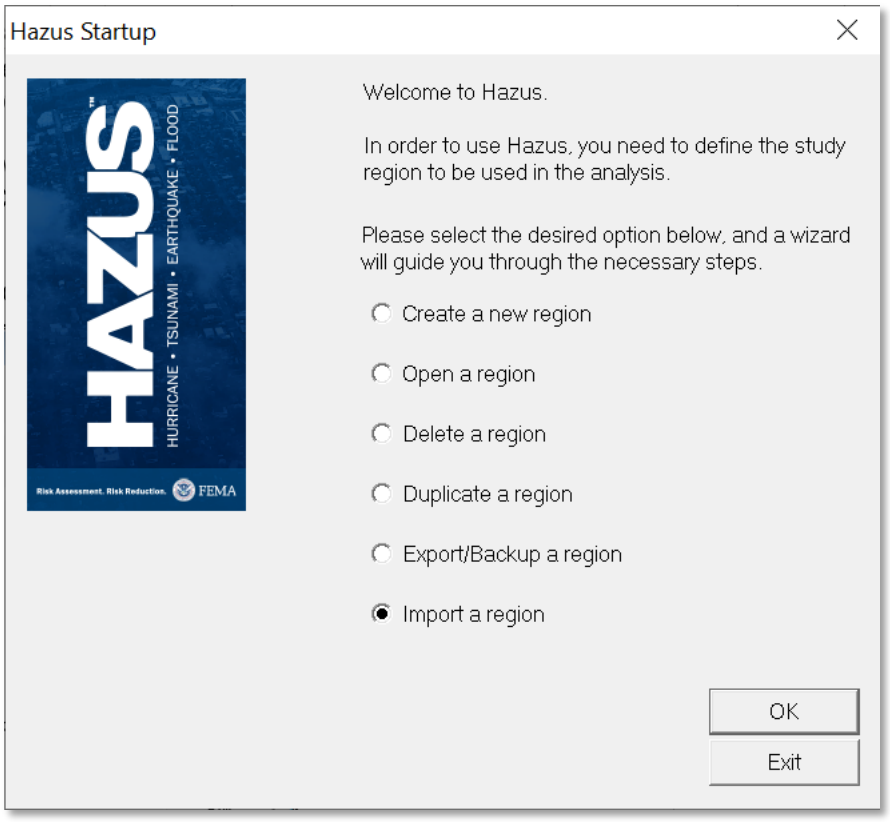


Figure 3-28 Select Import a Region

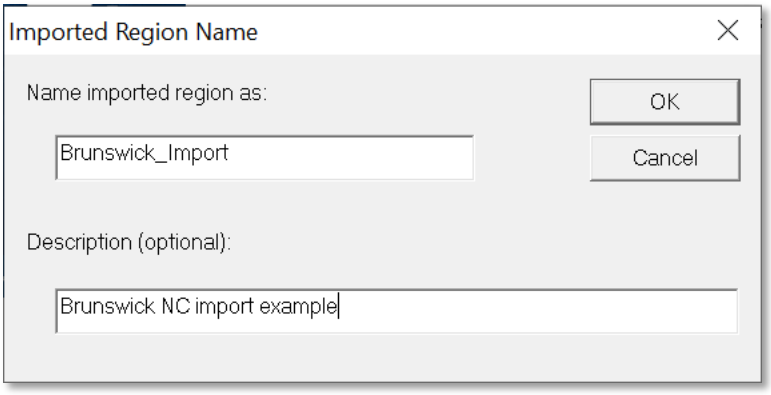


Figure 3-29 Provide the Name for the Imported Region

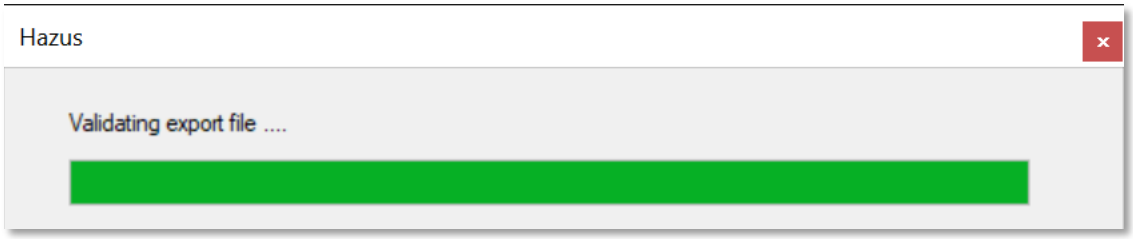


Figure 3-30 Import Region Progress

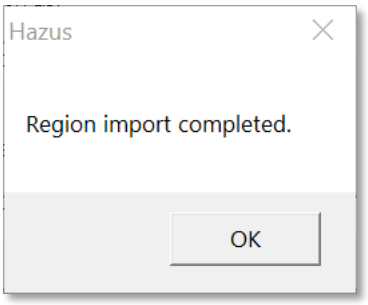


Figure 3-31 Region Import Completed

Section 4. Getting Started Part 2: Basic Hazus Analysis

The Flood Model allows practitioners to estimate the economic and social losses from flood events. The information provided by the model will help state and local officials evaluate, plan for, and mitigate the effects of flooding. The Flood Model provides practitioners and policy makers with a tool to help reduce flood damage, reduce disaster payments, and make wise use of the nation's emergency management resources.

Section 4 explains how to run a basic riverine Flood Level 1 GBS Analysis for a single flood event with flooding modeled by Hazus. This analysis makes use of Census blocks that have been dasymetrically-adjusted based on land cover data, meaning that areas with land cover types that typically do not contain structures have been removed from the Census block boundaries. Refer to the Flood Technical Manual for information on dasymetric Census blocks and the methodology used by Hazus to produce the flood depth raster.

Launch Hazus and select **Open a Region** on the **Hazus Startup** screen (Figure 4-1). Information on the other options is provided in Section 3. Click **OK**, which will open the **Welcome to the Open Region Wizard** (Figure 4-2). Select **Next**.

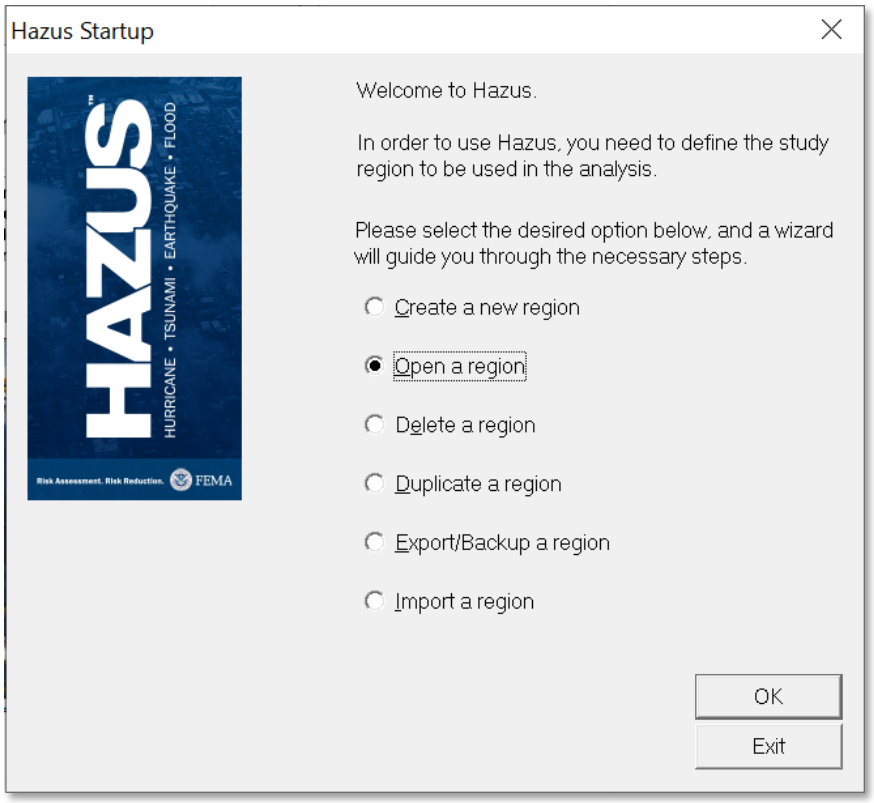


Figure 4-1 Open a Region

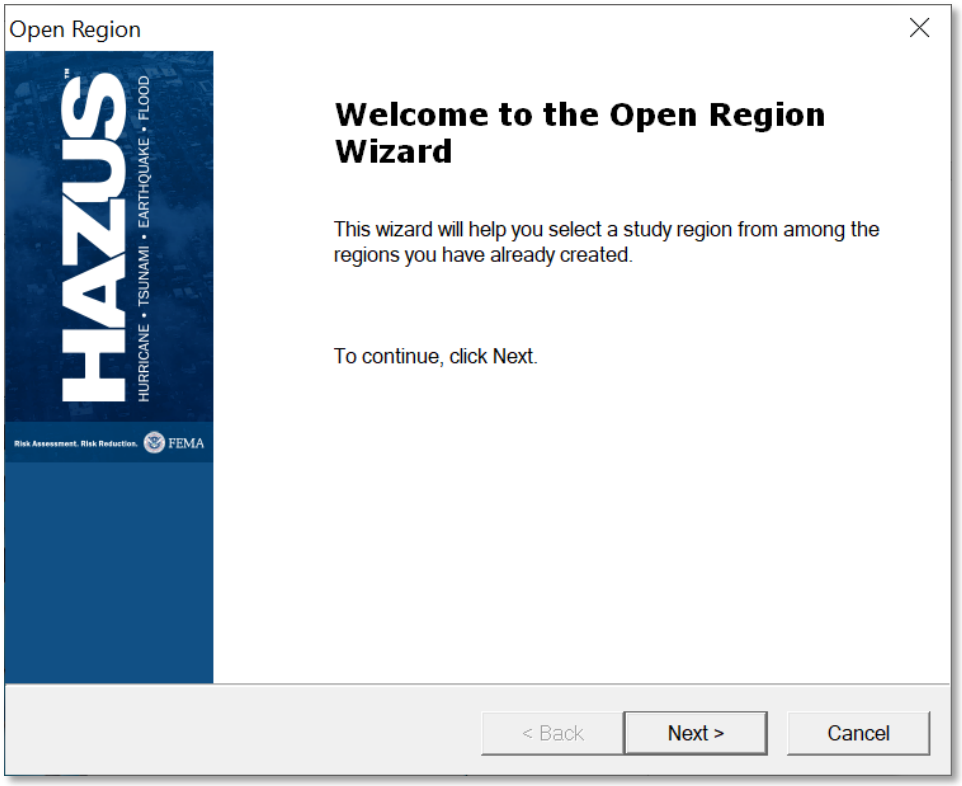


Figure 4-2 Open Region Wizard

In the **Select Region** window (Figure 4-3), select the desired Study Region. Click **Next,** which will open the **Completing the Region Review Wizard** (Figure 4-4). Here, the user can review the selected region and hazard. Select **Finish**. An ArcMap window showing the Study Region will open (Figure 4-5).

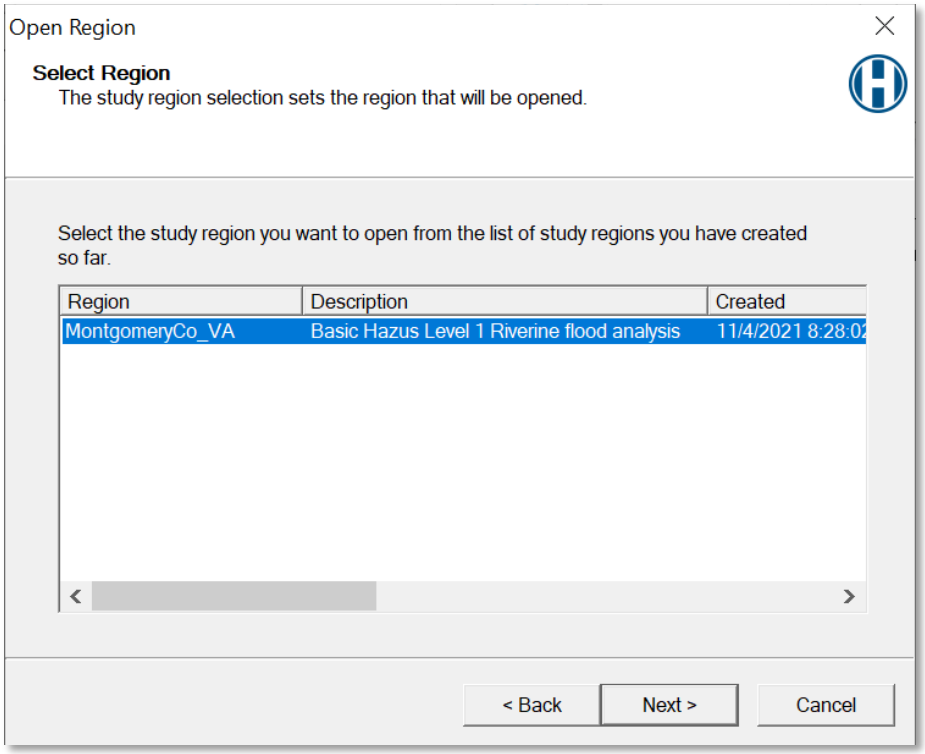


Figure 4-3 Select the Region to Open

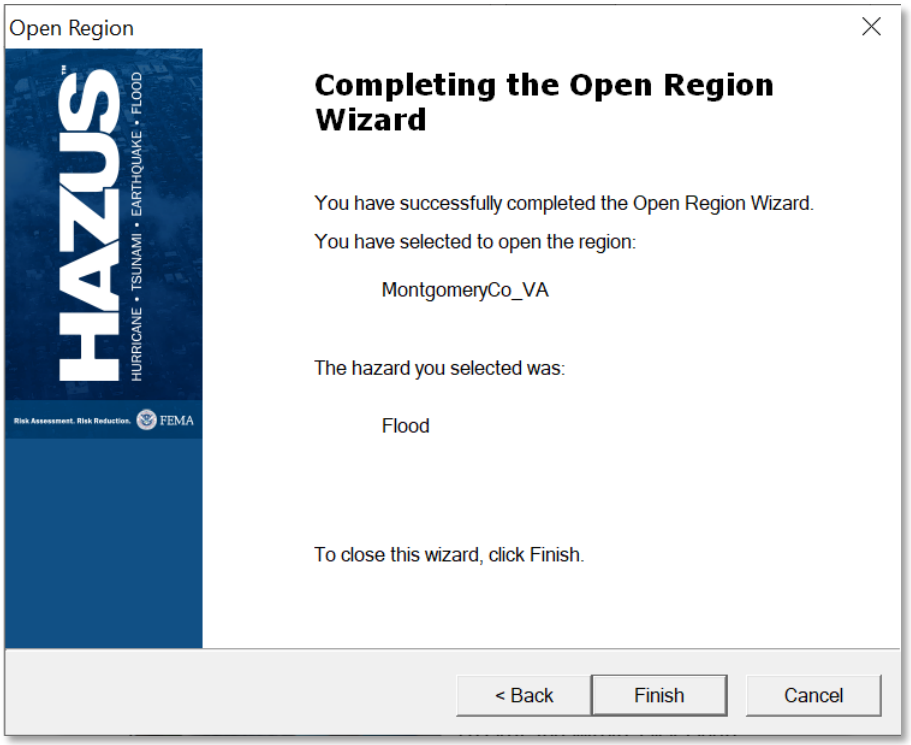


Figure 4-4 Confirm the Selected Region

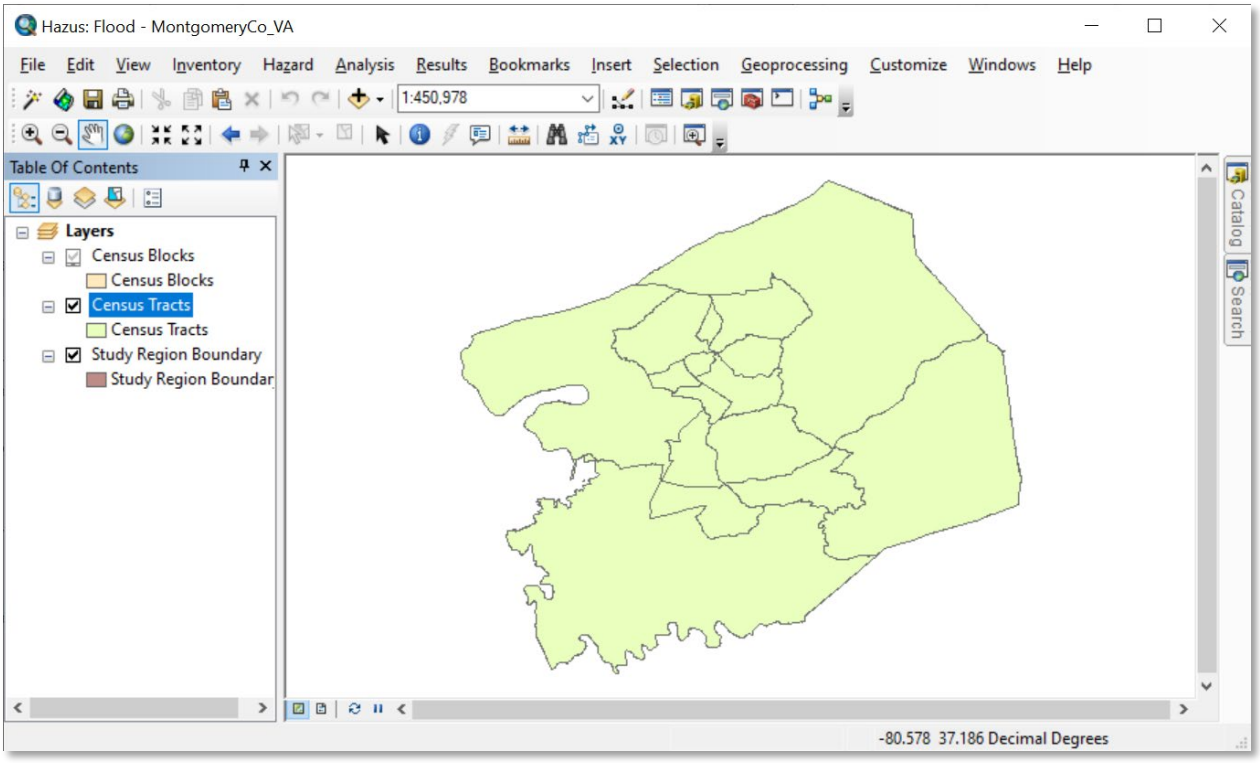


Figure 4-5 Example – Flood Model in ArcMap

To choose a riverine flood hazard type, open the **Hazard** drop-down menu and select **Flood Hazard Type** (Figure 4-6).

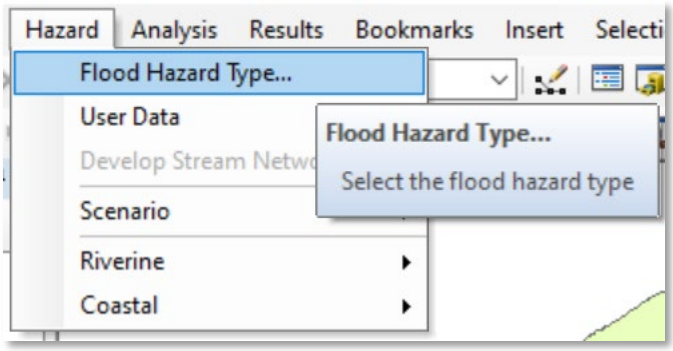


Figure 4-6 Select Flood Hazard Type in Hazard Menu

Selecting **Flood Hazard Type** will open the **Flood Hazard Type** window (Figure 4-7). Select **Riverine only** and click **OK**.

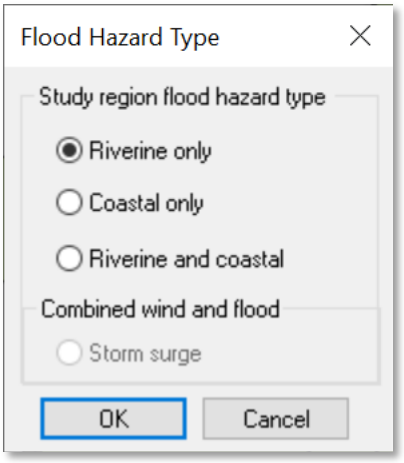


Figure 4-7 Select Flood Hazard Type

To obtain the digital elevation data required for this analysis, open the **Hazard** drop-down menu, and select **User Data** (Figure 4-8). Please note, it is recommended that users import user-defined flood hazard depth grids if available. The Hazus hydrology and hydraulic methodology here should only be used if user-defined data are not available. Please refer to *Hazus Flood Level 2 Standard Operating Procedure* published in the FEMA Library for more information.

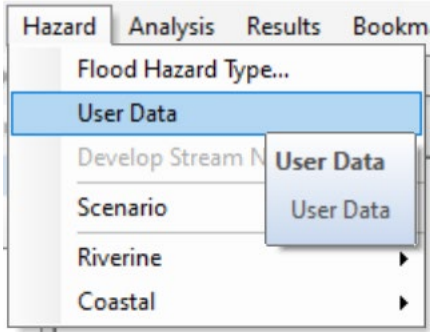


Figure 4-8 Select User Data in Hazard Menu

Selecting **User Data** will open the **User Data** window (Figure 4-9). Click **Determine required DEM extent**.

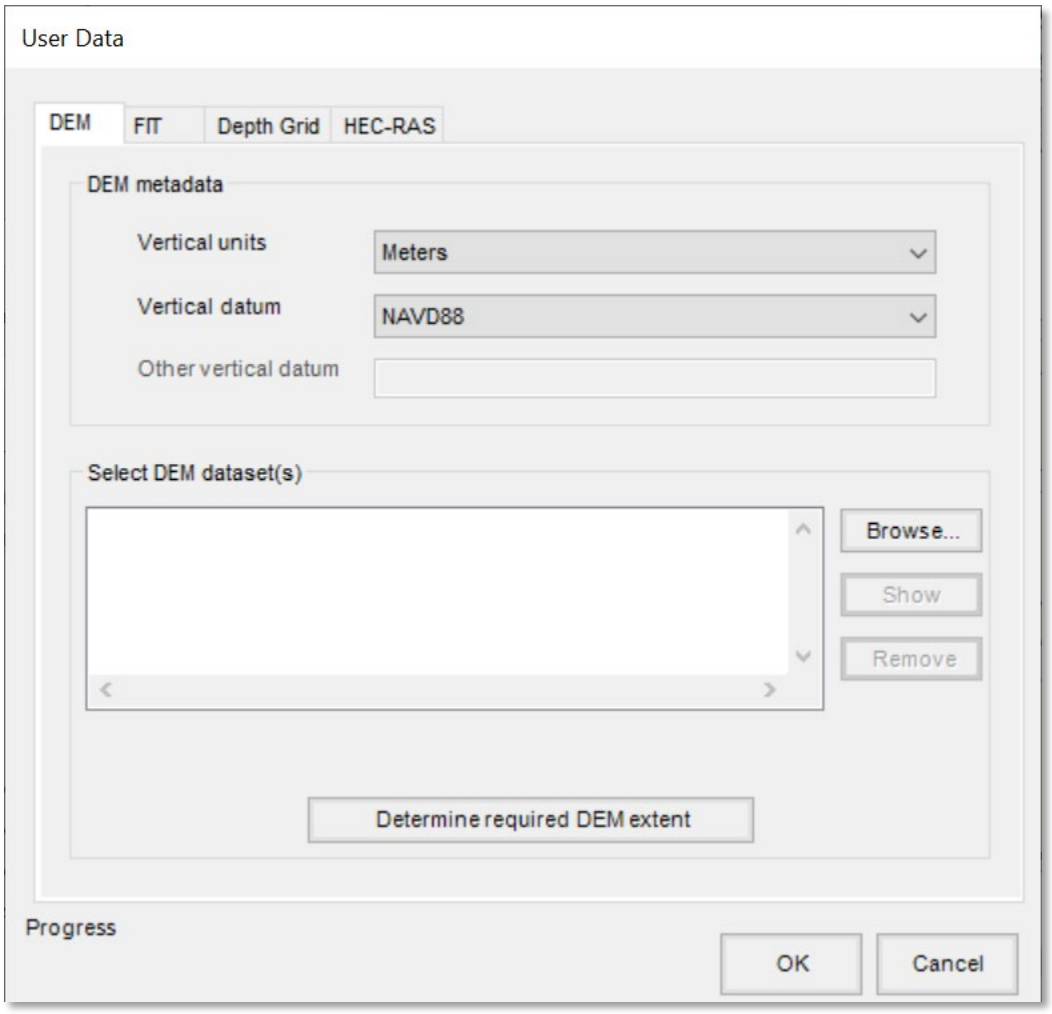


Figure 4-9 Select Determine Required DEM Extent

After a short pause, the **DEM Extent** window will appear (Figure 4-10). Click **Download required DEM** for Hazus to obtain all the required digital elevation model (DEM) files and save them within the Hazus Study Region folder.

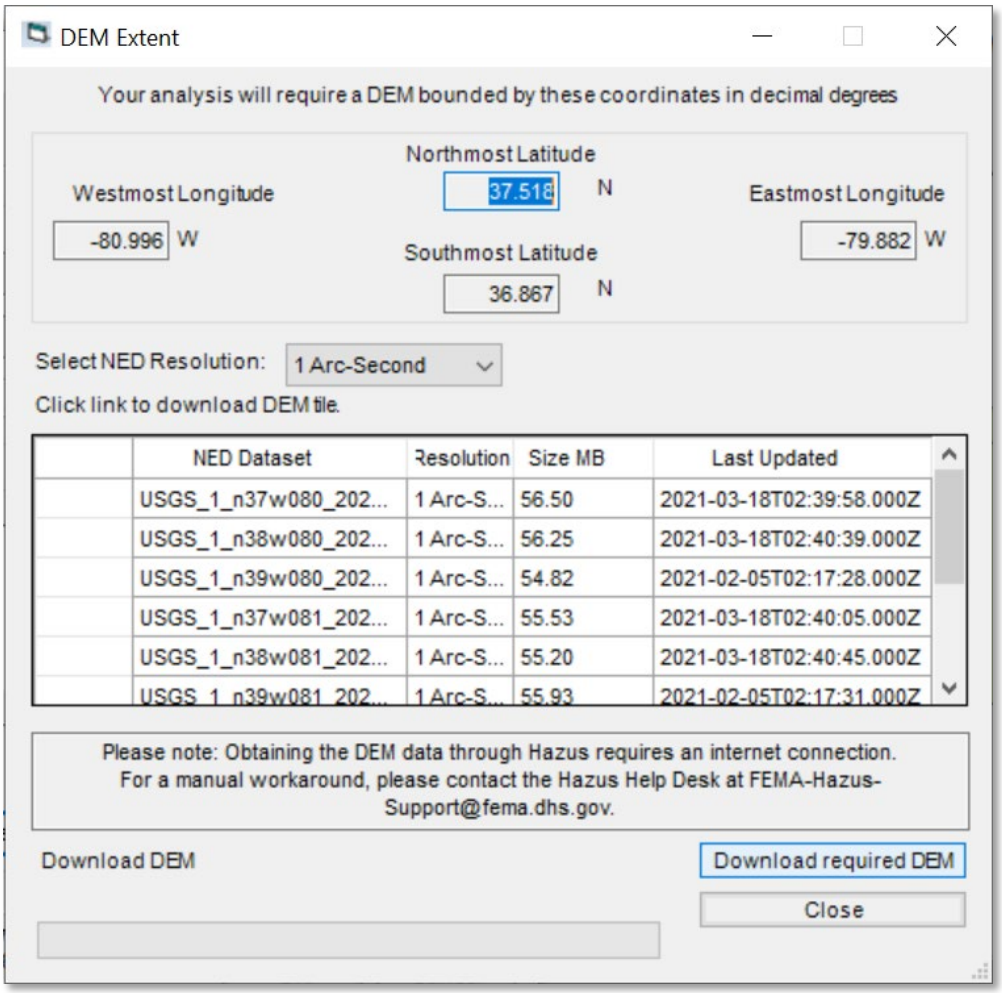


Figure 4-10 Select Download required DEM

Hazus will take several minutes to download all the DEM files. When the process has completed, a notification window will appear (Figure 4-11) to indicate the files have been downloaded and saved. Click **OK**.

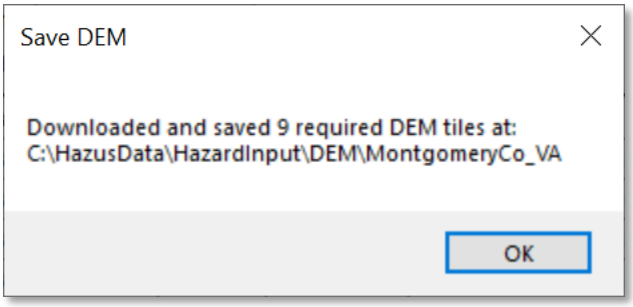


Figure 4-11 DEM Downloaded and Saved

A popup window (Figure 4-12) will ask the user whether to automatically load the DEM data into the **User Data** window. Click **Yes**.

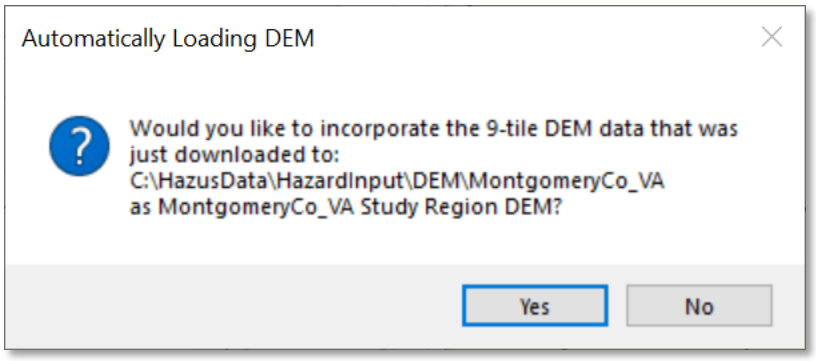


Figure 4-12 Automatically Load DEM

Hazus will load the file paths for all the DEM files into the **User Data** window (Figure 4-13). Click **OK** to complete importing the DEM files. Click **Yes** (not shown) on the next popup window to proceed with DEM analysis.

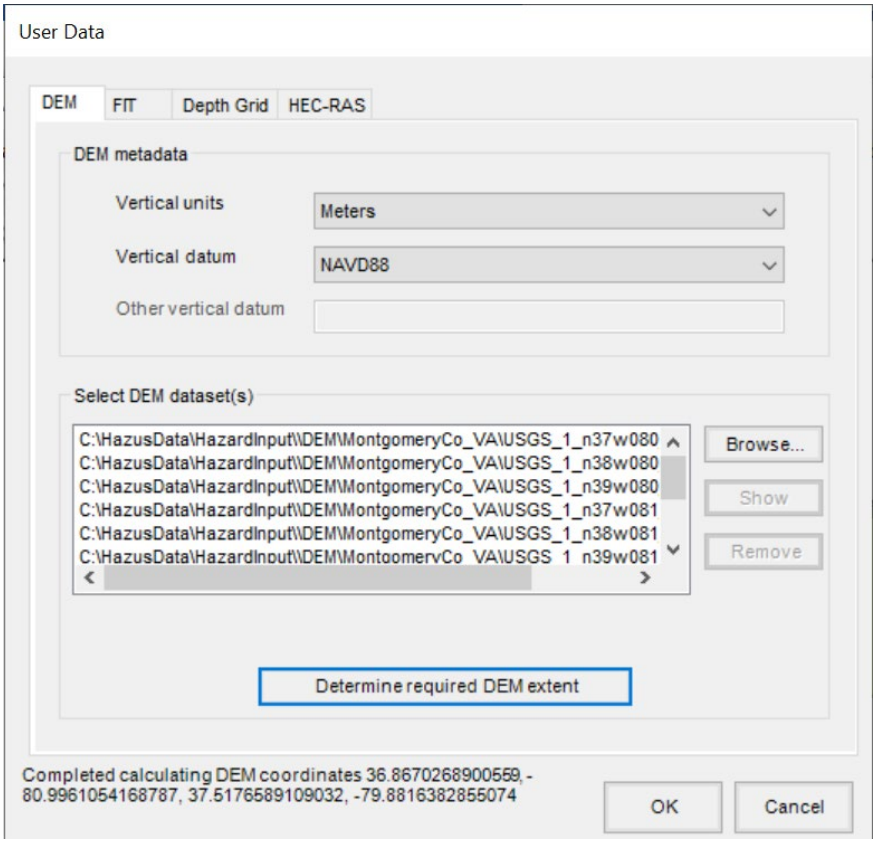


Figure 4-13 Import DEM Files into Hazus

A progress bar (Figure 4-14) will appear as Hazus imports and merges all the individual files into a single DEM for the Study Region. This may take several minutes depending on the size of the Study Region. A notification (Figure 4-15) will appear once the DEM import is completed. Click **OK**.

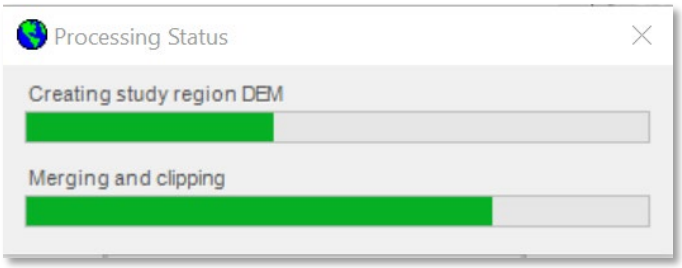


Figure 4-14 DEM Import Progress

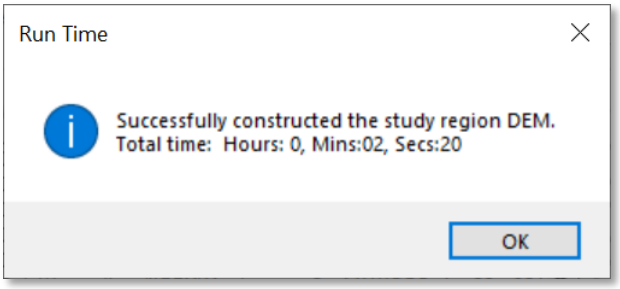


Figure 4-15 DEM Import Completed

The Hazus Flood Model mapping should look like Figure 4-16 after the DEM import.

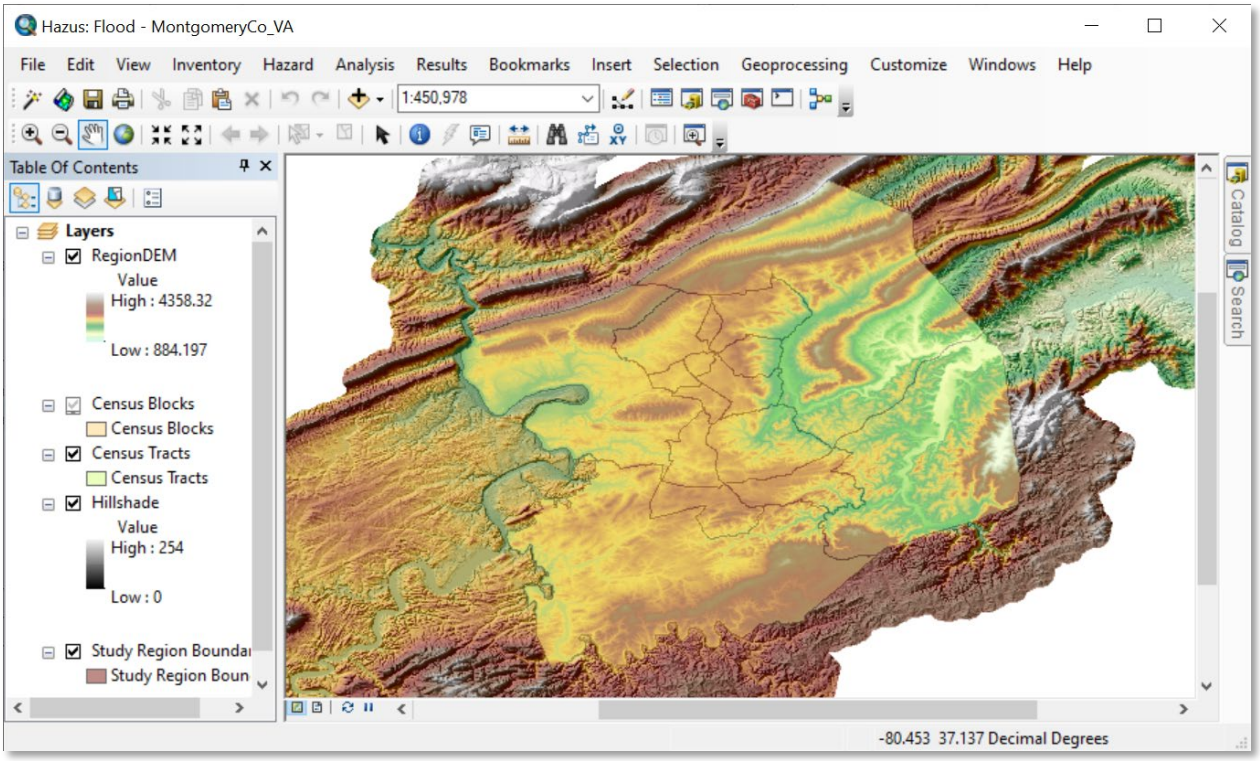


Figure 4-16 Example – Flood Model after DEM Import

To create the stream network, open the **Hazard** drop-down menu and select **Develop Stream Network** (Figure 4-17).

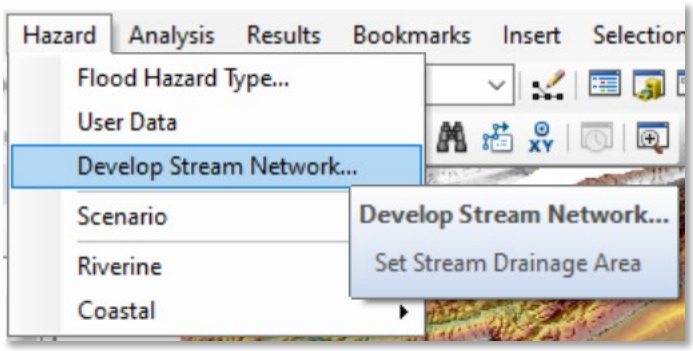


Figure 4-17 Select Develop Stream Network in Hazard Menu

The **Develop Stream Network** window (Figure 4-18) will appear. Use the default value of 10.0 square miles that appears in the drainage area field and click **OK**. Click **Yes** (not shown) on the next popup window to proceed with developing the stream network.

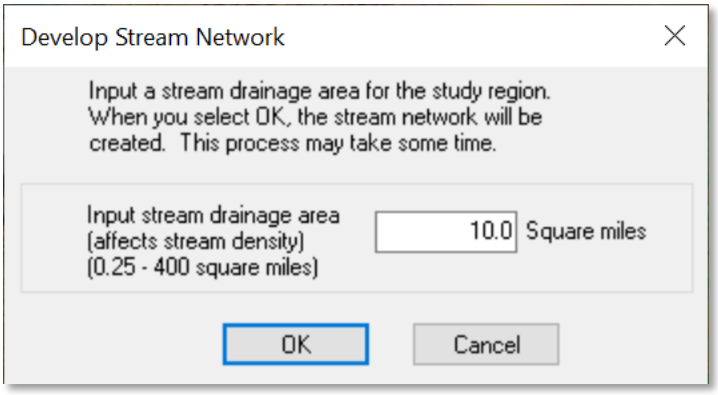


Figure 4-18 Enter Drainage Area for Develop Stream Network

A progress bar (Figure 4-19) will appear as Hazus performs the GIS analysis to develop the stream network. This may take several minutes to an hour depending on the size of the Study Region. A notification (Figure 4-20) will appear once the stream network has been completed. Click **OK**.

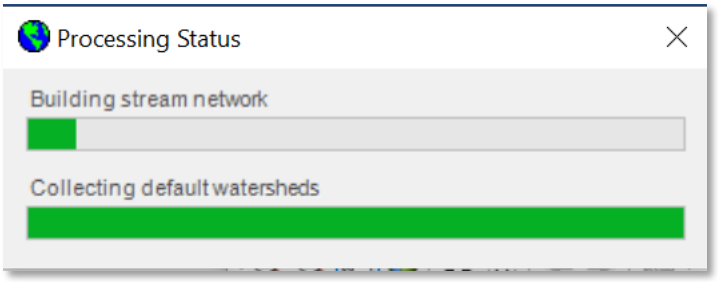


Figure 4-19 Develop Stream Network Progress

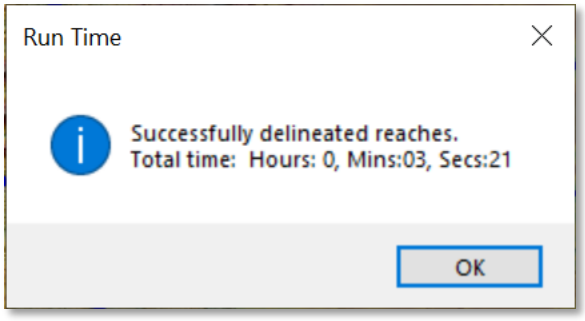


Figure 4-20 Develop Stream Network Completed

The Hazus Flood Model mapping should look like Figure 4-21 after developing the stream network.

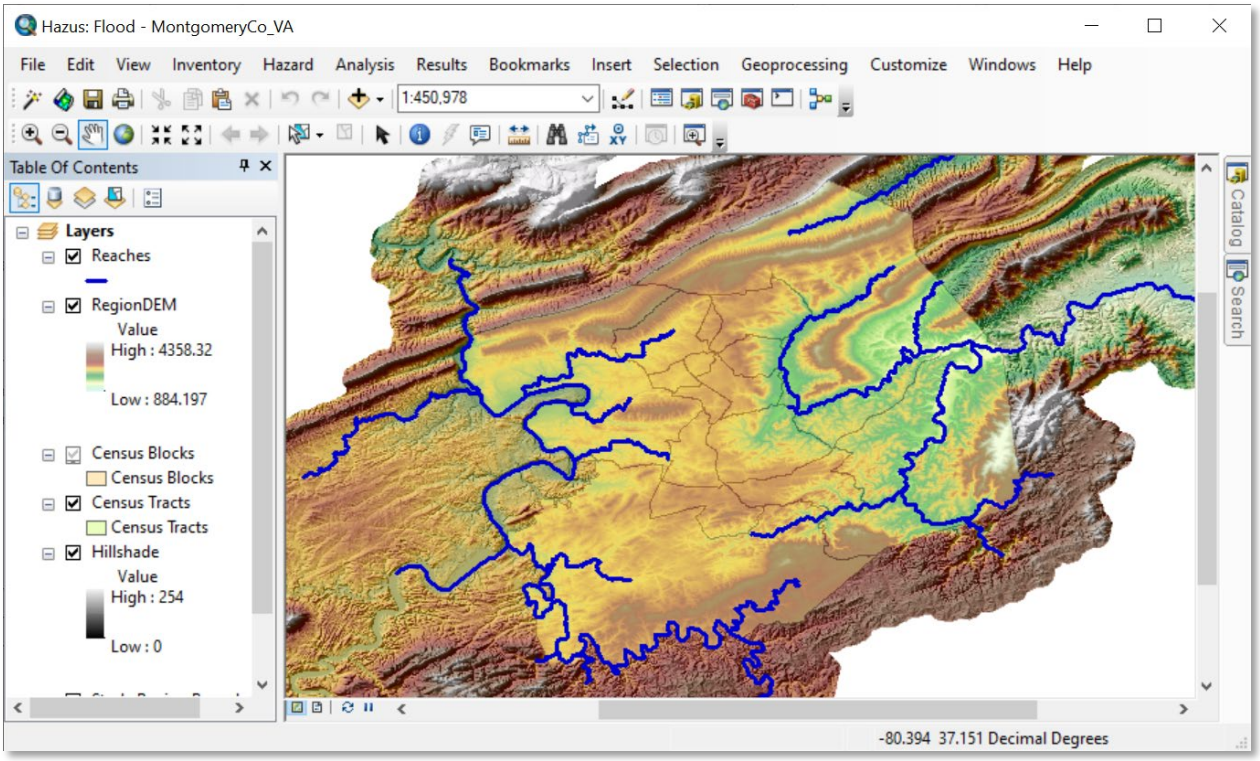


Figure 4-21 Example – Flood Model after Developing Stream Network

To create a scenario within the Flood Model, open the **Hazard** drop-down menu and select **Scenario** and **New** (Figure 4-22).

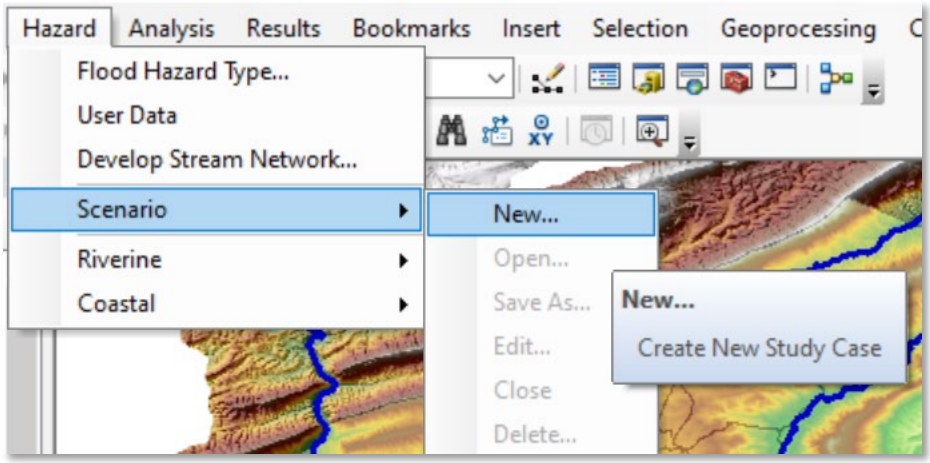


Figure 4-22 Select Scenario and New in Hazard Menu

The **Create New Scenario** window (Figure 4-23) will appear. Enter a unique name for the scenario and a brief description. Click **OK**.

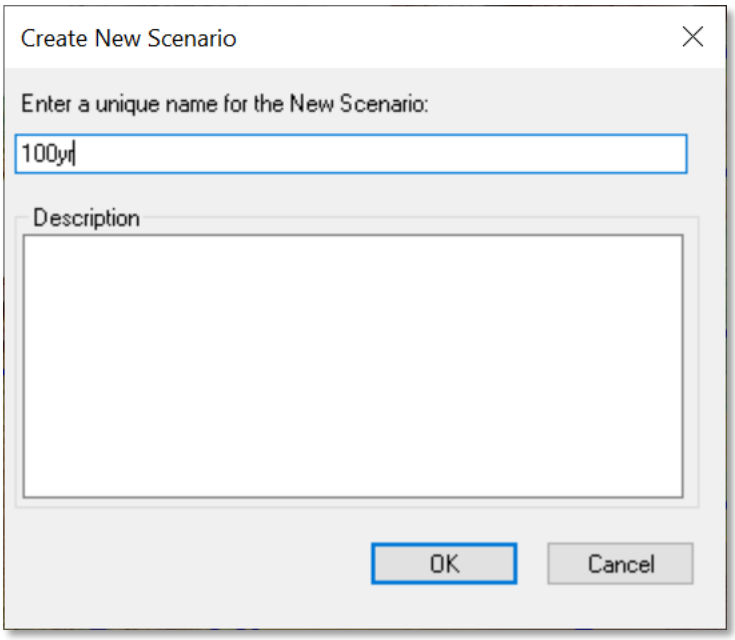


Figure 4-23 Provide Name for New Scenario

The **New Scenario** window (Figure 4-24) will appear. To select the streams to add to the scenario from the Flood Model mapping, click the **+** button to the right of **Add to selection**. This will activate the screen cursor on the mapping screen in ArcMap, which allows the user to select all the streams in the region.

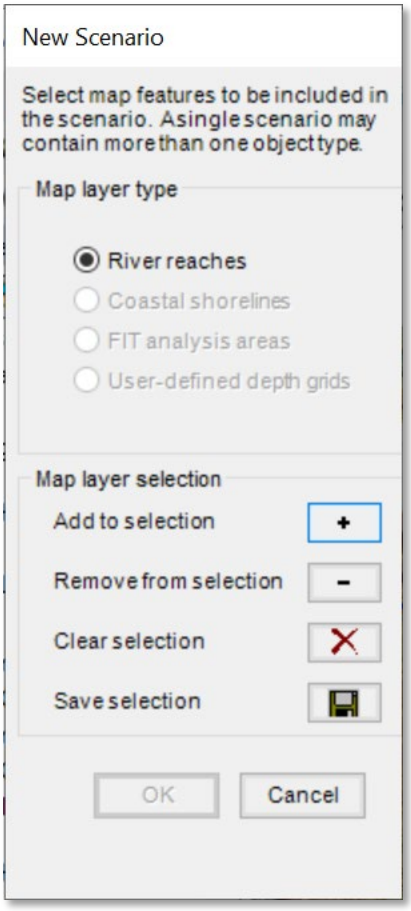


Figure 4-24 Select Add to Selection for River Reaches

Once the streams have been selected, the Flood Model will show the streams in a different color as shown in Figure 4-25.

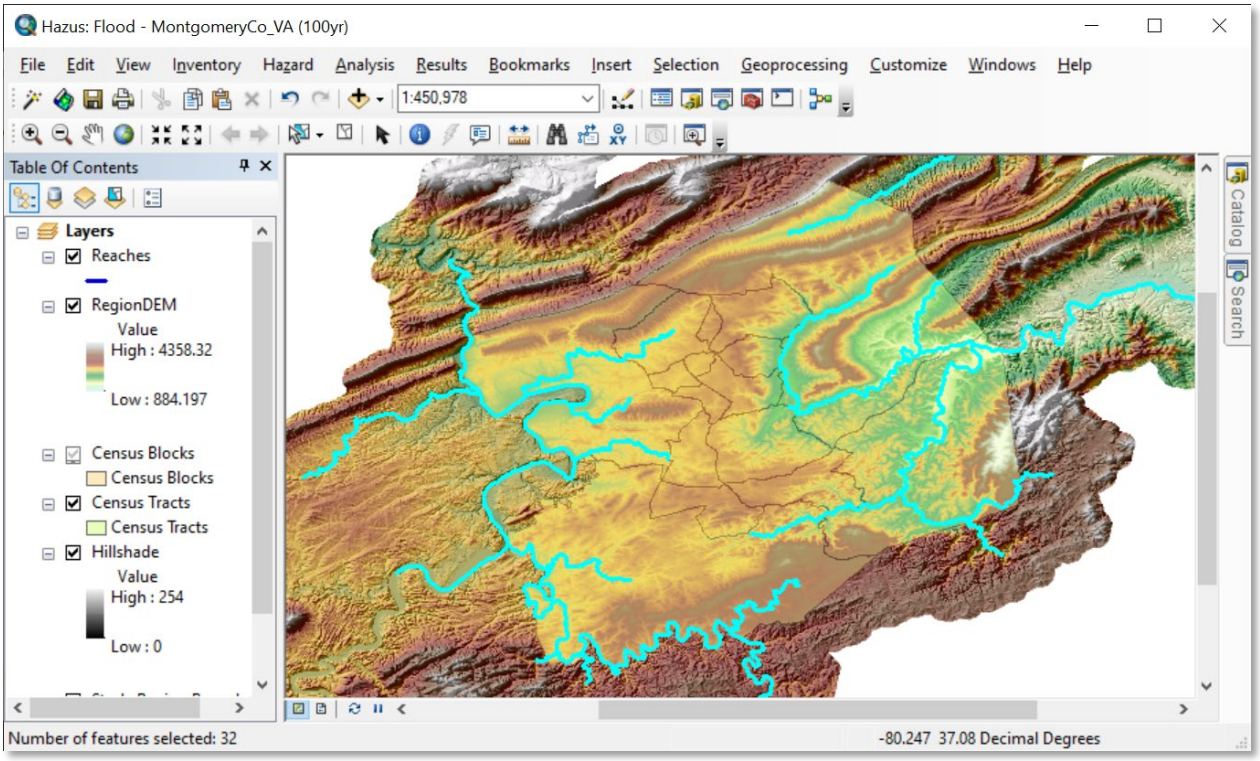


Figure 4-25 Example – Flood Model after Stream Selection

To complete the stream selection, go back to the **New Scenario** window and click on the button with the disk graphic to the right of **Save selection** (Figure 4-26). The **OK** button will become active. Click **OK** to complete the stream selection.

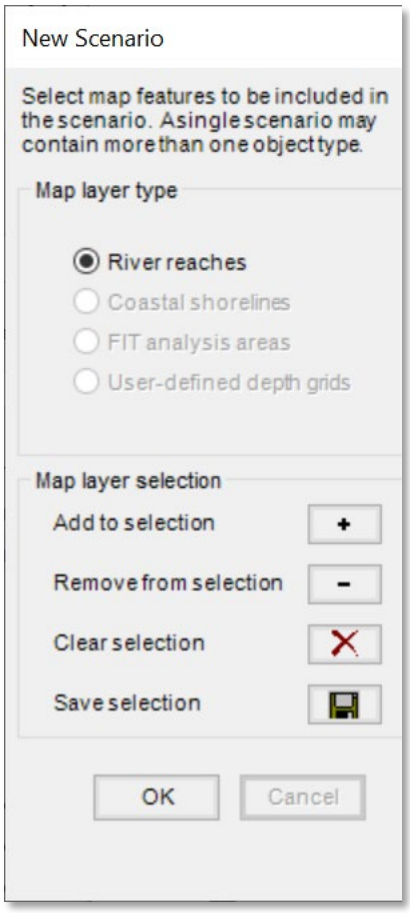


Figure 4-26 Select Save Selection to Finalize Selected River Reaches

If the stream selection was performed correctly, the Flood Model should look like Figure 4-27. All selected streams are saved to a new data layer called **Chosen Reaches** and are shown in red.

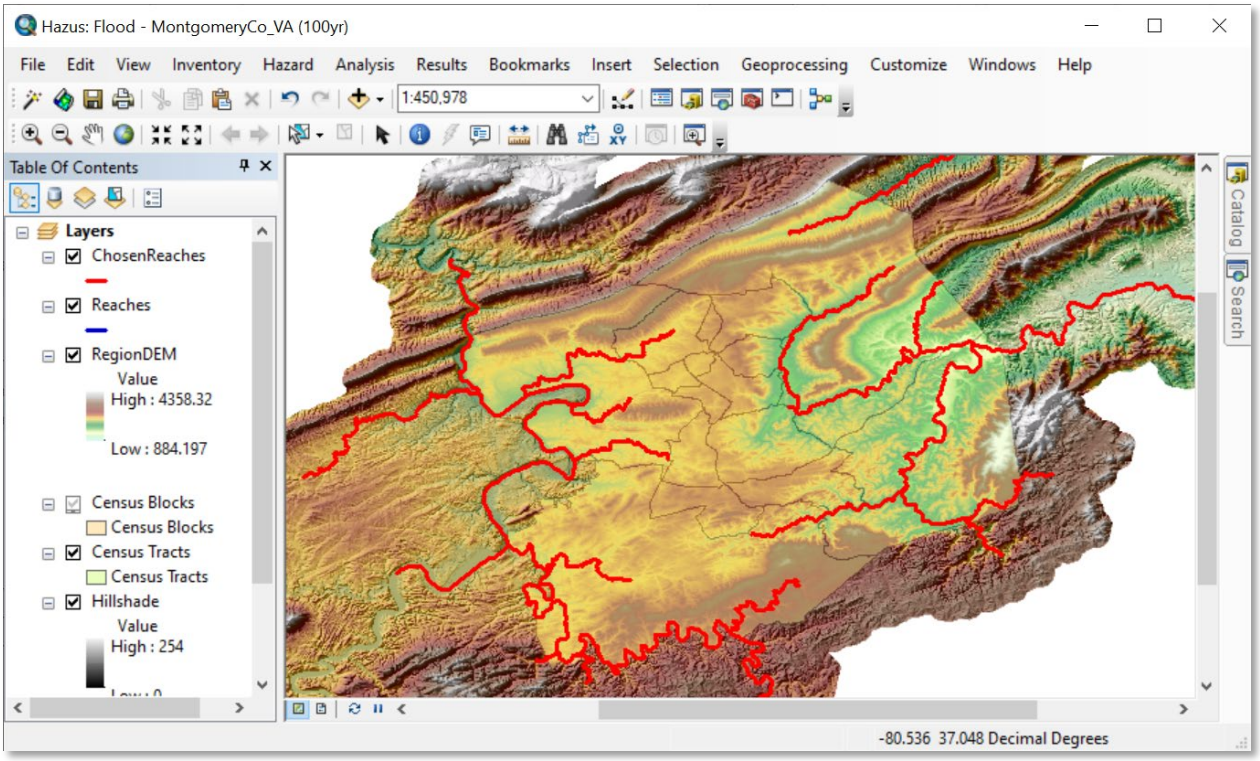


Figure 4-27 Example – Flood Model after Stream Reaches Chosen for a Scenario

To conduct the hydrologic analysis, open the **Hazard** drop-down menu and select **Hydrology** (Figure 4-28).

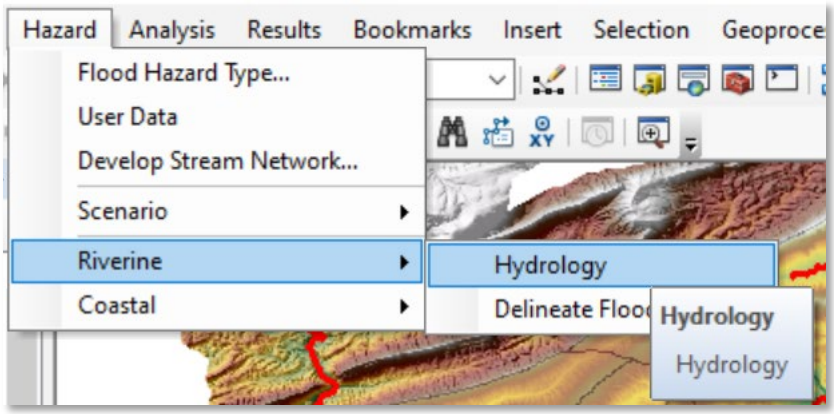


Figure 4-28 Select Riverine and Hydrology in Hazard Menu

A notification window (Figure 4-29) will warn the user that raster processing cannot be canceled. Click **Yes**.

A progress bar (Figure 4-30) will appear as Hazus performs the hydrologic analysis. This may take several minutes to several hours depending on the size of the Study Region and the number of selected streams. A notification (Figure 4-31) will appear once the hydrologic analysis has been completed. Click **OK**.

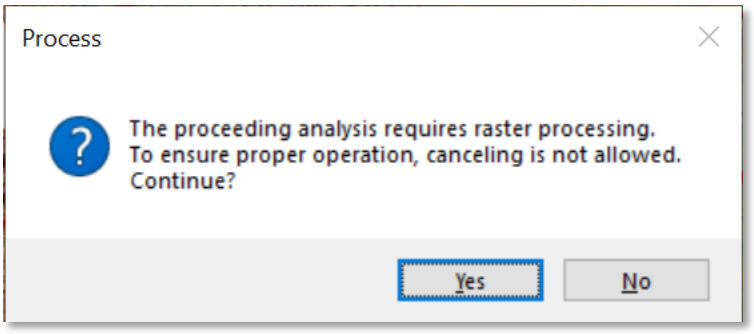


Figure 4-29 Select Yes to Start Hydrologic Analysis

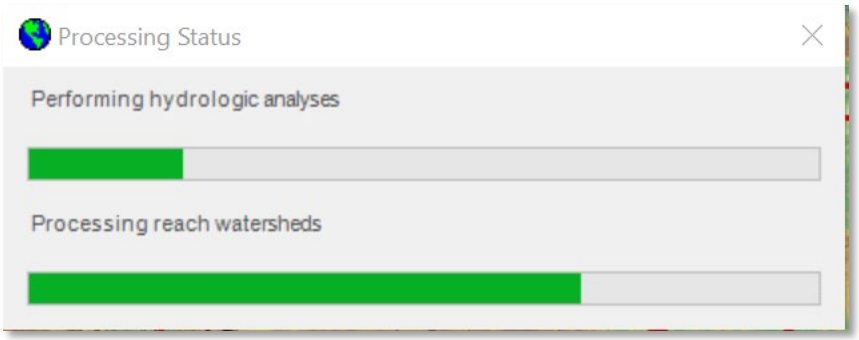


Figure 4-30 Hydrologic Analysis Progress

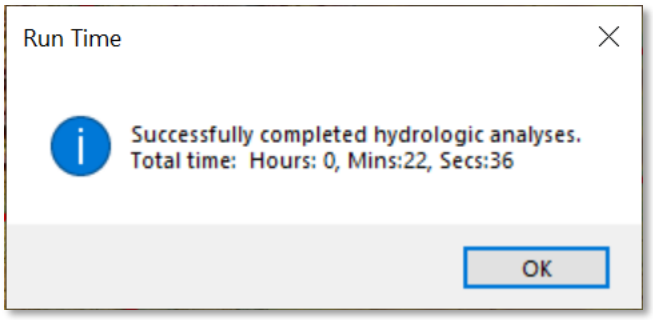


Figure 4-31 Hydrologic Analysis Completed

If the hydrologic analysis was performed correctly, the Flood Model should look like Figure 4-32.

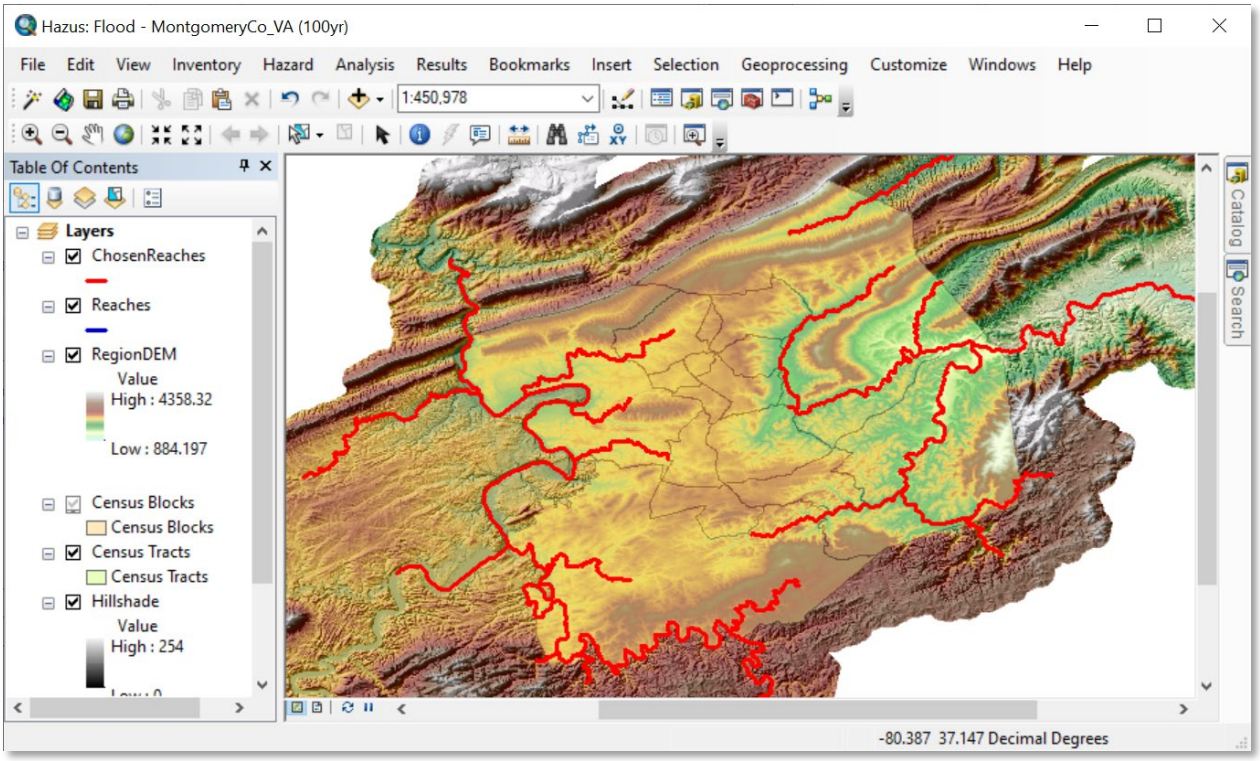


Figure 4-32 Example – Flood Model after Hydrologic Analysis

To conduct the floodplain analysis, open the **Hazard** drop-down menu and select **Delineate Floodplain** (Figure 4-33).

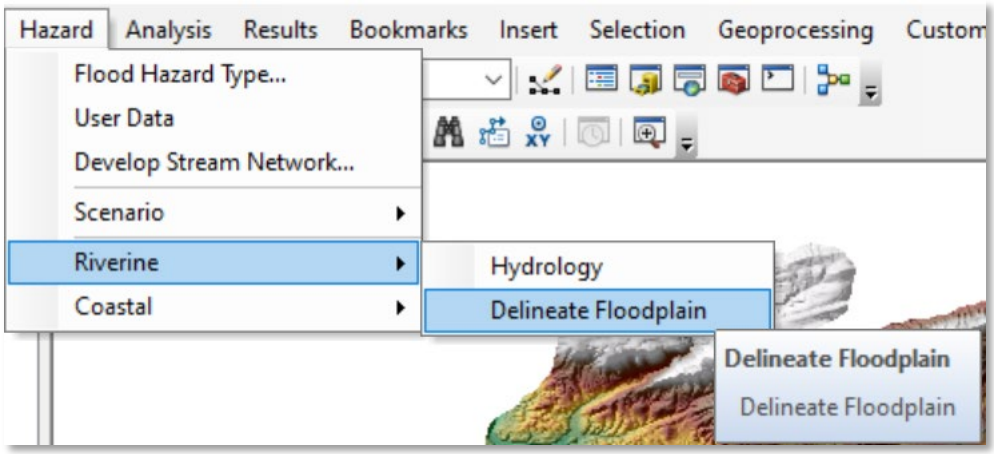


Figure 4-33 Select Riverine and Delineate Floodplain in Hazard Menu

The **Riverine Hydraulic Analysis** window (Figure 4-34) will open. Select **Single Return Period** for **Analysis type**. Keep the default **Output cell size**. Finally, for each stream keep the default return period of 100 years and the default Manning's roughness coefficient n-value shown in the third column of the table. Click **OK**.

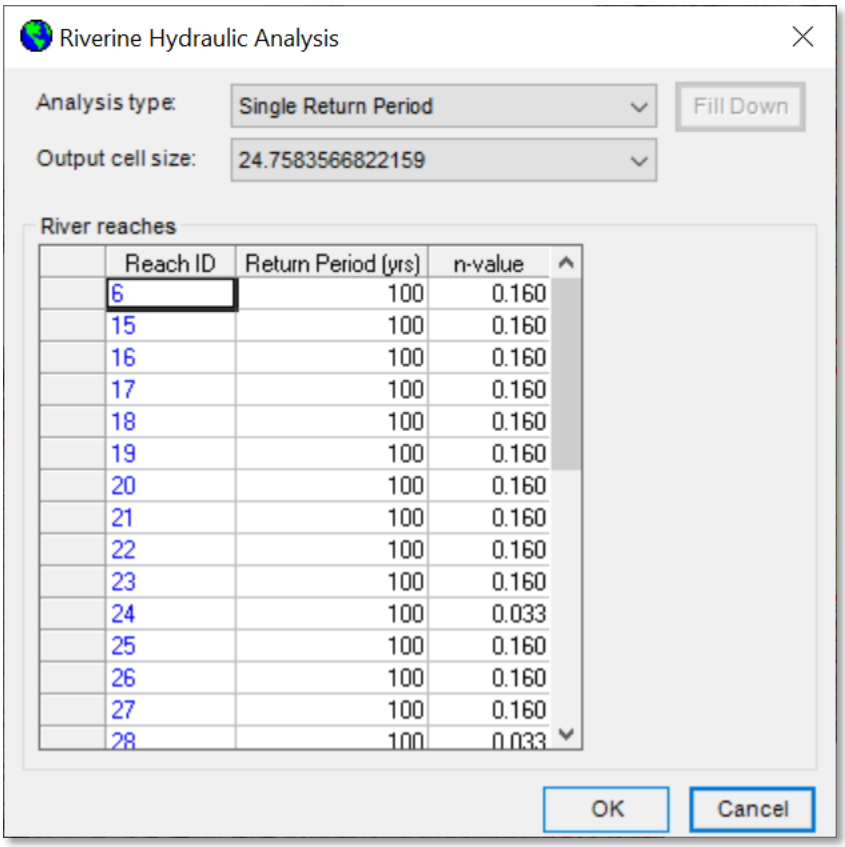


Figure 4-34 Delineate Floodplain for a Single Return Period

A progress bar (Figure 4-35) will appear as Hazus performs the hydraulic analysis needed to delineate the floodplain for each selected stream. This may take several minutes to several hours depending on the size of the Study Region and the number of selected streams. A notification (Figure 4-36) will appear once the floodplain analysis has been completed. Click **OK**.

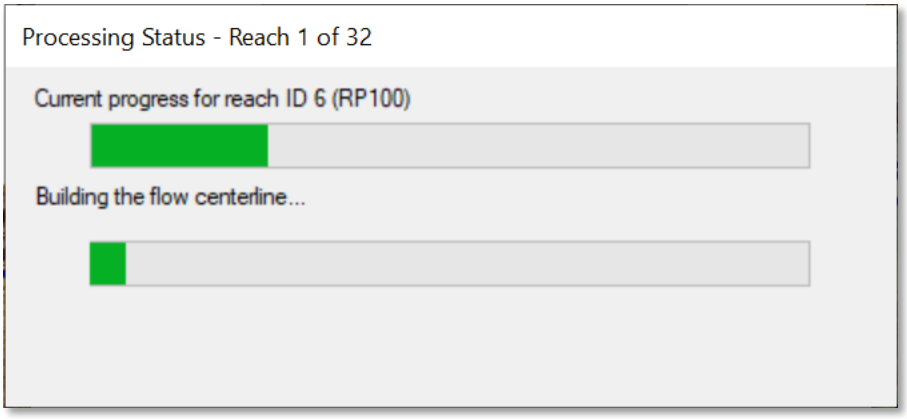


Figure 4-35 Delineate Floodplain Progress

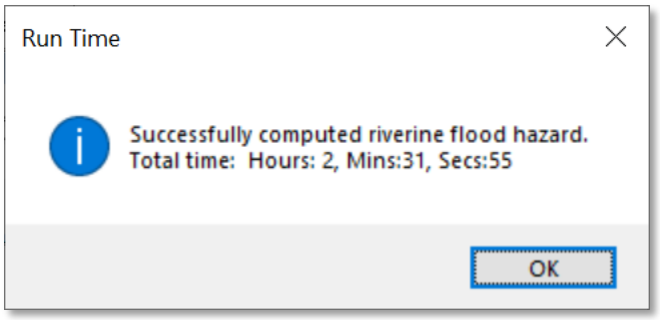


Figure 4-36 Delineate Floodplain Completed

If the floodplain analysis was performed correctly, the Flood Model should look like Figure 4-37.

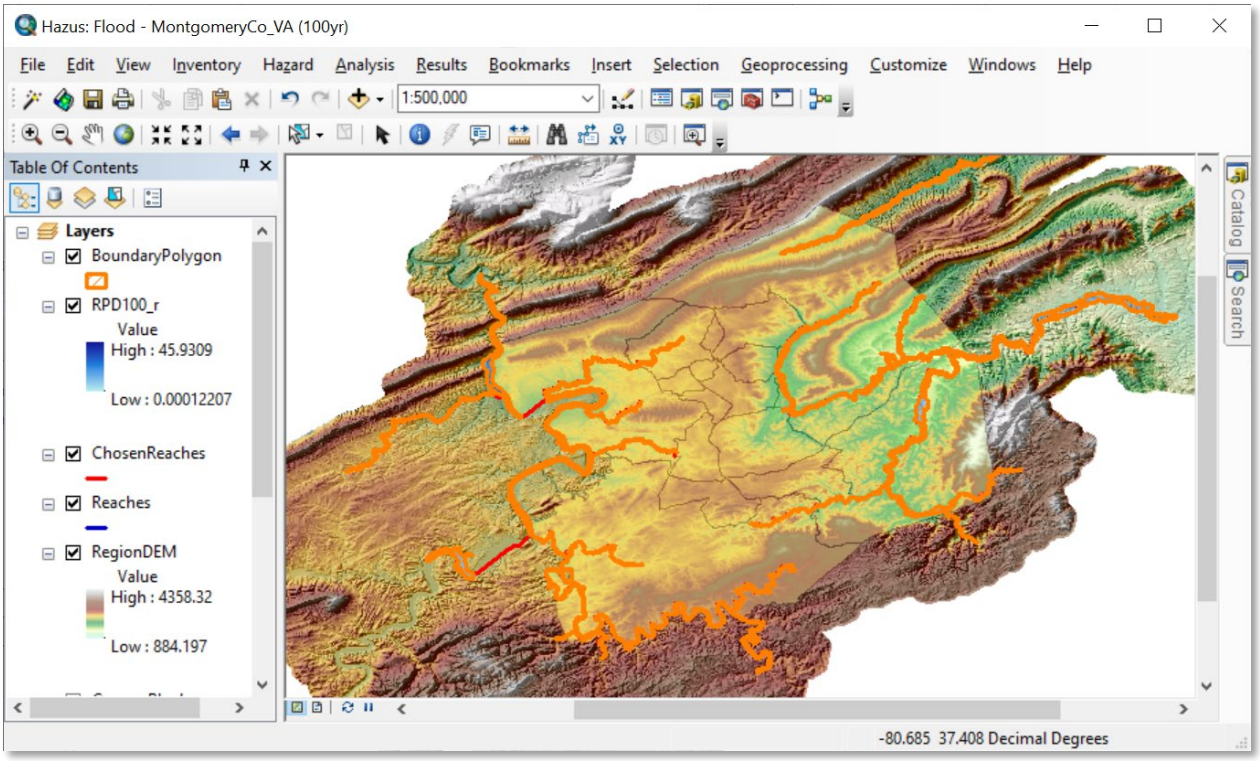


Figure 4-37 Example – Flood Model after Delineate Floodplain

Begin computing losses within the Study Region's newly delineated floodplains by opening the **Analysis** drop-down menu and selecting **Run** (Figure 4-38).

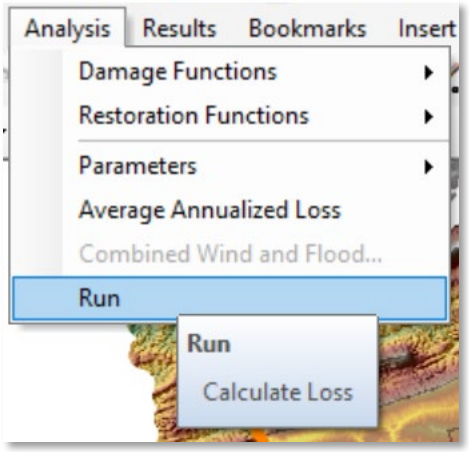


Figure 4-38 Select Run in Analysis Menu

The **Analysis Options** window (Figure 4-39) will open. Click the **+** button to the left of **General Building Stock Damage and Loss** to expand and view the loss category. Next, click the small open box to the left of **General Building Stock Damage and Loss** so that all subcategories are also selected. Click **OK**.

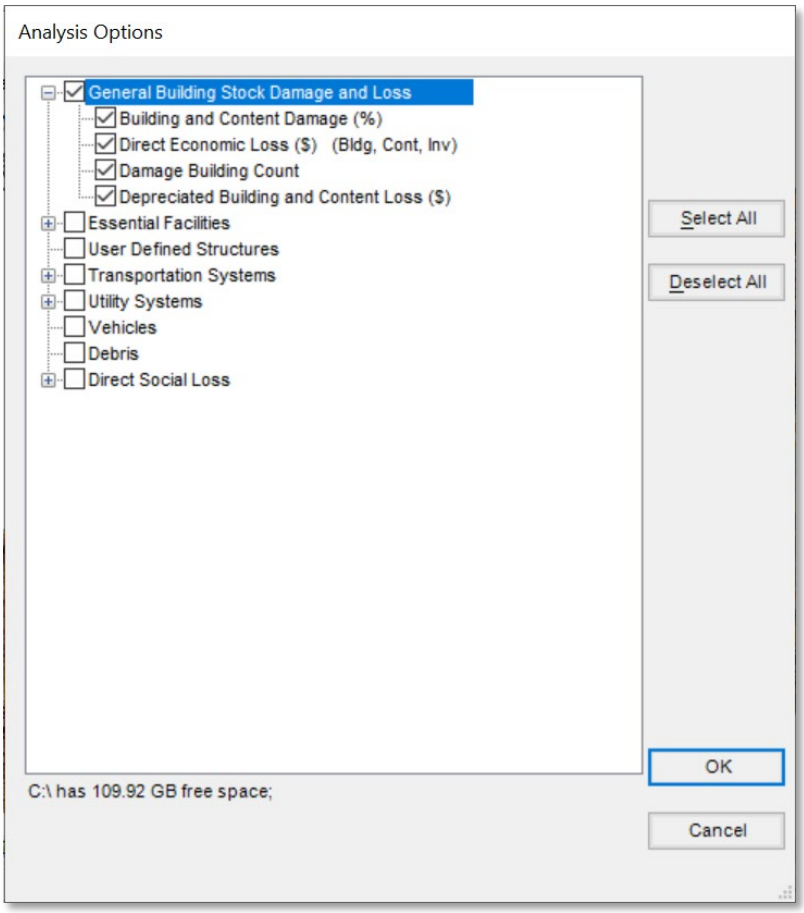


Figure 4-39 Select General Building Stock Damage and Loss from Analysis Options

A progress bar (Figure 4-40) will appear as Hazus calculates flood losses. This may take several minutes to several hours depending on the size of the Study Region. A notification (Figure 4-41) will appear once floodplain losses have been completed. Click **OK**.

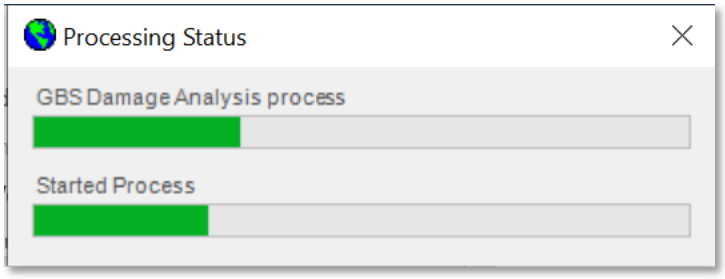


Figure 4-40 Flood Losses Progress

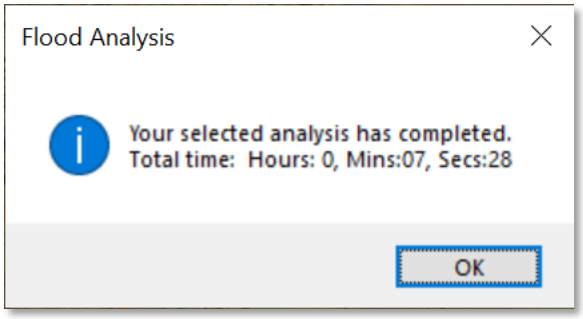


Figure 4-41 Flood Losses Completed

At this point, the user will have successfully created a Study Region, delineated streams and floodplains, and calculated losses. For more information on displaying, understanding, and exporting loss results, see Section 8.

Section 5. Model Menu: Inventory

The **Inventory** menu, shown in Figure 5-1, has inventory types and subtypes that allow the estimation of the amount of exposure and potential damage in the Study Region. Inventory data include basic information on population, buildings, and facilities obtained from the United States Census and other national sources. These data can be supplemented with additional user-supplied datasets. The screenshots in this section show all of the options for the **Inventory** menu.

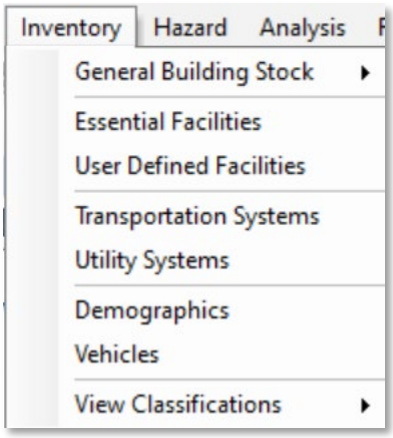


Figure 5-1 Inventory Menu

5.1 General Building Stock

The first type of inventory is General Building Stock. The subtypes are Square Footage, Building Count, Valuation Parameters, Dollar Exposure, Depreciation Parameters, Depreciated Exposure, General Occupancy Mapping, and Flood Specific Occupancy Mapping, as shown in Figure 5-2. First Floor Elevations is temporarily disabled.

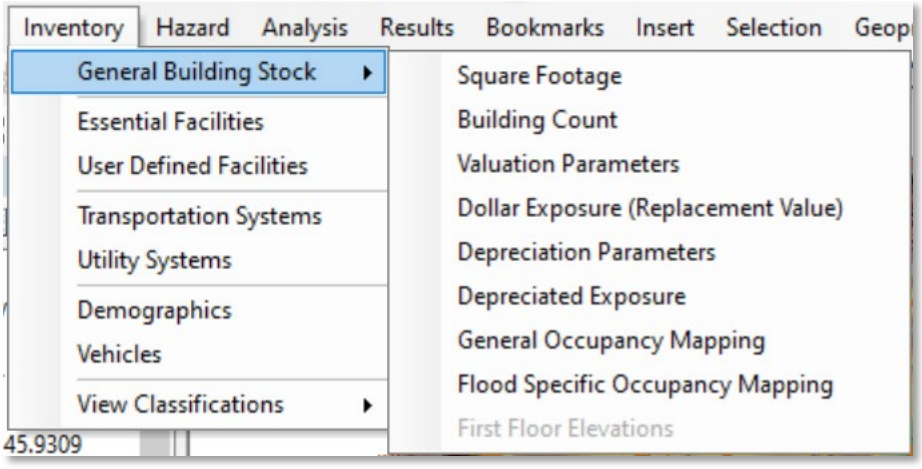
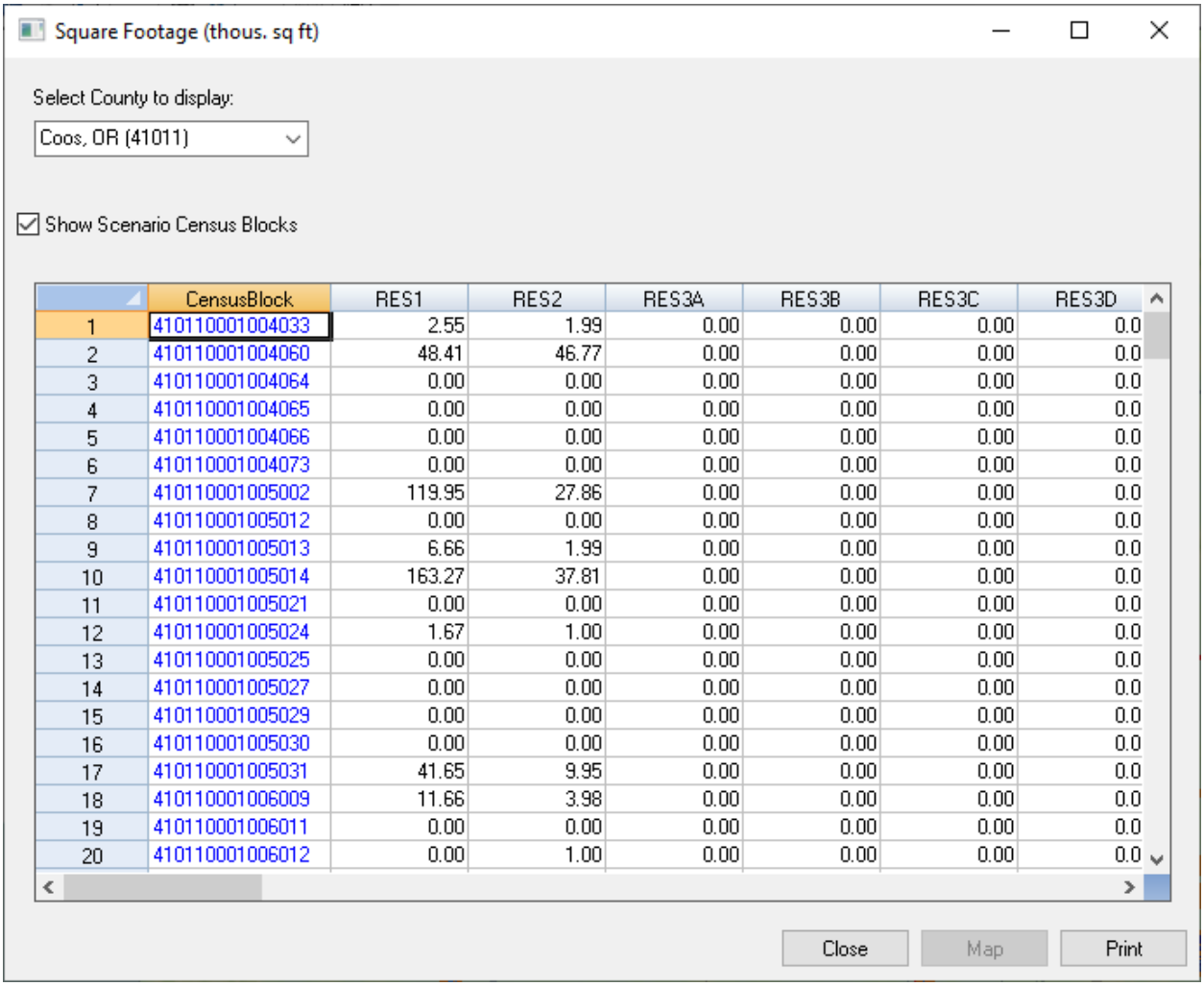


Figure 5-2 Inventory > General Building Stock Menu

5.1.1 Square Footage

Square Footage, opened through the menu shown in Figure 5-2, allows the user to view the type of square footage distribution per the Census block, as shown in Figure 5-3.

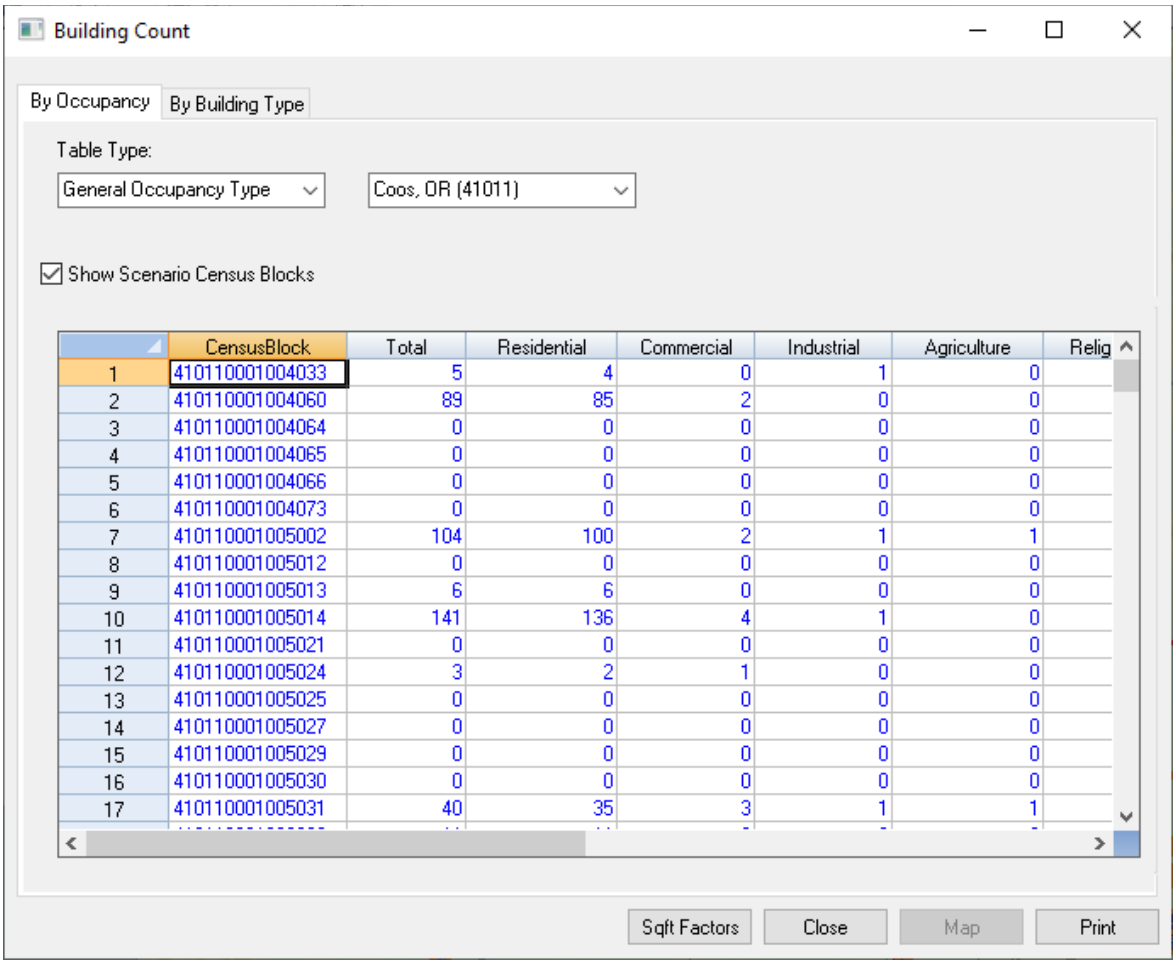


	CensusBlock	RES1	RES2	RES3A	RES3B	RES3C	RES3D
1	410110001004033	2.55	1.99	0.00	0.00	0.00	0.0
2	410110001004060	48.41	46.77	0.00	0.00	0.00	0.0
3	410110001004064	0.00	0.00	0.00	0.00	0.00	0.0
4	410110001004065	0.00	0.00	0.00	0.00	0.00	0.0
5	410110001004066	0.00	0.00	0.00	0.00	0.00	0.0
6	410110001004073	0.00	0.00	0.00	0.00	0.00	0.0
7	410110001005002	119.95	27.86	0.00	0.00	0.00	0.0
8	410110001005012	0.00	0.00	0.00	0.00	0.00	0.0
9	410110001005013	6.66	1.99	0.00	0.00	0.00	0.0
10	410110001005014	163.27	37.81	0.00	0.00	0.00	0.0
11	410110001005021	0.00	0.00	0.00	0.00	0.00	0.0
12	410110001005024	1.67	1.00	0.00	0.00	0.00	0.0
13	410110001005025	0.00	0.00	0.00	0.00	0.00	0.0
14	410110001005027	0.00	0.00	0.00	0.00	0.00	0.0
15	410110001005029	0.00	0.00	0.00	0.00	0.00	0.0
16	410110001005030	0.00	0.00	0.00	0.00	0.00	0.0
17	410110001005031	41.65	9.95	0.00	0.00	0.00	0.0
18	410110001006009	11.66	3.98	0.00	0.00	0.00	0.0
19	410110001006011	0.00	0.00	0.00	0.00	0.00	0.0
20	410110001006012	0.00	1.00	0.00	0.00	0.00	0.0

Figure 5-3 Square Footage Table

5.1.2 Building Count

Building Count allows the user to review the building count per Census block **By Occupancy** and **By Building Type** for specific and general occupancies, as shown in Figure 5-4. The user can view and modify the building count values by only specific occupancy for each Census block.



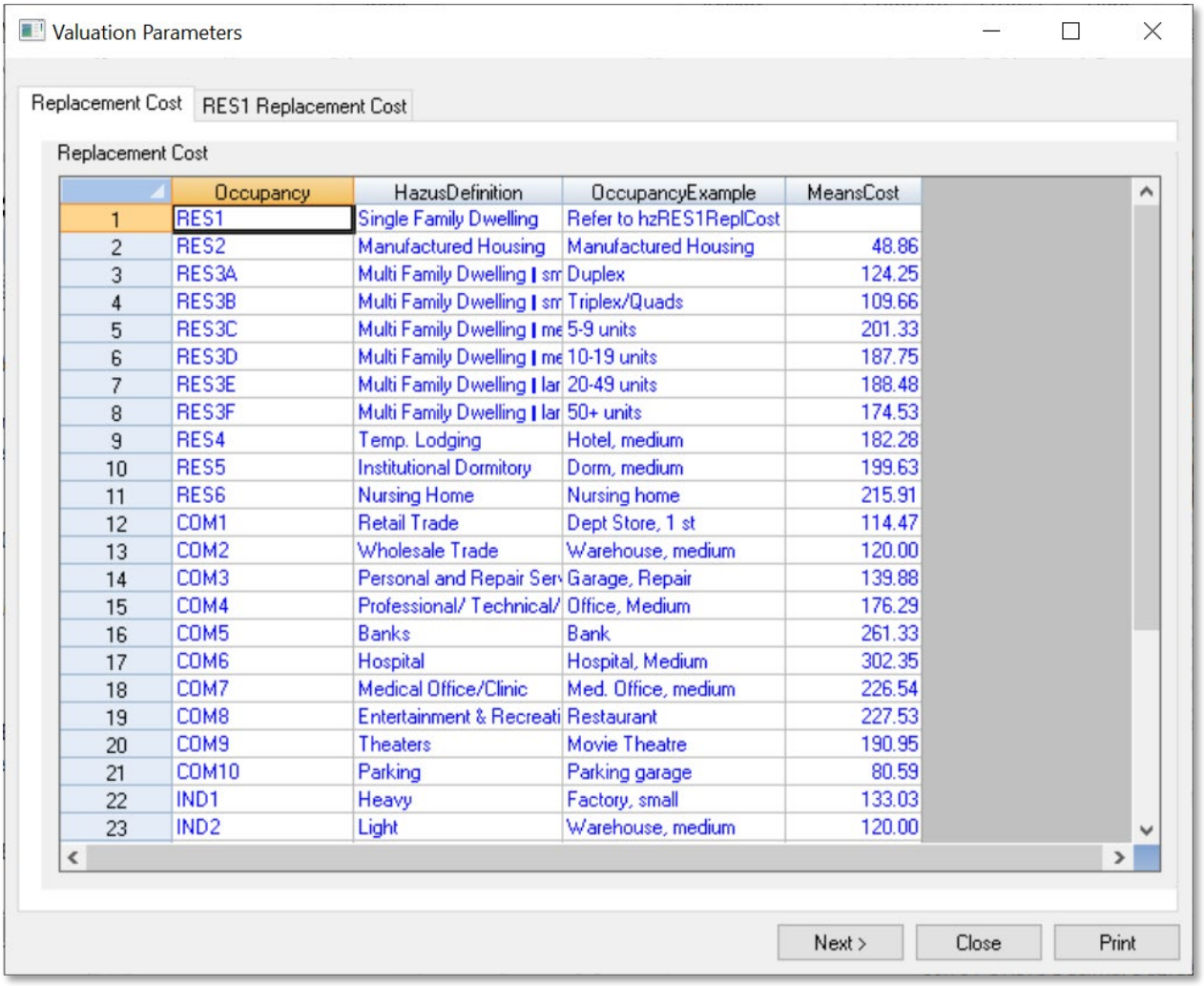
	CensusBlock	Total	Residential	Commercial	Industrial	Agriculture	Relig
1	410110001004033	5	4	0	1	0	
2	410110001004060	89	85	2	0	0	
3	410110001004064	0	0	0	0	0	
4	410110001004065	0	0	0	0	0	
5	410110001004066	0	0	0	0	0	
6	410110001004073	0	0	0	0	0	
7	410110001005002	104	100	2	1	1	
8	410110001005012	0	0	0	0	0	
9	410110001005013	6	6	0	0	0	
10	410110001005014	141	136	4	1	0	
11	410110001005021	0	0	0	0	0	
12	410110001005024	3	2	1	0	0	
13	410110001005025	0	0	0	0	0	
14	410110001005027	0	0	0	0	0	
15	410110001005029	0	0	0	0	0	
16	410110001005030	0	0	0	0	0	
17	410110001005031	40	35	3	1	1	

Figure 5-4 Building Count (by Occupancy) Table

5.1.3 Valuation Parameters

Valuation Parameters allow the user to review the replacement costs for each occupancy type, as shown in Figure 5-5. Clicking the Next button on each window will take the user through the following information windows:

1. Replacement Cost (based on a specific year)
2. Location Factors
3. Single-Family (RES1) Garage Distributions by Census Block
4. Single-Family (RES1) Garage Replacement Cost
5. Single-Family (RES1) Basement Distribution by Census Block
6. Height Distribution (Number of Stories) by Census Block

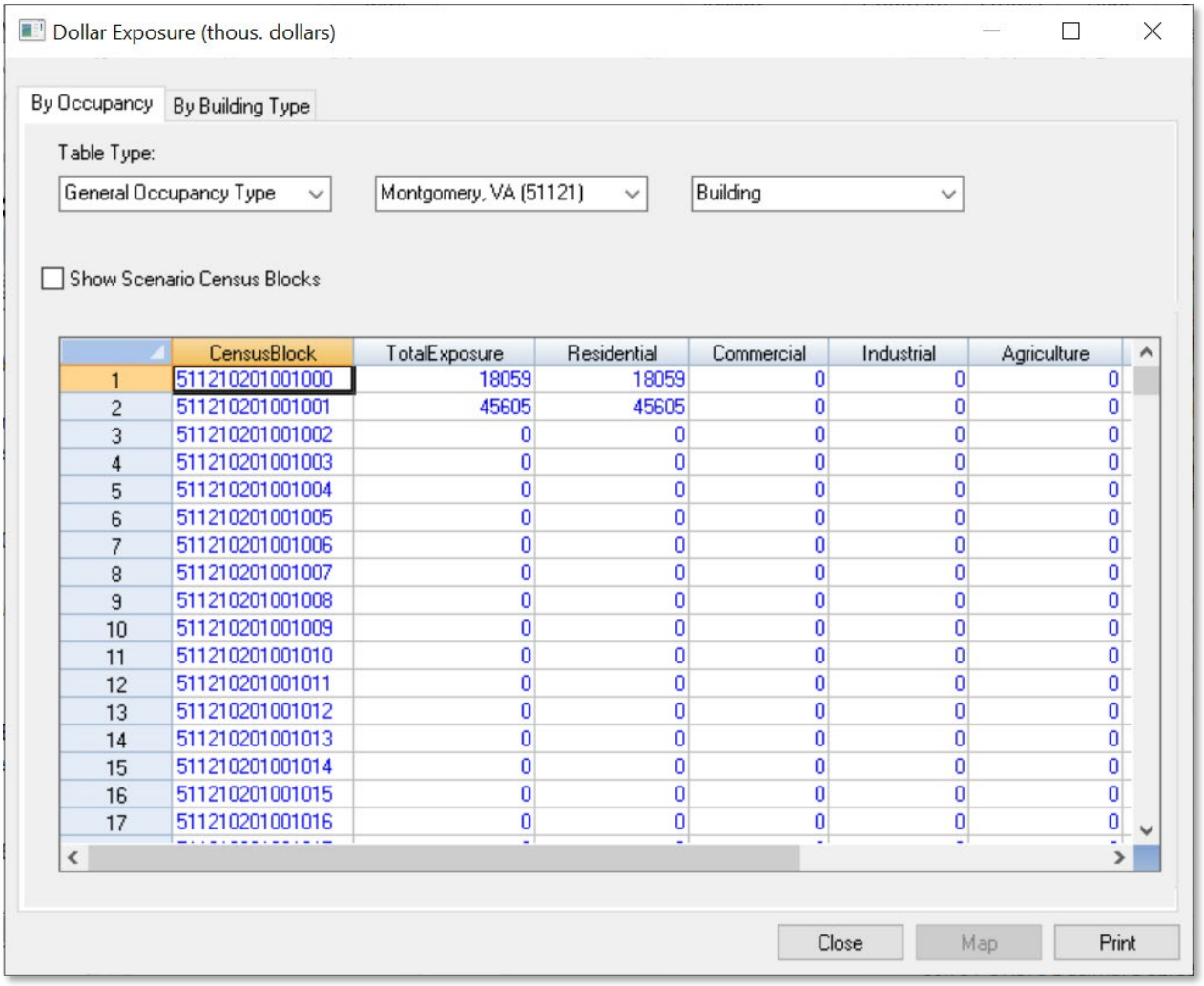


	Occupancy	HazusDefinition	OccupancyExample	MeansCost
1	RES1	Single Family Dwelling	Refer to hzRES1ReplCost	
2	RES2	Manufactured Housing	Manufactured Housing	48.86
3	RES3A	Multi Family Dwelling | sm	Duplex	124.25
4	RES3B	Multi Family Dwelling | sm	Triplex/Quads	109.66
5	RES3C	Multi Family Dwelling | me	5-9 units	201.33
6	RES3D	Multi Family Dwelling | me	10-19 units	187.75
7	RES3E	Multi Family Dwelling | lar	20-49 units	188.48
8	RES3F	Multi Family Dwelling | lar	50+ units	174.53
9	RES4	Temp. Lodging	Hotel, medium	182.28
10	RES5	Institutional Dormitory	Dorm, medium	199.63
11	RES6	Nursing Home	Nursing home	215.91
12	COM1	Retail Trade	Dept Store, 1 st	114.47
13	COM2	Wholesale Trade	Warehouse, medium	120.00
14	COM3	Personal and Repair Serv	Garage, Repair	139.88
15	COM4	Professional/ Technical/	Office, Medium	176.29
16	COM5	Banks	Bank	261.33
17	COM6	Hospital	Hospital, Medium	302.35
18	COM7	Medical Office/Clinic	Med. Office, medium	226.54
19	COM8	Entertainment & Recreati	Restaurant	227.53
20	COM9	Theaters	Movie Theatre	190.95
21	COM10	Parking	Parking garage	80.59
22	IND1	Heavy	Factory, small	133.03
23	IND2	Light	Warehouse, medium	120.00

Figure 5-5 Valuation Parameters Table

5.1.4 Dollar Exposure (Replacement Value):

Dollar Exposure (Figure 5-6) allows the user to review the exposure per Census block **By Occupancy** and **By Building Type**. The user can view and modify the exposure values by only specific occupancy for each Census block.



	CensusBlock	TotalExposure	Residential	Commercial	Industrial	Agriculture
1	511210201001000	18059	18059	0	0	0
2	511210201001001	45605	45605	0	0	0
3	511210201001002	0	0	0	0	0
4	511210201001003	0	0	0	0	0
5	511210201001004	0	0	0	0	0
6	511210201001005	0	0	0	0	0
7	511210201001006	0	0	0	0	0
8	511210201001007	0	0	0	0	0
9	511210201001008	0	0	0	0	0
10	511210201001009	0	0	0	0	0
11	511210201001010	0	0	0	0	0
12	511210201001011	0	0	0	0	0
13	511210201001012	0	0	0	0	0
14	511210201001013	0	0	0	0	0
15	511210201001014	0	0	0	0	0
16	511210201001015	0	0	0	0	0
17	511210201001016	0	0	0	0	0

Figure 5-6 Dollar Exposure Table

5.1.5 Depreciation Parameters

Depreciation Parameters (Figure 5-7) allow the user to review the median year built and median age of buildings in each Census block.

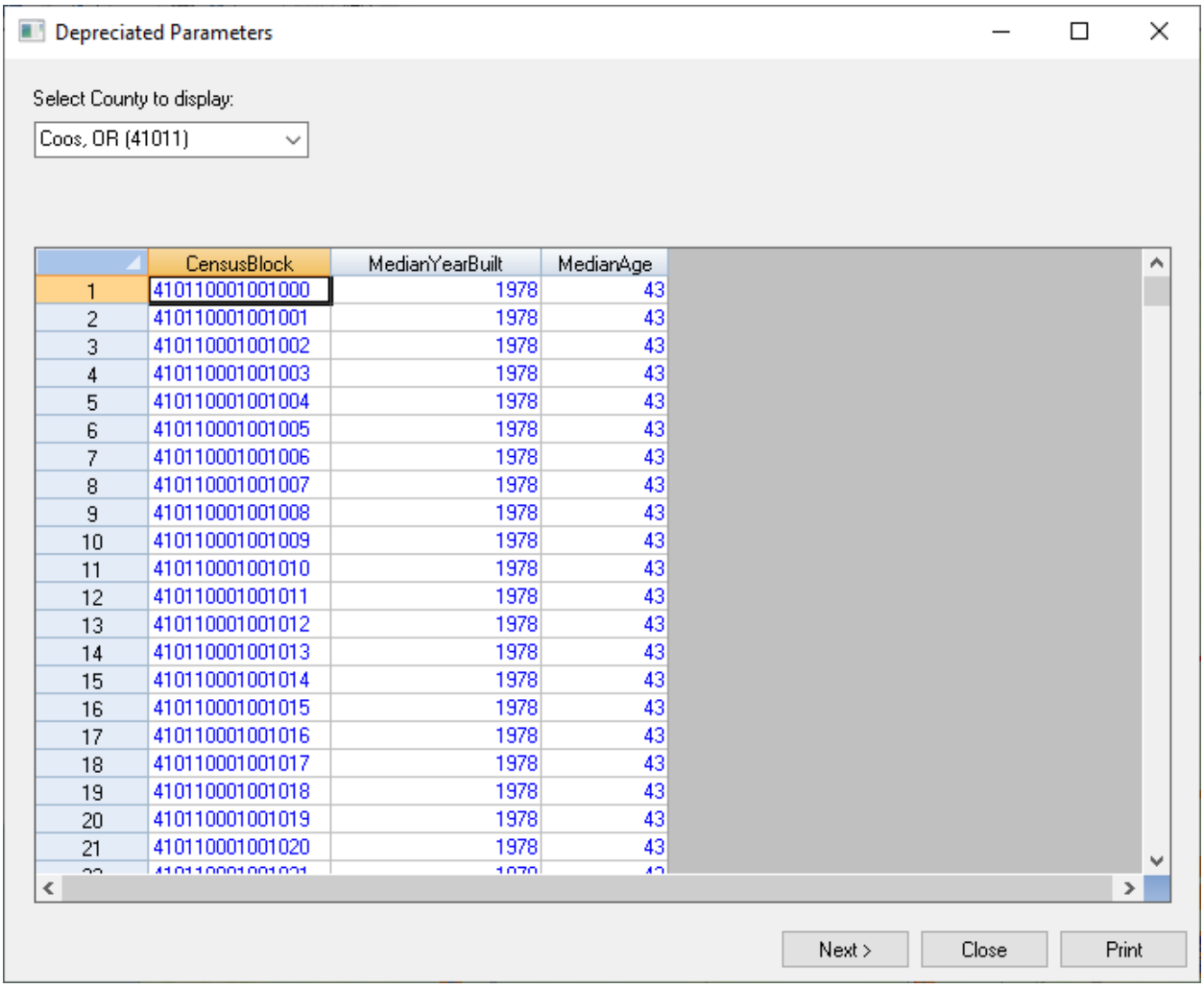
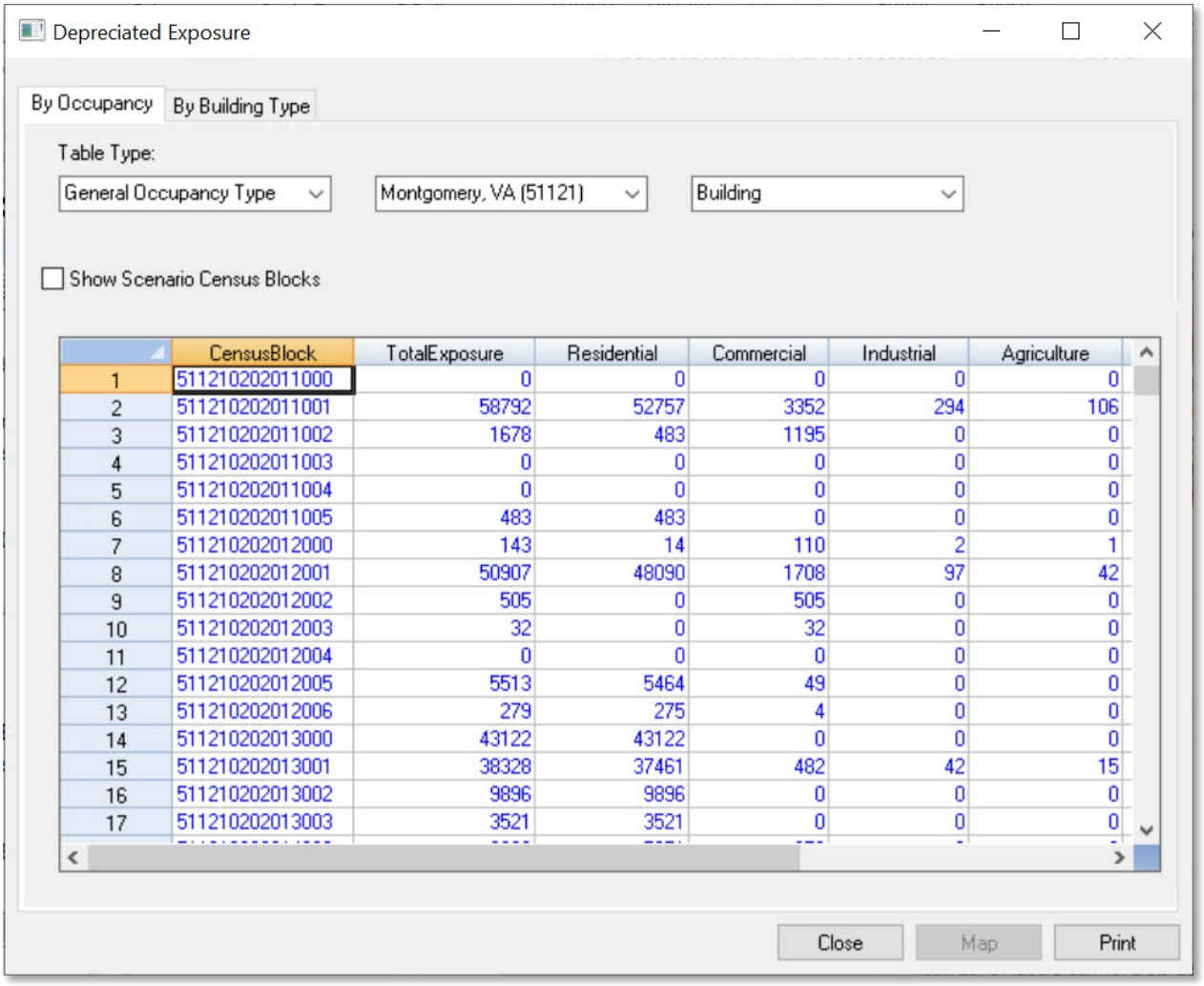


Figure 5-7 Depreciation Parameters Table

5.1.6 Depreciated Exposure

Depreciated Exposure (Figure 5-8) allows the user to review the depreciated exposure **By Occupancy** or **By Building Type**. This data is calculated based on the median building age and a depreciation curve. The user can view and modify the building depreciated values by only specific occupancy for each Census block.



	CensusBlock	TotalExposure	Residential	Commercial	Industrial	Agriculture
1	511210202011000	0	0	0	0	0
2	511210202011001	58792	52757	3352	294	106
3	511210202011002	1678	483	1195	0	0
4	511210202011003	0	0	0	0	0
5	511210202011004	0	0	0	0	0
6	511210202011005	483	483	0	0	0
7	511210202012000	143	14	110	2	1
8	511210202012001	50907	48090	1708	97	42
9	511210202012002	505	0	505	0	0
10	511210202012003	32	0	32	0	0
11	511210202012004	0	0	0	0	0
12	511210202012005	5513	5464	49	0	0
13	511210202012006	279	275	4	0	0
14	511210202013000	43122	43122	0	0	0
15	511210202013001	38328	37461	482	42	15
16	511210202013002	9896	9896	0	0	0
17	511210202013003	3521	3521	0	0	0

Figure 5-8 Depreciated Exposure Table

5.1.7 General Occupancy Mapping

The **General Occupancy Mapping** window (Figure 5-9) allows the user to view, copy, edit, and delete the distribution of general building types in the Study Region. By default, the specific state distribution is the only scheme available. This data can be viewed and copied but cannot be edited or deleted. The user can make a copy of the baseline data (by selecting the baseline data and clicking **Copy** and entering a new scheme name and description) and edit this data (by clicking the new copy and clicking **Edit**).

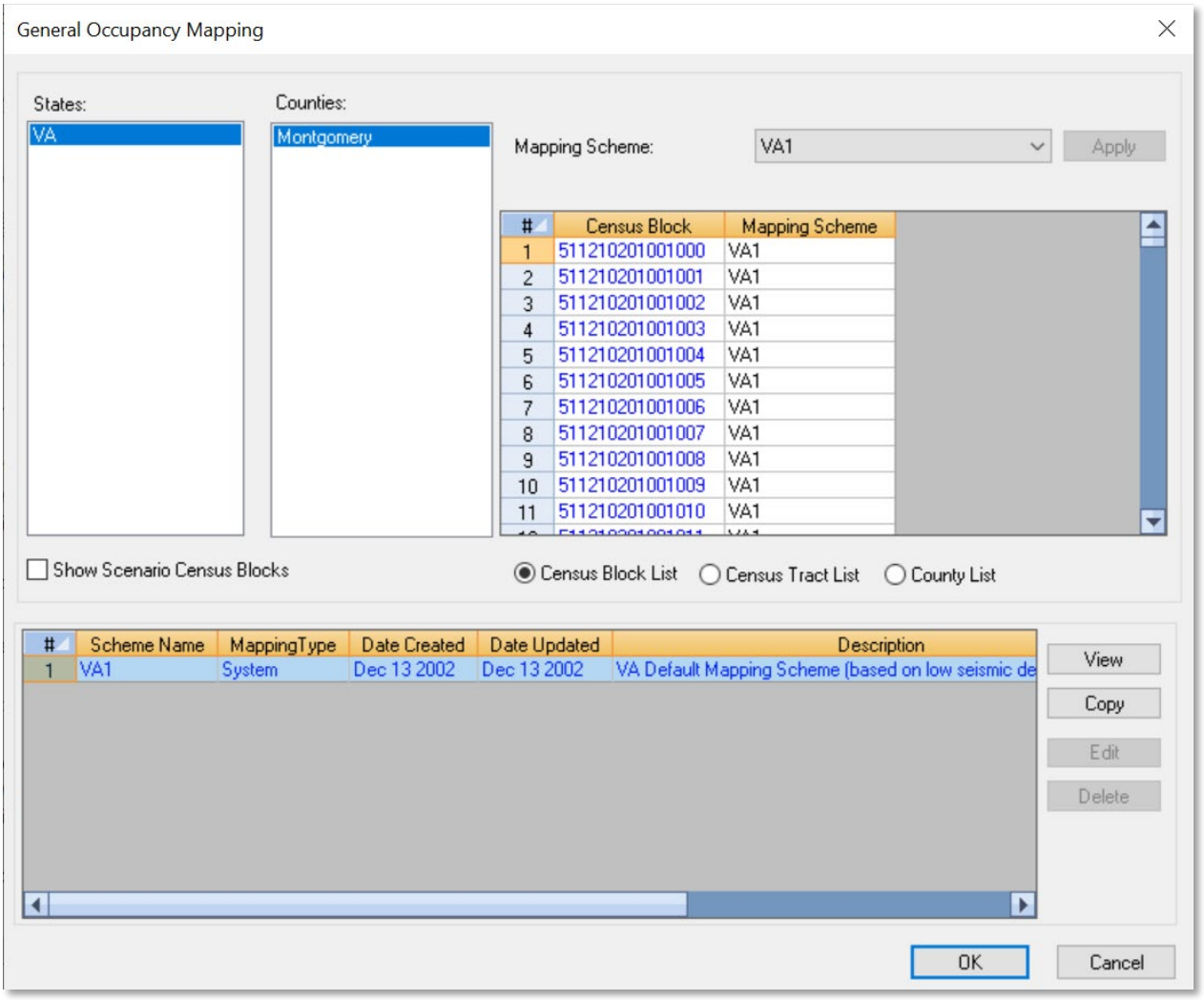


Figure 5-9 General Occupancy Mapping Schemes

5.1.8 Flood Specific Occupancy Mapping

Flood Specific Occupancy Mapping (Figure 5-10) allows the user to view the default assumptions for physical building characteristics of structures in any specific occupancy category. There are three default mapping schemes (Coastal, Great Lakes, and Riverine). All three schemes can be copied, and the copy versions can be edited to create custom schemes.

For example, to view the Pre- and Post-FIRM (Flood Insurance Rate Map) distributions of foundation types for all RES1 buildings, select a **Mapping Scheme** and click **View**. Figure 5-11 shows the **Flood Building Characteristics Distribution** window that will appear. Users can create custom schemes by clicking the **Copy** button, which activates the **Edit** button. Click **Edit** to change percentage values in the copy.

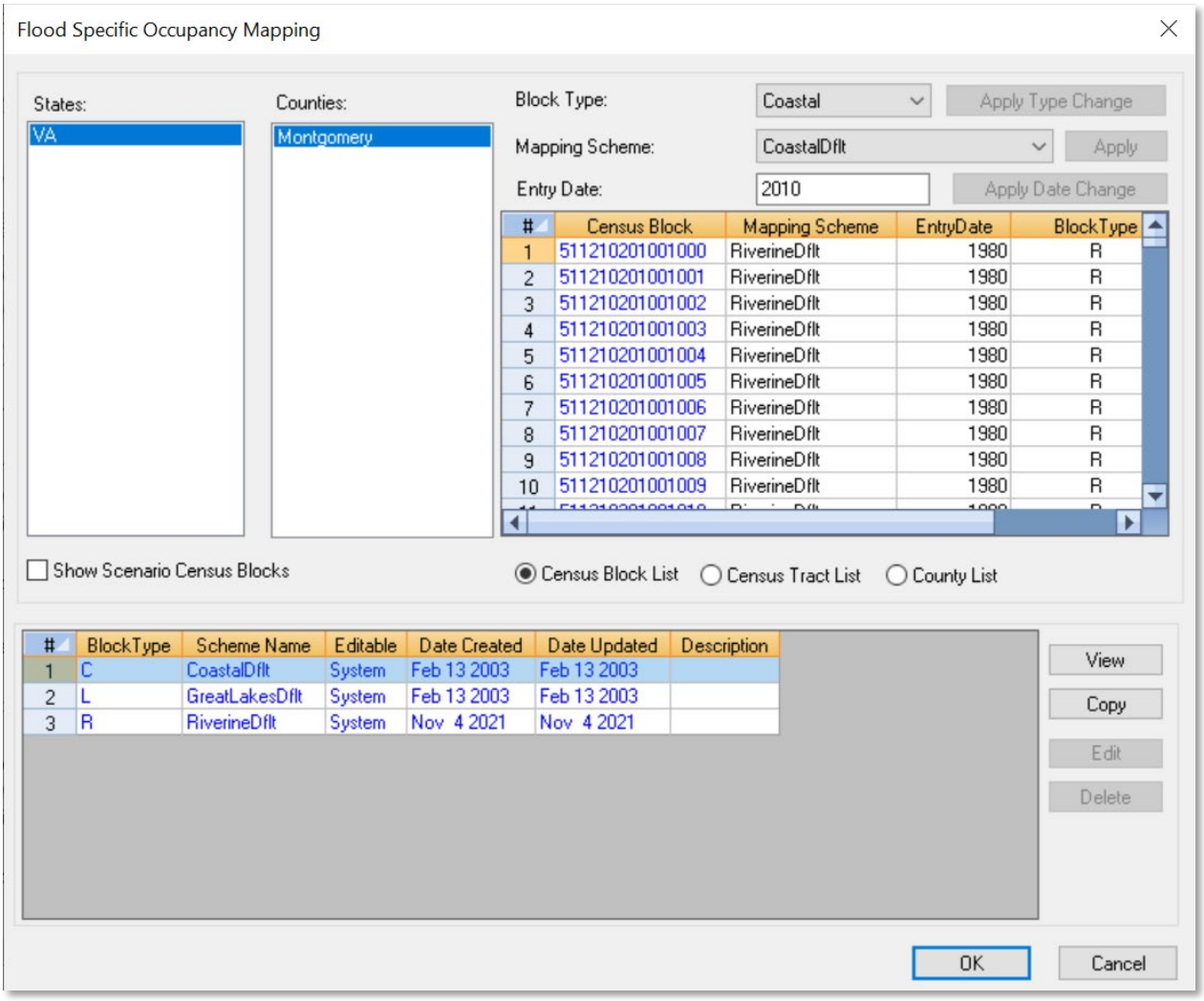


Figure 5-10 Flood-Specific Occupancy Mapping Schemes

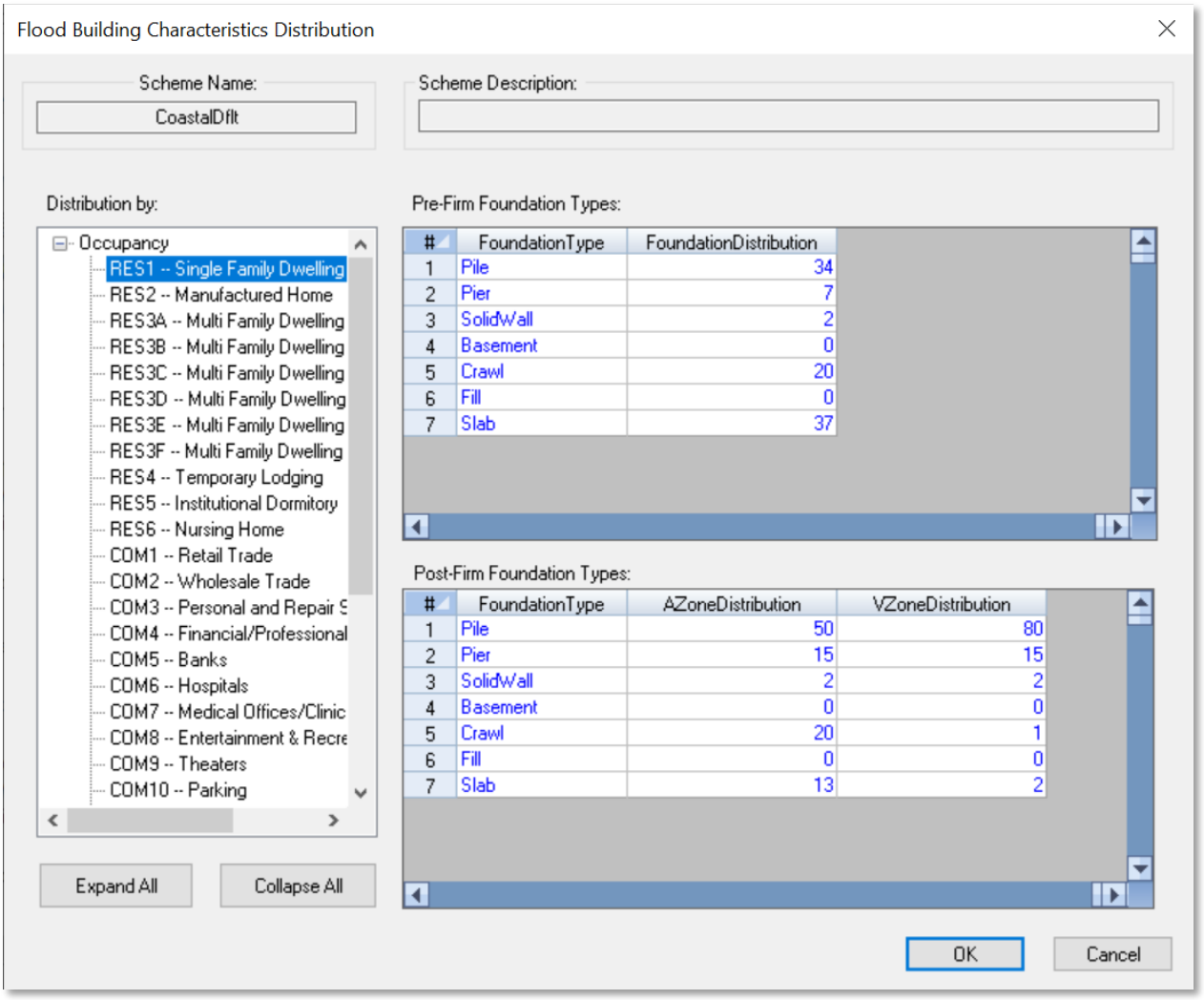
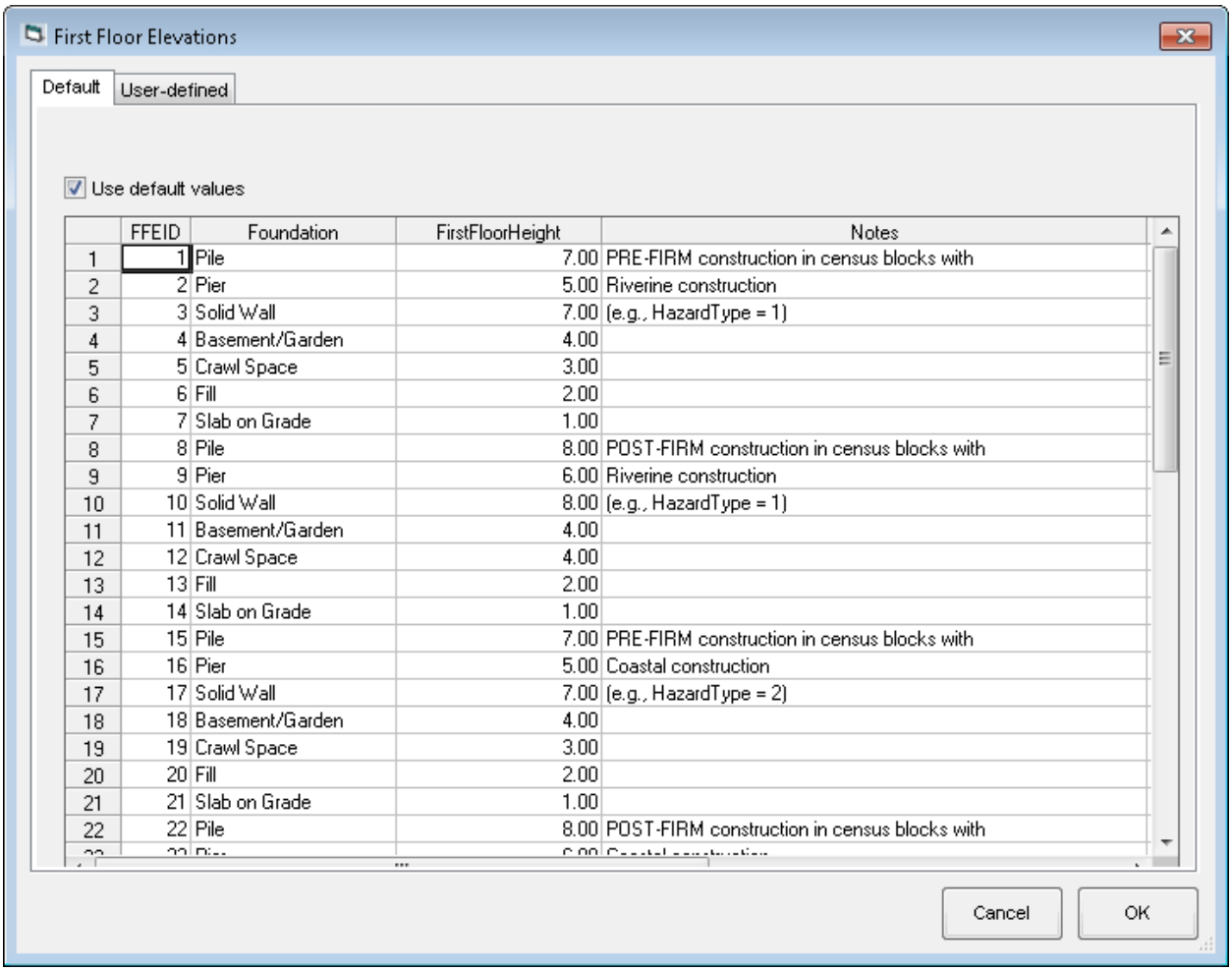


Figure 5-11 Flood Building Characteristics Distribution

5.1.9 First Floor Elevations Flood-Specific Occupancy Mapping

The **First Floor Elevations** window (Figure 5-12) allows the user to view the default assumptions for first floor heights of various foundation types. Editing functionality was temporarily disabled. The original process required user-defined first floor heights to be assigned by clicking on the **User-defined** tab and selecting the **Use user-defined values** check box, then editing the first-floor height values for the foundation types and clicking **OK**. If this functionality is not working, users can contact the Hazus Help Desk for guidance on using SQL Management Studio to view or modify Finished Floor Elevations.



	FFEID	Foundation	FirstFloorHeight	Notes
1	1	Pile	7.00	PRE-FIRM construction in census blocks with
2	2	Pier	5.00	Riverine construction
3	3	Solid Wall	7.00	(e.g., HazardType = 1)
4	4	Basement/Garden	4.00	
5	5	Crawl Space	3.00	
6	6	Fill	2.00	
7	7	Slab on Grade	1.00	
8	8	Pile	8.00	POST-FIRM construction in census blocks with
9	9	Pier	6.00	Riverine construction
10	10	Solid Wall	8.00	(e.g., HazardType = 1)
11	11	Basement/Garden	4.00	
12	12	Crawl Space	4.00	
13	13	Fill	2.00	
14	14	Slab on Grade	1.00	
15	15	Pile	7.00	PRE-FIRM construction in census blocks with
16	16	Pier	5.00	Coastal construction
17	17	Solid Wall	7.00	(e.g., HazardType = 2)
18	18	Basement/Garden	4.00	
19	19	Crawl Space	3.00	
20	20	Fill	2.00	
21	21	Slab on Grade	1.00	
22	22	Pile	8.00	POST-FIRM construction in census blocks with

Figure 5-12 First Floor Elevations

5.2 Essential Facilities

Selecting **Essential Facilities** from the **Inventory** menu (Figure 5-13) will display the **Essential Facilities Inventory** table (Figure 5-14), which allows the user to view and map the locations and characteristics of medical care facilities, emergency centers, and schools.

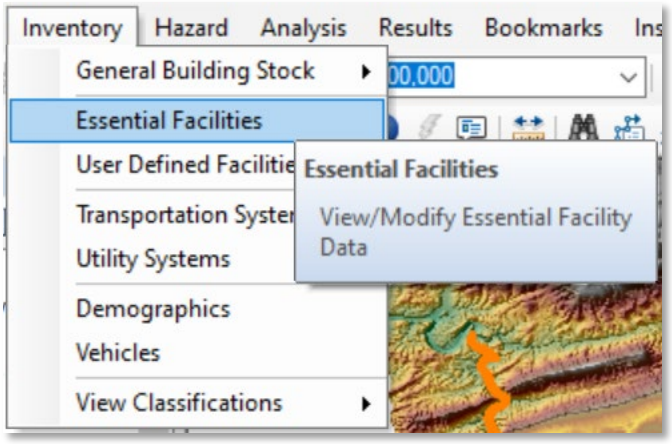


Figure 5-13 Inventory / Essential Facilities Menu

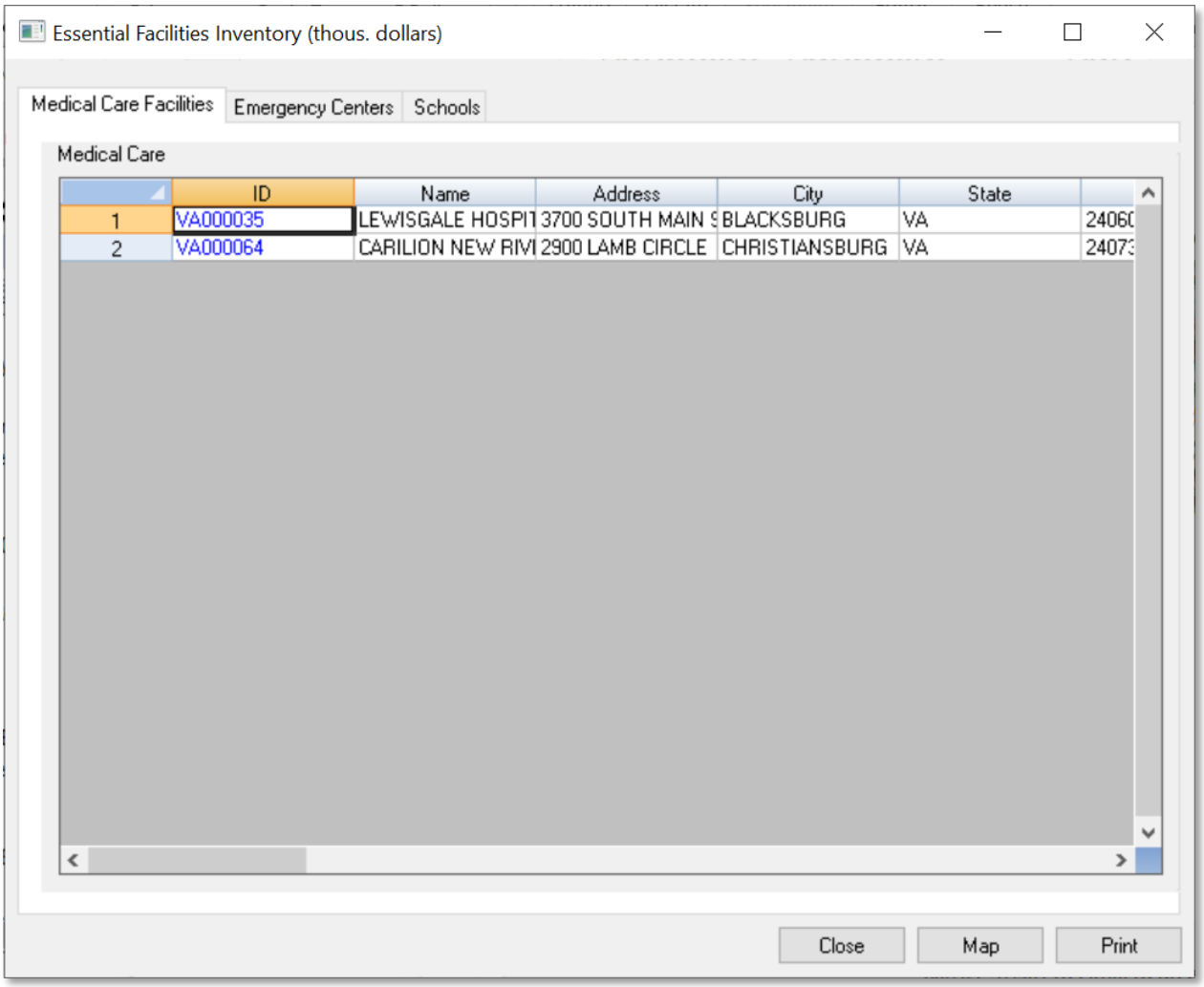


Figure 5-14 Essential Facilities (Medical Care Facilities) Table

5.3 User-Defined Facilities

Selecting **User-Defined Facilities** from the **Inventory** menu (Figure 5-15) will display the **User-Defined Facilities** table (Figure 5-16), which allows the user to view and map the locations and characteristics of any facilities that have been imported by the user.

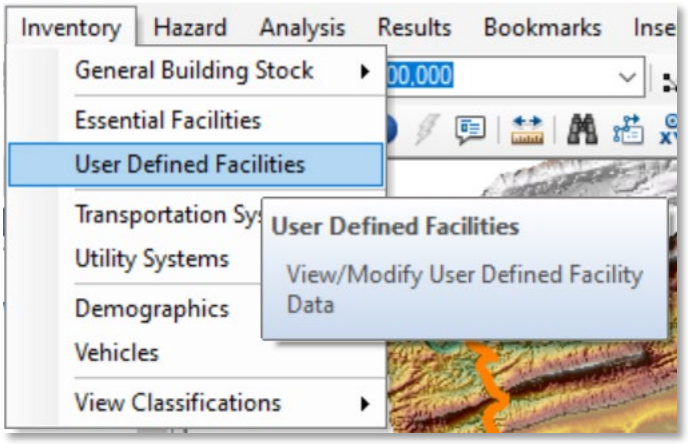


Figure 5-15 Inventory / User-Defined Facilities Menu

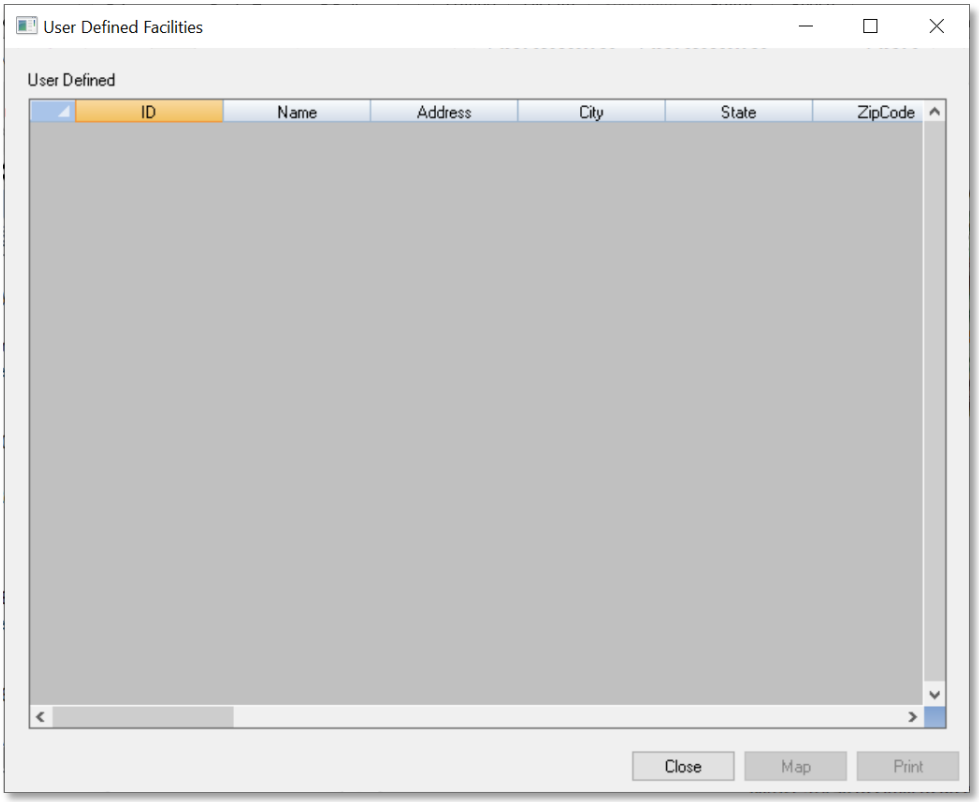


Figure 5-16 User-Defined Facilities Table

5.4 Transportation Systems

Selecting **Transportation Systems** from the **Inventory** menu (Figure 5-17) will display the **Transportation Systems Inventory Data** table (Figure 5-18), which allows the user to view and map the location and characteristics of highways, railways light rails, buses, ports, ferries, and airports.

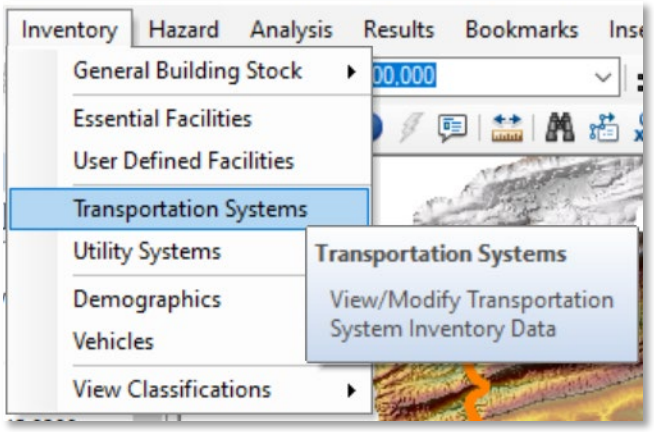
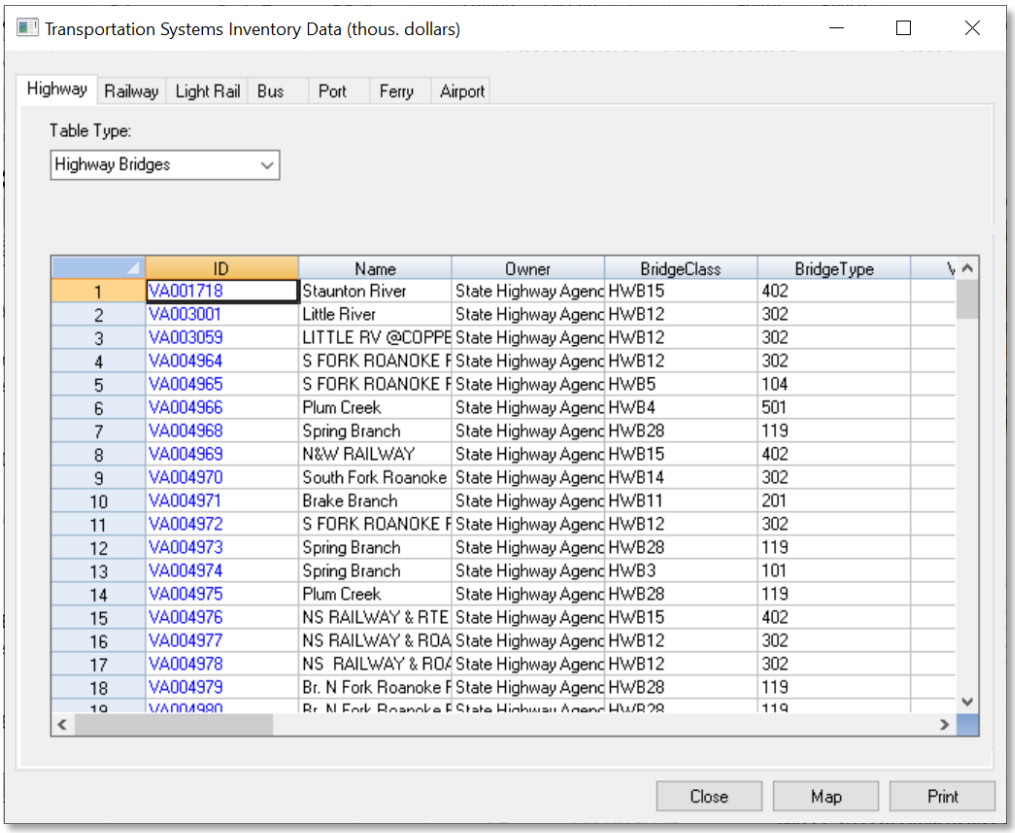


Figure 5-17 Inventory > Transportation Systems Menu



	ID	Name	Owner	BridgeClass	BridgeType
1	VA001718	Staunton River	State Highway Agenc	HWB15	402
2	VA003001	Little River	State Highway Agenc	HWB12	302
3	VA003059	LITTLE RV @COPPE	State Highway Agenc	HWB12	302
4	VA004964	S FORK ROANOKE F	State Highway Agenc	HWB12	302
5	VA004965	S FORK ROANOKE F	State Highway Agenc	HWB5	104
6	VA004966	Plum Creek	State Highway Agenc	HWB4	501
7	VA004968	Spring Branch	State Highway Agenc	HWB28	119
8	VA004969	N&W RAILWAY	State Highway Agenc	HWB15	402
9	VA004970	South Fork Roanoke	State Highway Agenc	HWB14	302
10	VA004971	Brake Branch	State Highway Agenc	HWB11	201
11	VA004972	S FORK ROANOKE F	State Highway Agenc	HWB12	302
12	VA004973	Spring Branch	State Highway Agenc	HWB28	119
13	VA004974	Spring Branch	State Highway Agenc	HWB3	101
14	VA004975	Plum Creek	State Highway Agenc	HWB28	119
15	VA004976	NS RAILWAY & RTE	State Highway Agenc	HWB15	402
16	VA004977	NS RAILWAY & ROA	State Highway Agenc	HWB12	302
17	VA004978	NS RAILWAY & ROA	State Highway Agenc	HWB12	302
18	VA004979	Br. N Fork Roanoke F	State Highway Agenc	HWB28	119

Figure 5-18 Transportation Systems Table

5.5 Utility Systems

Selecting **Utility Systems** from the **Inventory** menu (Figure 5-19) will display the **Utility Systems Inventory** table (Figure 5-20), which allows the user to view and map the locations and characteristics of facilities for potable water, wastewater, oil, natural gas, electric power, and communications.

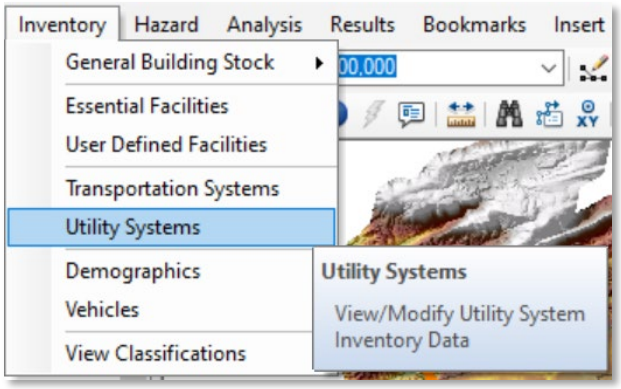


Figure 5-19 Inventory / Utility Systems Menu

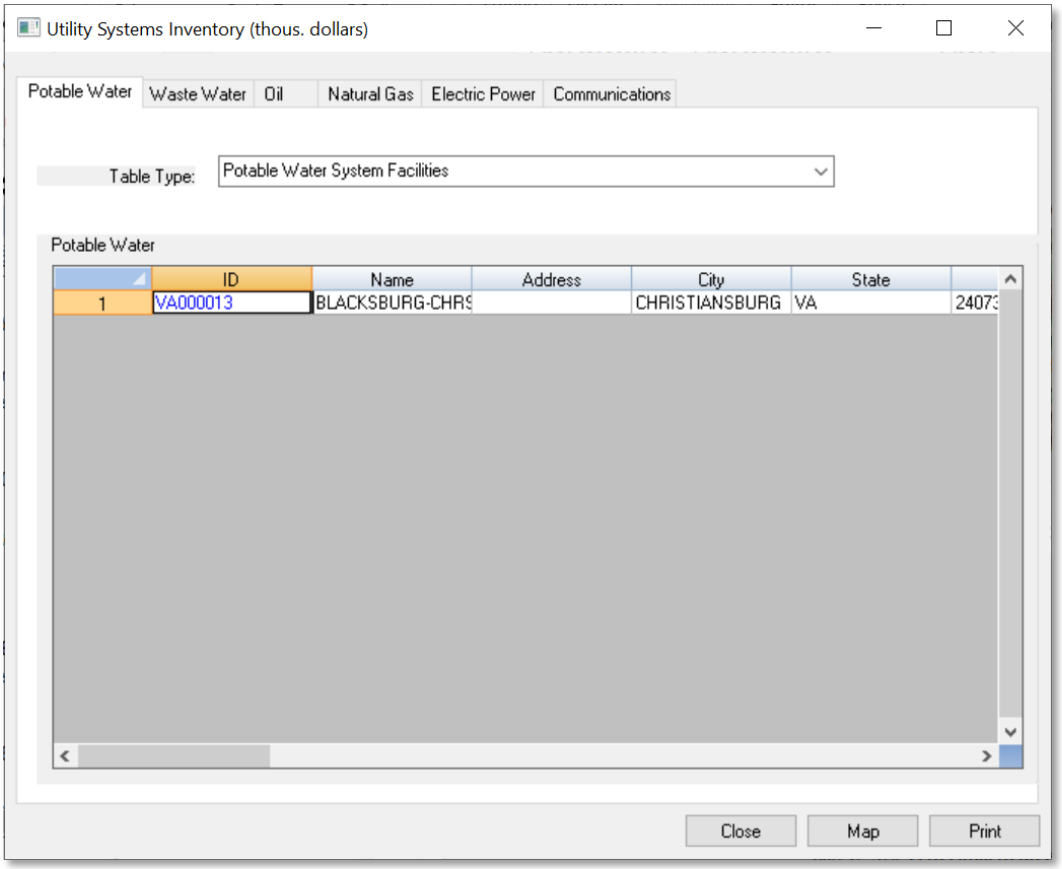


Figure 5-20 Utility Systems Table

5.6 Demographics

Selecting **Demographics** from the **Inventory** menu (Figure 5-21) will display the **Demographics** table (Figure 5-22), which allows the user to view and map categorical Census data aggregated by Census block.

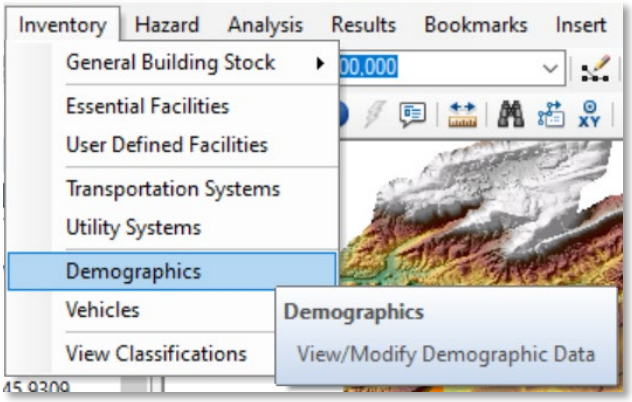
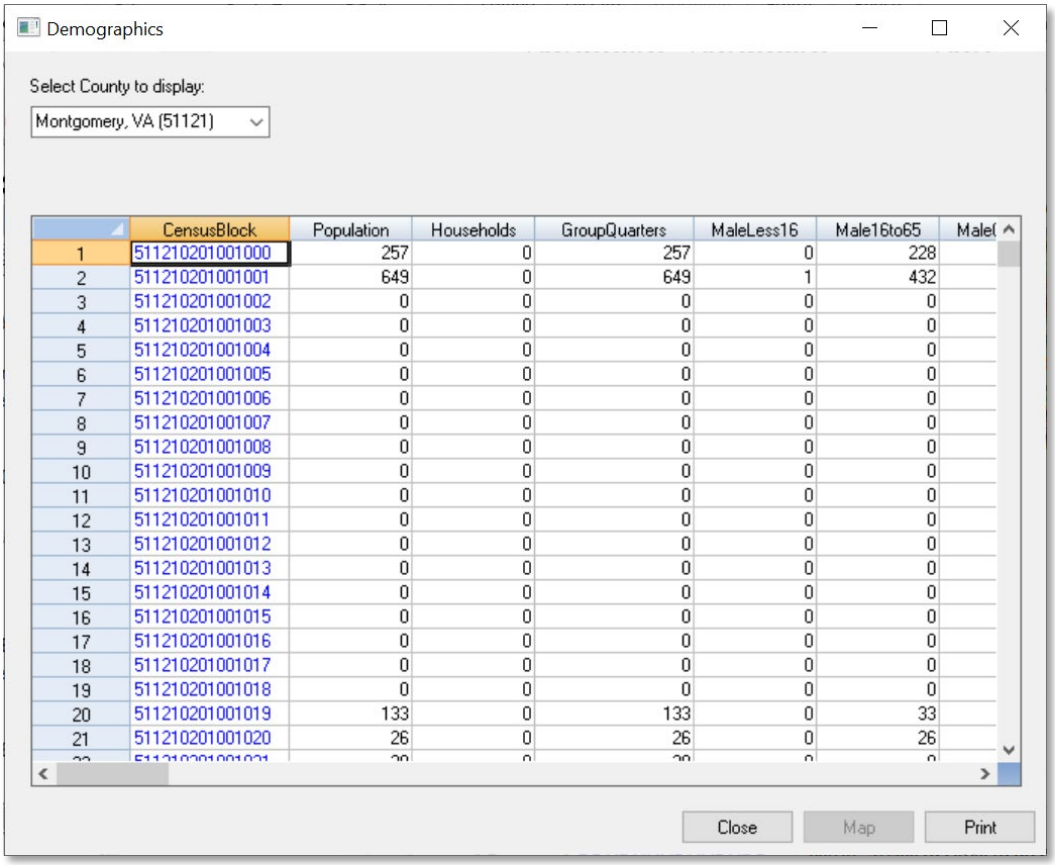


Figure 5-21 Inventory / Demographics Menu



	CensusBlock	Population	Households	GroupQuarters	MaleLess16	Male16to65	Male(
1	511210201001000	257	0	257	0	228	
2	511210201001001	649	0	649	1	432	
3	511210201001002	0	0	0	0	0	
4	511210201001003	0	0	0	0	0	
5	511210201001004	0	0	0	0	0	
6	511210201001005	0	0	0	0	0	
7	511210201001006	0	0	0	0	0	
8	511210201001007	0	0	0	0	0	
9	511210201001008	0	0	0	0	0	
10	511210201001009	0	0	0	0	0	
11	511210201001010	0	0	0	0	0	
12	511210201001011	0	0	0	0	0	
13	511210201001012	0	0	0	0	0	
14	511210201001013	0	0	0	0	0	
15	511210201001014	0	0	0	0	0	
16	511210201001015	0	0	0	0	0	
17	511210201001016	0	0	0	0	0	
18	511210201001017	0	0	0	0	0	
19	511210201001018	0	0	0	0	0	
20	511210201001019	133	0	133	0	33	
21	511210201001020	26	0	26	0	26	

Figure 5-22 Demographics Table

5.7 Vehicles

Selecting **Vehicles** from the **Inventory** menu (Figure 5-23) will display the **Vehicles** table (Figure 5-24), which shows two tabs with information about vehicle count and dollar exposure by Census block. The table can be changed to show daytime or nighttime values using the **Day / Night** drop-down. These values are estimated based primarily on the building occupancies in each Census block.

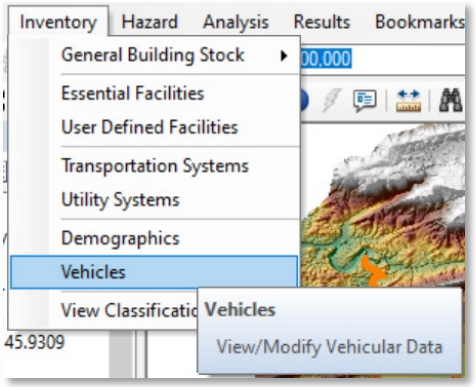
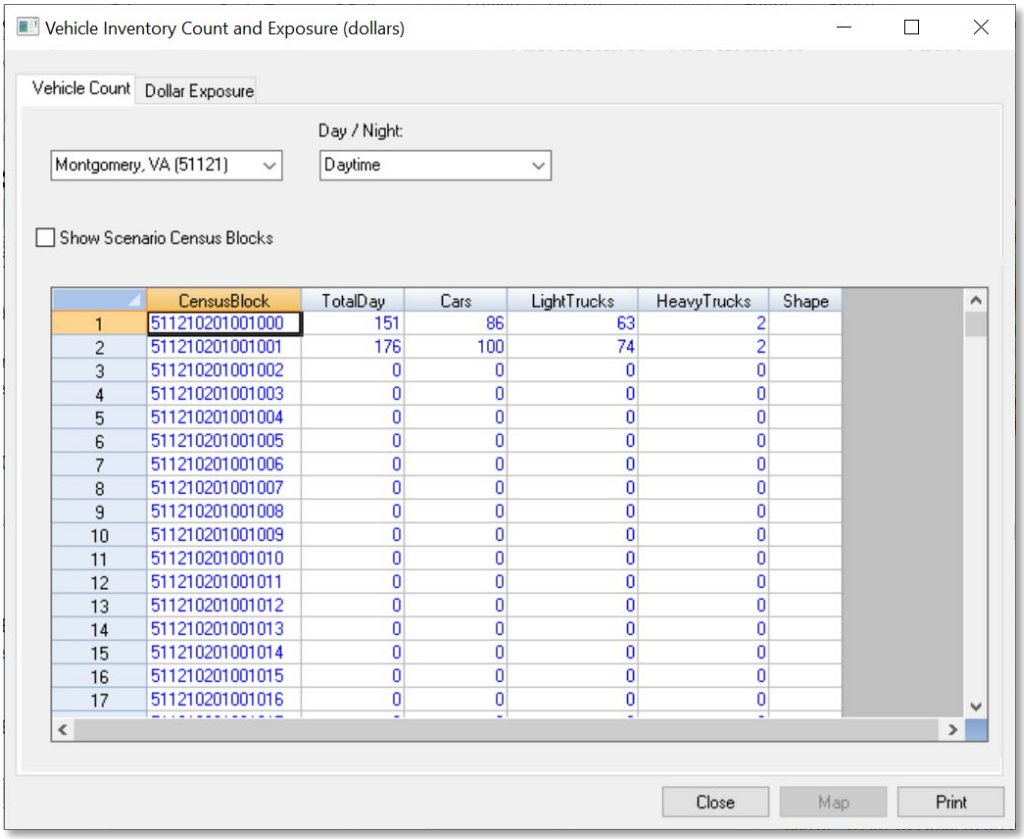


Figure 5-23 Inventory / Vehicles Menu



	CensusBlock	TotalDay	Cars	LightTrucks	HeavyTrucks	Shape
1	511210201001000	151	86	63	2	
2	511210201001001	176	100	74	2	
3	511210201001002	0	0	0	0	
4	511210201001003	0	0	0	0	
5	511210201001004	0	0	0	0	
6	511210201001005	0	0	0	0	
7	511210201001006	0	0	0	0	
8	511210201001007	0	0	0	0	
9	511210201001008	0	0	0	0	
10	511210201001009	0	0	0	0	
11	511210201001010	0	0	0	0	
12	511210201001011	0	0	0	0	
13	511210201001012	0	0	0	0	
14	511210201001013	0	0	0	0	
15	511210201001014	0	0	0	0	
16	511210201001015	0	0	0	0	
17	511210201001016	0	0	0	0	

Figure 5-24 Vehicles (Vehicle Count) Table

5.8 View Classifications

View Classifications (Figure 5-25) allows users to view definitions of the classification categories. The subtypes are **General Building Stock**, **Essential Facilities**, **High Potential Loss Facilities**, **Transportation Systems**, and **Utility Systems**, as shown in Figure 5-25.

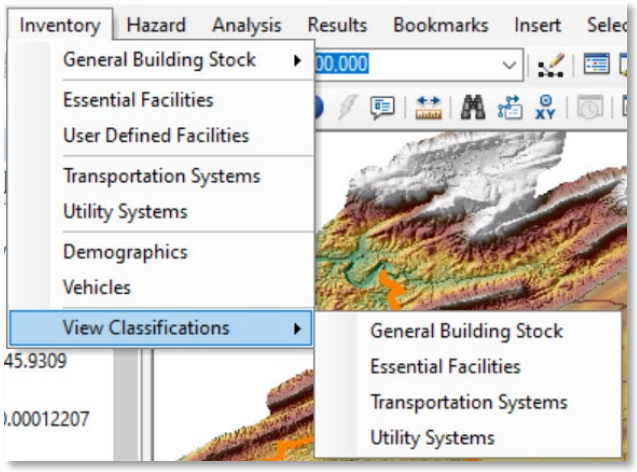
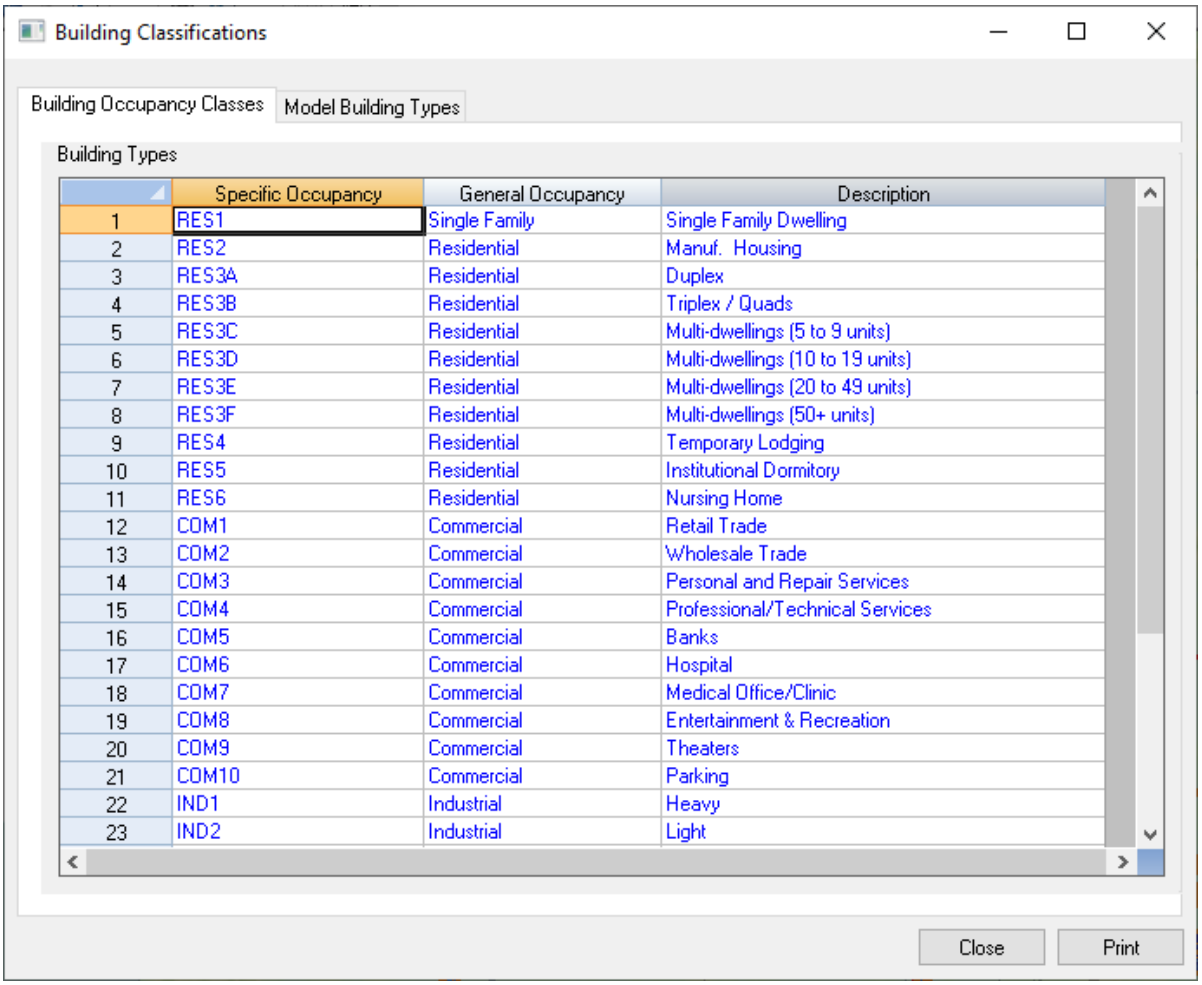


Figure 5-25 Inventory / View Classifications Menu

5.8.1 General Building Stock Classifications

The **Buildings Classifications** table (Figure 5-26) allows the user to view the assumptions used to define values for **Building Occupancy Classes** and **Model Building Types**.



	Specific Occupancy	General Occupancy	Description
1	RES1	Single Family	Single Family Dwelling
2	RES2	Residential	Manuf. Housing
3	RES3A	Residential	Duplex
4	RES3B	Residential	Triplex / Quads
5	RES3C	Residential	Multi-dwellings (5 to 9 units)
6	RES3D	Residential	Multi-dwellings (10 to 19 units)
7	RES3E	Residential	Multi-dwellings (20 to 49 units)
8	RES3F	Residential	Multi-dwellings (50+ units)
9	RES4	Residential	Temporary Lodging
10	RES5	Residential	Institutional Dormitory
11	RES6	Residential	Nursing Home
12	COM1	Commercial	Retail Trade
13	COM2	Commercial	Wholesale Trade
14	COM3	Commercial	Personal and Repair Services
15	COM4	Commercial	Professional/Technical Services
16	COM5	Commercial	Banks
17	COM6	Commercial	Hospital
18	COM7	Commercial	Medical Office/Clinic
19	COM8	Commercial	Entertainment & Recreation
20	COM9	Commercial	Theaters
21	COM10	Commercial	Parking
22	IND1	Industrial	Heavy
23	IND2	Industrial	Light

Figure 5-26 Buildings Classifications Table

5.8.2 Essential Facilities Classification

The **Essential Facilities Classifications** table (Figure 5-27) allows the user to view the assumptions used to define values for **Medical Care Facilities**, **Emergency Centers**, and **Schools**.

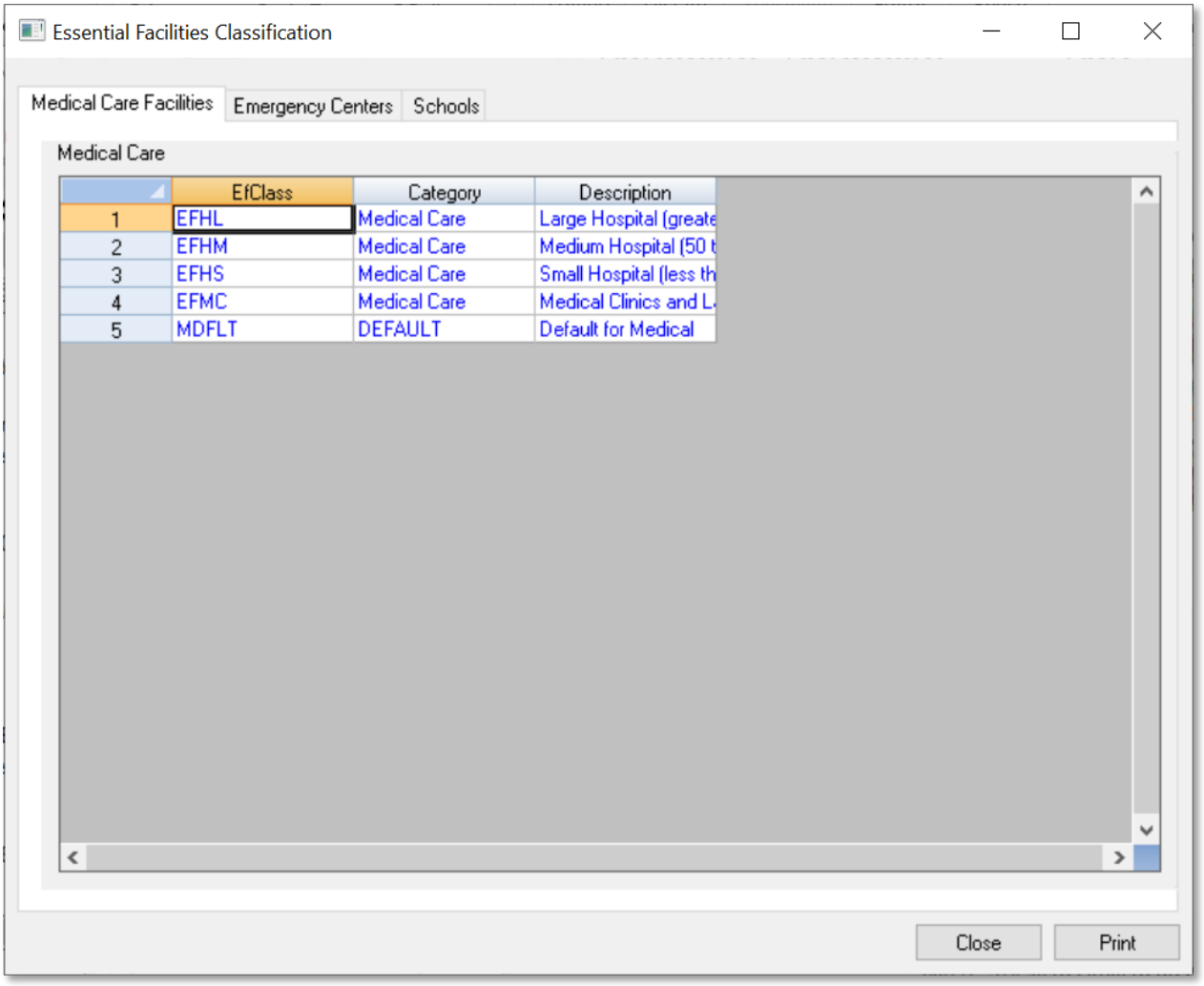


Figure 5-27 Essential Facilities Classification Table

5.8.3 Transportation Systems Classification

The **Transportation Systems Classification** table (Figure 5-28) allows the user to view the assumptions used to define values for **Highway**, **Railway**, **Light Rail**, **Bus**, **Port**, **Ferry**, and **Airport**.

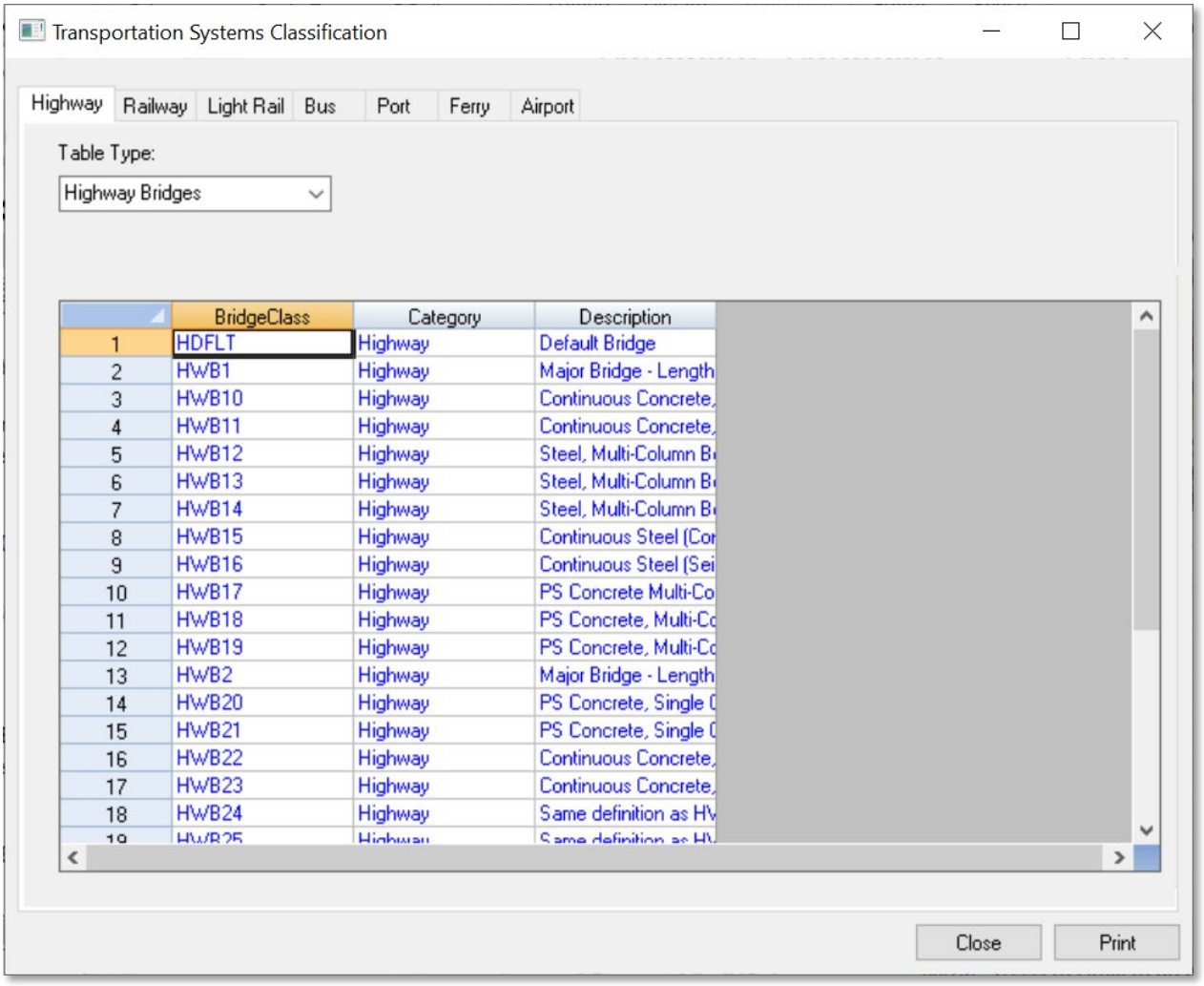


Figure 5-28 Transportation Systems Classification Table

5.8.4 Utility Classifications

The **Utility Classifications** table (Figure 5-29) allows the user to view the assumptions used to define values for **Potable Water**, **Wastewater**, **Oil**, **Natural Gas**, **Electric Power**, and **Communications.**

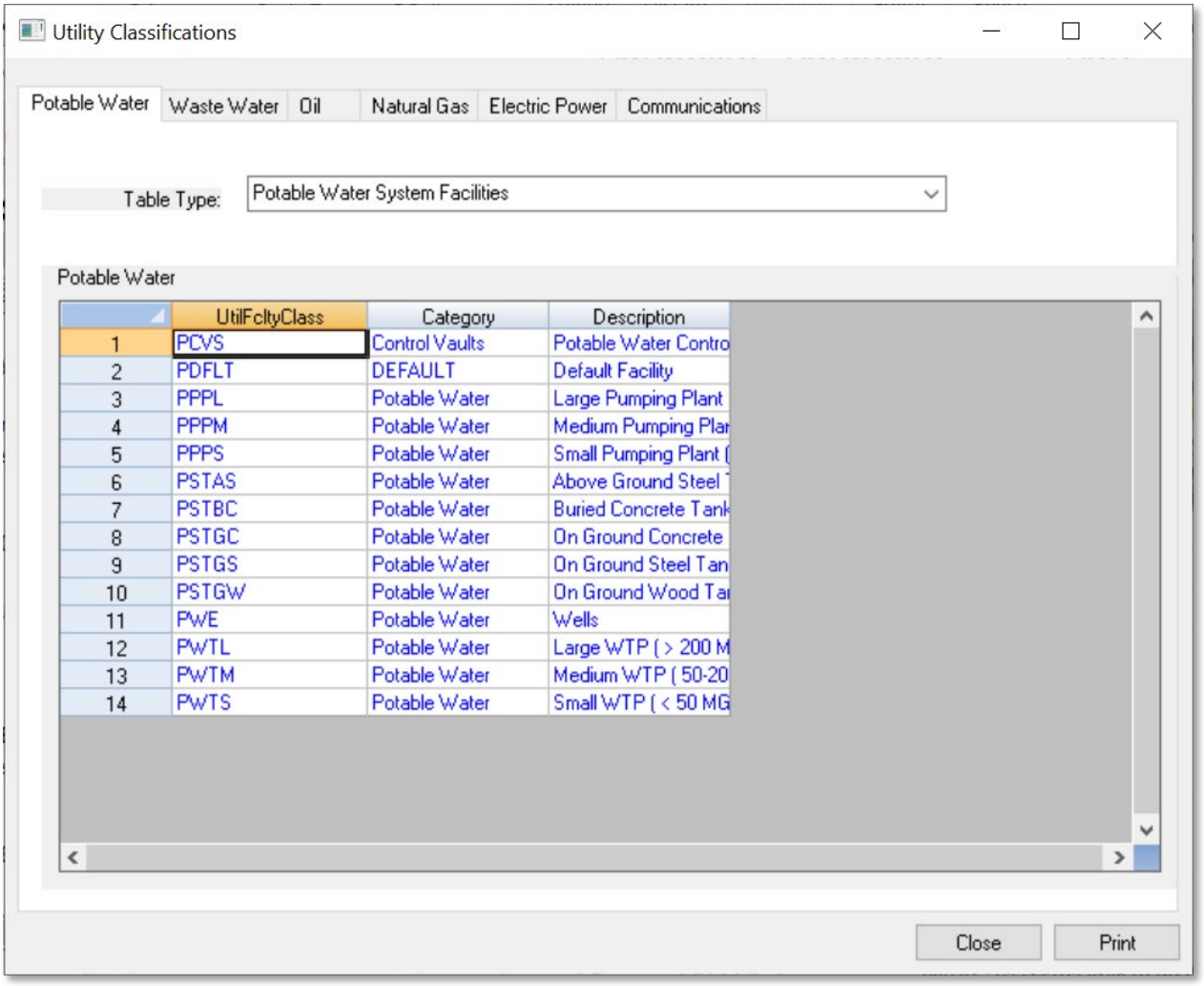


Figure 5-29 Utility Classifications Table

Section 6. Model Menu: Hazard

The **Hazard** menu (Figure 6-1) within Hazus has several analysis types from which to choose. These options enable the user to select the appropriate analysis to perform on the Study Region. This section explains the selections and the inputs required for each.

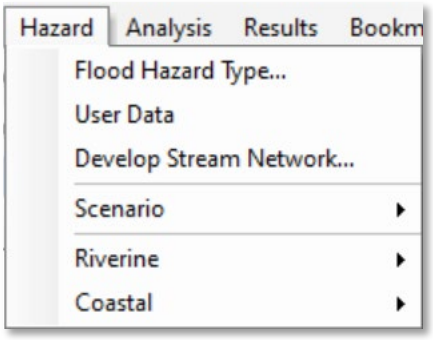


Figure 6-1 Hazard Menu

6.1 Flood Hazard Type

The riverine and coastal hazards have different requirements for developing the hazard and the digital elevation data required to support the analysis.

The first option on the **Hazard** menu (Figure 6-2) is **Flood Hazard Type**. Selecting this option activates the **Flood Hazard Type** dialog shown in Figure 6-3. In this dialog, the user selects the Study Region's flood hazard type for analysis. The **Storm surge** option is only enabled if the user is conducting a combined Hurricane and Flood hazard analysis and previously ran the Hurricane model.

The **Flood Hazard Type** selection on the **Hazard** menu (Figure 6-2) prevents users from having to supply unnecessary digital terrain data for the selected hazard type and enables only those menu items that are needed to support the hazard.

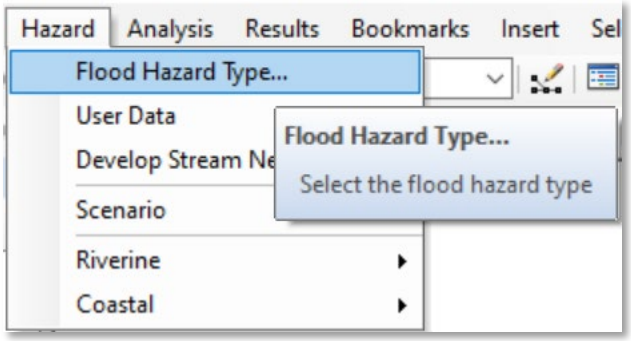


Figure 6-2 Select Flood Hazard Type

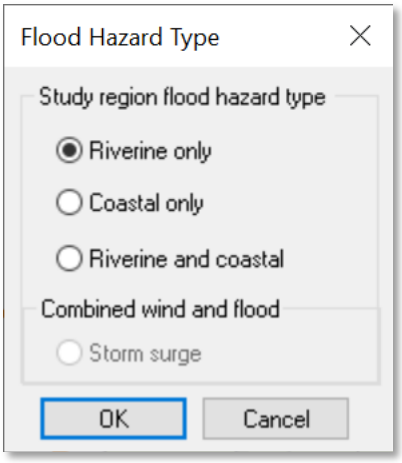


Figure 6-3 Flood Hazard Type Dialog

Users should think carefully about which hazard type (or both) they are interested in analyzing, as the selection will drive the entire hazard assessment. Changing the **Flood Hazard Type** selection will change the DEM requirements and prevent the user from accessing some of the menu items not applicable for that flood hazard type. For example, selection of the **Riverine only** button will require a DEM that covers both the Study Region and all the watersheds that intersect that Study Region and will require the user to develop a stream network, creating a Scenario (described later in this section). A coastal analysis does not require a stream network or hydrologic analysis but does require a DEM for the coastal area of the Study Region.

6.2 User Data

The **User Data** selection from the **Hazard** menu (Figure 6-4) activates the window shown in Figure 6-5. Here, the user can select the appropriate tab to import the relevant data for the analysis. The **User Data** window offers four data import options: **DEM**, **Depth Grid**, and **HEC-RAS**. This section will provide details on using the DEM import option, while Section 12 provides more details on the other two options. Note: the FIT Tool has been deprecated as of Hazus 5.0, however, users with existing FIT data may still import FIT folders using the FIT tab.

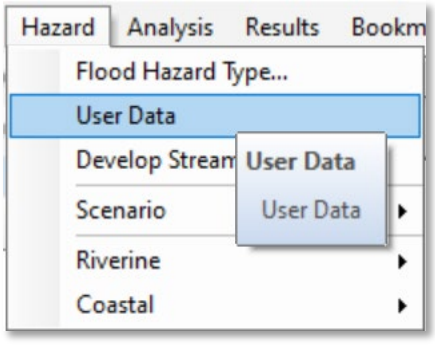


Figure 6-4 Select User Data

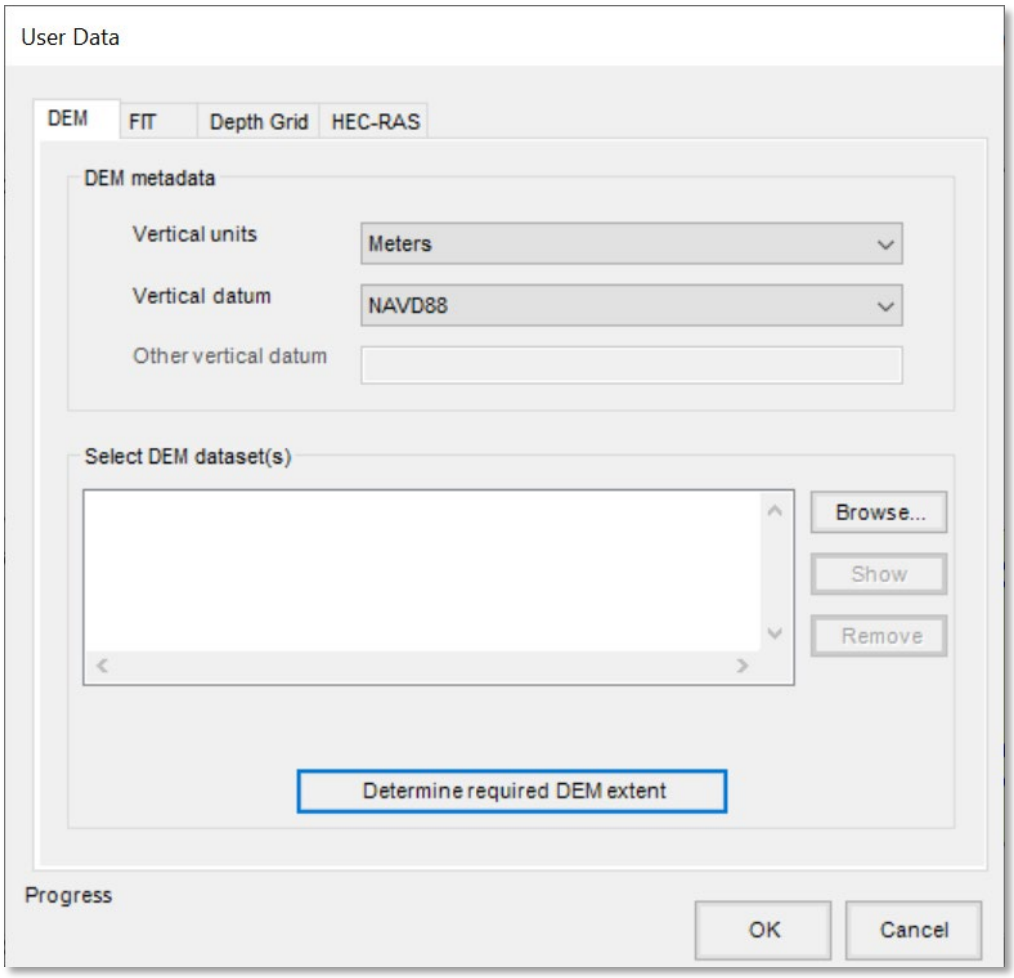


Figure 6-5 User Data Options Window

Click **Determine required DEM extent** shown in Figure 6-5 to have the Flood Model determine the DEM files required for the analysis. The extent will be different for riverine versus coastal flood analysis.

After a short pause, the **DEM Extent** window will appear, as shown in Figure 6-6. This window lists the required latitude and longitude coordinates that are needed to download the U.S. Geological Survey (USGS) DEM data. The latitude and longitude shown may extend beyond the defined boundaries of the Study Region because the watersheds that affect the region's flood risk probably extend outside the political boundaries.

Note that any DEM imported into the Flood Model must meet the bounding coordinate constraints established by this dialog. The Model will discontinue processing if it identifies gaps in the data coverage.

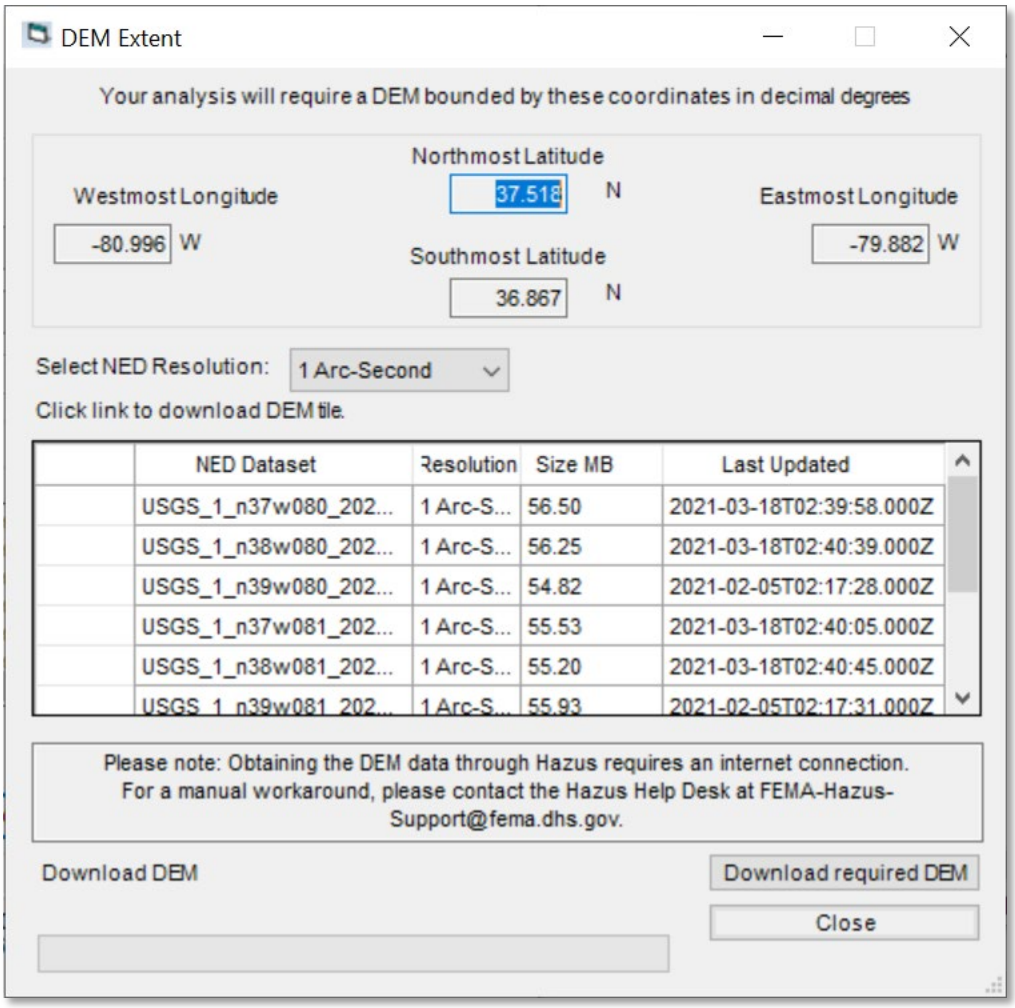


Figure 6-6 DEM Extent Window

Use the **Select NED Resolution** drop-down menu to choose the desired resolution. The default is 1 Arc-Second (~30 meters). Not all Study Regions will have available USGS DEM data for resolutions other than 1 Arc-Second. For example, choosing 1/3rd Arc-Second for a Study Region in Montgomery County, VA, will refresh the table and warn the user, "Problem downloading DEM"

6.2.1 Automated DEM Download

Click **Download required DEM** in the **DEM Extent** window shown in Figure 6-6 for Hazus to obtain all the required DEM files and save them within the Hazus Study Region folder.

Hazus will take several minutes to download all of the DEM files. When the process has completed, a notification window will appear (Figure 6-7) to indicate the files have been downloaded and saved. Click **OK**.

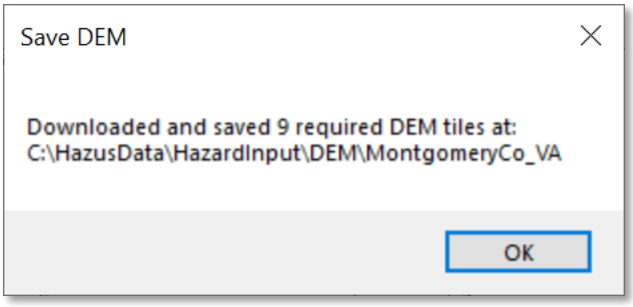


Figure 6-7 DEM Downloaded, Unzipped, and Saved

A popup window (Figure 6-8) will ask the user whether to automatically load the DEM data into the **User Data** window. Click **Yes**.

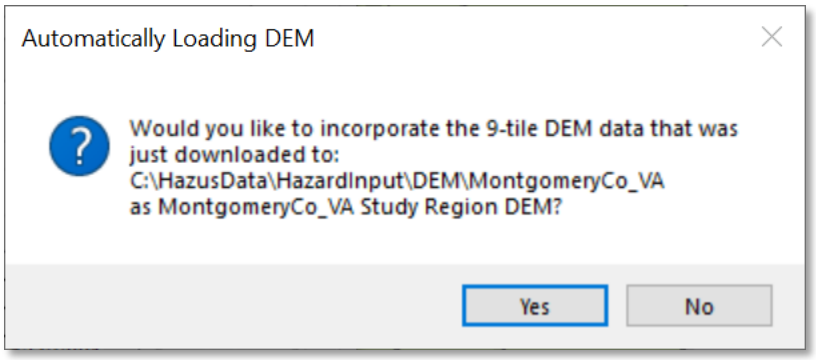


Figure 6-8 Automatically Load DEM

Hazus will load the file paths for all of the DEM files into the **User Data** window (Figure 6-9).

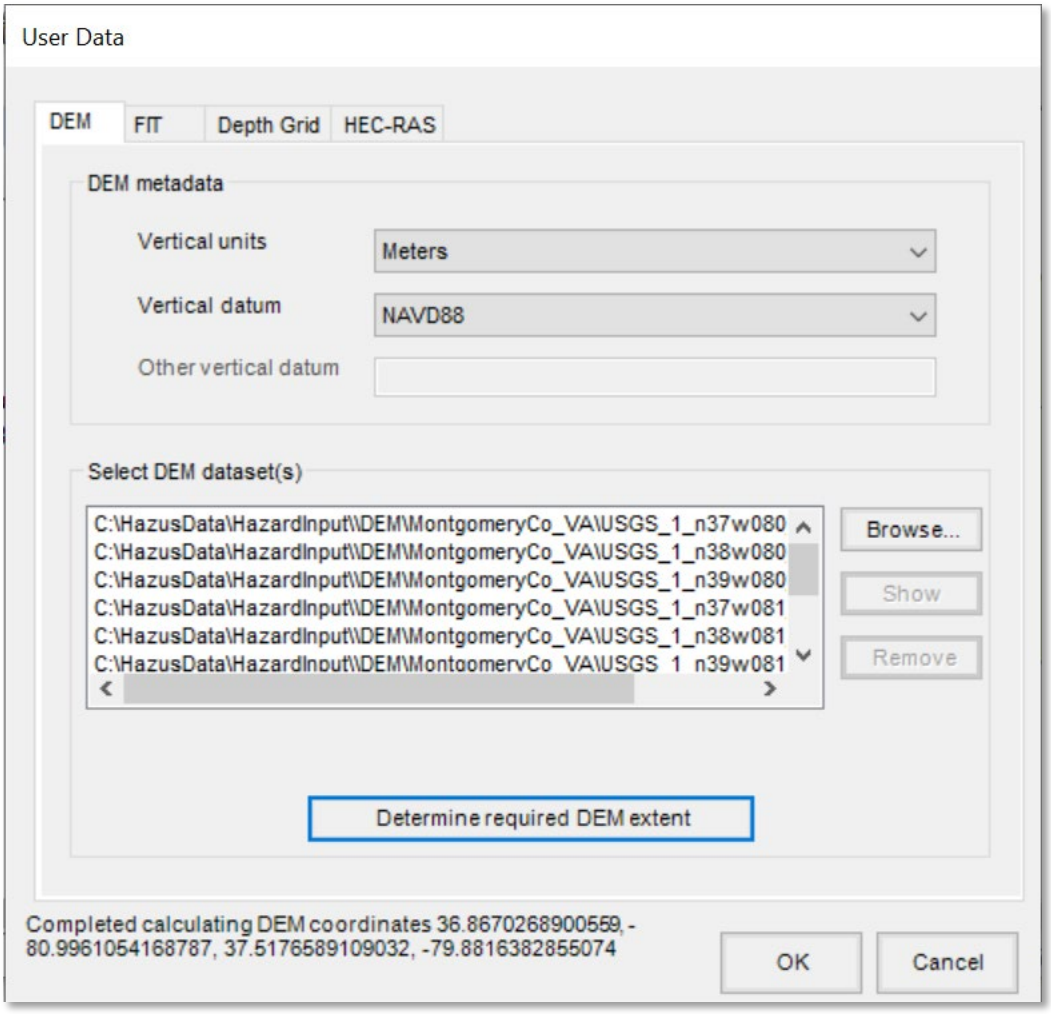


Figure 6-9 Import DEM Files into Hazus

Click **OK** to complete importing the DEM files. Click **Yes** (not shown) on the next popup window to proceed with DEM analysis.

A progress bar (Figure 6-10) will appear as Hazus imports and merges all the individual files into a single DEM for the Study Region. This may take several minutes depending on the size of the Study Region. A notification (Figure 6-11) will appear once the DEM import is completed. Click **OK**.

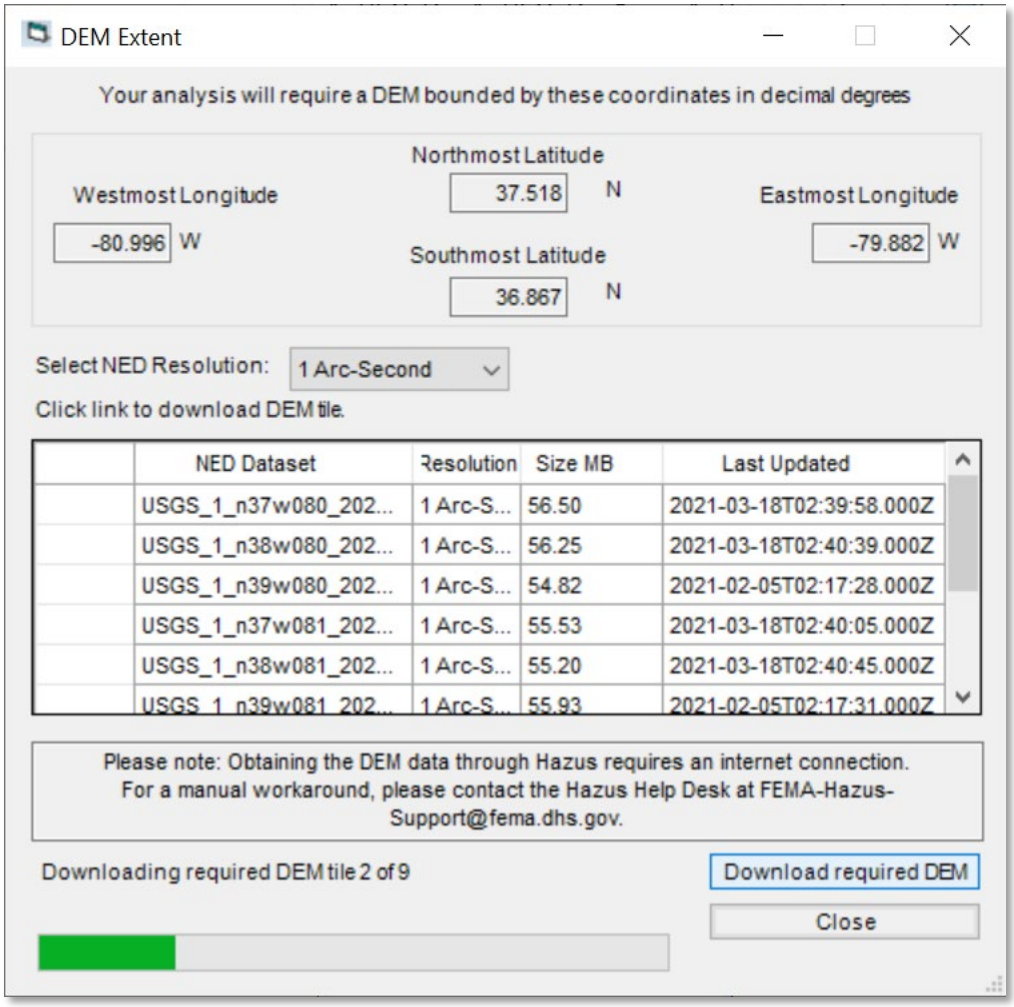


Figure 6-10 DEM Import Progress

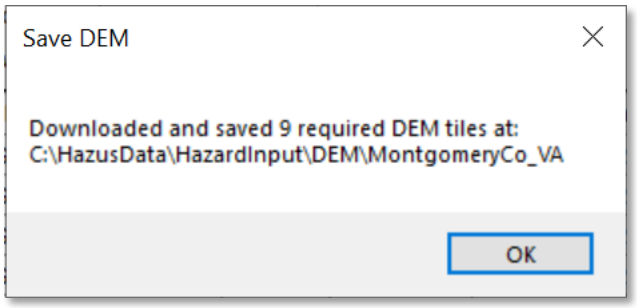


Figure 6-11 DEM Import Completed

6.3 Develop Stream Network

If the Study Region is subject to riverine flood hazard, the next step is to generate a stream network. This is not required if the user is only running scenarios with the recommended user-supplied flood hazard data (depth grids or HEC-RAS floating-point binary [.FLT] grids). Generating a stream network is a one-time analysis that establishes the river network identity for all subsequent scenarios.

The **Develop Stream Network** selection on the **Hazus** menu (Figure 6-19) activates the **Develop Stream Network** dialog shown in Figure 6-20. Enter the number of square miles that define the stream drainage area for the Study Region.

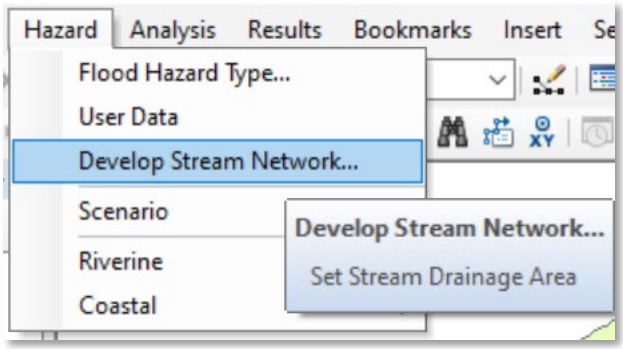


Figure 6-12 Select Develop Stream Network

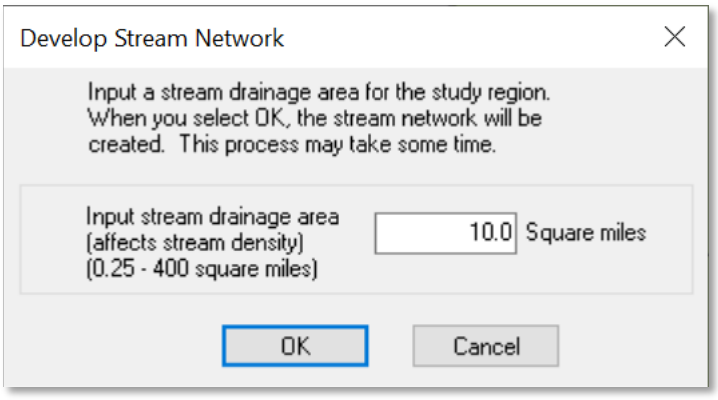


Figure 6-13 Develop Stream Network Dialog

The model will process the DEM for the Study Region to determine the locations of streams. This analysis will take some time, ranging from 5 minutes to several hours, depending on the computer's processing speed, the size of the Study Region, and the complexity of the DEM. When the process is complete, the identified streams will appear on the Study Region, like Figure 6-21.

- Selecting a small number of square miles, such as 1, for the drainage area will result in a highly defined stream network. This value represents the total land area, in square miles, that drains into any given reach, excluding that drainage at the starting node of the reach (the downstream node from the prior reach). The smaller the drainage area, the more processing time required by the Flood Model for subsequent analyses.

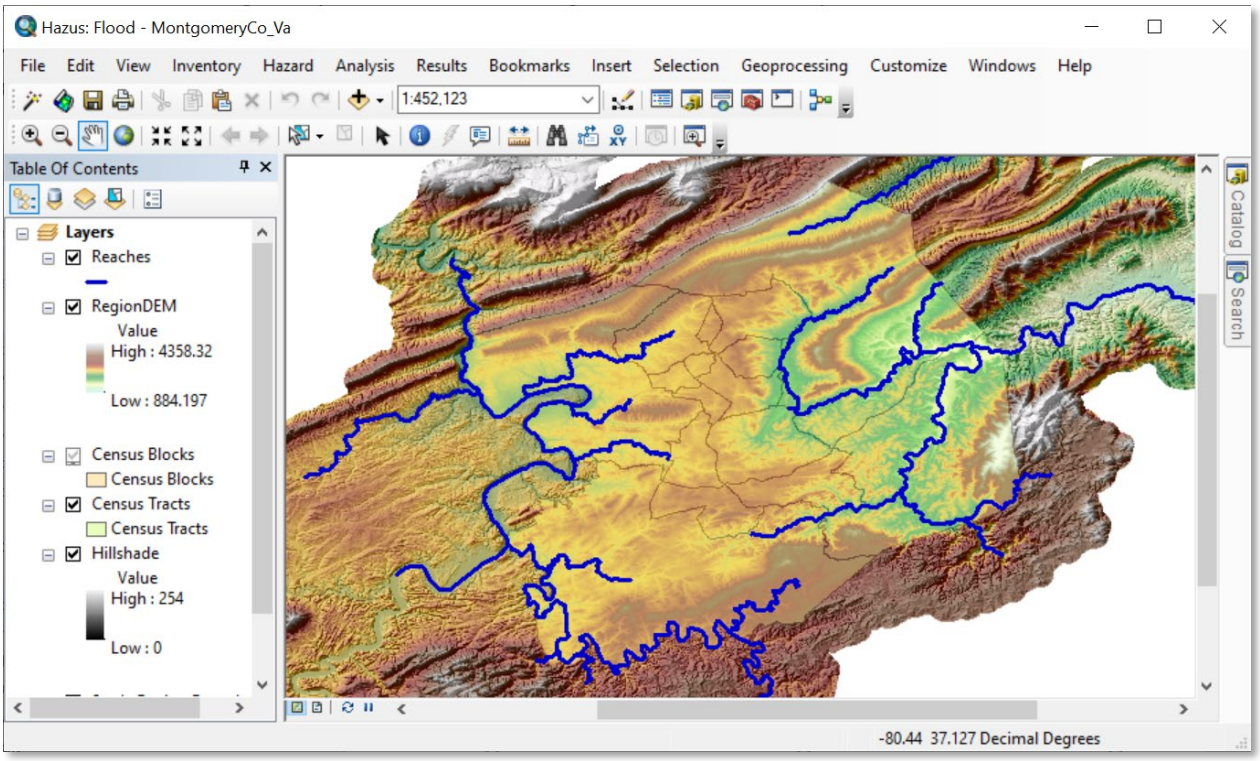


Figure 6-14 Example – Flood Model after Developing Stream Network

- Running the stream network, the first time, is fairly time consuming as the model performs an analysis to fill in spurious sinks in the DEM. However, to save the user time for subsequent runs, the model saves the results of the sink-filling process. As such, if the user decides to change the drainage area number, the model will not require nearly as much time to perform the analysis. For example, if the user runs the stream network at 5 square miles and then decides that the network requires more detail, changing the drainage area to 1 square mile will process significantly faster than the original analysis. Please note that Hazus must still re-calculate and assign the Manning's-n coefficient, associated with stream roughness, to each reach. This process will appear to the user as "Finalizing Stream Network" and will take additional processing time if the user changes the **drainage area** value.

If a river in the analysis forms a border between two counties, including both counties on either side of the river in the Study Region is recommended. The stream network in Hazus is known as a synthetic network because it is derived entirely from the DEM. No imagery or pre-existing map layers are used in its generation. More specifically, streams in a synthetic network exist at DEM grid cell

locations that receive drainage from a threshold number of upstream grid cells. If the DEM is not large enough, the threshold number of grid cells may not be reached.

Figure 6-22 shows an example of this situation with a discontinuous synthetic stream. The Study Region consists of one county, for which the one river (displayed in red) forms a border. Because the DEM does not include areas draining to both sides of the river, the resulting synthetic stream is discontinuous. There are simply not enough DEM grid cells draining to the discontinuous portions to properly delineate them.

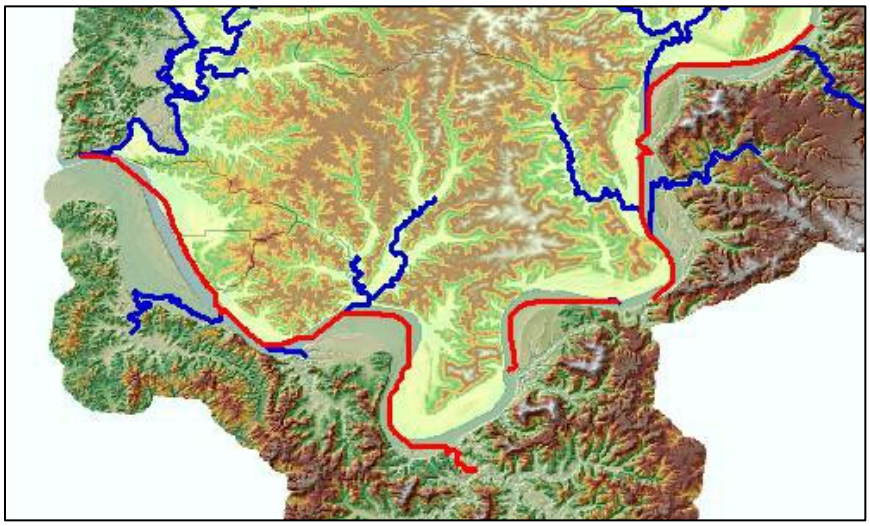


Figure 6-15 Example Discontinuous Synthetic Stream

The solution to this discontinuity problem is to include counties on both sides of the river during Study Region creation. Including both counties will result in a larger DEM that drains to both sides of the river. Figure 6-23 illustrates this concept using the same stream as shown in Figure 6-22. The second Study Region consists of counties on either side of the river (shown in red) and the resulting synthetic stream network is now continuous.

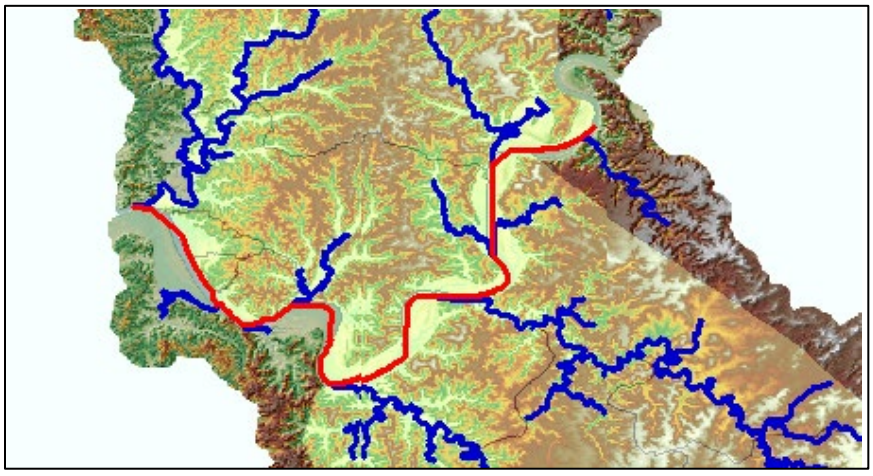


Figure 6-16 Example Continuous Synthetic Stream

6.4 Scenario

A scenario defines the specific stream reaches, or lengths of coastline for coastal users, and the hydrologic and hydraulic characteristics to be included in one analysis run. A scenario could include all stream reaches in the Study Region, and/or the coastline in a coastal Study Region. However, because the analysis requires significant computer processing, dividing the region into several smaller scenarios may be preferable. Figure 6-24 shows the **Hazard** > **Scenario** menu with only the **New** selection active prior to defining the first scenario for a Study Region. Figure 6-25 shows the **Hazard > Scenario** menu with all selections active after the initial scenario has been defined.

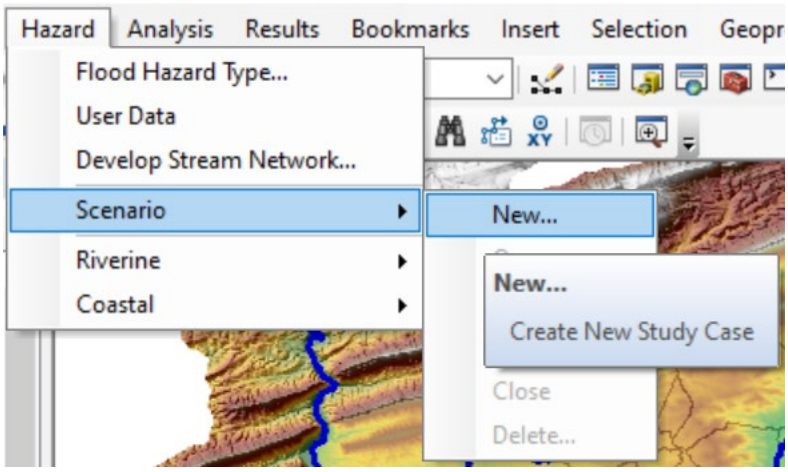


Figure 6-17 Select New Scenario (Prior to Defining First Scenario)

6.4.1 New

Under the **Scenario** menu option, select **New,** as shown in Figure 6-25, to create a new scenario. The process of defining a new scenario for riverine, coastal, and combined analyses each require different steps. These steps are detailed in the next sections.

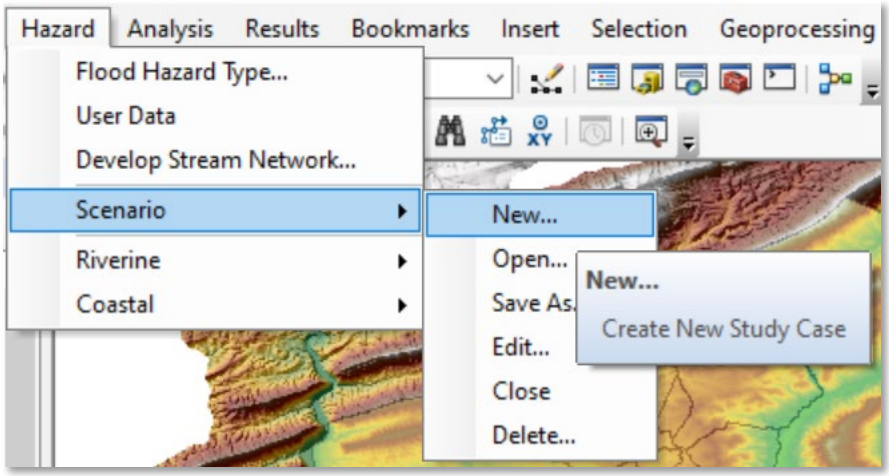


Figure 6-18 Select New Scenario (After Defining First Scenario)

6.4.1.1 Riverine Scenario

The **Create New Scenario** window, shown in Figure 6-26, will appear. Enter a name for the scenario and an optional description. Be careful not to include any leading or trailing spaces. The **Description** will be visible to the user when opening scenarios in the future to help differentiate between similarly named scenarios.

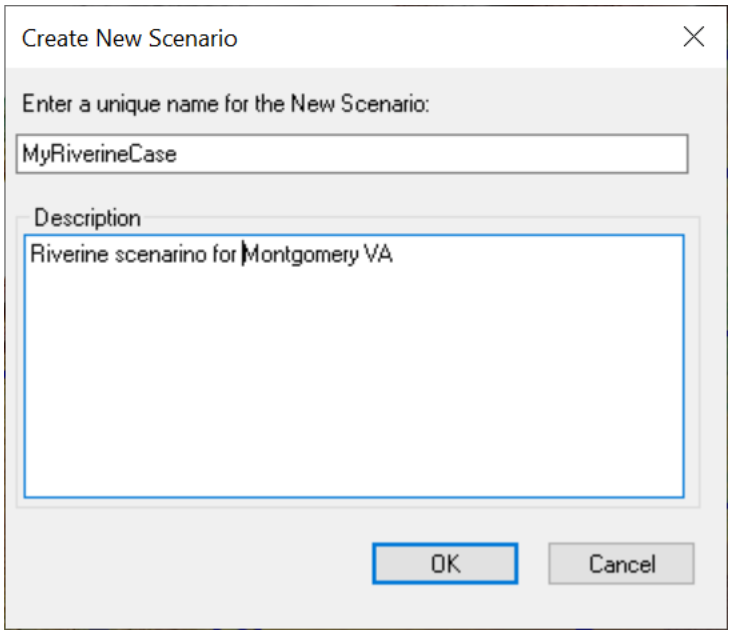


Figure 6-19 Enter a Name for the New Scenario

After naming the scenario, the **New Scenario** window (Figure 6-27) will open, allowing the user to select which stream reaches to include in the scenario. Click the radio button next to the appropriate **Map layer type**. To select features, click the **Add to selection** (**+**) button, then drag the selection box around the features to be selected to add reaches to the scenario and then click **Save selection** (the floppy disk icon). The **Remove from selection** (**−**) button removes reaches from the selected reaches. Similarly, the **Clear selection** (**✕**) button clears all reaches from the selection.

The selected features will be highlighted in a light blue color, as shown in Figure 6-28. After saving the selected stream reaches, click **OK** to complete the definition of the scenario. The color of the selected reaches changes from light blue to red when this process is complete.

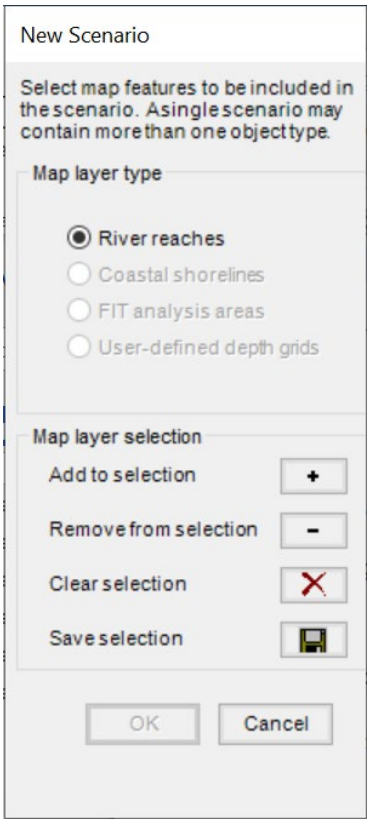


Figure 6-20 Select Map Features

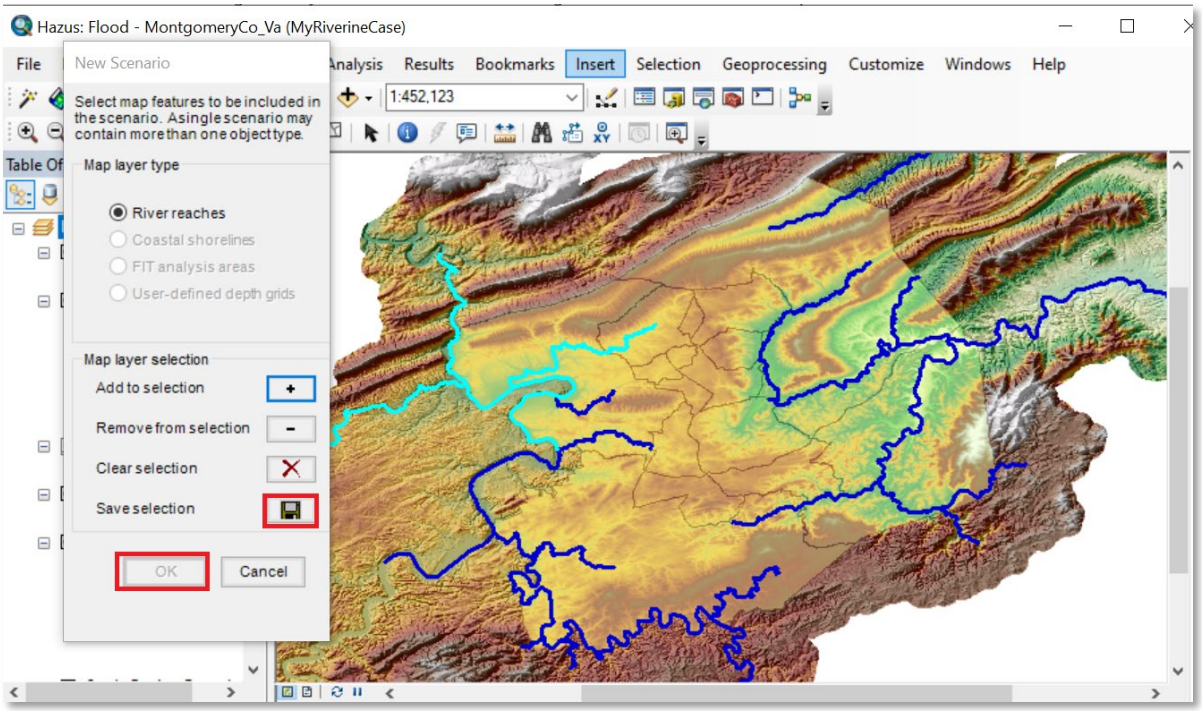


Figure 6-21 Select River Reaches for a Scenario

- After selecting the features in the map layer, users must click **Save selection** for each specific map layer type. For example, if a user wants to create a scenario with river reaches and coastal shorelines, the user must: 1. Select the **River reaches** radio button, click the **Add to selection** button, select reach(es), click the **Save selection** button. 2. Select the **Coastal shorelines** radio button, click the **Add to selection** button, select shoreline(s), click the **Save selection** button. Click **OK**.

If the user has imported any flood depth grid(s), those areas can be selected by clicking on the **User-defined depth grids** radio buttons. Note, Hazus provides an option to import data from the Hazus FIT tool, however FIT is no longer supported. Select and save FIT areas and/or flood depth grids in the same manner as the reach selection if necessary, however it is considered a best practice to use user-supplied depth grids.

If more than one flood depth grid is selected for the scenario, the dialog will expand to show the list of selected flood depth grids selections, as shown in Figure 6-29. Users can select one or more depth grids for the scenario.

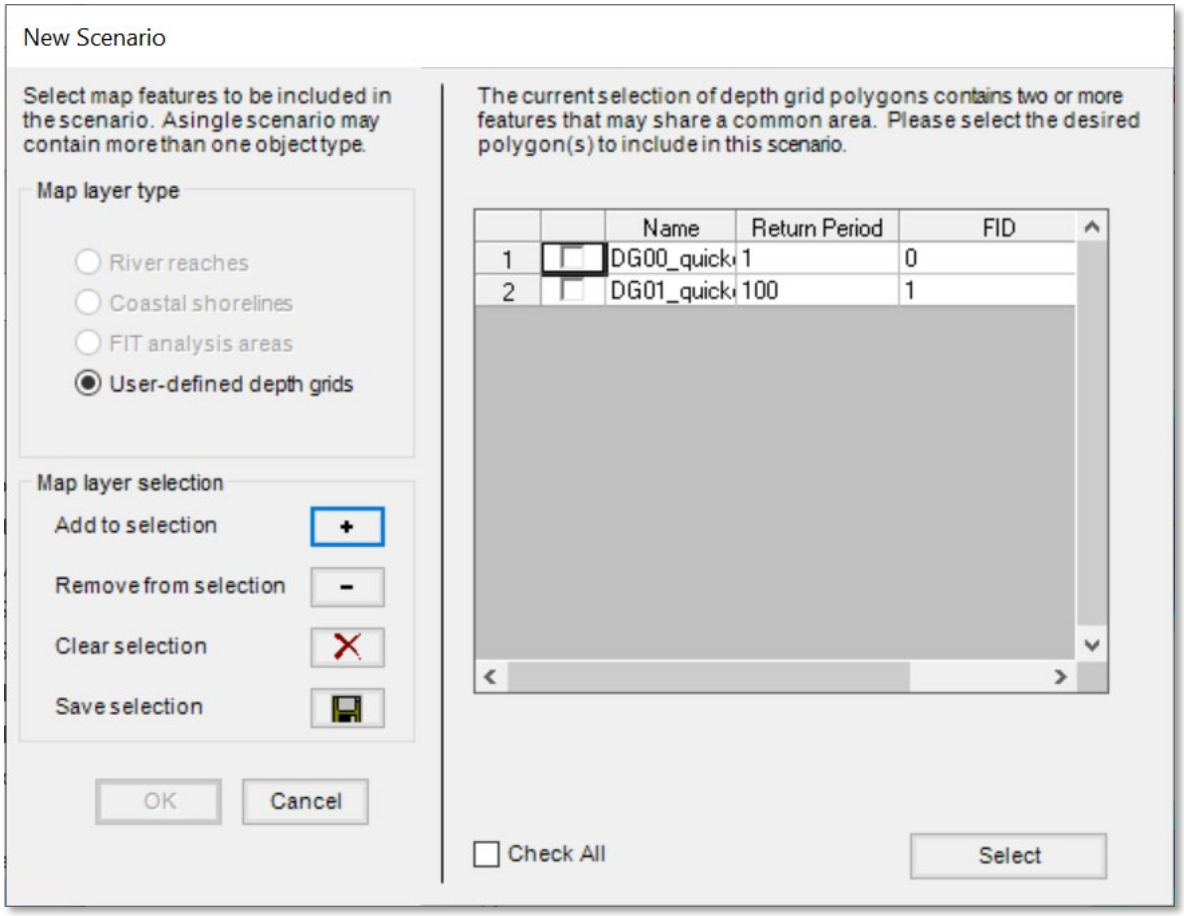


Figure 6-22 Select User-Defined Depth Grids for a Scenario

6.4.1.2 Coastal Scenario

The coastal analysis does not require the user to generate a stream network or run the hydrologic analysis. However, the user will still be required to obtain and identify the DEM to be used in the analysis. The extent of the DEM necessary for the coastal flood hazard is different from that required for the riverine flood hazard. The necessary DEM is determined by the union of the region shoreline with the Study Region boundary.

Once the DEM has been added, the user can move directly to defining a scenario by selecting **New** from the **Hazard > Scenario** menu. The **Create New Scenario** window will appear (Figure 6-30). As with the riverine analysis, enter a name and, if desired, a description for the scenario, and click **OK**. The window shown in Figure 6-31 will appear.

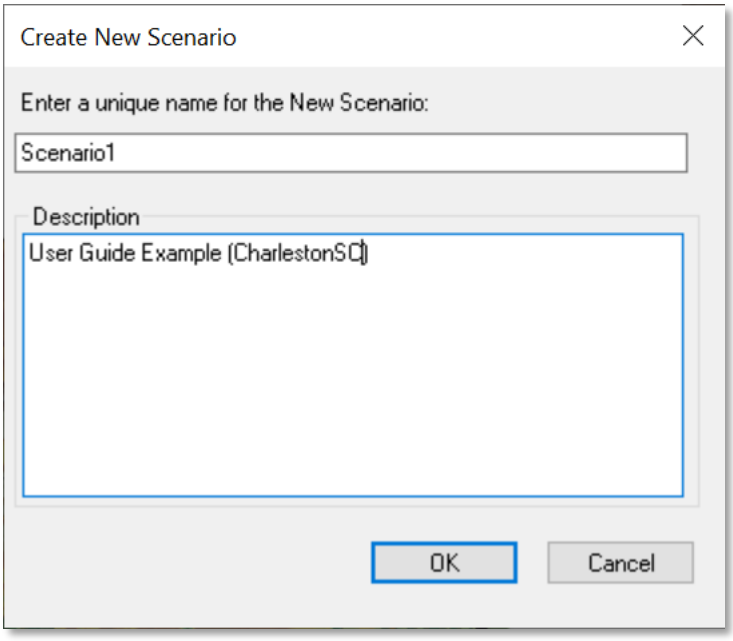


Figure 6-23 Enter a New Scenario (Coastal)

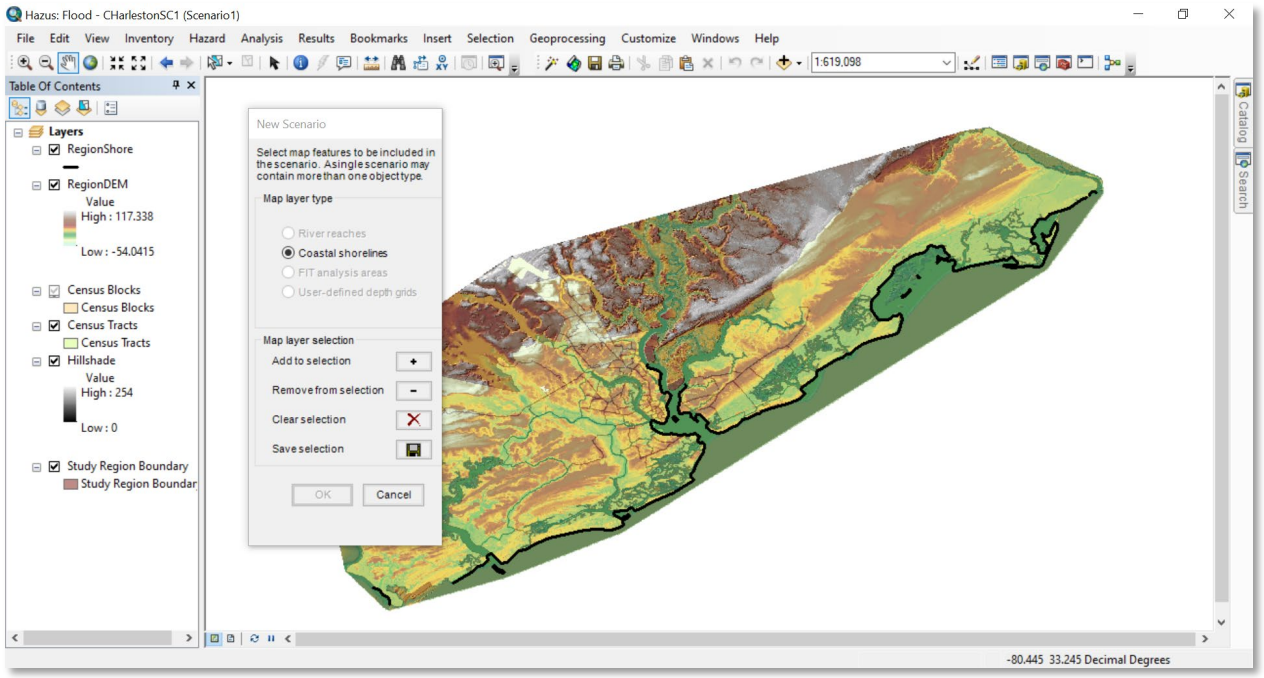


Figure 6-24 Select a Shoreline for a New Coastal Scenario

Like the riverine hazard, the user will be asked to select a shoreline or shorelines for analysis (Figure 6-31). Click the radio button next to the appropriate **Map layer type** (Figure 6-32). The Flood Model uses a standard GIS selection tool to allow the user to select the shorelines. Click the **Add to selection** (**+**) button, then either click on the shoreline or draw a box to select more than one shoreline. Note that although the shoreline is simplified, selecting small island areas off the main coast can produce island transects that interfere with the main coastal segment. They should be analyzed separately or left out of the analysis.

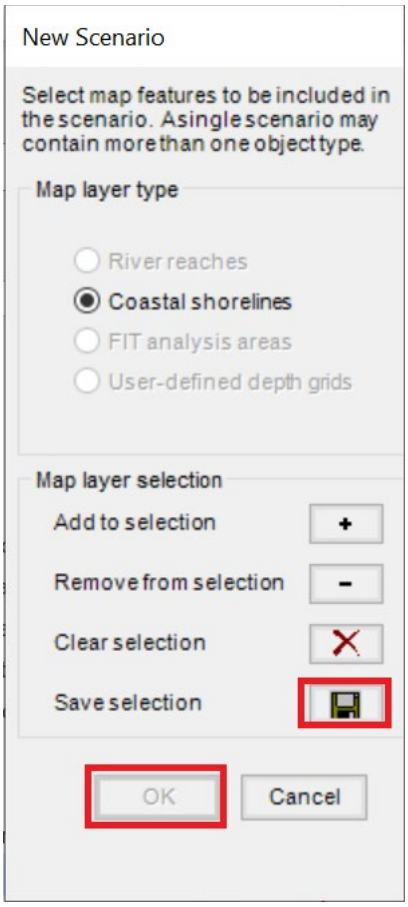


Figure 6-25 Select Shoreline

- To select discontinuous shorelines, such as islands, press the **Shift** key while selecting additional shorelines. To deselect shorelines, press the **Shift** key and click on the shorelines that are not to be included in the selected shorelines.

- Hazus has a built-in default national shoreline that is delineated by county. In Study Regions that are sub-county or a combination of multiple sub-counties, all the associated shorelines of the counties will be brought in. This is by design to account for coastal flooding at specific locations that does not necessarily originate from the closest shorelines to those locations.

- The Flood Model has shorelines for mainland areas, barrier islands, large islands, small islands, and the Great Lakes. These shorelines have been smoothed to allow the Flood Model to build shore normal transects in a less time-consuming fashion.

Once the shorelines have been selected, click the **Save Selection** button (the floppy disk icon); the **OK** button will become enabled (Figure 6-32). Click **OK**. This completes the process of creating the new scenario and selecting shorelines. The next step in the process is to characterize the chosen shorelines.

The **Shoreline Limits** dialog (Figure 6-33) will automatically pop up after shorelines are selected for the scenario to characterize the limits of the shoreline. This dialog begins the process in which the user identifies where they wish to start characterizing the shoreline (**Shoreline Start**) and where they would like to finish the characterization (**Shoreline End**) as shown on the interactive map layer (Figure 6-34). In between these two points, the user will want to add any breaks in the shoreline (**Breaklines**) where the geographic characteristics of the shoreline change. The Flood Model will develop transects at 1,000-foot increments and perform the analysis (e.g., simplified Wave Height Analysis for Flood Insurance Studies [WHAFIS]) only between the **Shoreline Start** and **Shoreline End** lines. If the default locations (at the end of each segment) are moved, the Flood Model will limit the development of transects between these locations.

- The Flood Model will develop transects and perform a simplified WHAFIS and runup analysis between the **Shoreline Start** and **Shoreline End** lines—either the default locations or those generated by the user. The Flood Model will still develop a stillwater elevation (SWEL) surface over the entire Study Region to ensure that flooding through other low-lying areas is properly accounted for.

The **Shoreline Limits** dialog allows the user to perform the segmentation of the shoreline if necessary (Figure 6-33). Figure 6-34 shows the interactive map layer.

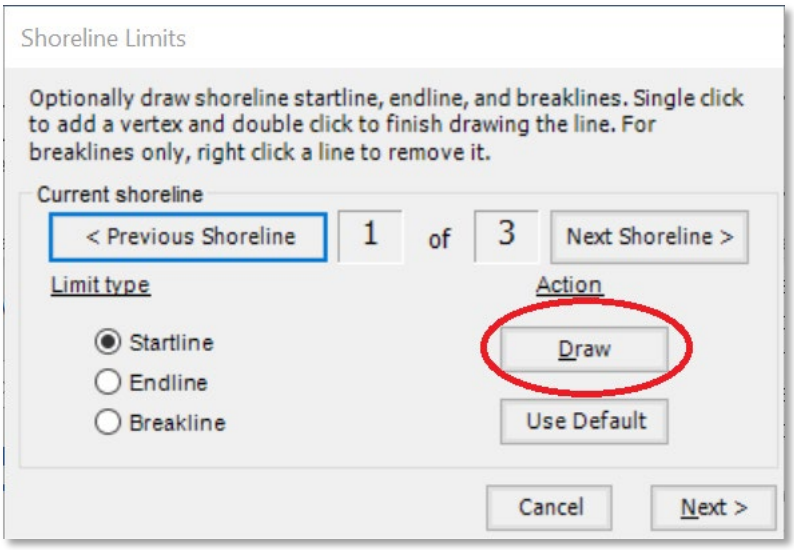


Figure 6-26 Input Shoreline Limits

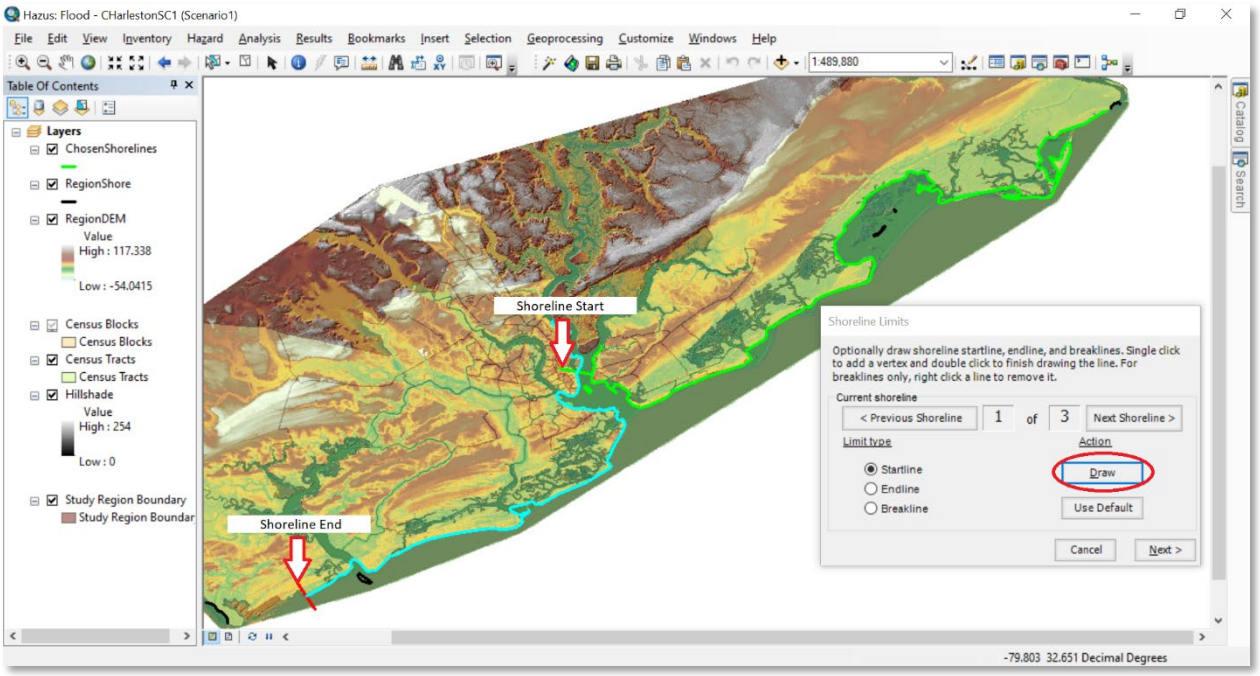


Figure 6-27 Example – Setting Shoreline Limits

The user can leave the shoreline start and end as shown in Figure 6-34 or change the limit(s) (**Startline** or **Endline**) and click the **Draw** button (circled) to draw a new line on the map. The model will remove the default line and replace it with the newly drawn line. For example, Figure 6-35 shows what the user might see upon changing the **Shoreline Start** point (**Startline**).

- The user must be sure to draw the line so that it crosses the shoreline only once. This could be from inland into the flood source or from the flood source inland. The Flood Model will automatically make the line shore normal or perpendicular to the shoreline.

- Hazus allows users to zoom in or out of the map before clicking on the **Draw** button. After clicking the **Draw** button, the tool is set to the Line tool, and the customization becomes locked; therefore, users will not be able to select any other tool until the **Startline**, **Endline**, and **Breakline**(s) are drawn.

- The user can move the **Startline** if the initial effort is not in the right location by merely reselecting the **Draw** button and drawing the **Startline** in another location. Similarly, if the user decides not to change the **Startline** after having drawn one, the user can click on the **Use Default** button and restore the **Startline** to its default location.

- Clicking on the **Use Default** button (see Figure 6-35) will only restore the active **Limit type**, such as the **Startline** or the **Endline**. To restore both the **Startline** and the **Endline**, the user needs to select the appropriate radio button and click on the **Use Default** button for each line.

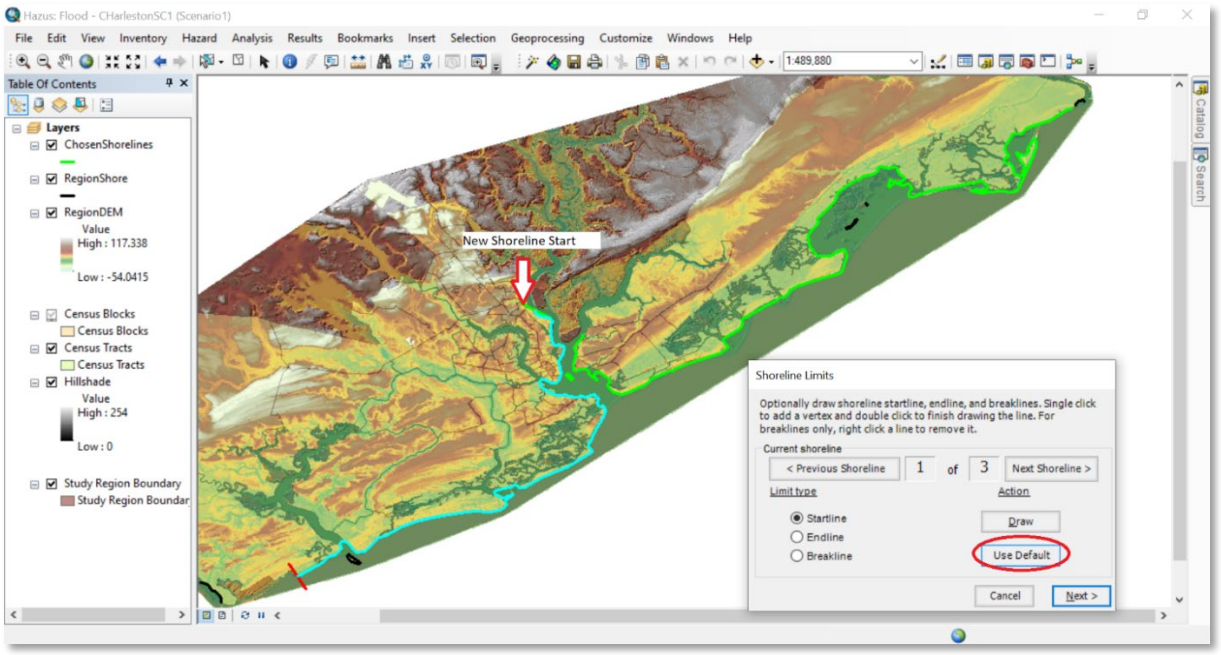


Figure 6-28 Example – Resetting the Shoreline Startline

Figure 6-36 shows an example of a changed **Shoreline End** (**Endline**). Like the **Startline**, the user can change the location of the **Endline** by clicking on the **Draw** button and drawing a new line. To restore the **Endline** to its default location, click on the **Use Default** button with the **Endline** radio button enabled.

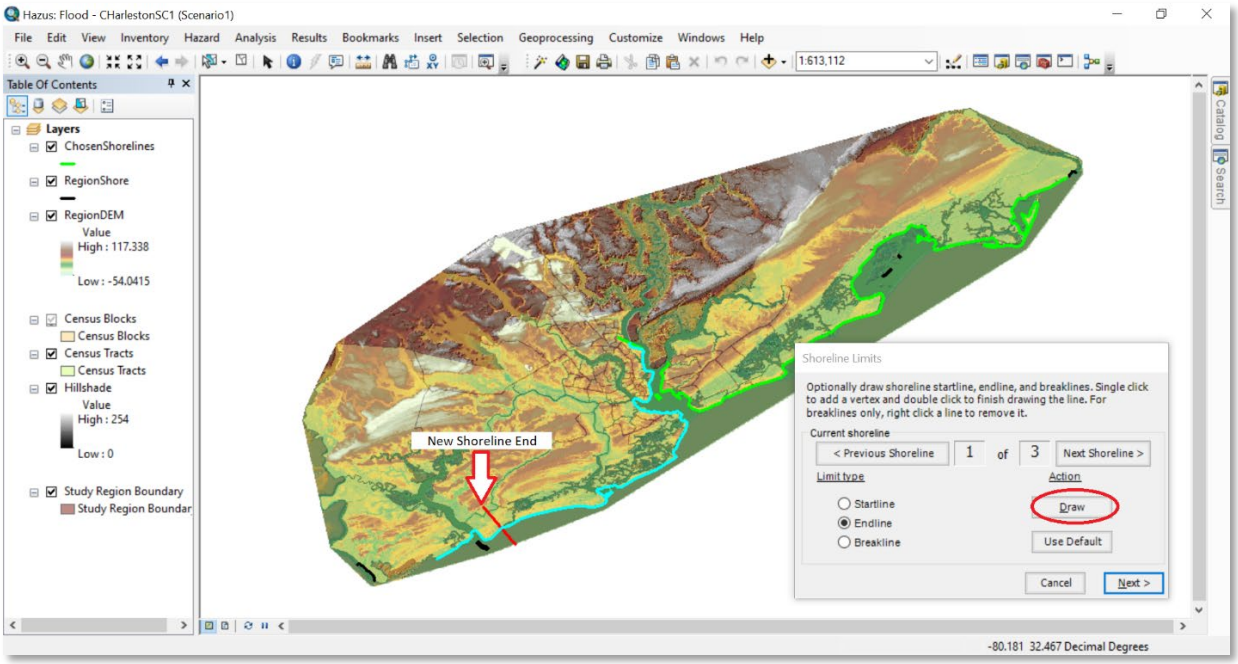


Figure 6-29 Example – Resetting the Shoreline Endline

As stated previously, if the Study Region geography changes along the shoreline, the user will want to segment the shoreline and classify the shoreline into the proper geophysical properties. Consult a Flood Insurance Study (FIS), identify the areas along the shoreline where the SWEL changes, and create a **Breakline** at these points. Select the **Breakline** radio button and click **Draw**. As with the **Startline** and the **Endline** drawing, draw a line crossing the shoreline only once, as circled in Figure 6-37.

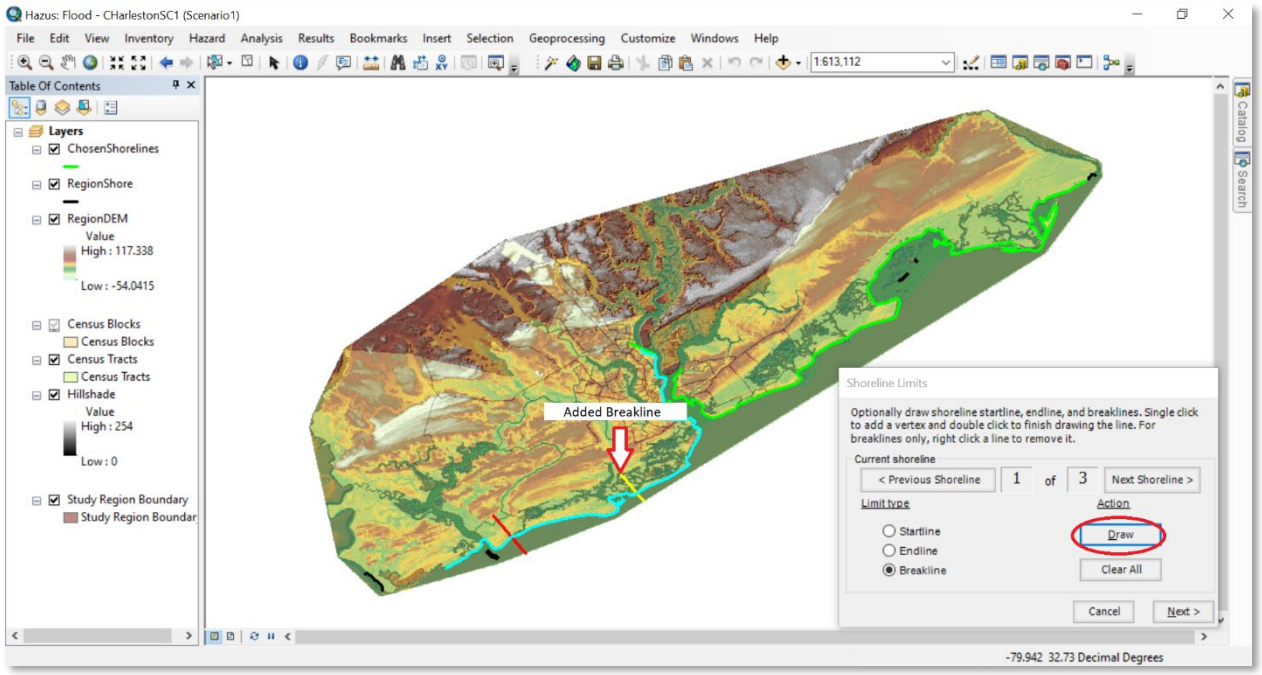


Figure 6-30 Example – Adding a Breakline to the Selected Shoreline

- The user cannot change or move a **Breakline** once it has been drawn; to remove the line, clear the **Breakline** using the **Clear All** button and redraw the **Breakline** in the new location.

After all breaklines have been drawn, click **Next** to open the **Shoreline Characteristics** window shown in Figure 6-38. The information for this window can be obtained from a FEMA FIS. Check the FEMA website for information on obtaining an effective FIS for the Study Region.

Input the SWEL in the **Elevation** field shown in the **Shoreline Characteristics** window (Figure 6-38). This field and the **Vertical Datum** field are required and will be shown in red text. The Hazus default vertical datum is NGVD29, however, users should be aware that NAVD88 is more commonly associated with the SWEL for recent FEMA studies. The other SWEL fields are loaded with default parameters calculated using the standard FEMA ratios but can be edited and overwritten by the user if the data are available from the FIS.

- The user should review the FIS carefully to determine whether the 100-year SWEL includes wave setup. If it does, the user should put in the 100-year SWEL as noted in the FIS but must also

check the **Yes** radio button under the **Elevation includes wave setup?** question. Doing this will enable the **Wave Setup (ft)** field. The user should enter the wave setup value here. If the user cannot identify whether wave setup is included, quickly graph the SWELs listed in the FIS and check whether the 100-year SWEL is higher than expected by the graph. If so, it most likely includes wave setup.

- Users should select a wave exposure for each segment corresponding to its fetch under 100-year flood conditions, not under normal conditions. For example, a mainland shoreline segment, landward of a low-lying island, may have a short fetch under normal conditions, but the island may be flooded, and the fetch may increase under more severe conditions.

After entering the **Elevation** and **Vertical Datum** for each shoreline segment, click **Finish**.

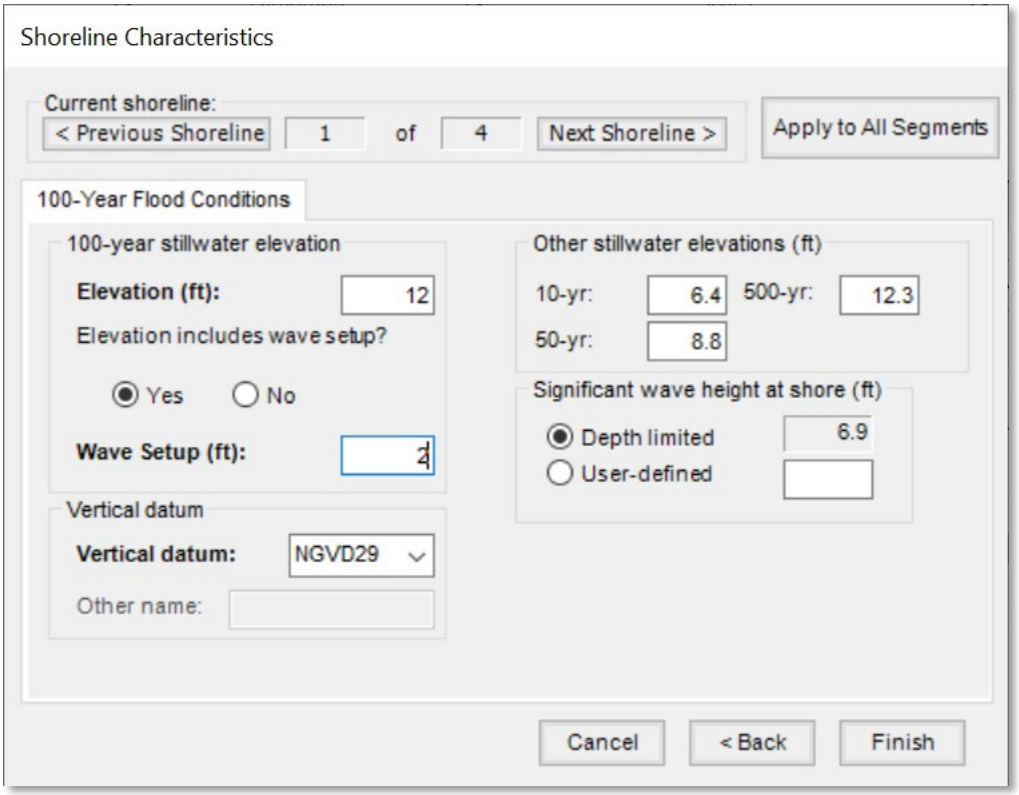


Figure 6-31 Shoreline Characterization – Stillwater Flood Conditions Window

Once the user has completed inputting the required information in the **Shoreline Characteristics** window, the Flood Model has the necessary data to perform a coastal analysis for any given return interval.

6.4.1.3 Combined Riverine and Coastal Scenario

Hazus asks the user to select between three flood hazard types in the **Flood Hazard Type** dialog (Figure 6-3) to limit the DEM requirements: **Riverine Only**, **Coastal Only**, or **Riverine and Coastal**. Selecting **Riverine and Coastal** will require the user to acquire a DEM that supports the analysis for both hazard types. Once the user provides the DEM, they can perform any of the hazard analyses.

For example, if the user selects **Riverine and Coastal**, they are required to build the **Stream Network** with the shorelines already available. While creating a scenario, the user has the option to build a scenario with only river reaches, only shorelines, or a combination of reaches and shorelines. The Flood Model maintains the riverine and the coastal hazard depth grids separately because the depth of flooding alone does not determine which hazard is producing the most damage by occupancy.

Create a riverine and coastal flood hazard analysis within the Study Region. If necessary, first create a new Study Region. Once the Study Region is created, open it, open the **Hazard** drop-down menu, and select **Flood Hazard Type**. Choose the **Riverine and Coastal** flood hazard type (Figure 6-3). See Section 3 to review how to create a flood Study Region and Section 4 for details on opening a Study Region.

If the user chooses to run a scenario with river reaches and coastal shorelines, the Flood Model will analyze the impact of both hazards on the inventory independently. It will then compare the resulting losses to determine which hazard is the controlling hazard (i.e., the hazard that has the greatest impact on that occupancy or structure).

To perform a combined analysis, the user would create a new scenario with both riverine and coastal components. After the **Create New Scenario** window (not shown), select the **River reaches** radio button (Figure 6-39). Then, select reach(es) using the **Add to selection** (**+**) button, and click **Save selection**. Second, select the **Coastal shorelines** radio button (Figure 6-39). Then, select shoreline(s) using the **Add to selection** button, and click **Save selection**. Click **OK** to ensure that both selected layers are saved. For more detailed instructions, refer to the previous sections on creating Riverine and Coastal Scenarios separately.

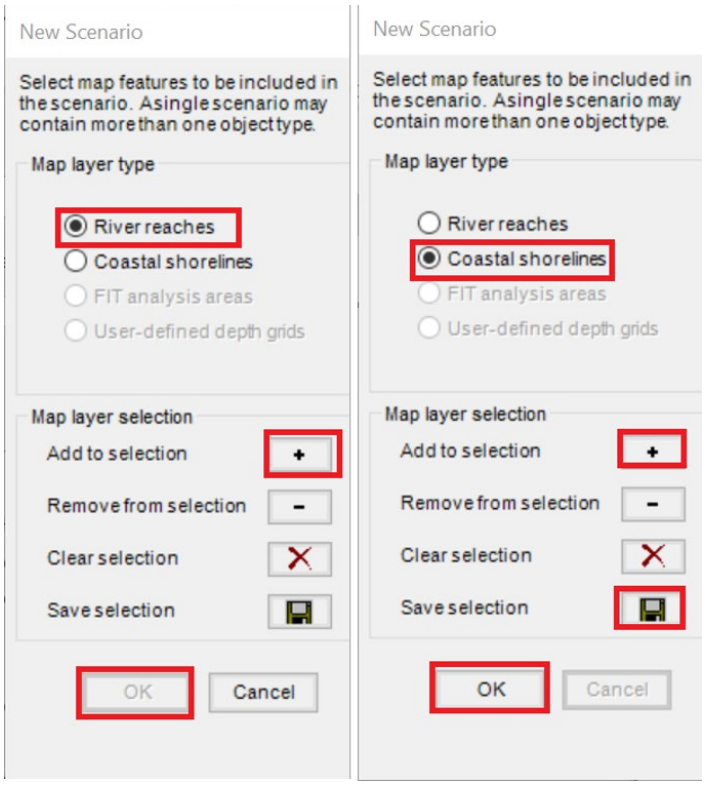


Figure 6-32 Select River Reaches and Coastal Shorelines

6.4.2 Open

A user may create multiple scenarios for each Study Region. Select **Open** from the **Scenario** menu, as shown in Figure 6-40, to open a previously created scenario. The **Open Scenario** dialog will appear (Figure 6-41). Click on the scenario's name to highlight it, and then click **OK**. Only one scenario can be opened at a time.

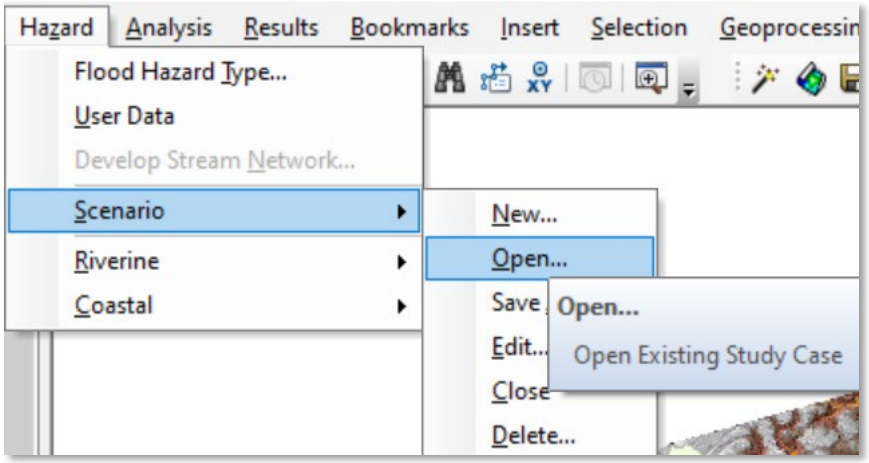


Figure 6-33 Select Open Scenario

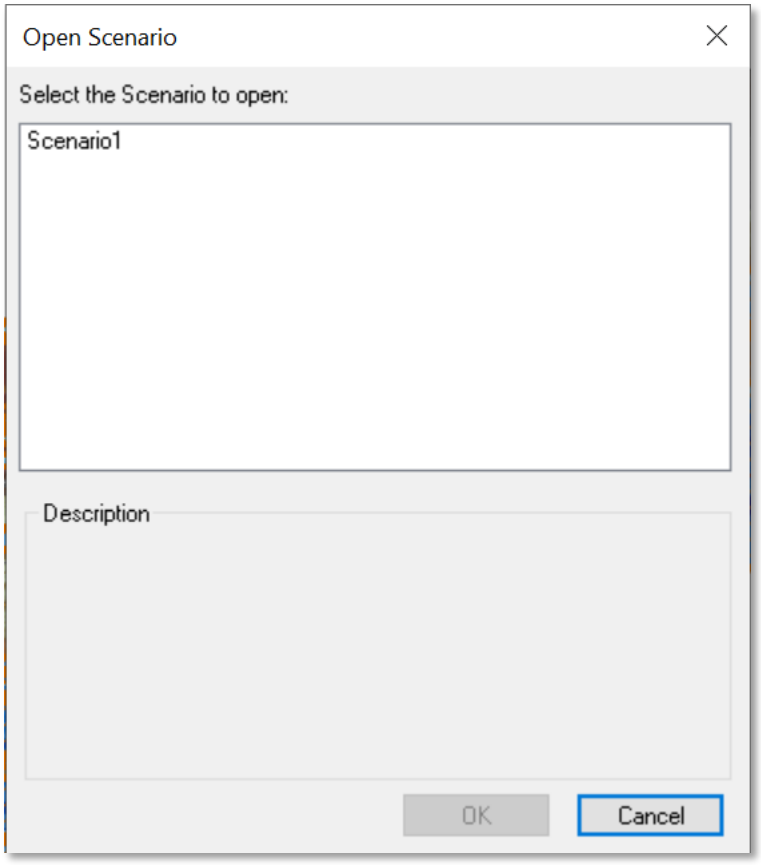


Figure 6-34 Open Scenario Dialog

6.4.3 Save As

The **Save As** option under the **Scenario** menu allows users to skip the hazard analysis every time they want to run different parameters in the **Inventory** or **Analysis** menu. It saves the user time by skipping the hazard selection and rerunning the analysis. It also provides the user a way to preserve previous results without using the **Duplicate Study Region** function, which requires much more disk space. The results tables are scenario-specific and creating a new scenario using the **Save As** function assumes the user wants new results. As such, the old results are not carried over.

In addition to creating a new scenario and opening a scenario, the **Scenario** menu options shown in Figure 6-42 let the user edit, close, or delete any created scenarios. To use the **Save As** capability, the scenario to be saved must be open. From the **Scenario** menu, select **Save As**. The **Save Scenario As** window, shown in Figure 6-43, will appear. Enter a name for the new scenario and an optional description. Click **OK** to save the old scenario and automatically open the new scenario.

NOTE: Each scenario must have a unique name.

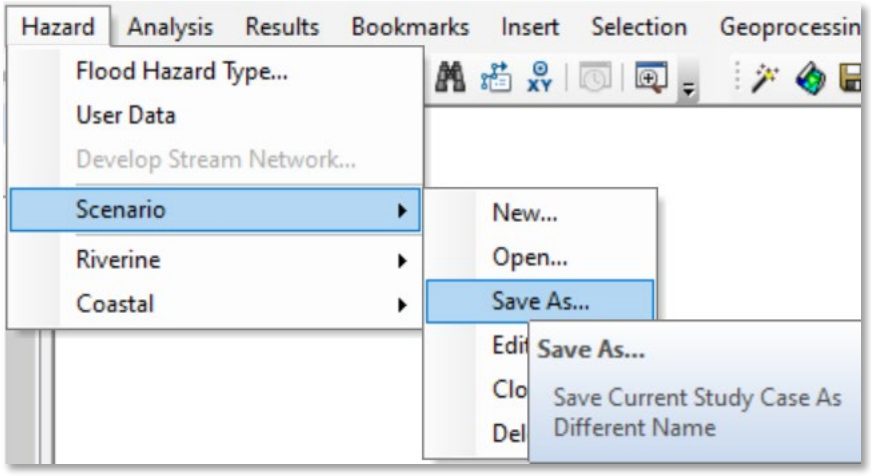


Figure 6-35 Select Save As

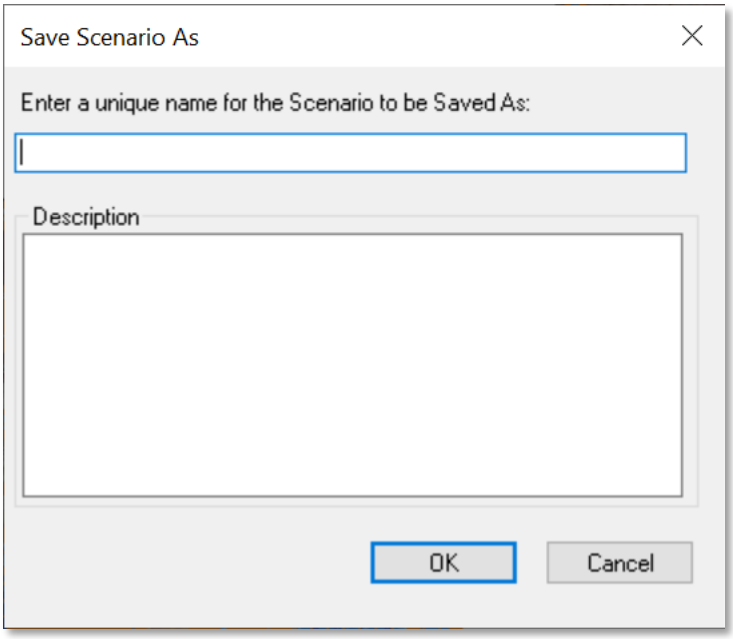


Figure 6-36 Enter a New Name for the Scenario

- When a user modifies the inventory, all future results are affected as future analyses will use the updated inventory. If the inventory is modified, the analysis should be rerun. Users that plan on modifying the inventory should “duplicate” the Study Region to compare results, otherwise the results are overwritten. The results will be overwritten if and only if the user reruns the analysis on the same scenario.

Users that plan to modify the functions/parameters in the Damage and Loss Estimate analysis should use the **Save As** capability to compare results between scenarios, otherwise they are overwritten. The changes to damage functions are per Study Region, so the user is responsible for knowing which damage functions were used to create the results of which scenario. The user will not be able to display which damage functions were used for each scenario.

Users that plan to modify the hazard analysis do not need to use the **Save As** capability. However, a few cases must be taken into consideration:

Mix grid: Mix grids are created when Hazus does not know what return period to assign to the grid, such as the case of running a specific discharge analysis or assigning different return periods to different reaches in a single scenario. If a user is dealing with a mix grid case and reruns the hazard by changing some parameters (return period of one or more reaches, or the discharges), the changes to the depth grid and floodplain polygon due to this rerun will not be reflected in the loss analysis results until the loss analysis is rerun.

Edits to scenario: If a user reruns the hazard by adding or subtracting at least one reach from the scenario but uses the same return period, the user should rerun the loss analysis so that the results reflect the changes to the hazard.

User Depth Grids and HEC-RAS .FLT Depth Grids: Inside the Flood Model, the only option available to the user in terms of modifying User Depth Grid/.FLT Depth Grid results is to choose which User Depth Grid/.FLT Depth Grid polygons to include in the scenario. If that kind of modification is made to the hazard, the user should rerun the flood delineation analysis so that the results reflect the changes to the hazard.

In all three cases, if the user reruns the analysis without using the **Save As** capability, the previous results will be lost.

6.4.4 Edit

The **Edit** option under the **Scenario** menu, shown in Figure 6-44, allows users to add/remove reaches to the scenario. If a user has not selected the correct reaches or shoreline, the **Edit** option allows the user to go in and re-select the correct reaches or shoreline.

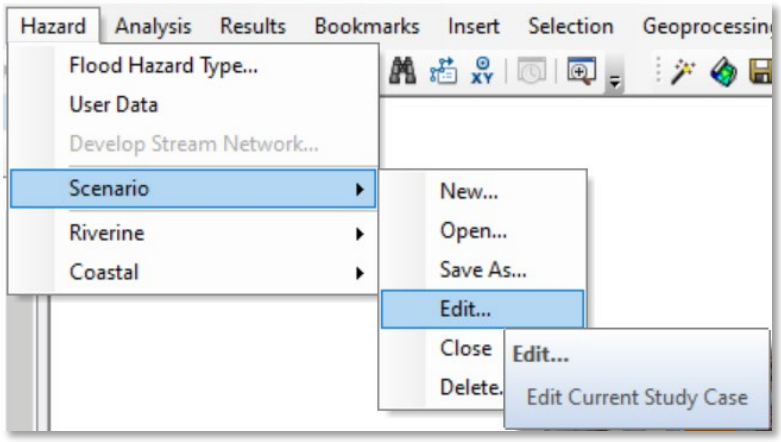


Figure 6-37 Select Edit

6.4.5 Close

The **Close** option under the **Scenario** menu, shown in Figure 6-45, closes the scenario in the mxd. The scenario is not deleted but will not be the active scenario for any changes or updates.

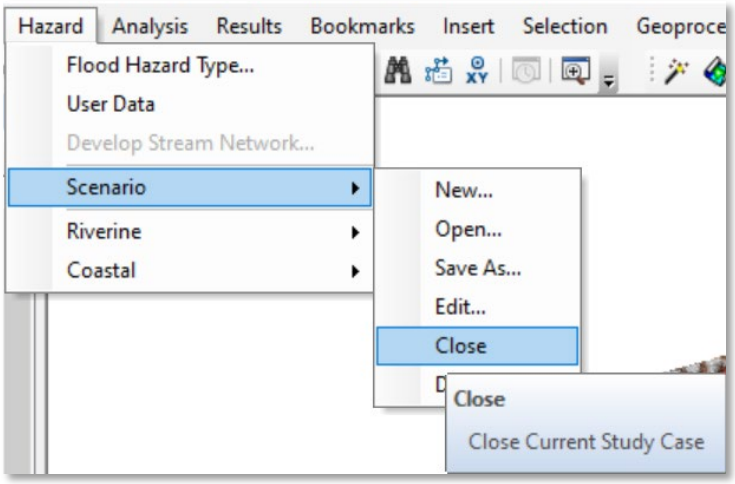


Figure 6-38 Select Close

6.4.6 Delete

The **Delete** option under the **Scenario** menu, shown in Figure 6-46, allows users to delete scenarios that are no longer needed. The **Delete** option allows users to delete multiple scenarios all at once by clicking on the scenarios. To use the **Delete** capability, the scenario to be deleted must be closed. Select **Delete** from the **Scenario** menu. The **Delete Scenario** dialog will appear (Figure 6-47). Select the scenario(s) to be deleted and click **OK**.

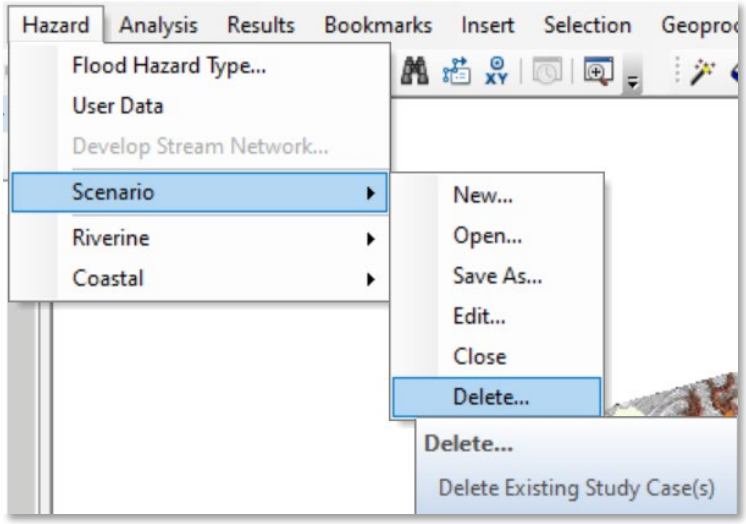


Figure 6-39 Select Delete

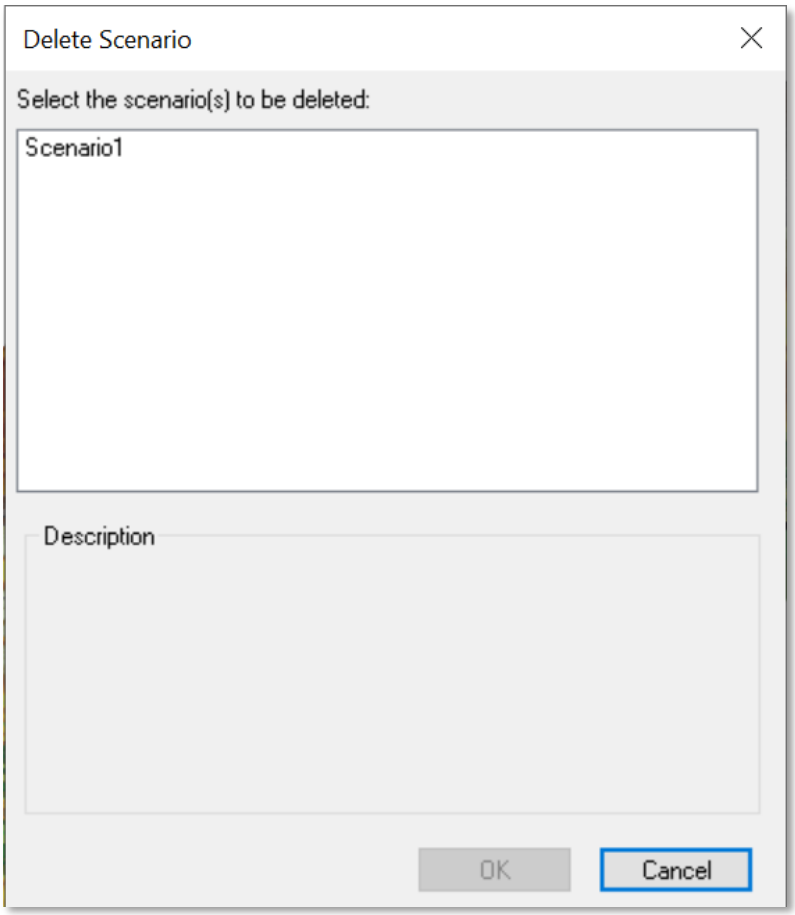


Figure 6-40 Delete Scenario Dialog

NOTE: To delete a scenario, manually close out of all references to the scenario itself or any of the scenario directory sub-tree files, such as log files, rasters, shapefiles, personal geodatabases, and file geodatabases in either text editor, ArcCatalog, ArcMap, or Windows Explorer. Failure to do so will result in an incorrect sync between the scenario database-related data and their file system-related objects.

6.5 Riverine

The **Hazard / Riverine** menu provides the Flood Model riverine analyses for deriving peak flows (**Hydrology**) and associated flood depths and boundaries (**Delineation Floodplain**). Like other Hazus analyses, this menu requires the analyses to be performed in sequential steps. For example, Figure 6-48 shows the **Hydrology** and **Delineation Floodplain** selections active, while the other three selections are inactive.

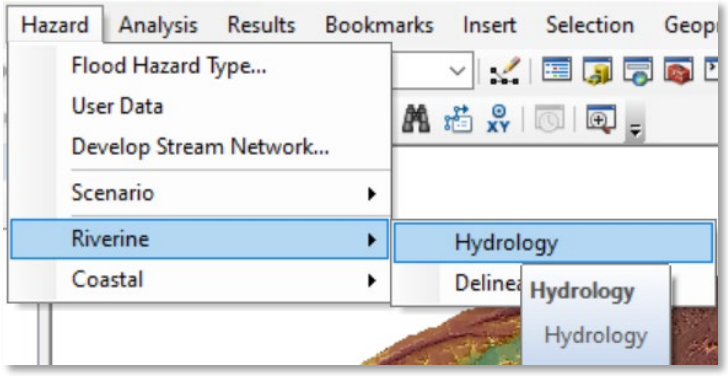


Figure 6-41 Select Hydrology

6.5.1 Hydrology

Once the user has defined the scenario, the **Hydrology** option, on the **Hazard > Riverine** menu, becomes enabled (Figure 6-48). To conduct the hydrologic analysis, select **Hydrology** and a notification window (Figure 6-49) will warn the user that raster processing cannot be canceled. Click **Yes**.

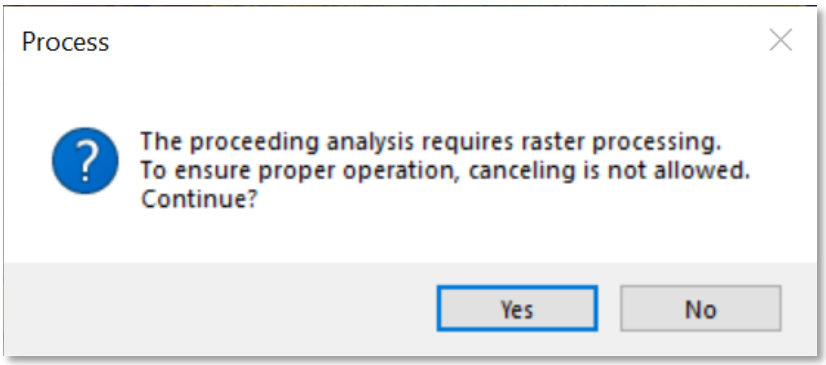


Figure 6-42 Select Yes to Start Hydrologic Analysis

A progress bar (Figure 6-50) will appear as Hazus performs the hydrologic analysis. This may take several minutes to several hours depending on the size of the Study Region and the number of selected streams. A notification (Figure 6-51) will appear once the hydrologic analysis has been completed. Click **OK**.

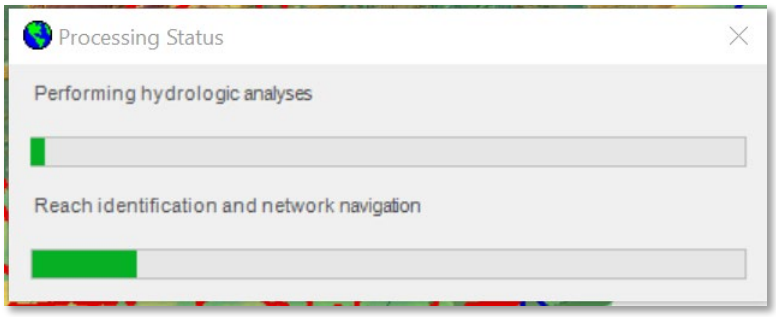


Figure 6-43 Hydrologic Analysis Progress

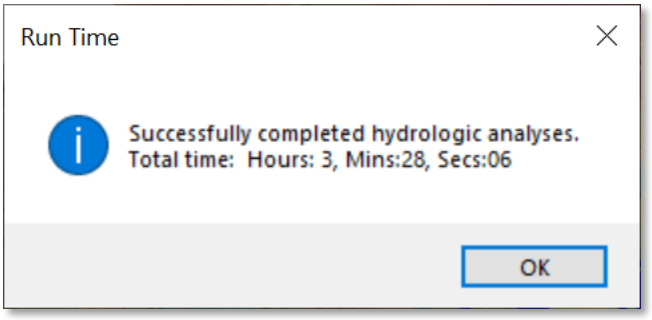


Figure 6-44 Hydrologic Analysis Completed

6.5.1.1 Best Practices and Troubleshooting

There is a tendency for ArcMap and Hazus to experience runtime issues that can lead to the Flood Model failing to complete the analysis. Because the hydrologic analysis is specific to the Study Region and is dependent only on the river network developed by the user, there are options to reduce the possibility of the code reaching a memory limit.

Performing the hydrologic analysis on a watershed-by-watershed basis is recommended, thereby limiting the processing within the model. Here are two recommended approaches:

1. Create a scenario for each watershed and then perform the hydrologic analysis on each scenario. The hydrologic results are stored in a single table independent of scenario.

2. Create a single scenario, start with one county or watershed, and perform the hydrologic analysis. When completed, edit the scenario, add the next county or watershed, and rerun the

hydrologic analysis. The model will skip those reaches for which the hydrologic analysis has already been performed and will perform the analysis on the added reaches. Repeat as needed to complete all watersheds in the Study Region.

For scenarios with many stream reaches, running the hydrologic analysis for large areas is recommended to improve processing time. Figure 6-52 provides an example showing reaches selected for analysis (shown in red).

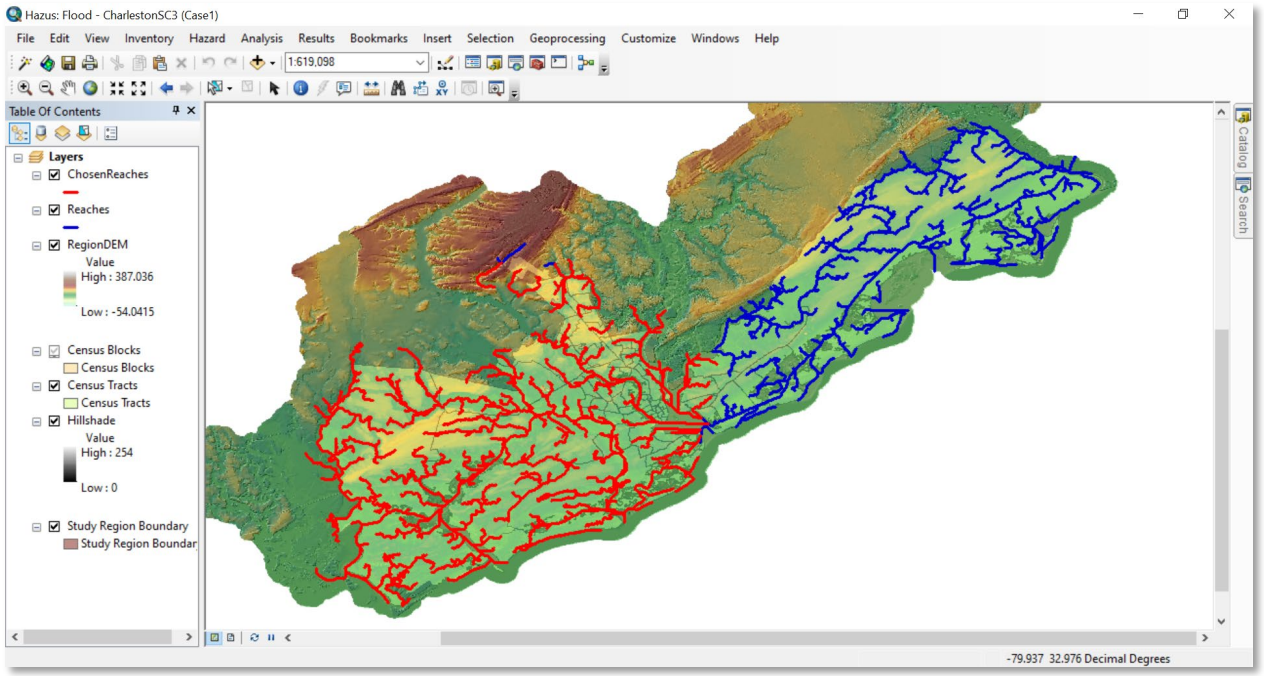


Figure 6-45 Select Streams for Hydrology

When running hydrologic analysis on large stream networks, continue to add streams by editing the scenario using the **Edit Scenario** dialog shown in Figure 6-53.

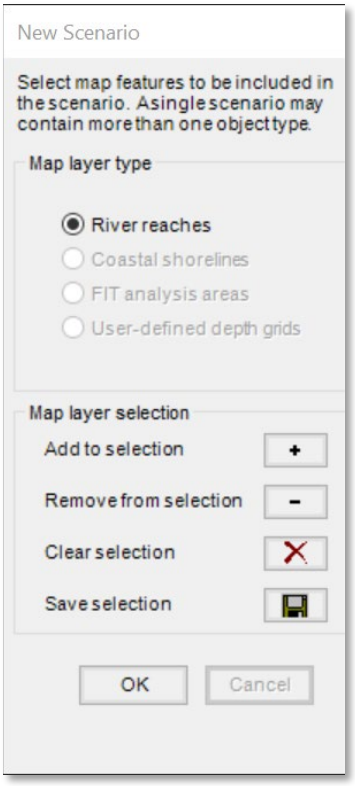


Figure 6-46 Edit Scenario Dialog to Add Streams

Once streams have been added into the scenario, select **Hydrology** from the **Riverine** menu as shown in Figure 6-54.

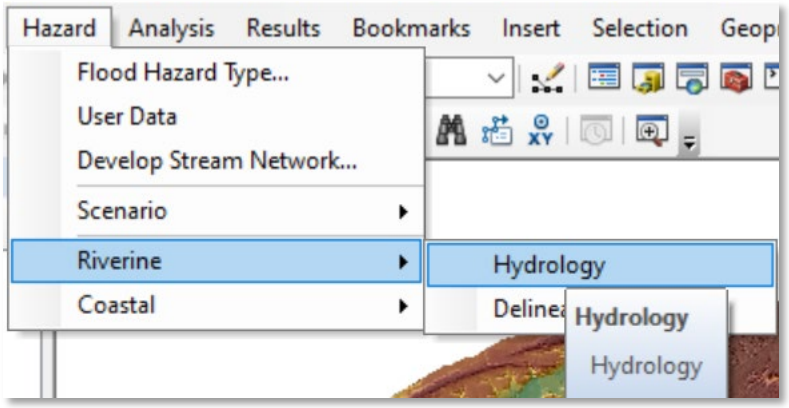


Figure 6-47 Select Hydrology

The **Process** dialog (Figure 6-55) will appear and ask if the user wants to continue with the processing. Click **Yes** to continue. Once the hydrologic analysis has started, the process cannot be canceled.

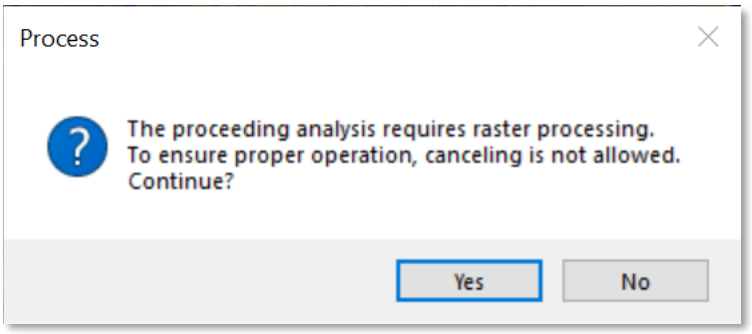


Figure 6-48 Hydrology Processing Dialog

Once the user has edited the scenario and added more streams for hydrologic analysis, the **Overwrite Existing Results** dialog will appear (Figure 6-56). If the user selects **Yes** to overwrite, Hazus will overwrite previous hydrology values, which requires more processing time. If the user selects **No**, the new results will be appended to the previous results and stored.

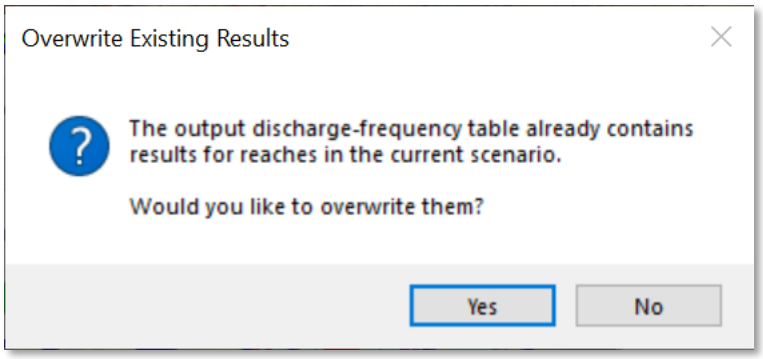


Figure 6-49 Overwrite Hydrology Dialog

Hydrologic analysis is only important for performing frequency-related flood analyses (i.e., 100-year return period, annualized loss, etc.). If the user wishes to apply a specific discharge to the reach(es), they should proceed directly to the **Delineate Floodplain** option on the **Riverine** menu and select **Single Discharge** (see Section 6.5.2).

When running hydrologic analysis, the Hazus screen might go blank, or the Task Manager **Applications** tab will indicate that Hazus is not responding. This is a common occurrence for any process-heavy software. To see whether Hazus is still running, check the Task Manager **Processes** tab and sort the **CPU** column in descending order. The “ArcMap.exe” process should be on top. If the

"System Idle Process" is constantly on top at 99–100%, Hazus is not responding. Also, check the **Performances** tab and make sure the CPU Usage is not 0 over a period of time. Another option is to open the Study Region folder (in "Details" view within Windows Explorer) and make sure the FlHydrologyLog.txt file is updating by looking at the "Date modified."

6.5.1.2 Excluding Problem Reaches from Scenario

Problem reaches are reaches for which regression equations and/or data are not available. When computing the flood hazard, analysis results for a specific return period or suite of return periods will not be available for reaches designated as Problem Reaches. Input of discharges will be required to develop the flood hazard grids for Problem Reaches.

Users have the option to set Hazus to automatically remove problem reaches (if they exist) from the scenario after the hydrologic process by selecting the **Automatically remove problem reach(es)** checkbox under **Customize** > **Flood Options** on the main Hazus menu bar, as shown in Figure 6-57.

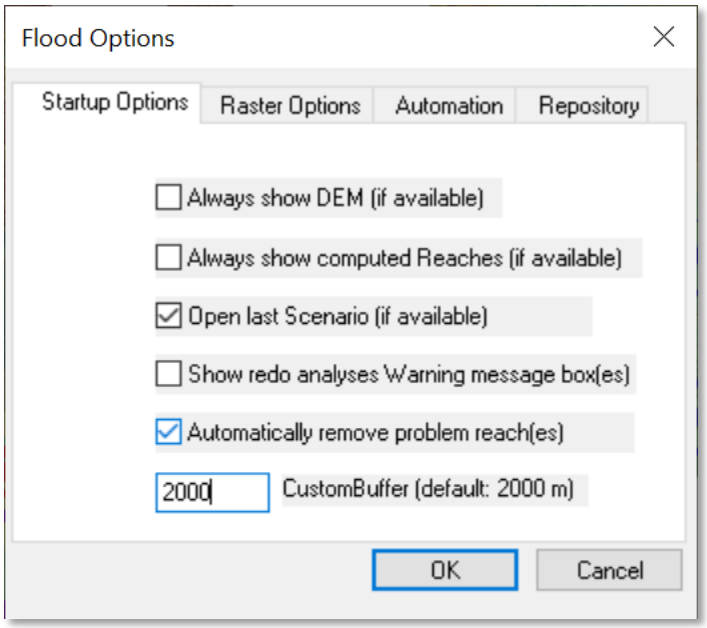


Figure 6-50 Flood Options, Check Automatically Remove Problem Reach(es)

If the **Automatically remove problem reach(es)** checkbox is not selected, at the end of the hydrologic process, a **Remove Problem Reaches** message will appear, as shown in Figure 6-58, to notify the user that problem reaches exist in the scenario and to give the user the option to remove the problem reaches from the scenario (with one click of **Yes** button).

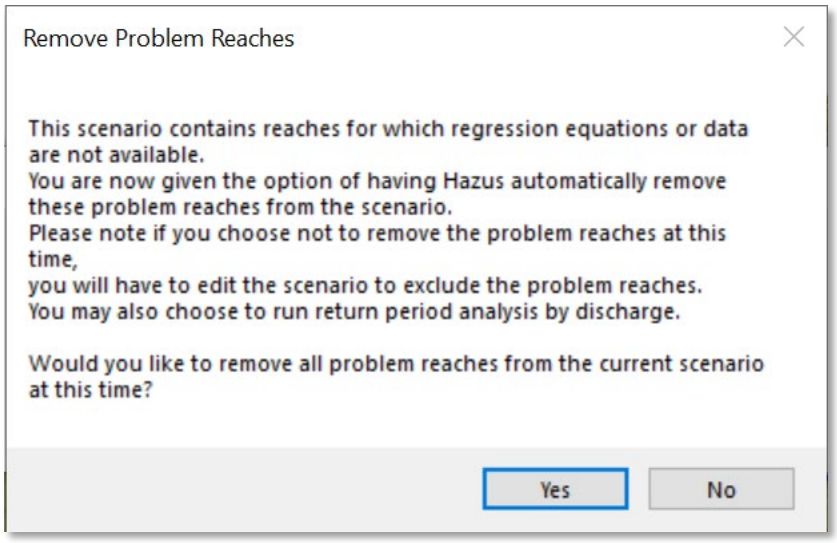


Figure 6-51 Notification and Option to Remove Problem Reaches

If the user selects **No** in the **Remove Problem Reaches** notification, but later wishes to remove problem reaches, they can manually edit the scenario to exclude the problem reaches. This only applies to cases where the problem reaches exist in the scenario.

To manually remove problem reaches, click on the **Hazard** menu, select **Scenario**, and then click **Edit**. The **Edit Scenario** dialog will open, as shown in Figure 6-59. Click **OK**.

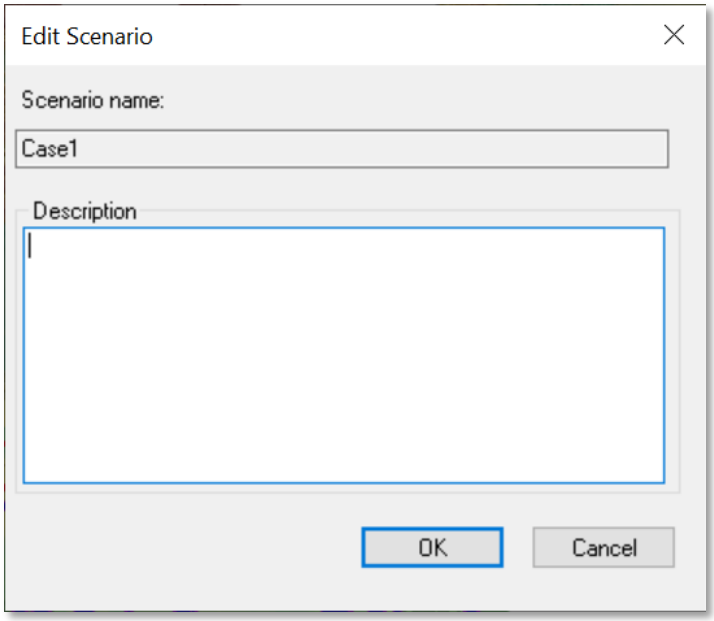


Figure 6-52 Edit Scenario Window

Once the user clicks **OK,** all the reaches in the scenario will be highlighted in light blue. Click the **Remove Problem Reaches** button (as shown in Figure 6-60), to remove all the problem reaches, and then click the **Save selection** button. After the user clicks **OK**, the new scenario will be mapped, shown in Figure 6-61.

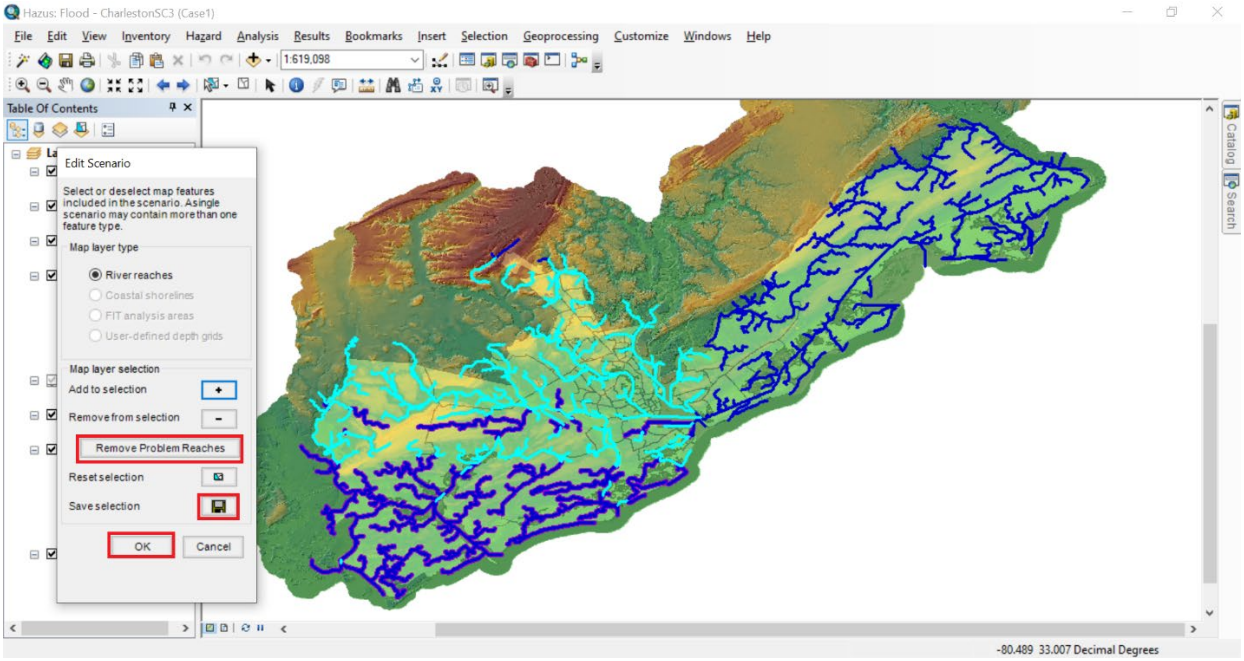


Figure 6-53 Edit Scenario Dialog to Remove Problem Reaches

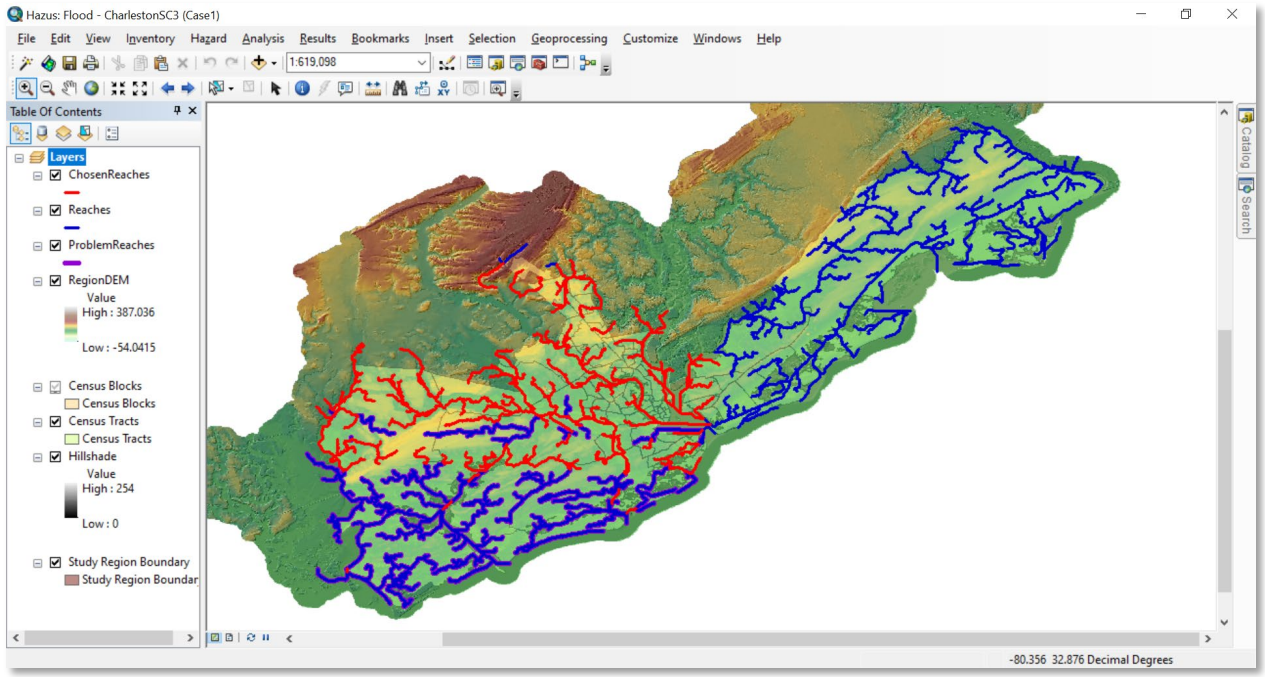


Figure 6-54 Example Edited Scenario with Problem Reaches Removed

The scenario is now ready to start hydraulics (**Riverine** > **Delineate Floodplain**) for the Chosen Reaches. The hydrologic analysis does not need to be rerun because Hazus has already computed discharges for non-Problem Reaches. If the hydrologic analysis is rerun, the results will remain the same because the Problem Reaches have been removed from the scenario.

6.5.2 Delineate Floodplain

Once the hydrologic calculations are complete, the **Delineate Floodplain** option on the **Hazard > Riverine** menu is enabled (Figure 6-62). Select **Delineate Floodplain** to initiate the hydraulic analysis. The **Riverine Hydraulic Analysis** dialog in Figure 6-63 will appear. Use the **Analysis Type** pull-down menu to select the type of hazard analysis to run.

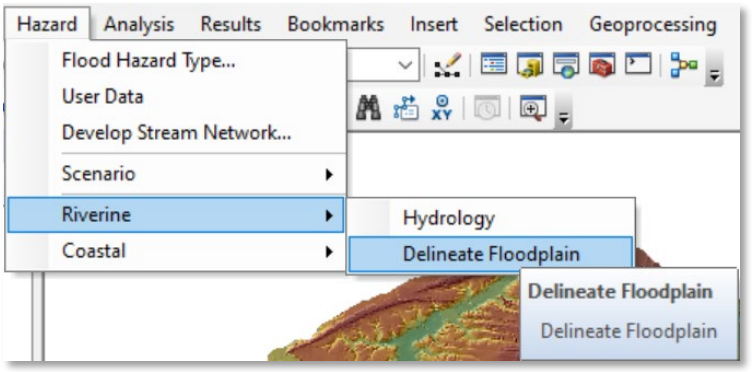


Figure 6-55 Select Delineate Floodplain

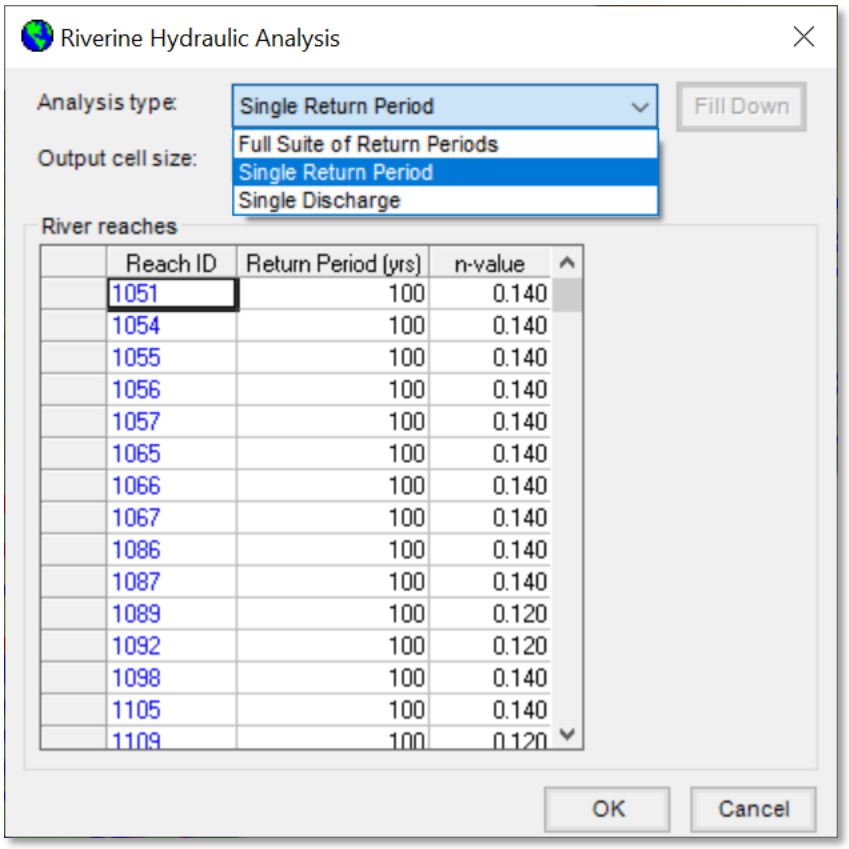


Figure 6-56 Riverine Hydraulic Analysis Dialog

1. Select **Full Suite of Return Periods** to calculate flood depths and floodplains for the 10-year, 25-year, 50-year, 100-year, and 500-year return period floods on each of the stream reaches in the scenario. Starting with the 500-year return period, the Flood Model will go through each selected reach and develop a single 500-year flood depth grid. This process is duplicated for the other four return intervals. This option is required for average annualized loss.

2. Select **Single Return Period** to specify a return period between 2 years and 1,000 years for which the flood characteristics will be calculated. Choose different return periods for different stream reaches, if desired. Depending on the user selection, the resultant grid will be a single return interval for all reaches selected by the user, like option 1 above, or a single grid of mixed return intervals for the selected reaches.

3. Select **Single Discharge** to input anticipated stream discharge levels for each stream reach. Like option 2 above, the user can enter different discharges for each reach.

    - If the user opts to run different return intervals or specific discharges for each reach in their scenario, the Transportation Bridge analysis cannot be run because the return

interval for the reaches in question needs to be specified and has not been defined for a single discharge analysis.

- The **Single Discharge** option can decrease the runtime significantly if data are available.

The final delineated floodplain should look like Figure 6-64, where only the selected reaches for the scenario have flood depth grids and boundaries delineated.

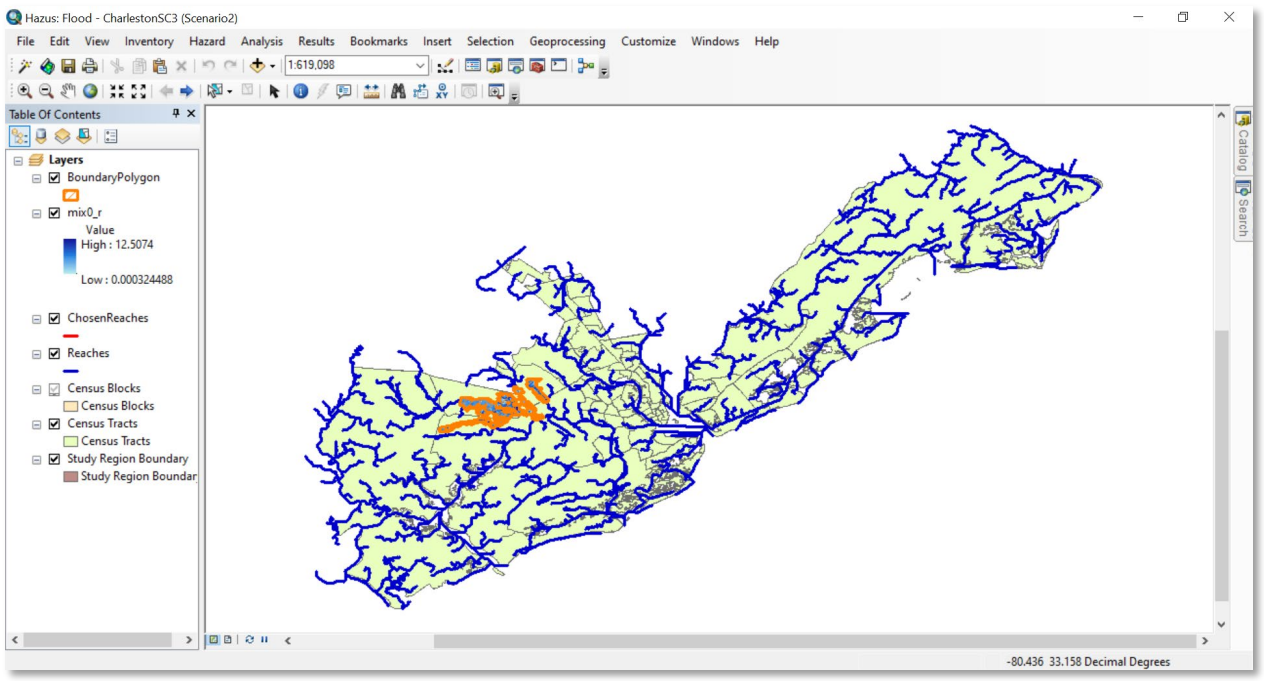


Figure 6-57 Example Riverine Hydraulic Analysis Results

6.5.2.1 Best Practices and Troubleshooting

The **Delineate Floodplain** analysis can take large amounts of time, especially when generating a flood depth grid in Hazus rather than importing a grid. Several days of processing time are possible with the **Full Suite of Return Periods** Analysis Type for an individual county. Some general guidance is listed below for the **Delineate Floodplain** analysis; however, this is not an exclusive list of best practices and troubleshooting for issues experienced during the **Delineate Floodplain** analysis. Please contact the Hazus Helpdesk (see Section 1.5) for support regarding specific issues.

Blank Screen:

When running the hydraulic analysis, the Hazus screen might go blank, or the Task Manager **Applications** tab will indicate that Hazus is not responding. This is a common occurrence for any process-heavy software. To see whether Hazus is still running, check the Task Manager **Processes** tab and sort the **CPU** column in descending order. The "CoreOfHydraulics.exe" process should be on top. If the "System Idle Process" is constantly on top at 99–100%, Hazus is not responding. Also,

check the **Performances** tab and make sure the CPU Usage is not 0 over a period of time. Another option is to open the scenario folder (in "Details" view within Windows Explorer) and make sure the FlHydraulicsLog.txt file is updating by looking at the "Date modified."

Grid Cell Sizes:

Using a smaller cell size could dramatically increase the processing time and the size of the output raster. Resampling larger cells into smaller cells to allow a merged grid for Study Regions with different topographic source data may lead to issues in Hazus. The recommended approach would be to run the multiple source depth grids separately in Hazus and then combine flood loss results after all Hazus loss runs.

Reaches with Hydraulic Problems:

If running the hydraulics (i.e., **Delineate Floodplain**) is taking a long time, the hydraulic process may be hanging (i.e., getting stuck on a couple of reaches so that it cannot finish the hydraulics). The following instructions will help bypass the problem.

1. Look in the log (flHydraulicsLog.txt located in Scenario folder) and note any reaches (ReachID) that have many errors and did not successfully complete processing. Example below:

```
: ----------------------------------------------------------------
: ReachID: 1425 Core of Hydraulics

: ----------------------------------------------------------------
  modLevelOne - CoreOfHydraulics: Reach 100 of 267

  modLevelOne - CoreOfHydraulics: Return period: 100

  modLevelOne - CoreOfHydraulics: What-if:

  modLevelOne - CoreOfHydraulics: Available memory: 1631.05 mb

  modInitialBuffer - InitBuffer: Reach length = 0.2 km

  modInitialBuffer - InitBuffer: Reference (downstream node) discharge: 3,981 cfs

  modXSections - PlaceInitXsects: Short centerline length: 964.462826043346 feet

  modXSections - PlaceInitXsects: Buffer 3 of 9

  modXSections - PlaceInitXsects: Buffer 4 of 9

  modXSections - PlaceInitXsects: Buffer 5 of 9

  modXSections - PlaceInitXsects: Buffer 6 of 9
```

modXSections - PlaceInitXsects: Buffer 7 of 9

modXSections - PlaceInitXsects: Buffer 8 of 9

modXSections - PlaceInitXsects: Buffer 9 of 9

modXSections - PlaceInitXsects: Cross section count: 3

modXSections - InitialXSectElevs: Drainage area reset from 219.9631 to 140.0594

modXSections - InitialXSectElevs: Drainage area reset from 220.2029 to 140.0594

GeometryToFeatureClass: Feature class: LeftBuffer

GeometryToFeatureClass: Feature class: RightBuffer

modGeometry - CleanPolygonIslands: Input geometry is nothing, leaving early.

ModBoundsandEnds - ValidateFloodPolygon: Error Number: 91

ModBoundsandEnds - ValidateFloodPolygon: Error: Object variable or With block variable not set

modGeometry - CleanPolygonIslands: Input geometry is nothing, leaving early.

modGeometry - IntersectABS: Input geometry #1 is invalid. No intersection.

modLimits - NewLimitsandCenterlines: Error Number: 91

modLimits - NewLimitsandCenterlines: ERROR: Object variable or With block variable not set at 8

modLevelOne - CoreOfHydraulics: Error Number: 91

modLevelOne - CoreOfHydraulics: ERROR: Object variable or With block variable not set at 20

modLevelOne - CoreOfHydraulics: Error Number: 91

modLevelOne - CoreOfHydraulics: ERROR: Object variable or With block variable not set at 20

modLevelOne - CoreOfHydraulics: Error Number: 91

modLevelOne - CoreOfHydraulics: ERROR: Object variable or With block variable not set at 20

modLevelOne - CoreOfHydraulics: Error Number: 91

modLevelOne - CoreOfHydraulics: ERROR: Object variable or With block variable not set at 20

modWsePts - FinalWsePts: Error Number: 5

modWsePts - FinalWsePts: ERROR: Invalid procedure call or argument at 2

modLevelOne - CoreOfHydraulics: WARNING: FinalWsePts failed, continuing process using points from InitialWsePts and/or IncreaseWsePts

modLevelOne - CoreOfHydraulics: Error Number: 91

modLevelOne - CoreOfHydraulics: ERROR: Object variable or With block variable not set at 45

modAddBack - AddBack: Entering

modAddBack - FillDEMMask: Error Number: 91

modAddBack - FillDEMMask: ERROR: Object variable or With block variable not set at 4

modAddBack - AddBack: Error Number: 91

modAddBack - AddBack: ERROR: Object variable or With block variable not set at 5

MakePermanent: Entering for grid: 1425

MakePermanent: Path: C:\HazusData\Regions\CharlestonSC3\Hydraulics\Reaches\100

MakePermanent: Leaving

modAddBack - AddBack: Leaving

GeometryToFeatureClass: Feature class: 1425_cl

ExportGDBFClass: Error: Featureclass Reach1425ConvPGRP100 not found.

modLevelOne - CoreOfHydraulics: Leaving

2. Open the Attribute Table for the Chosen Reaches layer.

3. Search for the reach using the ArcID and highlight/select the problem reach.

4. Right click on the line of the selected reach and select **Zoom to Selected** as shown in Figure 6-65 below.

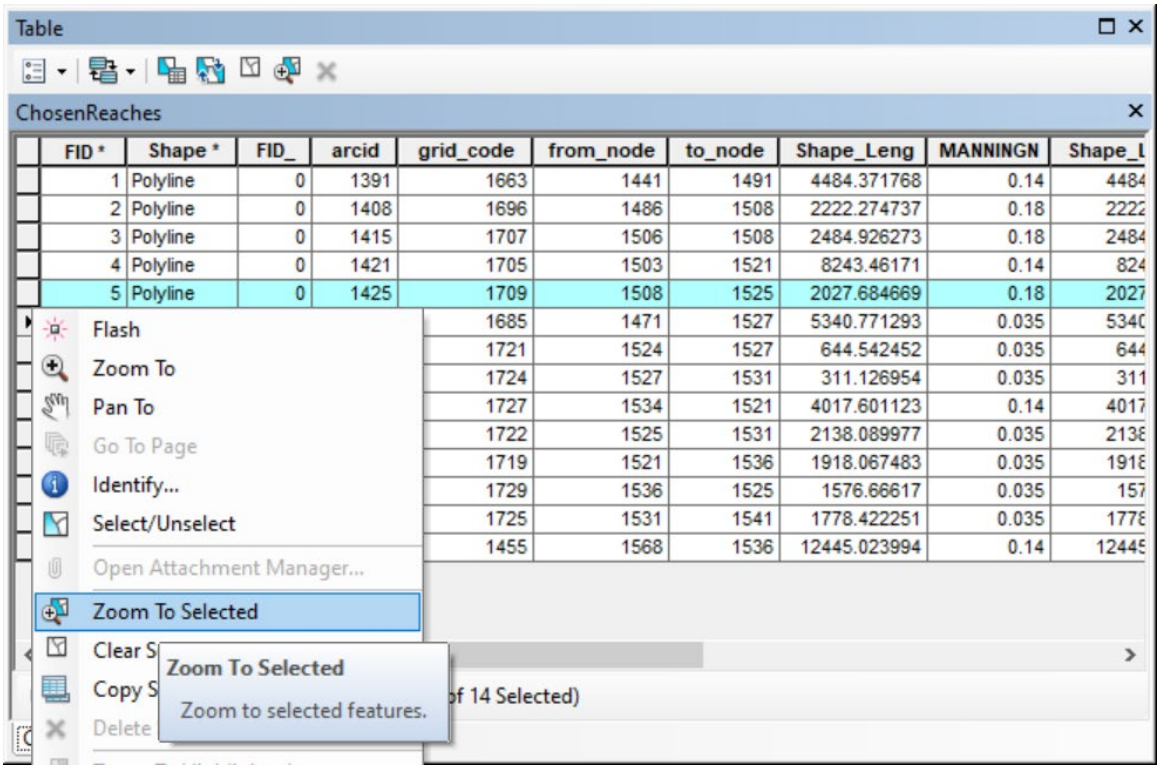


Figure 6-58 Chosen Reaches Attribute Table, Zoom to Selected Reach

5. The map will now zoom into the reach selected. Zoom out of the map to locate where the selected reach is on the map (Figure 6-66). Keep in mind what the reach looks like.

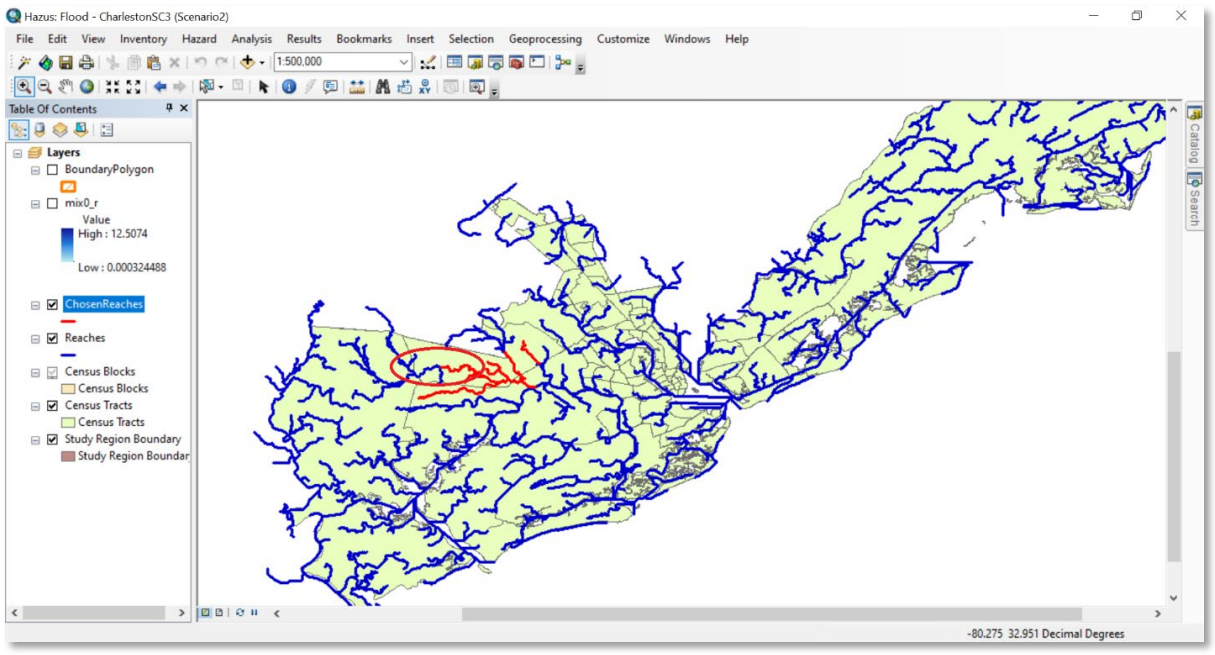


Figure 6-59 Example Selected Chosen Reach (highlighted), Zoomed Out

6. Click on the **Hazard** menu, select **Scenario**, then click **Edit**.

7. Once the **Edit Scenario** tool is available, zoom in to the area where the problem reach is located.

8. Click **Remove from selection** and select the problem reach. The reach selected will be highlighted in red.

9. Click **Save selection**.

10. After the selection has been saved, the problem reach will be dark blue and will be excluded from the scenario.

11. Click **OK**.

12. If the scenario is a riverine/coastal scenario, the **Shoreline Characterization** dialog will appear after edits are made to the scenario. The original parameters that were set for the shoreline(s) are saved if the shoreline(s) wasn't added/removed from the scenario. Select the **Nex**t and **Finish** buttons if the existing parameters are desired.

13. The scenario is now ready to re-start hydraulics (Riverine\Delineate Floodplain) for the ChosenReaches. The hydraulics process will automatically rerun any reaches that did not successfully process in the previous run, skip any reaches that have been successfully processed, and then will continue on the last reach processed. If there were any reaches where the Task Manager was used to stop Core of Hydraulics, repeat the steps to get past those reaches.

6.5.2.2 *Failed Reaches*

Failed reaches are reaches that have been processed in the hydraulics process, but do not produce a flood depth grid. An error message will appear to notify the user when a reach fails during the hydraulics process. Click the **Close** button on any errors and the hydraulics process will continue processing the next reach in the queue. The **FailedReaches** layer will appear on the map after the hydraulics process completes, as shown below in Figure 6-68.

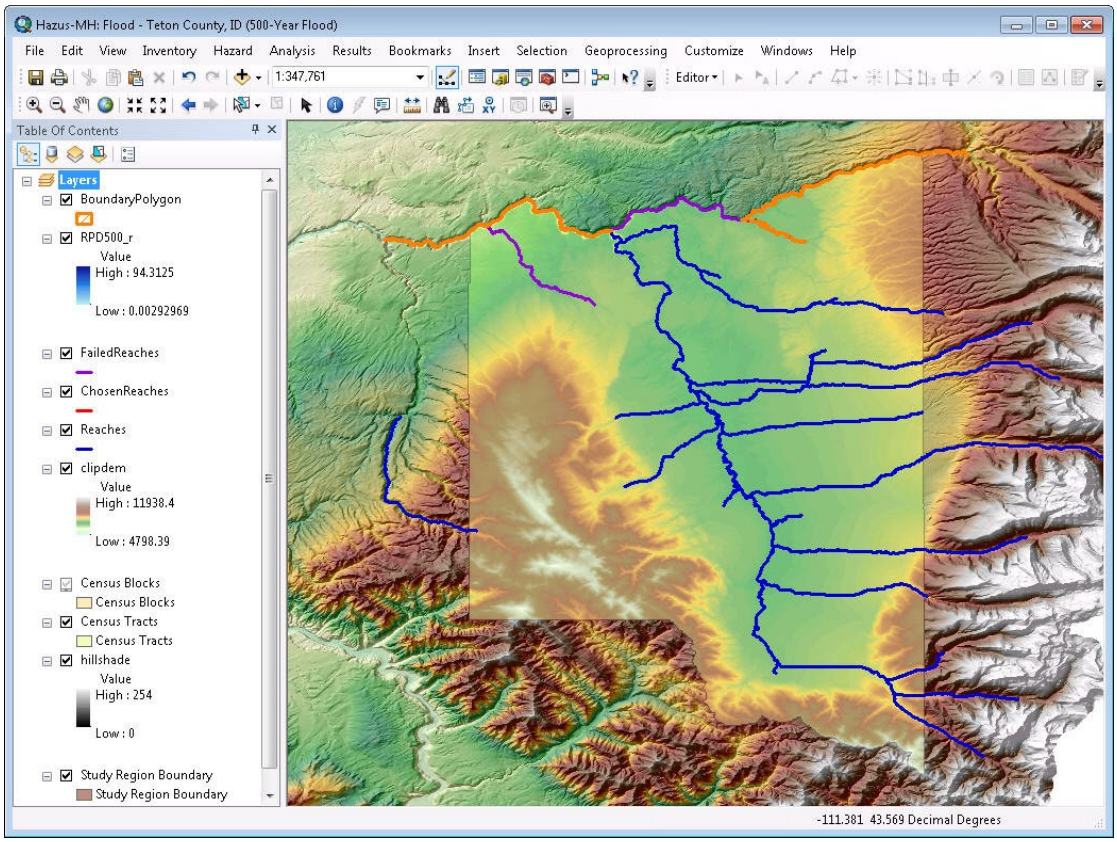


Figure 6-60 Example Failed Reaches (purple) on Map after Hydraulics Completed

The hydraulics process should complete even if there are failed reaches. The only reason the hydraulics process will not complete is if a failed reach causes the hydraulics process to hang.

When running the analysis on a scenario with failed reaches, the analysis will only process in areas where the depth grid exists.

6.6 Coastal

The **Hazard / Coastal** menu (Figure 6-75) provides the Flood Model coastal analyses for deriving flood depths and boundaries (**Delineation Floodplain**) associated with the coastal flood elevations and shoreline segments entered when defining the scenario.

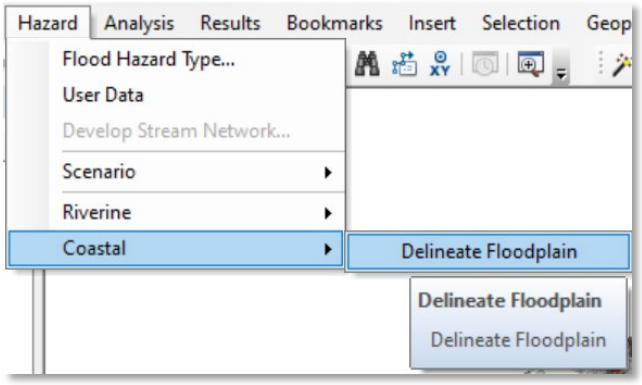


Figure 6-61 Select Delineate Floodplain

6.6.1 Delineate Floodplain

To delineate the floodplain, select **Delineate Floodplain** from the **Hazard > Coastal** menu (Figure 6-75). The **Coastal Hazard Analysis** dialog will open (Figure 6-76). This dialog allows the user to select from two coastal analysis options:

1. If the user selects **Full Suite of Return Periods** from the **Analysis Type** drop-down menu, Hazus will calculate flood depths and floodplains for the 10-year, 25-year, 50-year, 100-year, and 500-year return period floods for the entire shoreline in the scenario. The Flood Model will produce a single flood depth grid for the shoreline for each of the five return intervals.

2. If the user selects **Single Return Period** from the **Analysis Type** drop-down menu, the user can specify any flood return period between 10 and 500 years for which the flood characteristics will be calculated. Unlike the riverine hazard, the user cannot choose different return periods for different shoreline segments. The Flood Model will produce a single flood depth grid for the shoreline for the selected return period.

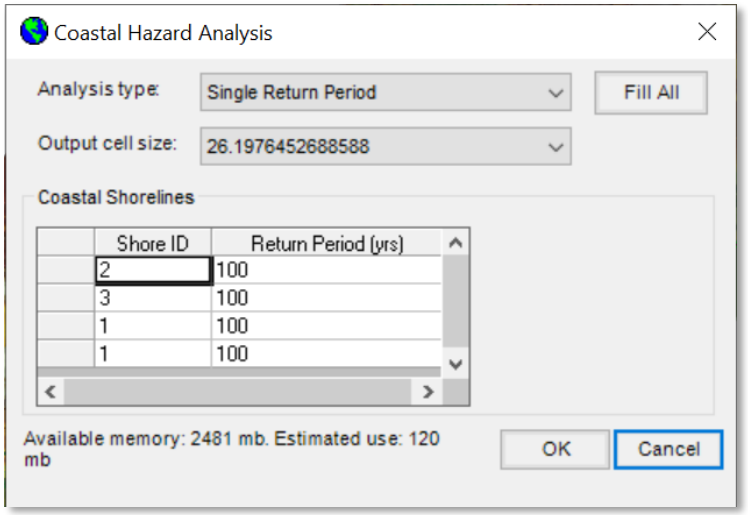


Figure 6-62 Coastal Hazard Analysis Dialog

6.6.2 User Inputs, Shoreline Segmentation and Characterization

The Hazus user is required to supply certain information for the coastal Flood Model to run -- without this information no coastal hazard results can be produced. More accurate user-supplied information will result in more accurate coastal hazard and economic loss results. *The following user inputs are required:*

- **Study region**, over which coastal flood hazards will be computed. The study region boundaries must be specified by the user at the beginning of the analysis. Given the region, 4-78 Chapter 4. Potential Earth Science Hazards (PESH) the model will determine which coastal counties are part of the study region and will locate default data (in look-up tables) associated with each coastal county.

- **Shoreline(s)**. The user must identify the start and end of shorelines across which coastal flooding will propagate. Except for small islands, the user may choose to divide each shoreline into two or more segments. Segmentation of shorelines is not required (if a shoreline is not segmented, the entire shoreline will be attributed with the same shore characterization and 100-yr flood conditions). Coastal flood return period(s). The user may specify one or more return periods between 10 years and 500 years. A separate coastal hazard analysis will be performed for each return period specified. In the Combined Wind and Flood (Coastal Surge) Model, one input required to characterize each segment of a shoreline if "No Waves" was selected in the Hurricane Surge analysis is:

    - **Wave exposure**, used to determine whether coastal wave analyses will be run, and if so, to determine the peak wave period Tp at the shoreline from a look-up table (default wave period data are listed for 364 coastal counties in the table): - open coast (full exposure), with over-water fetches > 50 miles - moderate, with fetches between 10 miles and 50 miles - minimal, with fetches between 1 and 10 miles - sheltered, with fetches less than 1 mile (Note that if a shoreline or segment is classified as sheltered, the model assumes that no damaging waves will affect that shoreline or segment, and no dune/bluff erosion or wave analyses will be computed along transects associated with that shoreline or segment – a stillwater flood surface will be computed by the model.)

Two inputs are required to characterize 100-yr flood conditions at each shoreline segment (See Figure 6-63:

- **(1) 100-yr Flood Stillwater Elevation (SWEL)**, obtained from the FIS report or from another source

- **(2) 100-yr wave setup**, obtained from the FIS report or from another source. In addition, the user may edit certain parameters calculated by the model:

- **(3) Other stillwater elevations (ft):** the model calculates values for the 10, 50 and 500-yr based on the 100-yr value and default flood elevation ratios; the user may specify site specific values from the FIS or another source.

(4) Significant wave height Hs at shore (ft): the model assumes depth-limited wave heights at all shorelines and exposures; the user may specify a value less than the depth-limited height.

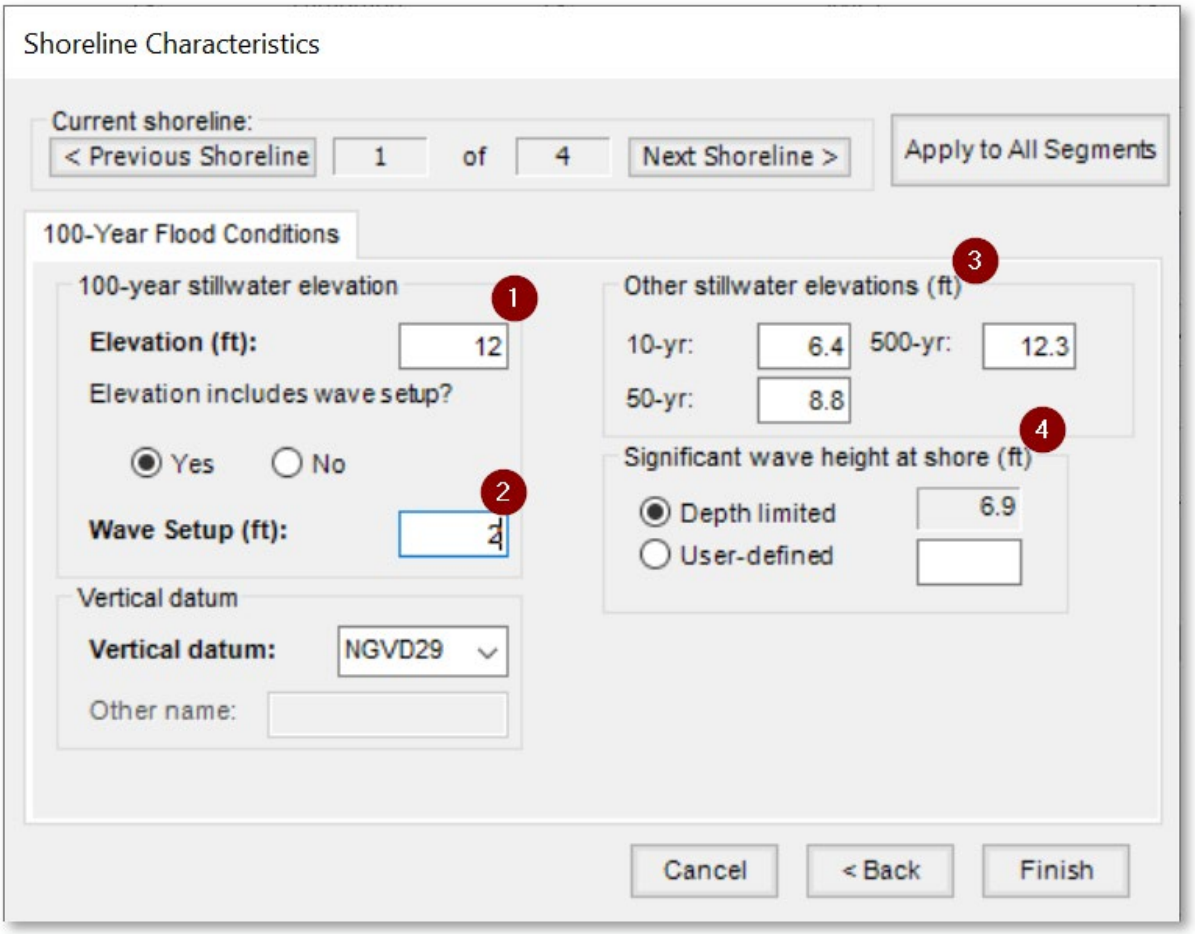


Figure 6-63 Required Shoreline Inputs

The coastal Flood Model will take the user inputs and default data, then create a stillwater flood surface throughout the entire study region (i.e., the coastal model will: 1) overlay a stillwater flood surface over the DEM, and 2) identify and remove any isolated pools without a hydraulic connection to the flood source). Subsequent erosion and wave analyses will be used to determine where the flood surface will lie above the stillwater surface. Figure 6-64 illustrates the overall coastal hazard modeling process.

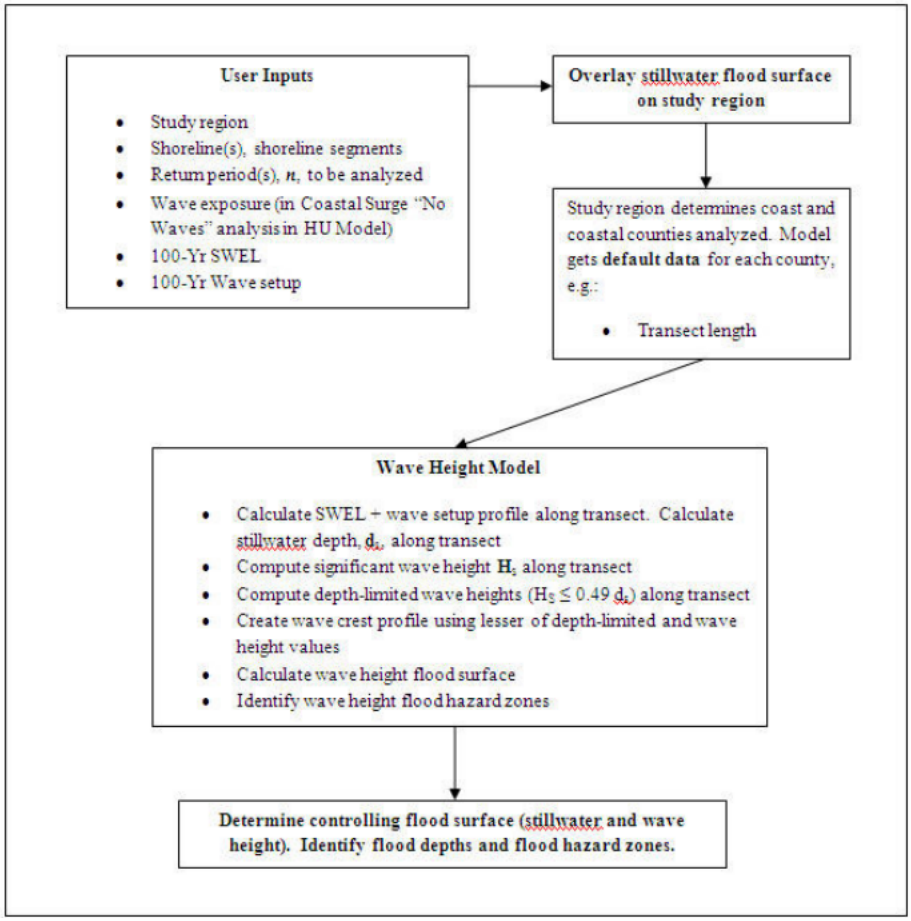


Figure 6-64 Overview of Hazus Coastal Flood Hazard Modeling Process

6.6.3 Best Practices and Troubleshooting

Coastal floodplain delineation in the Flood Model is much less likely to have issues than riverine analysis. However, memory issues can still influence a larger coastal analysis. At the bottom of the **Coastal Hazard Analysis** window (Figure 6-62), Hazus indicates how much virtual memory is available on the machine and the estimated virtual memory that will be used for the coastal analysis. When running the coastal flood delineation analysis, the Hazus screen might go blank, or the Task Manager **Applications** tab will indicate that Hazus is not responding. This is a common occurrence for any process-heavy software. To see whether Hazus is still running, check the Task Manager **Processes** tab and sort the **CPU** column in descending order. The "ArcMap.exe" process should be on top. If the "System Idle Process" is constantly on top at 99–100%, Hazus is not responding. Also, check the **Performances** tab and make sure the CPU Usage is not 0 over a period of time. Another option is to open the scenario folder (in "Details" view within Windows Explorer) and make sure the FlCoastalLog.txt file is updating by looking at the "Date modified."

Section 7. Model Menu: Analysis

After Hazus has calculated the hazards, it will need to run the loss analysis to provide damage estimates using the **Analysis** menu (Figure 7-1). As with other Hazus Flood Model menus, items grayed out represent functionality not currently available given the type of analysis being conducted and the completion of required prerequisite analysis steps.

In a Hazus loss analysis, the characteristics of the structures and people of the Study Region are analyzed for vulnerability to the flood or floods that have been calculated in the scenario. Default depth damage functions, which estimate percent damage relative to the depth of floodwater as measured from the top of the first finished floor (riverine) or bottom of the first floor (coastal), are provided within the Hazus program. Other damage functions are also included in the Flood Model to estimate damages to vehicles, utility components, and transportation bridges.

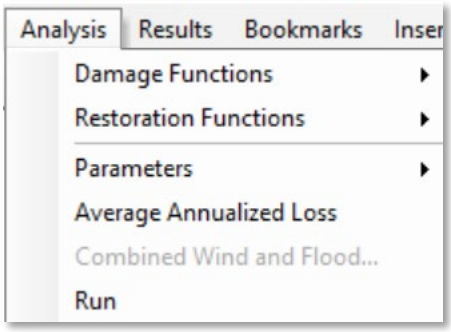


Figure 7-1 Analysis Menu

7.1 Damage Functions

The **Analysis** menu options reflect the functions that will be used to estimate damage of various types. This section discusses the options on the **Analysis > Damage Functions** menu.

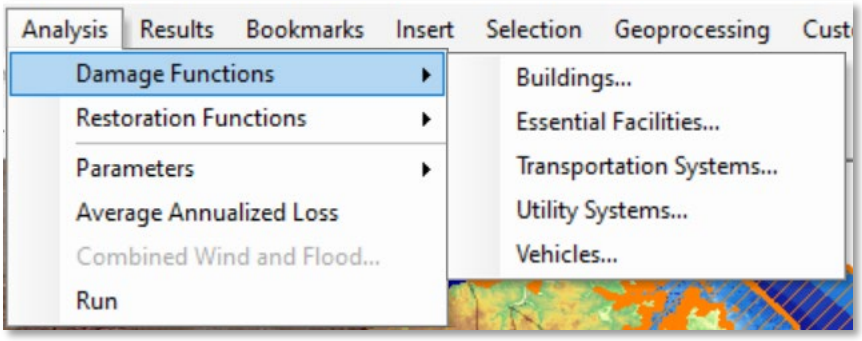


Figure 7-2 Analysis > Damage Functions Menu

Select **Buildings** from **Analysis > Damage Functions** menu. The **General Building Stock Depth-Damage Functions** table shown in Figure 7-3 will appear. The **Structure** table provides information on the default damage function associated with each specific occupancy class (e.g., RES1) and subclass (e.g., RES1, one-story, no basement). Scroll to the right to see the percent of damage, expressed in terms of building replacement cost, estimated at different water depths. The pull-down menus at the top of the window allow the user to view the default damage functions for the flood hazard types (Zone V, Coastal Zone A, and riverine) and other occupancy classes (e.g., COM1, AGR1, IND1). Click on the different tabs at the top (**Structure**, **Contents**, **Inventory**) to view default damage functions associated with building structures, and their contents, for all specific occupancy types and inventory for selected occupancies (e.g.,COM1, IND1-6, AGR1).

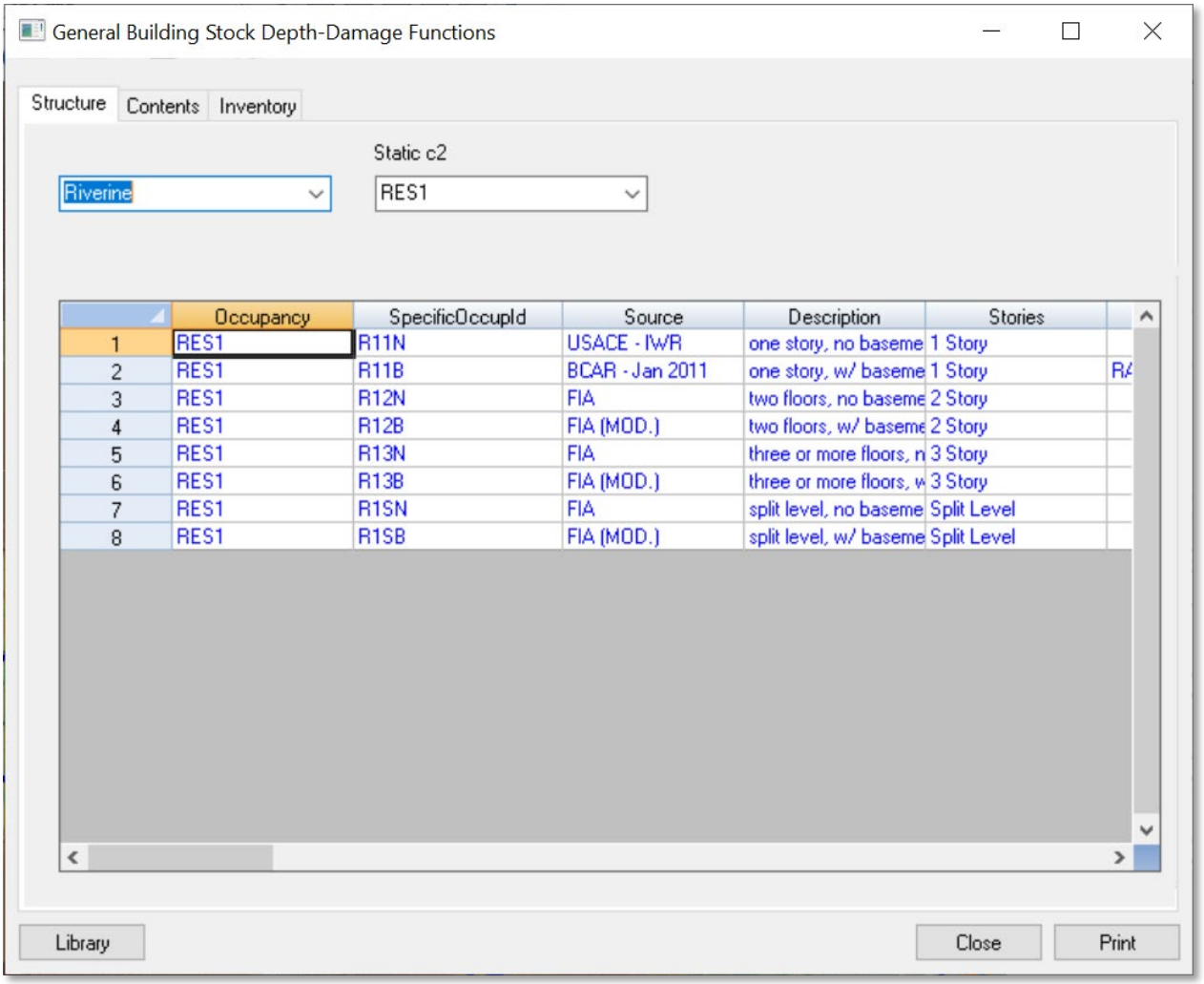


Figure 7-3 Building Depth-Damage Functions by Occupancy (Riverine) Table

Click on the **Library** button in the lower left corner of the **Building Stock Depth-Damage Functions** window. The **Structure Damage Functions** library shown in Figure 7-4 will appear. Viewing the library

of damage functions allows the user to review other damage functions applicable to the occupancy under consideration relative to the current default, as well as replace the current default with another function from the library.

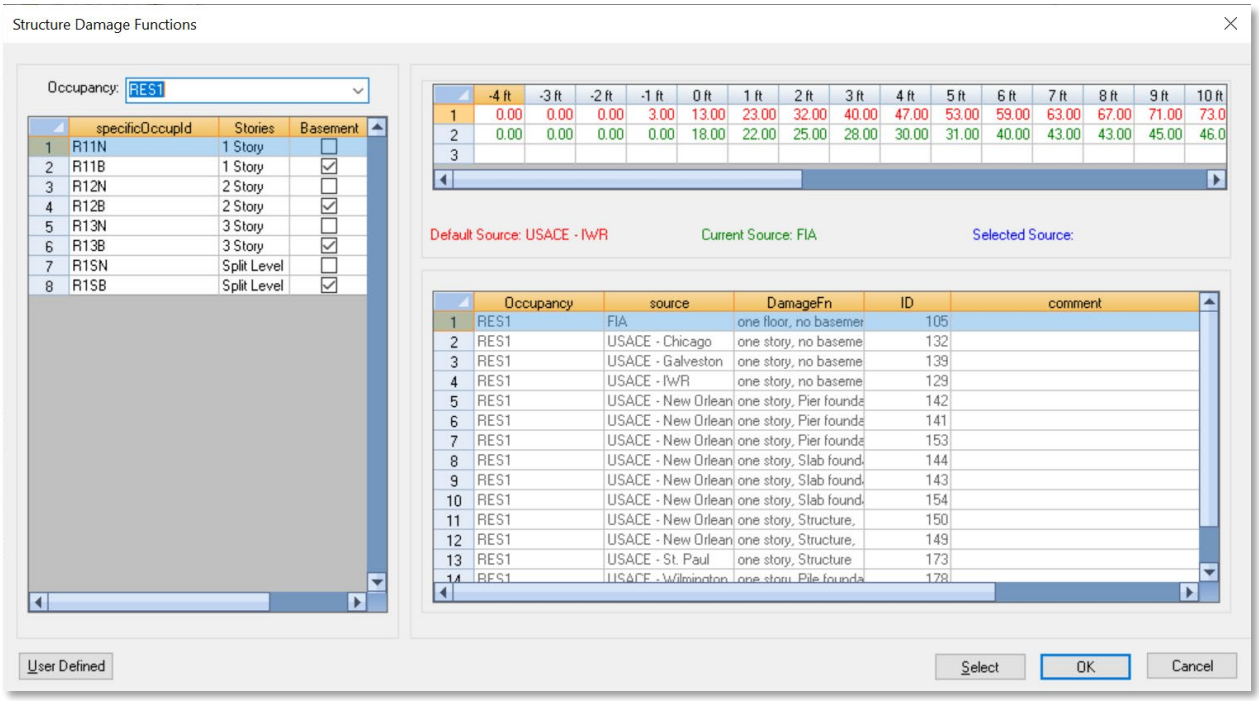


Figure 7-4 Building Depth-Damage Function Library

The Library uses color codes to help the user identify any changes and selections they may make in the dialog. The Library dialog comprises three windows.

The left window is the navigation window where the user can change between occupancies, foundation heights, and number of stories. This window allows the user to select a specific occupancy (e.g., RES1) and shift through the potential foundation types (slab on grade, fill, basement, crawlspace, pier, post, and pile) and number of stories typical for the selected specific occupancy (one-story, two-story, three-story, split level for residential and low-, mid-, and high-rise for non-residential) within that occupancy. The sub-occupancies displayed in the window (shown in the first column) are a form of shorthand that identifies the occupancy class. The shorthand was developed by taking the first letter and numeric values of the specific occupancy name (e.g., RES1 becomes R1 and COM10 become C10); this is concatenated with the value for the number of stories (e.g., two-story becomes 2 and low-rise becomes L), and finally the existence of a basement derives the last value (e.g., structures with a basement get a B and structures without a basement get an N). Therefore, the residential occupancy classified as RES1 with one story and no basement becomes R11N while the commercial occupancy classified as COM10, mid-rise, with a basement becomes C10MB.

The bottom right window is where the library of damage functions is displayed for the user to view and/or select. The user can browse between damage functions for the foundation and number of stories by selecting the sub-occupancies in the left column grid. In this case, Figure 7-4 displays all the functions available for the sub-occupancy R11N (RES1, one- Story, with no basement). Selection of C10MB (COM10, mid-rise, with basement) would display an entirely different set of damage functions in the grid on the lower right.

Finally, the window in the upper right allows the user to make comparisons and selections among the damage functions. The first row in the grid will always display the Hazus default function in red. The second line in the upper right grid displays the "current" function or any damage function that the user has highlighted in the lower window. To help the user view the current function, it is also displayed in green text. The user may want to use the "current function" line as a way of displaying a function and directly comparing it to the default damage function. Figure 7-4 displays a U.S. Army Corps of Engineers (USACE) New Orleans District damage function (highlighted row 10) for RES1, one- story, slab on grade. The third row in the upper right grid displays any function the user may have "selected" as their damage function. That is, a damage function the Flood Model will use rather than the default damage function. This is how the user can override the default damage functions with either a library function that they believe better represents the local area or a custom function they have built themselves as described below.

Figure 7-5 displays a USACE New Orleans District damage function (lower right grid, blue text RES1, one-story, pier foundation) that was selected in place of the default function. If the user chooses, they may use one of the library functions to build their own custom damage function. To do this, click the **User Defined** button in the lower left corner of the dialog. When the user selects this button, the Flood Model takes the highlighted damage function, if any, and opens an editable dialog (Figure 7-6) for the user to make modifications. The Flood Model inserts the damage function description from the starting damage function the user selected (or the default damage function if none is selected) and adds a comment that identifies the original source damage function. This allows the user to remember where they started the process. The user is required to enter a source (or name) for the damage function. Editing of the **Enter Comment** or **Enter DmgFn Description** fields is not recommended.

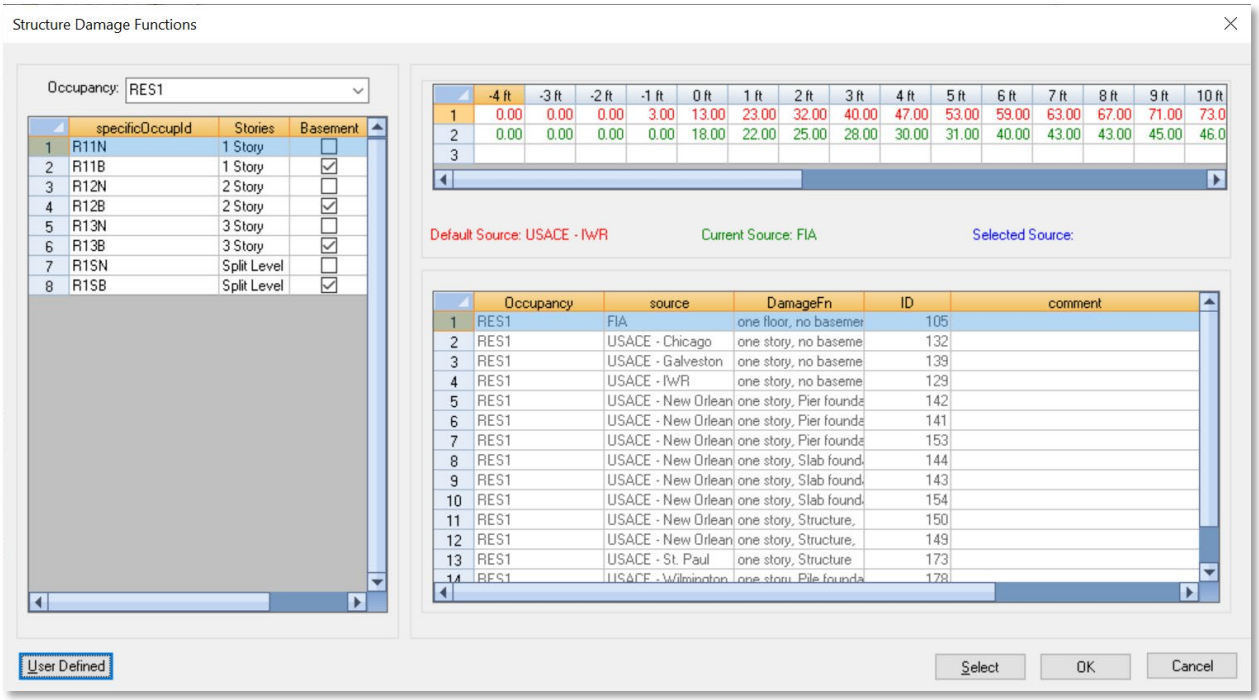


Figure 7-5 Building Depth-Damage Function Library User-Defined Option

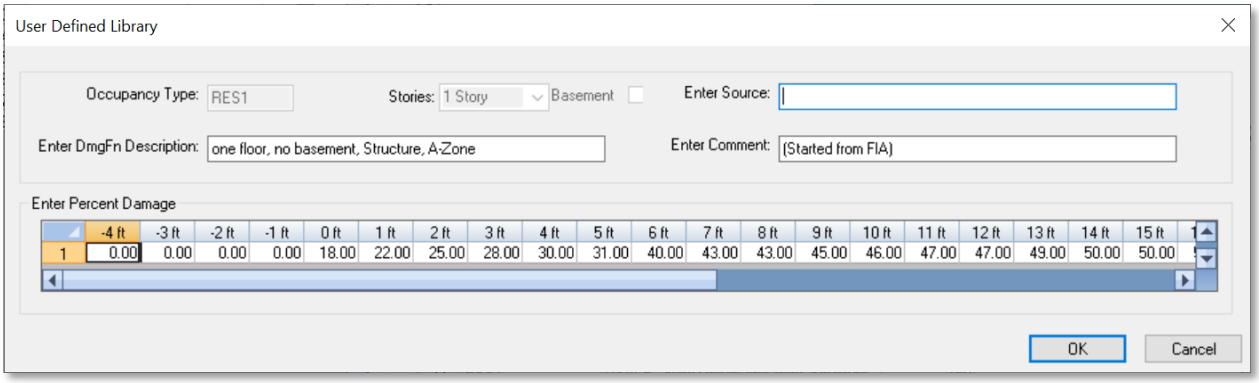


Figure 7-6 Editing Dialog for User-Defined Function Development

If the user has decided to select a new damage function for use in the Flood Model, the entry dialog will highlight the damage function to remind the user that a default function is not being used. Figure 7-7 shows how the change would appear in the entry dialog as compared to that shown earlier in this section in Figure 7-3 using a User-Defined Depth-Damage Function.

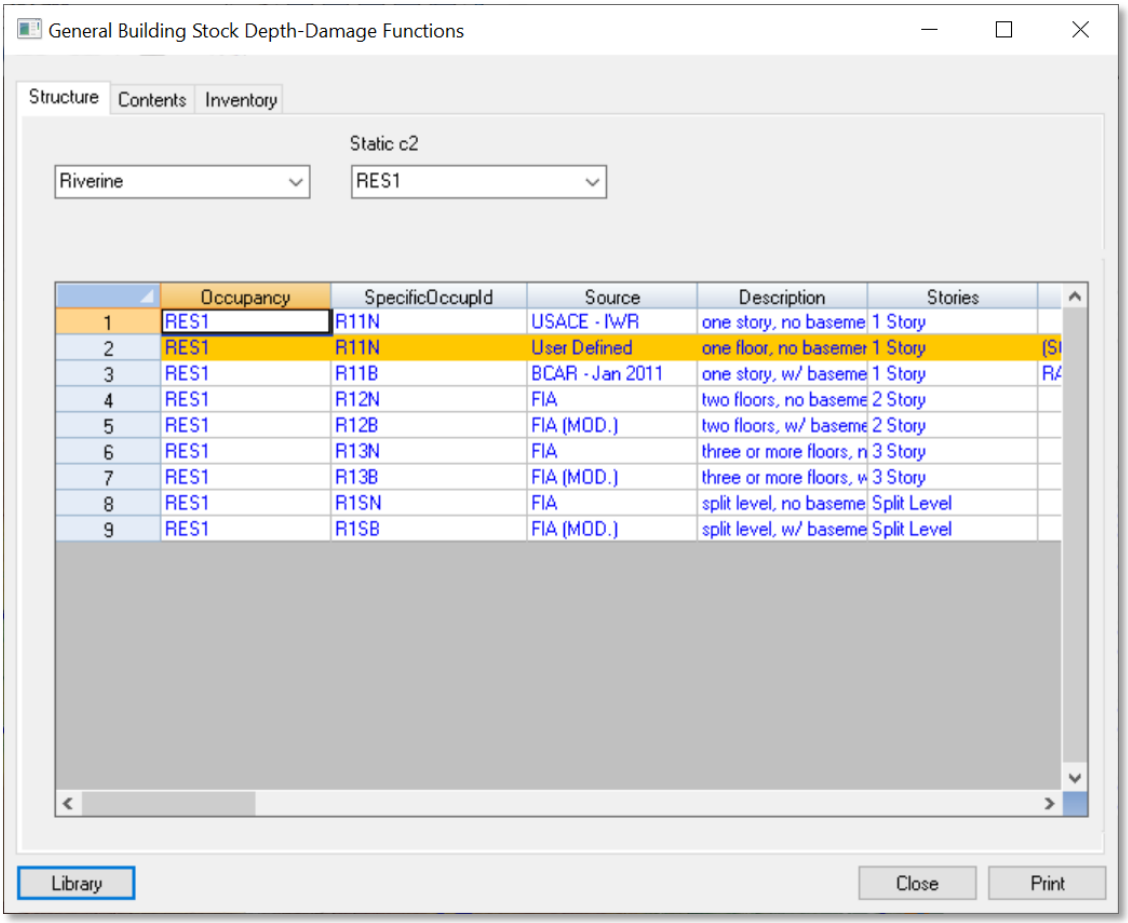


Figure 7-7 Building Depth-Damage Function Dialog with a User-Defined Damage Function

Similar default damage functions are available for other facilities from the **Damage Functions** menu, as shown in Figure 7-8 below. The damage function dialogs for **Essential Facilities** function in the same way as those discussed above for the **General Building Stock**. In most cases, the damage functions available in the **Essential Facilities** dialog area also available for the Government structures in GBS. The **Essential Facilities** dialog does not have an inventory tab because the Essential Facilities occupancies do not produce inventory for sale.

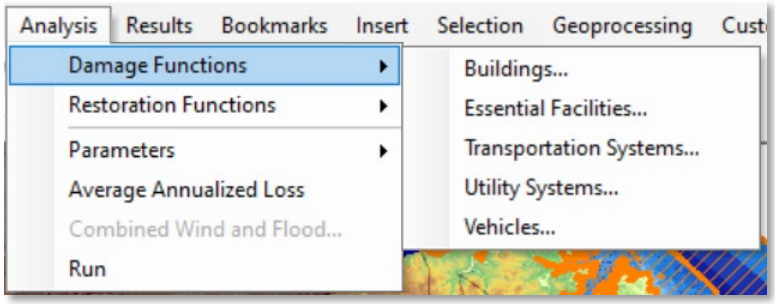
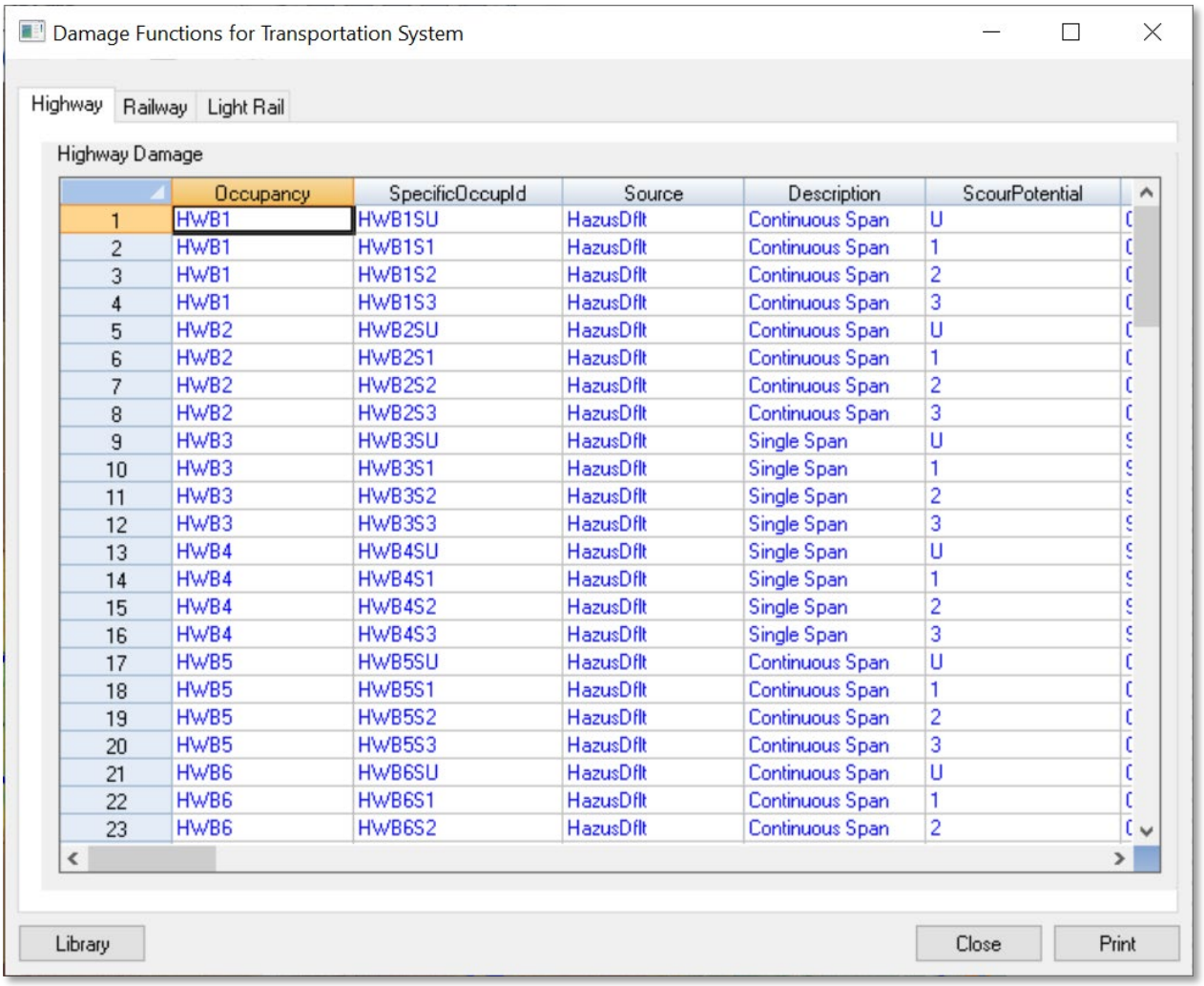


Figure 7-8 Analysis > Damage Functions Menu

The **Transportation Systems** damage function dialog looks slightly different as there is only a structure damage function (no contents or inventory), and the dialog's tabs allow the user to shift between highway, railway, and light rail facilities.

- Currently, the Flood Model has damage functions for bridges only related to highway, railway, and light rail facilities.
- The **Transportation Systems** damage functions for bridges are based on return period. An analysis cannot be performed on bridges if the user assigns mixed return periods on the selected reaches. In other words, if the user assigns a different return period to each reach, or a single discharge on the reaches, the Flood Model will not be able to analyze the bridges.

Figure 7-9 shows the **Damage Functions for Transportation System** table, which has the same table columns for highway, railway, and light rail facilities.



	Occupancy	SpecificOccupId	Source	Description	ScourPotential
1	HWB1	HWB1SU	HazusDflt	Continuous Span	U
2	HWB1	HWB1S1	HazusDflt	Continuous Span	1
3	HWB1	HWB1S2	HazusDflt	Continuous Span	2
4	HWB1	HWB1S3	HazusDflt	Continuous Span	3
5	HWB2	HWB2SU	HazusDflt	Continuous Span	U
6	HWB2	HWB2S1	HazusDflt	Continuous Span	1
7	HWB2	HWB2S2	HazusDflt	Continuous Span	2
8	HWB2	HWB2S3	HazusDflt	Continuous Span	3
9	HWB3	HWB3SU	HazusDflt	Single Span	U
10	HWB3	HWB3S1	HazusDflt	Single Span	1
11	HWB3	HWB3S2	HazusDflt	Single Span	2
12	HWB3	HWB3S3	HazusDflt	Single Span	3
13	HWB4	HWB4SU	HazusDflt	Single Span	U
14	HWB4	HWB4S1	HazusDflt	Single Span	1
15	HWB4	HWB4S2	HazusDflt	Single Span	2
16	HWB4	HWB4S3	HazusDflt	Single Span	3
17	HWB5	HWB5SU	HazusDflt	Continuous Span	U
18	HWB5	HWB5S1	HazusDflt	Continuous Span	1
19	HWB5	HWB5S2	HazusDflt	Continuous Span	2
20	HWB5	HWB5S3	HazusDflt	Continuous Span	3
21	HWB6	HWB6SU	HazusDflt	Continuous Span	U
22	HWB6	HWB6S1	HazusDflt	Continuous Span	1
23	HWB6	HWB6S2	HazusDflt	Continuous Span	2

Figure 7-9 Transportation Damage Function Table

Figure 7-10 shows the **Damage Functions For Utility System** table. As with the **Transportation Systems**, the tabs allow the user to choose the utility type for review. Note, there are no communication facility damage functions currently available.

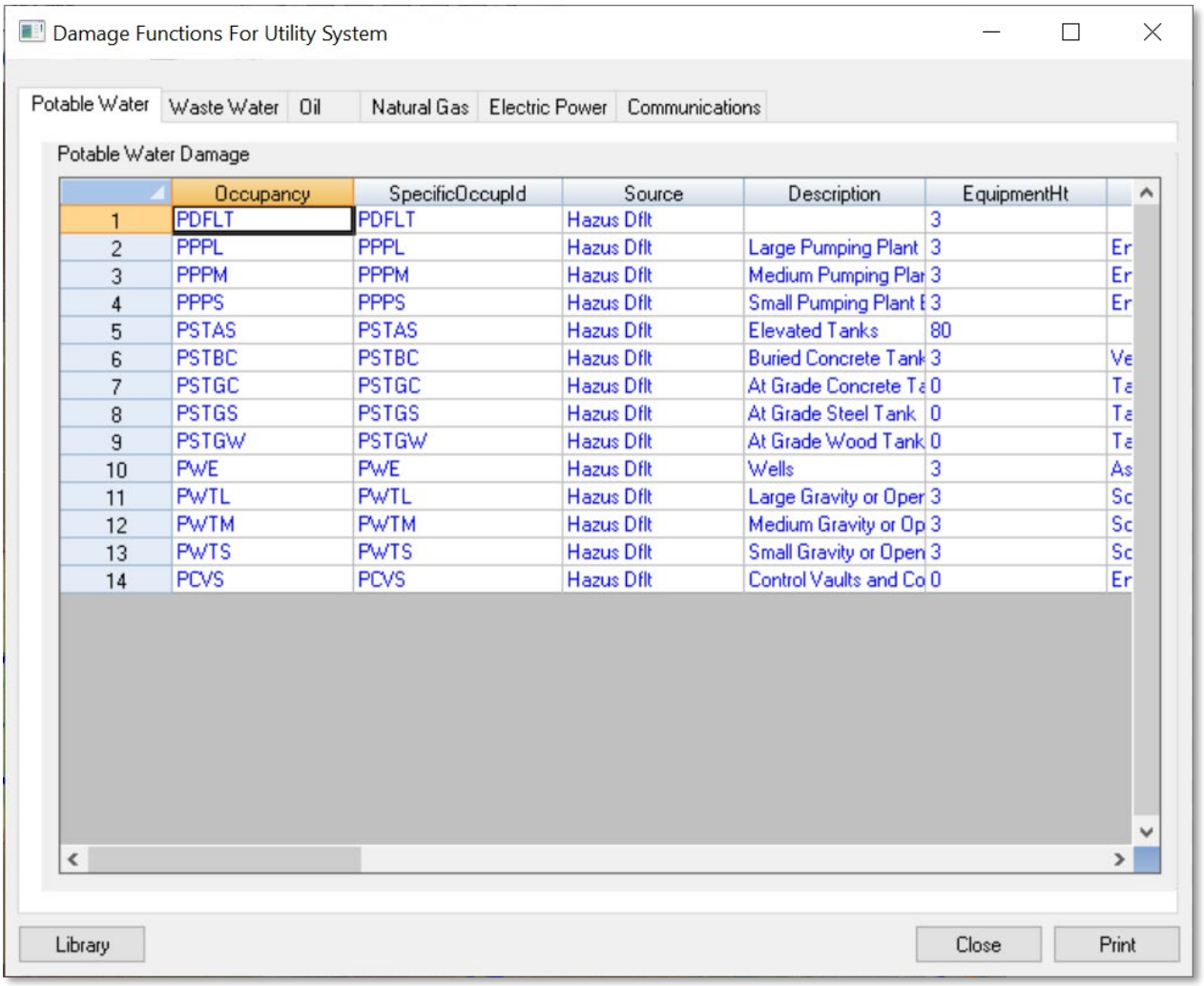


Figure 7-10 Utility Facility Damage Function Table

Figure 7-11 shows the **Damage Functions For Vehicles** table.

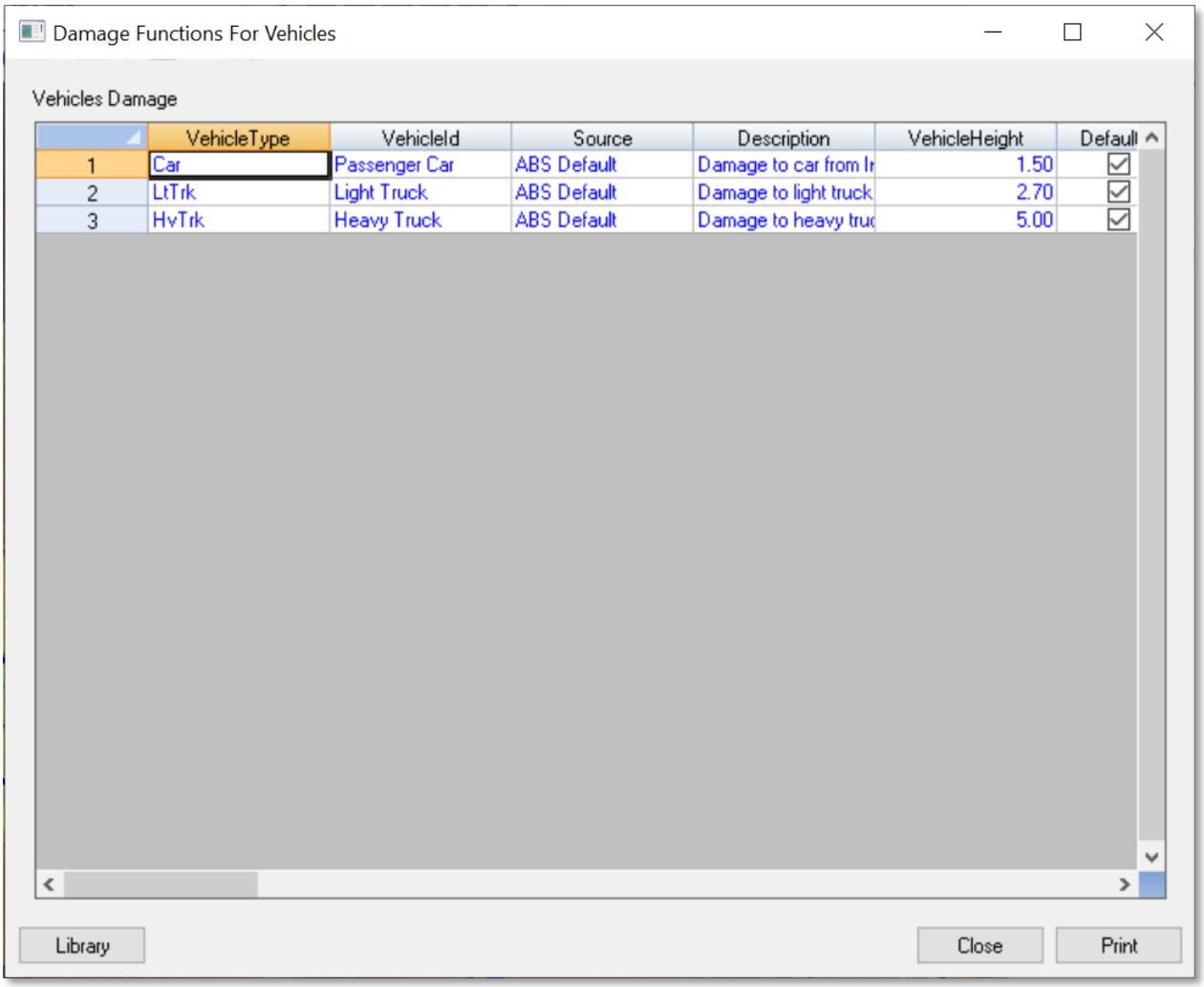


Figure 7-11 Vehicle Damage Functions Table

7.2 Restoration Functions

The Flood Model provides restoration functions for GBS and Essential Facilities. The GBS restoration functions are discussed in the **Analysis > Parameters** menu discussion, as the GBS values are included in the **Direct Economic** parameter tables. Built from the restoration timelines for the related GBS occupancies, the Essential Facilities restoration models provide the user with a general indication of the *maximum* restoration time for 100% operations. Obviously, there will be a great deal of effort to quickly restore Essential Facilities to full functionality and therefore, this will be an indication of the maximum downtime.

Selecting **Essential Facilities** from the **Analysis / Restoration Functions** menu (Figure 7-12) opens the dialog shown in Figure 7-13. In this case, the figure shows the dialog on the **Medical Care Facilities** tab. The **Restoration Functions** are editable, and the user can adjust the **MaxDaysToRestoration**

column and the **FunctionalDepth** column (scroll to the right). These values are based on the depth of flooding at the specific facility (the latitude and longitude).

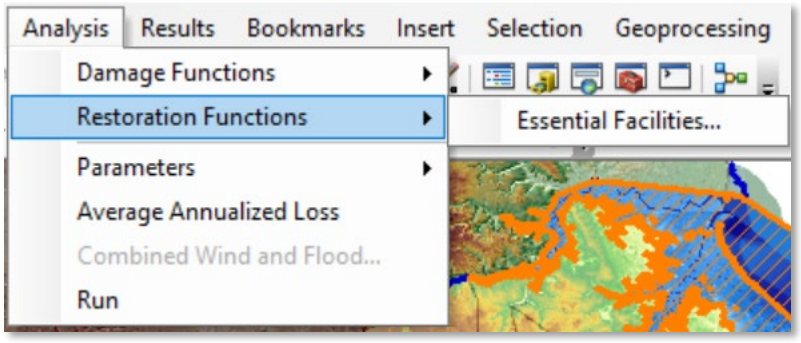
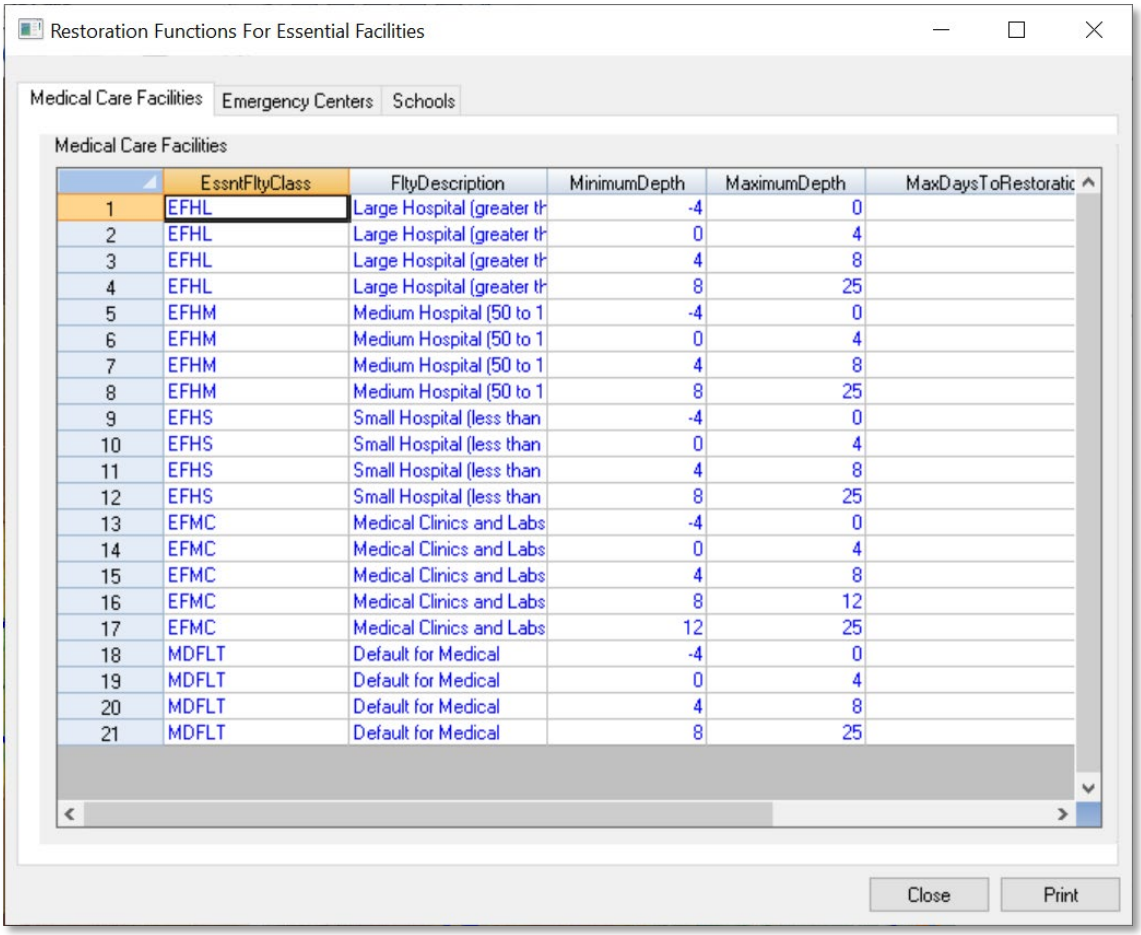


Figure 7-12 Analysis > Restoration Functions Menu



	EssntFltyClass	FltyDescription	MinimumDepth	MaximumDepth	MaxDaysToRestoratic
1	EFHL	Large Hospital (greater th	-4	0	
2	EFHL	Large Hospital (greater th	0	4	
3	EFHL	Large Hospital (greater th	4	8	
4	EFHL	Large Hospital (greater th	8	25	
5	EFHM	Medium Hospital (50 to 1	-4	0	
6	EFHM	Medium Hospital (50 to 1	0	4	
7	EFHM	Medium Hospital (50 to 1	4	8	
8	EFHM	Medium Hospital (50 to 1	8	25	
9	EFHS	Small Hospital (less than	-4	0	
10	EFHS	Small Hospital (less than	0	4	
11	EFHS	Small Hospital (less than	4	8	
12	EFHS	Small Hospital (less than	8	25	
13	EFMC	Medical Clinics and Labs	-4	0	
14	EFMC	Medical Clinics and Labs	0	4	
15	EFMC	Medical Clinics and Labs	4	8	
16	EFMC	Medical Clinics and Labs	8	12	
17	EFMC	Medical Clinics and Labs	12	25	
18	MDFLT	Default for Medical	-4	0	
19	MDFLT	Default for Medical	0	4	
20	MDFLT	Default for Medical	4	8	
21	MDFLT	Default for Medical	8	25	

Figure 7-13 Essential Facilities Restoration Functions Table

7.3 Parameters

There are several parameters the user may want to view and/or modify before starting the analysis. This section walks the user through the available parameters. Every effort has been made to provide default values wherever possible, which allow the model to perform most requested analysis without user intervention.

The **Analysis > Parameters** menu appears in Figure 7-14. The menu provides access to the default parameters used in the analysis of **Debris**, **Shelter**, **and Direct Economic**.

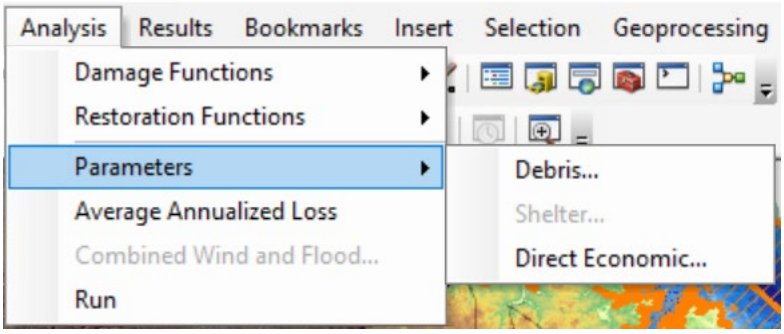


Figure 7-14 Analysis > Parameters Menu

Selection of the **Debris** menu item opens an editable **Debris Parameters** dialog (Figure 7-15) that allows the user to view the default debris values. Debris is estimated based on the depth of flooding within the structure, like the estimation of GBS damage, specific occupancy, and whether the foundation has a footing or a slab. The user can use the combo boxes to shift between specific occupancies and the foundation types.

Debris is estimated in three main classifications that align loosely with the earthquake models method of classification: finishes (dry wall, flooring, insulation, etc.), structure (framing, walls, exterior cladding), and foundation weight (concrete slab, concrete block, or other foundation). Unlike the earthquake model, where moderate damage may still result in the foundation being removed, flooding requires the structure to be considered substantially damaged before the foundation is removed. The weights are in tons per thousand square feet of the structure.

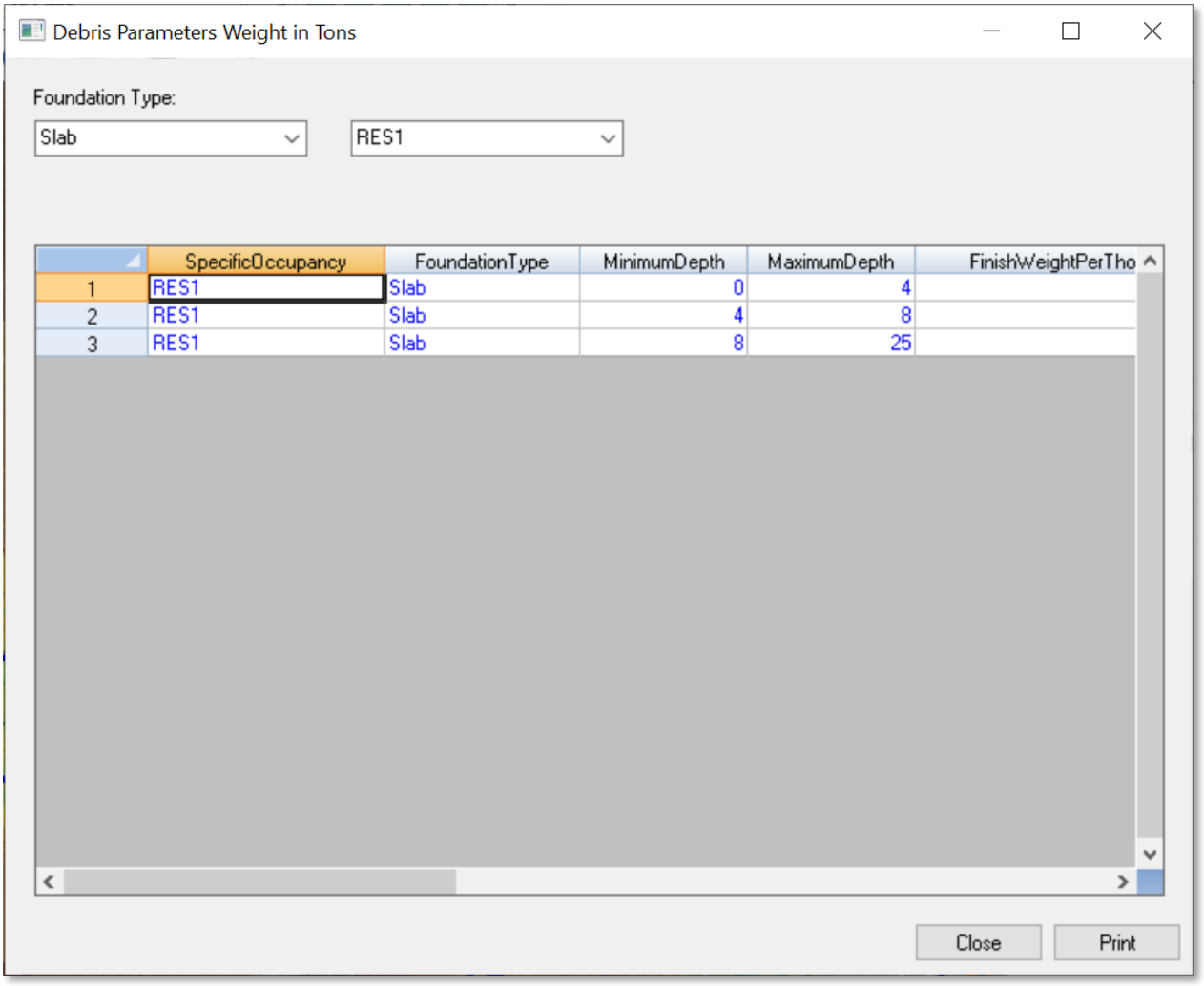


Figure 7-15 Debris Analysis Parameters Table

The **Direct Economic** parameter menu item opens the **Direct Economic Loss Parameters** dialogs, which includes three tabs shown in Figure 7-16 through Figure 7-18. This dialog provides the user with access to the default parameters that control the estimation of the direct damages to the GBS. This includes the impact of the flood scenario on the wages, income, inventory, and maximum restoration time for the GBS. The **Business Inventory** tab defines the amount of inventory in the Study Region based on the square footage of specific Census blocks.

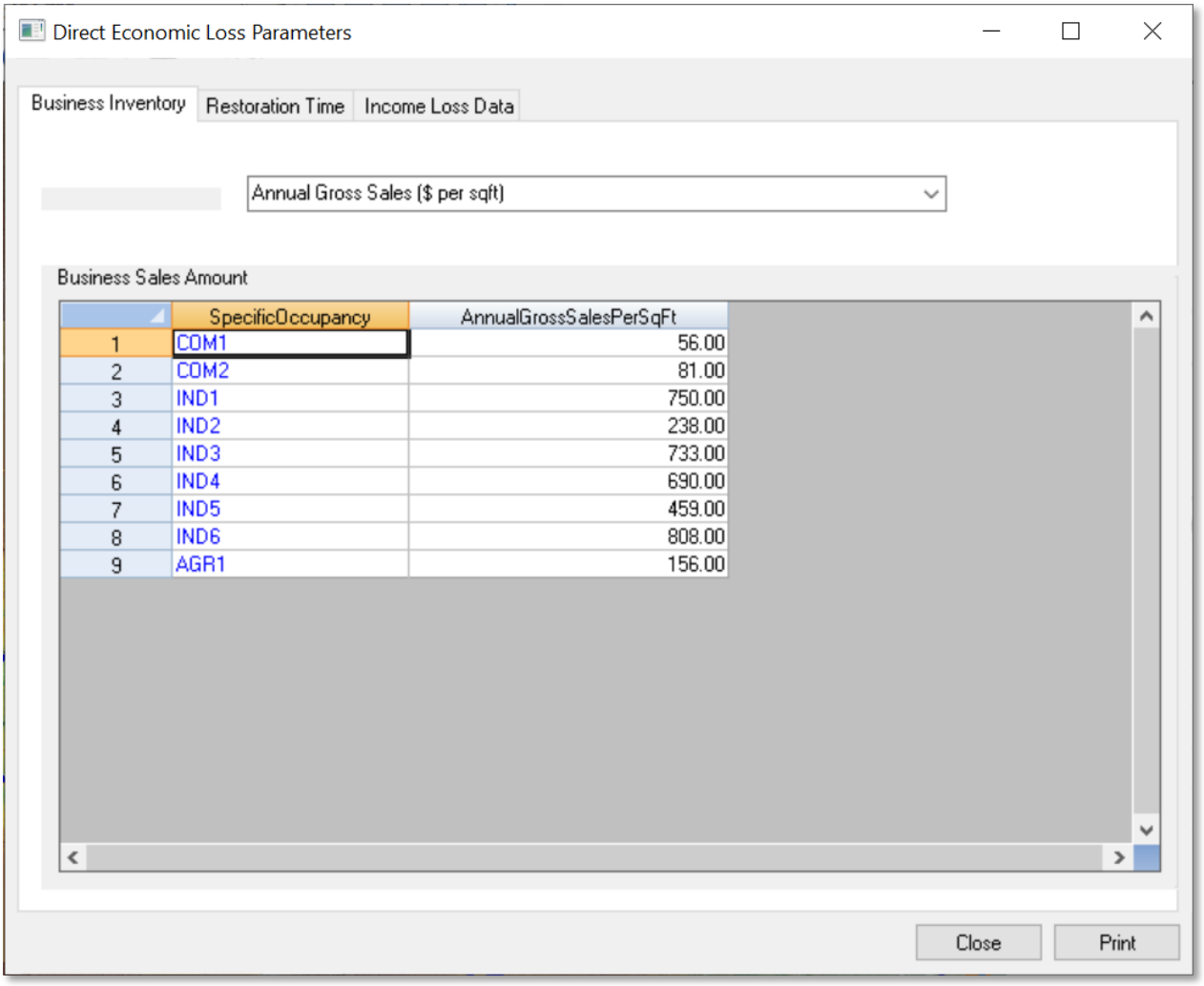


Figure 7-16 Direct Economic Loss – Business Inventory Table

The GBS restoration functions define the maximum amount of time it should take for any given specific occupancy to be restored. For example, in Figure 7-17 the RES1 restoration time is based on the depth of flooding within the structure. In the case of RES1, even though the water has not fully entered the structure, it may take up to a year to clean up the structure, replace any sub-flooring that may be damaged, obtain permits, and perform inspections. This is a maximum timeline meant to provide a conservative estimate for the losses associated with the restoration process.

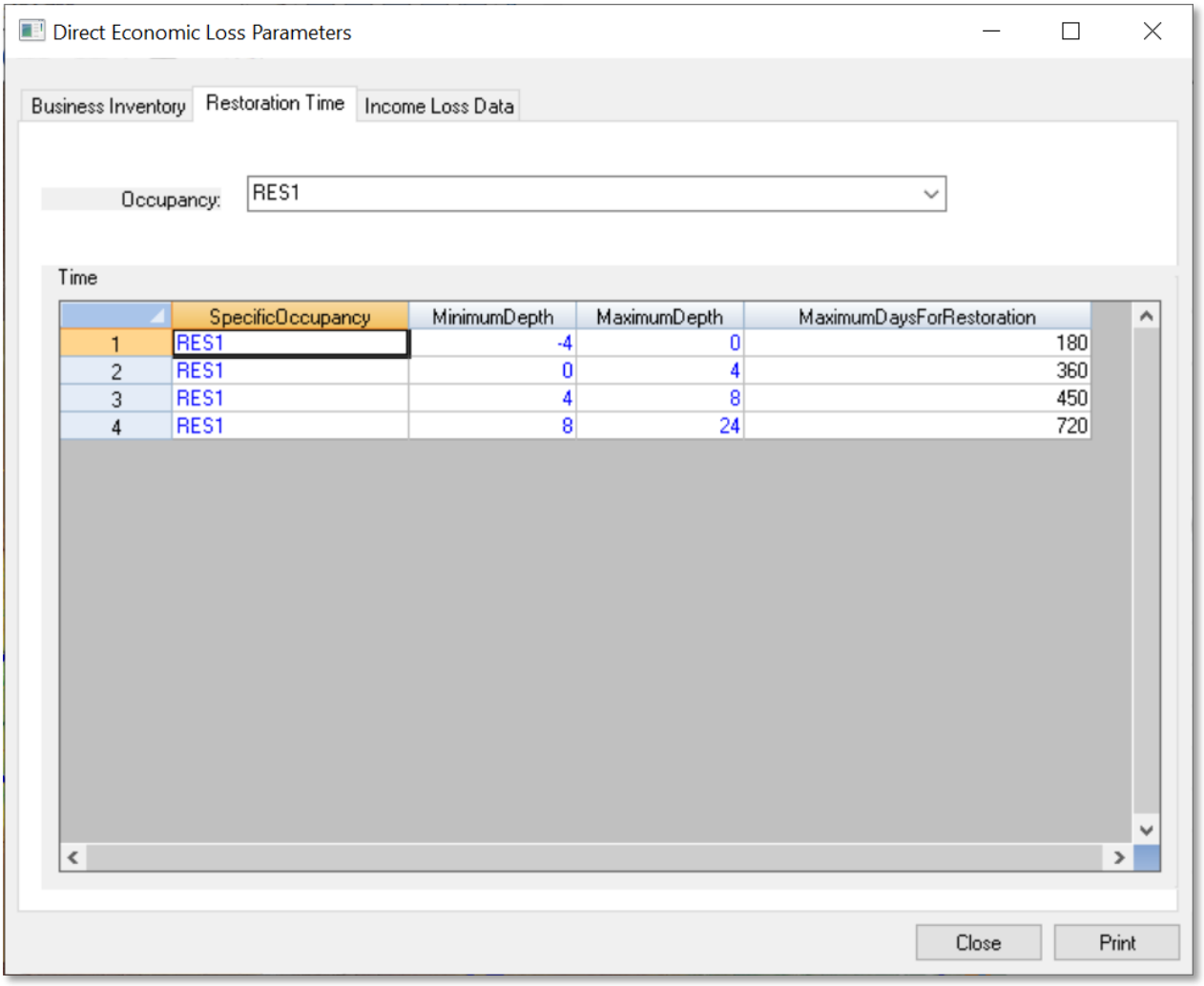


Figure 7-17 Direct Economic Loss –Restoration Time Table

Figure 7-18 shows some additional parameters used to develop the direct losses for wages and capital income presented in the GBS economic losses.

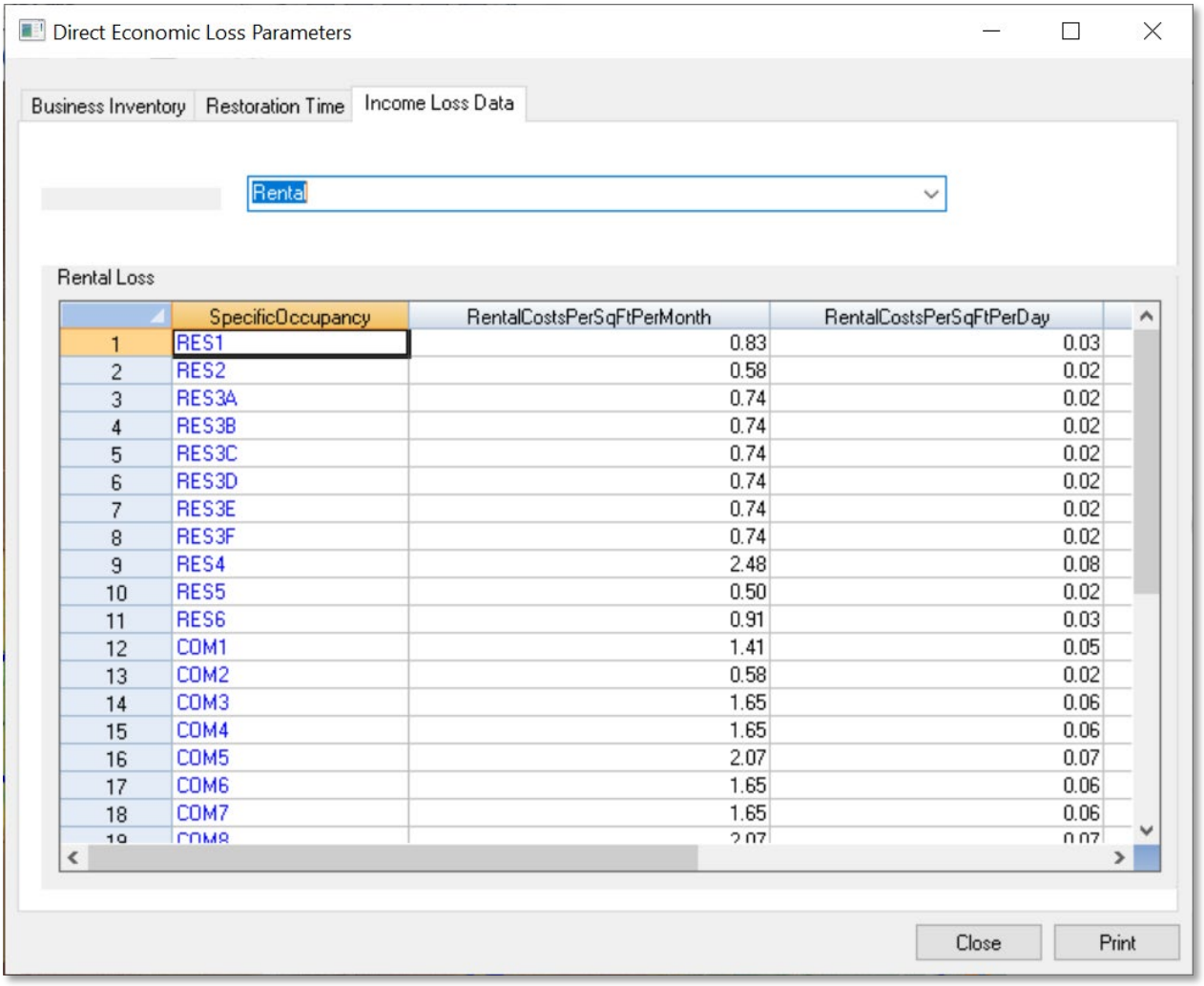


Figure 7-18 Direct Economic Loss – Rental, Owner-Occupied, Wages and Capital, and Recapture Features Table

7.4 Annualized Loss

Average Annualized Loss Menu, shown in Figure 7-19, is the calculation step where a user combines a series of individual recurrence interval losses into an additional estimate for annual loss. This analysis is performed after the user has performed a **Full Suite of Return Periods** analysis in the **Hazard** menu (as shown in Figure 7-20 and Figure 7-21 for riverine and coastal analysis) and has performed a loss analysis in the **Analysis > Run** menu.

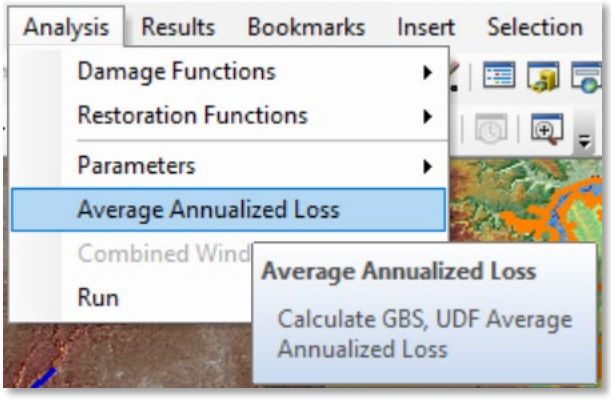


Figure 7-19 Analysis > Average Annualized Loss Menu

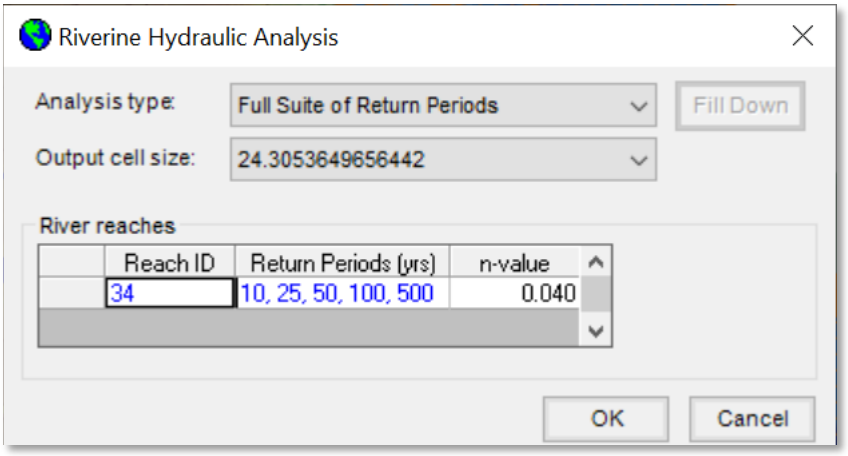


Figure 7-20 Riverine Flood Full Suite of Return Periods Analysis

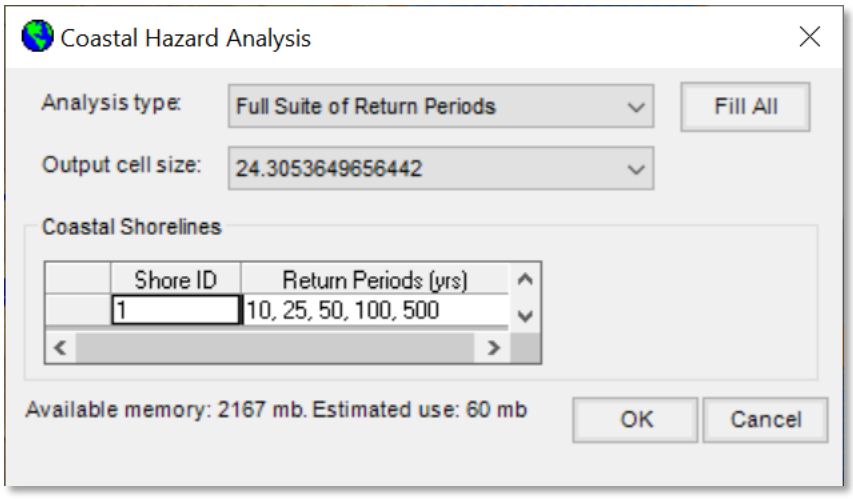


Figure 7-21 Coastal Flood Full Suite of Return Periods Analysis

The user has the option of performing average annualized loss calculations for either GBS or UDF data, as shown in the **Average Annualized Loss Analysis** dialog (Figure 7-22) if loss analysis has been performed for the five required events (10-, -25-, 50-, 100-, and 500-year).

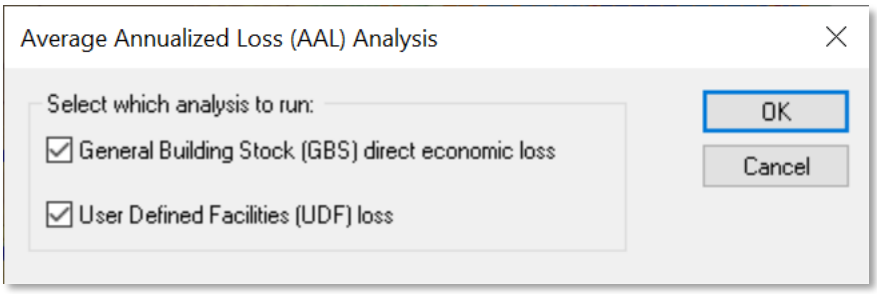


Figure 7-22 Average Annualized Loss Analysis Dialog

If the user has not performed the required loss analysis prior to trying to run the Average Annualized Loss (AAL), Hazus will produce the error messages shown in Figure 7-23 and Figure 7-32 requesting the user to perform these prerequisite analyses.

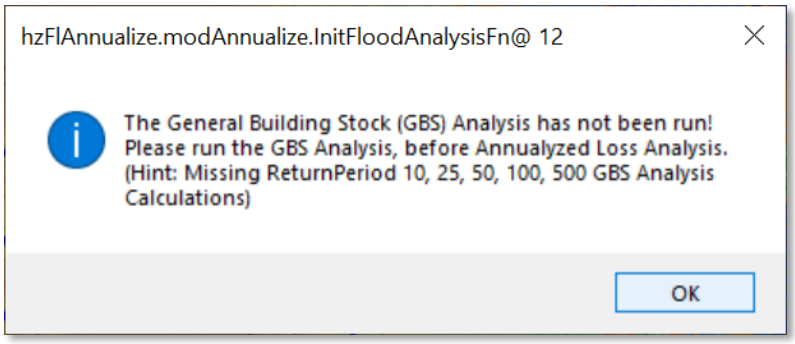


Figure 7-23 Average Annualized Loss GBS Error Dialog

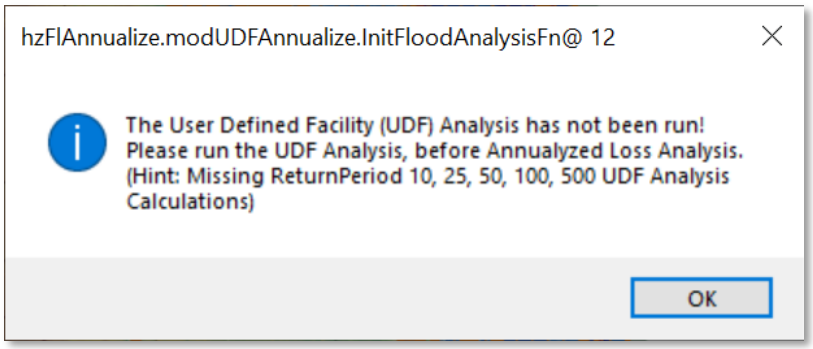


Figure 7-24 Average Annualized Loss UDF Error Dialog

7.5 Combined Wind and Flood

The **Combined Wind and Flood** menu (Figure 7-25) will become activated when a user has performed the prerequisite analysis for a storm surge analysis in both the Hurricane Model and Flood Model. See Section 11 for more details on all the steps to perform this type of analysis.

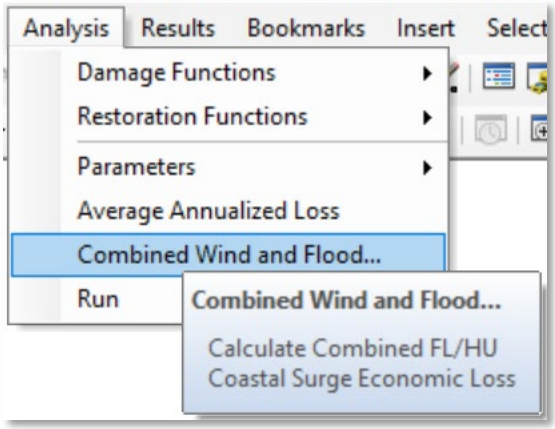


Figure 7-25 Analysis > Combined Wind and Flood Menu

7.6 Run

Once the user parameters have been selected or modified, select **Run** from the **Analysis** menu (Figure 7-26). The Analysis Options dialog shown in Figure 7-27 will appear. Clicking on the plus and minus signs will expand and collapse the lists of available options, respectively. Click on the boxes of the desired analysis options. A check mark will appear to indicate the options have been selected. Note that some analysis options have pre-requisite analysis requirements and selection of those options will automatically check the box of the prerequisites. At the bottom of the dialog, Hazus will indicate the amount of hard drive disk space available on the machine and the percentage of the Study Region's database that has been used thus far. The Study Region's database has a limit of 10 GB; therefore, if the percentage used is more than 50%, less than 5 GB of space is available for the analysis.

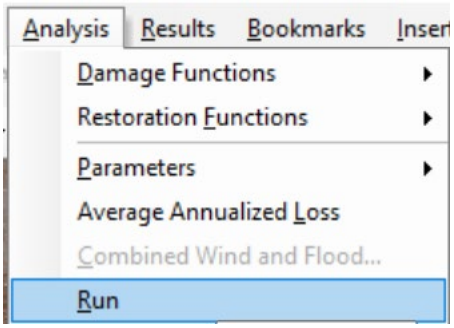


Figure 7-26 Analysis > Run Menu

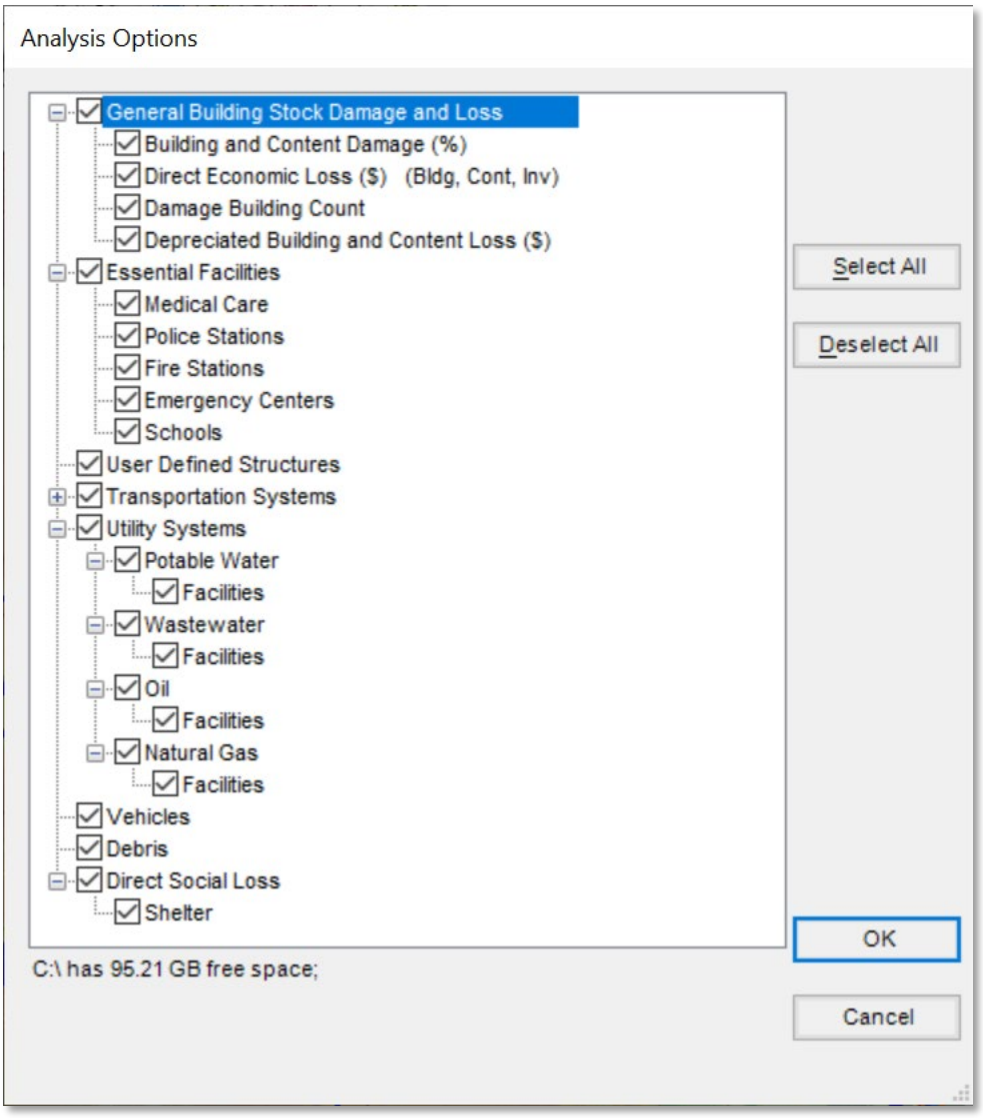


Figure 7-27 Select Analysis Options

Hazus can conduct default analysis runs for the following items:

- GBS
- Essential facilities
- Selected infrastructure, including highway bridges and water systems
- Vehicles
- Debris
- Shelter requirements

The types of baseline data provided for the Study Region limit the type of analysis that can be run. To run a What-If analysis, the same analysis must have been run from the hazard menu. When the desired analysis options have been selected, click **OK**.

- When running the Analysis, the **Hazus** screen might go blank, or the Task Manager **Applications** tab will indicate that **Hazus** is not responding. This is a common occurrence for any software process-heavy software. To see whether **Hazus** is still running, check the Task Manager **Processes** tab and sort the **CPU** column in descending order. The "sqlservr.exe" process should be on top. If the "System Idle Process" is constantly on top at 99–100%, **Hazus** is not responding. Also, check the **Performances** tab and make sure the CPU Usage is not 0 over a period of time. Another option is to open the scenario folder (in "Details" view within Windows Explorer) and make sure the FlAnalysisLog is updating by looking at the "Date modified."

- Running the Analysis, specifically the General Building Stock Damage and Loss, can take up too many hours to process and successfully complete.

For users who would like to view the intermediate analysis completion status, go to **Customize** menu and select **Flood Options** (as shown in Figure 7-28), and check the **Show redo analyses Warning message box(es)** checkbox (example shown in Figure 7-29). This option only applies if the user is redoing the analyses.

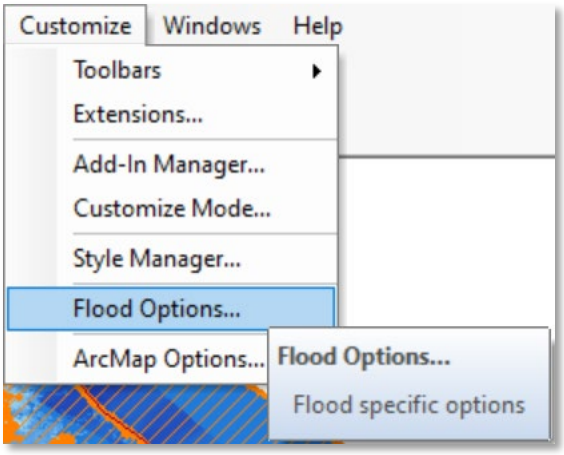


Figure 7-28 Customize > Flood Options Menu

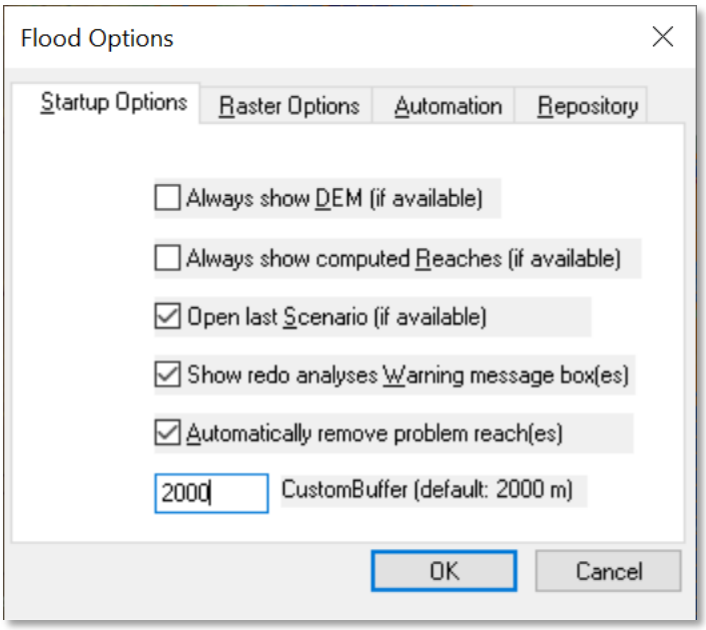


Figure 7-29 Check Show Redo Analyses Warning Message Box(es)

Section 8. Model Menu: Results

The **Results** menu (Figure 8-1) within Hazus has several analysis types and menus from which to choose. These options enable the user to select the appropriate results to review in the Study Region. This section explains each selection and menu to further the user's understanding of these options.

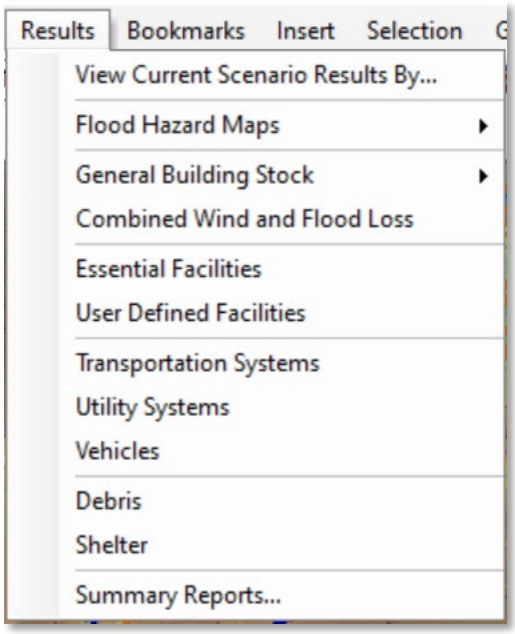


Figure 8-1 Results Menu

8.1 View Current Scenario Results By

Once the loss analysis has been run, the next step is to view the results. The first option within the **Results** menu (Figure 8-2) is **View Current Scenario Results By...**. Selecting this option activates the **View Results by** window shown in Figure 8-3. Select one of the **Available Results**. No results can be viewed until a hazard analysis has been selected.

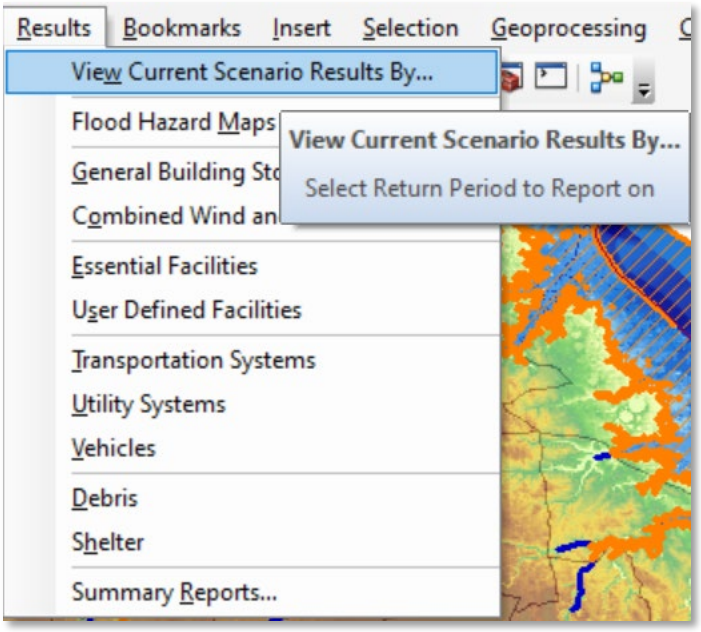


Figure 8-2 Results > View Current Scenario Results By Menu

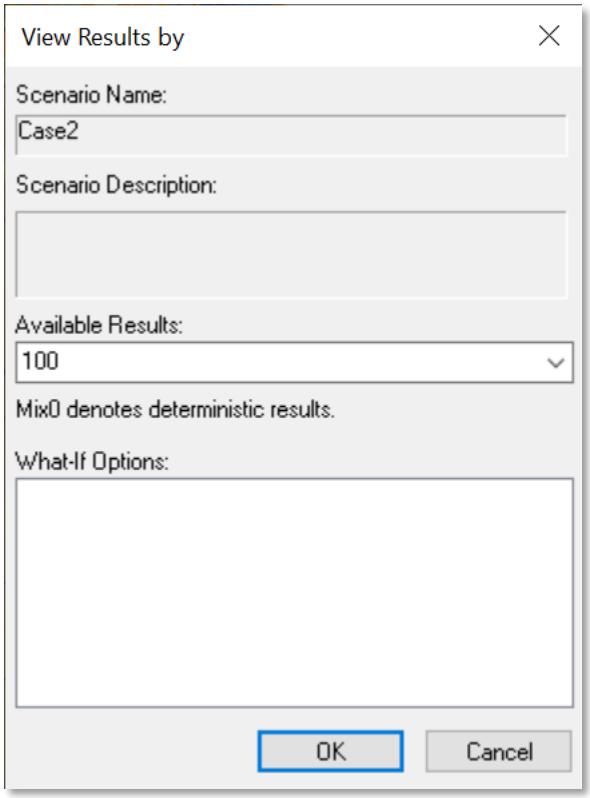


Figure 8-3 Select Available Results

8.2 Flood Hazard Map

To map the flood depth grid and floodplain boundary for the current scenario and return period/discharge(s), select **Thematic Map of Depth** from the **Results > Flood Hazard Maps** menu. The flood depth grid will be displayed in blue. The floodplain boundary will be displayed in orange in the main Flood Model map window.

In the **Results > Flood Hazard Maps** menu (Figure 8-4), **Thematic Map of Depth**, will add specific symbolized layers to the map. This option can be used as visualization tools to understand specific spatial patterns in the Study Region.

Hazus automatically maps the flood depth grid and floodplain boundary for one of the available depth grids when the hazard is computed, but other flood depth grids are available to be mapped that may have also been computed.

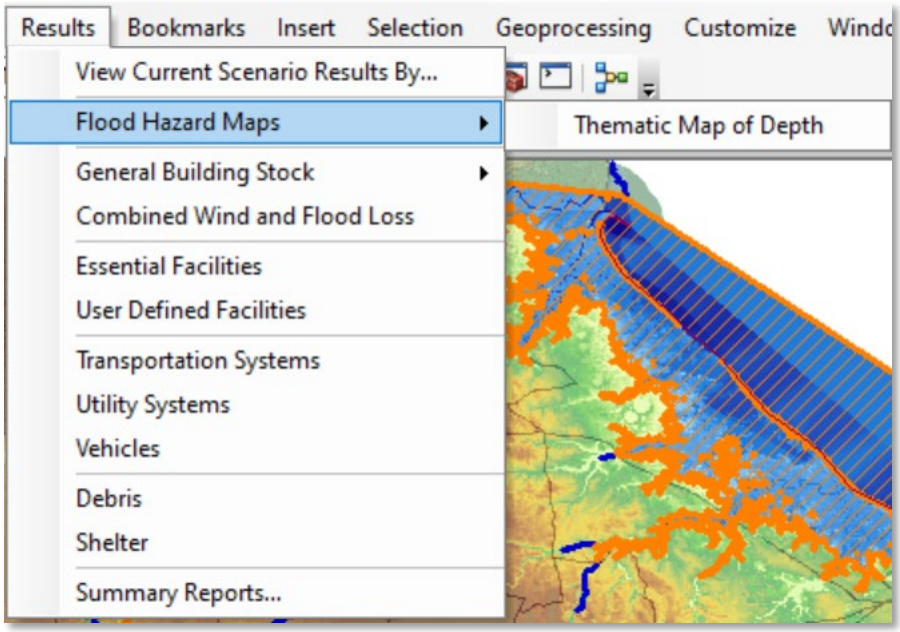


Figure 8-4 Results > Flood Hazard Maps Menu

8.3 General Building Stock Damage

To view and map the general inventory damage results **By Occupancy, By Building Type, By Count** and by **Economic Loss**, select **General Building Stock** from the **Results** menu (Figure 8-5).

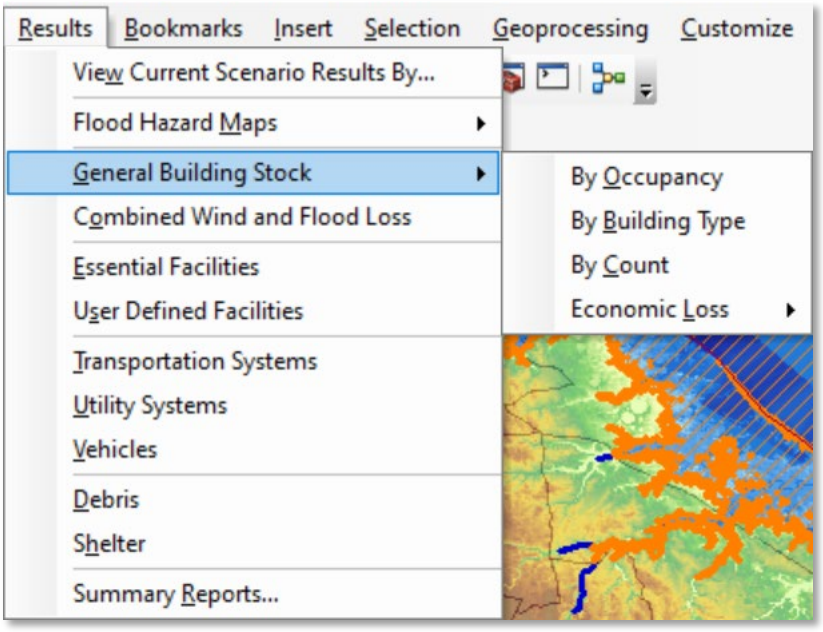
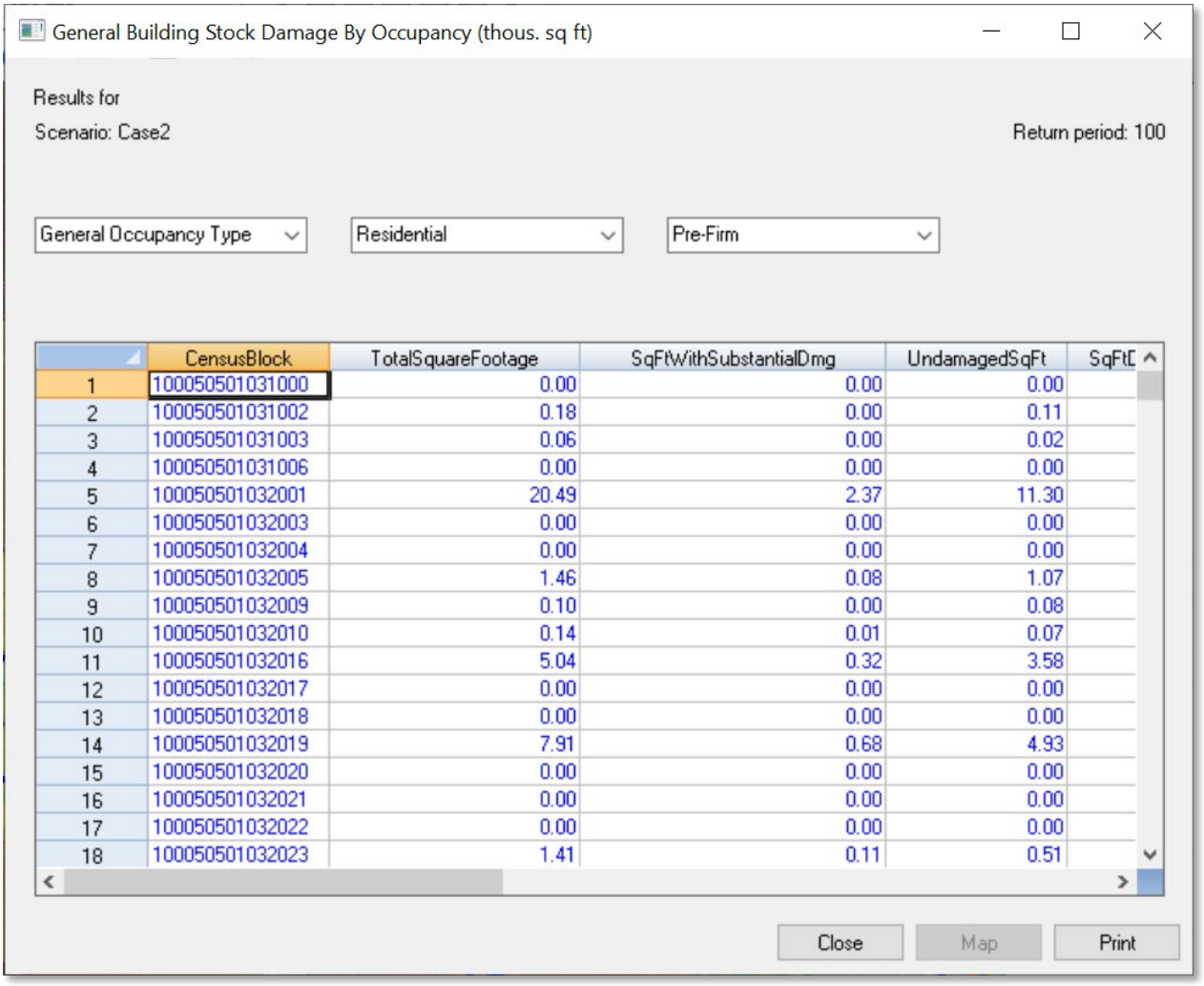


Figure 8-5 Results > General Building Stock Menu

8.3.1 General Building Stock Damage by Occupancy

Select **By Occupancy** from the **Results** > **General Building Stock** menu (Figure 8-5) to view and map tabular damage results by Census block. The user can show values based on **General Occupancy Type** or **Specific Occupancy Type** and choose between **Pre-Firm**, **Post-Firm**, or **All** (Figure 8-6). Select a specific column with numeric values in the table and click the **Map** button to map the tabular results. Mapped results will appear on the screen.

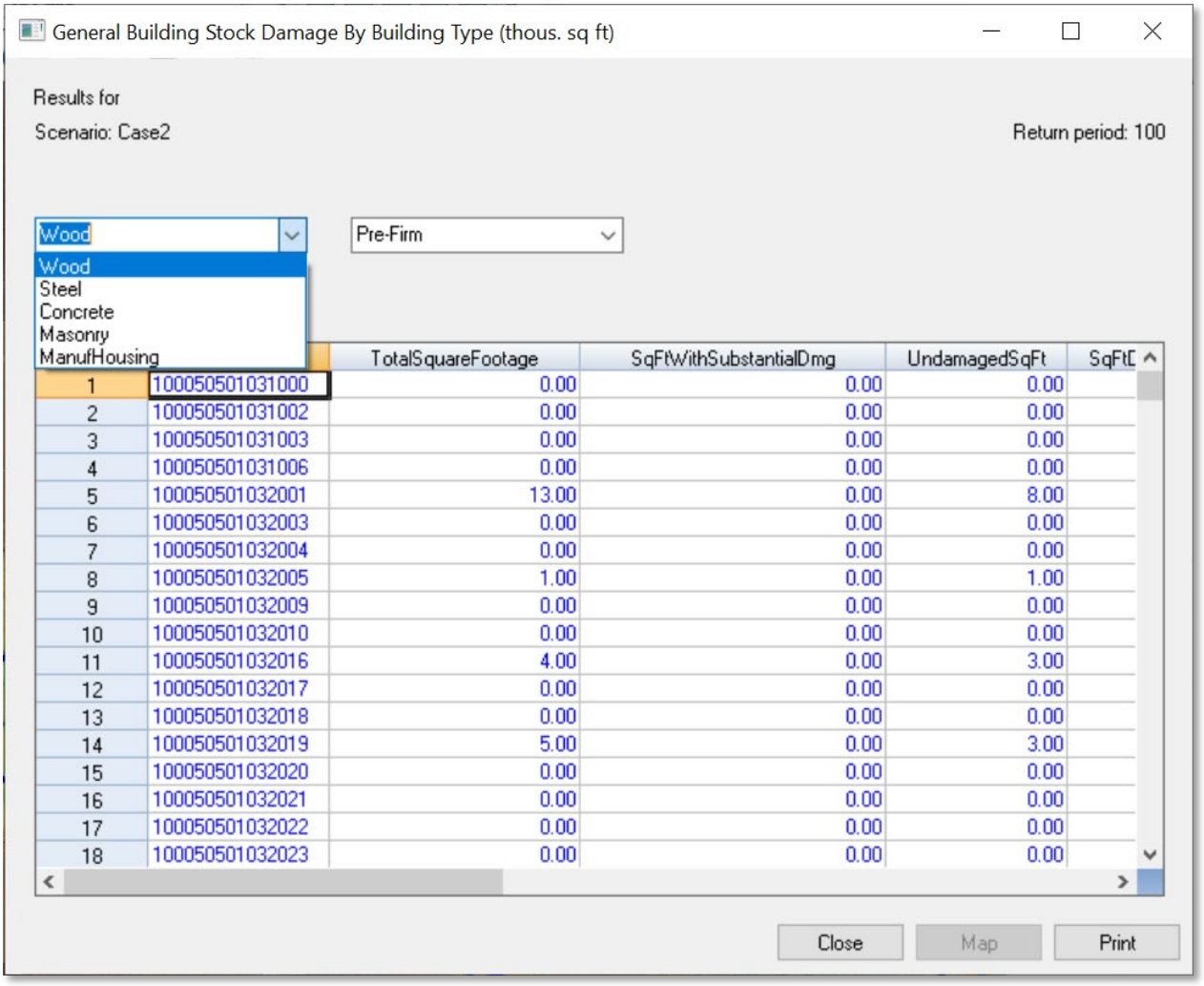


	CensusBlock	TotalSquareFootage	SqFtWithSubstantialDmg	UndamagedSqFt	SqFtD
1	100050501031000	0.00	0.00	0.00	
2	100050501031002	0.18	0.00	0.11	
3	100050501031003	0.06	0.00	0.02	
4	100050501031006	0.00	0.00	0.00	
5	100050501032001	20.49	2.37	11.30	
6	100050501032003	0.00	0.00	0.00	
7	100050501032004	0.00	0.00	0.00	
8	100050501032005	1.46	0.08	1.07	
9	100050501032009	0.10	0.00	0.08	
10	100050501032010	0.14	0.01	0.07	
11	100050501032016	5.04	0.32	3.58	
12	100050501032017	0.00	0.00	0.00	
13	100050501032018	0.00	0.00	0.00	
14	100050501032019	7.91	0.68	4.93	
15	100050501032020	0.00	0.00	0.00	
16	100050501032021	0.00	0.00	0.00	
17	100050501032022	0.00	0.00	0.00	
18	100050501032023	1.41	0.11	0.51	

Figure 8-6 General Building Stock Damage Results Table

8.3.2 General Building Stock Damage by Building Type

Select **By Type** from the **Results** > **General Building Stock** menu (Figure 8-5) to view and map tabular damage results for wood, steel, concrete, masonry, and manufactured housing types. Select the desired type of structure from the drop-down menu (Figure 8-7).

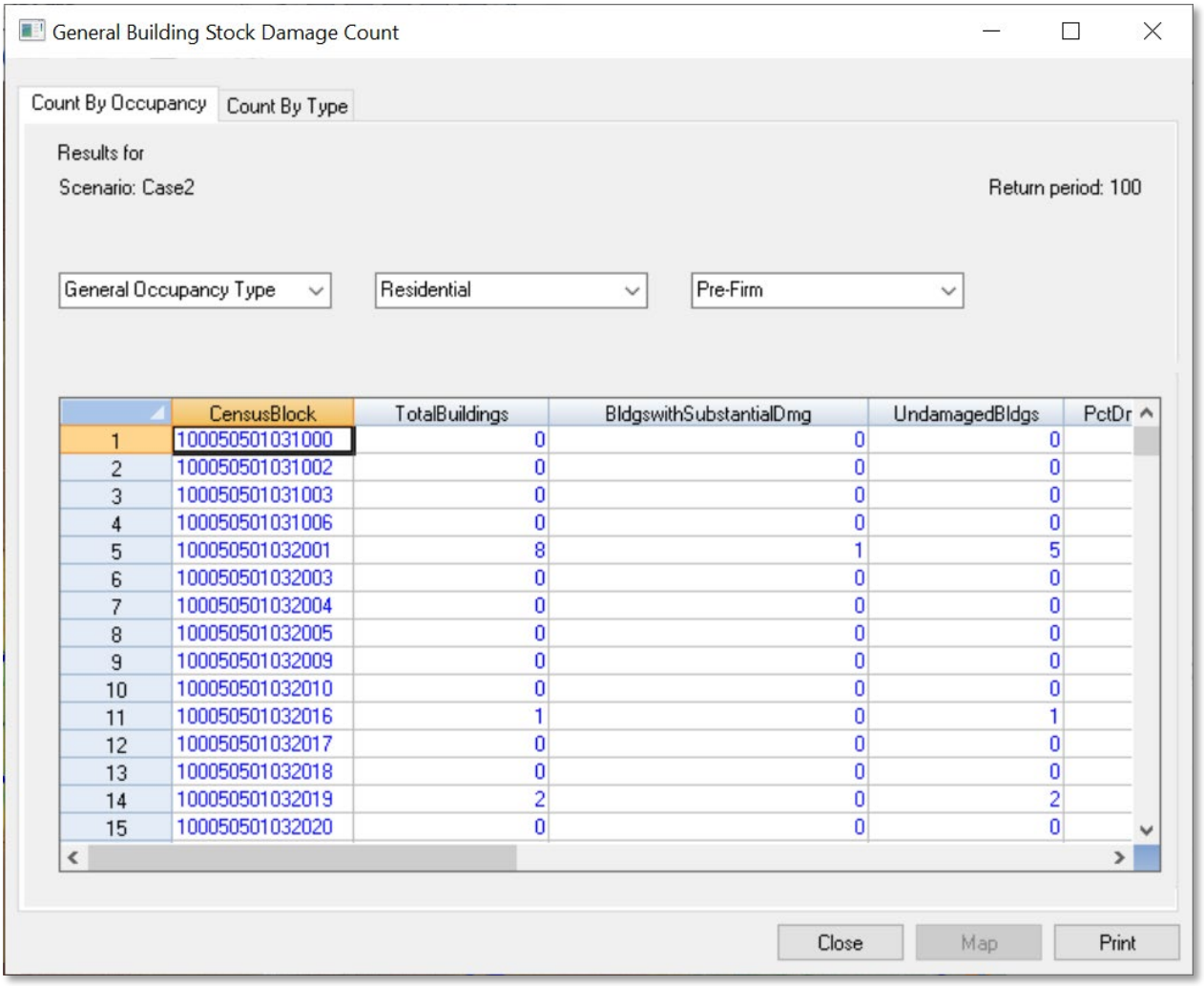


		TotalSquareFootage	SqFtWithSubstantialDmg	UndamagedSqFt
1	100050501031000	0.00	0.00	0.00
2	100050501031002	0.00	0.00	0.00
3	100050501031003	0.00	0.00	0.00
4	100050501031006	0.00	0.00	0.00
5	100050501032001	13.00	0.00	8.00
6	100050501032003	0.00	0.00	0.00
7	100050501032004	0.00	0.00	0.00
8	100050501032005	1.00	0.00	1.00
9	100050501032009	0.00	0.00	0.00
10	100050501032010	0.00	0.00	0.00
11	100050501032016	4.00	0.00	3.00
12	100050501032017	0.00	0.00	0.00
13	100050501032018	0.00	0.00	0.00
14	100050501032019	5.00	0.00	3.00
15	100050501032020	0.00	0.00	0.00
16	100050501032021	0.00	0.00	0.00
17	100050501032022	0.00	0.00	0.00
18	100050501032023	0.00	0.00	0.00

Figure 8-7 Building Stock Damage by Building Type Table

8.3.3 General Building Stock Damage Count

Select **By Count** from the **Results > General Building Stock** menu (Figure 8-5) to view and map the tabular damage results. For **County by Occupancy**, the user can choose counts based on **General Occupancy Type** or **Specific Occupancy Type** and choose between **Pre-Firm**, **Post-Firm**, or **All** (Figure 8-8). Use the drop-down menus to select which data to view.



	CensusBlock	TotalBuildings	BldgswithSubstantialDmg	UndamagedBldgs	PctDr
1	100050501031000	0	0	0	
2	100050501031002	0	0	0	
3	100050501031003	0	0	0	
4	100050501031006	0	0	0	
5	100050501032001	8	1	5	
6	100050501032003	0	0	0	
7	100050501032004	0	0	0	
8	100050501032005	0	0	0	
9	100050501032009	0	0	0	
10	100050501032010	0	0	0	
11	100050501032016	1	0	1	
12	100050501032017	0	0	0	
13	100050501032018	0	0	0	
14	100050501032019	2	0	2	
15	100050501032020	0	0	0	

Figure 8-8 General Building Stock Damage Count Table

8.3.4 General Building Stock Direct Economic Losses

The **Economic Loss** option on the **Results > General Building Stock** menu allows the user to view and map economic losses for the GBS by Census block by full replacement value and depreciated replacement value. Direct economic losses can be displayed **By General Occupancy**, **By Specific Occupancy**, **By General Building Type**, and **Total** as shown in Figure 8-9. Use the drop-down menus to select which data to view.

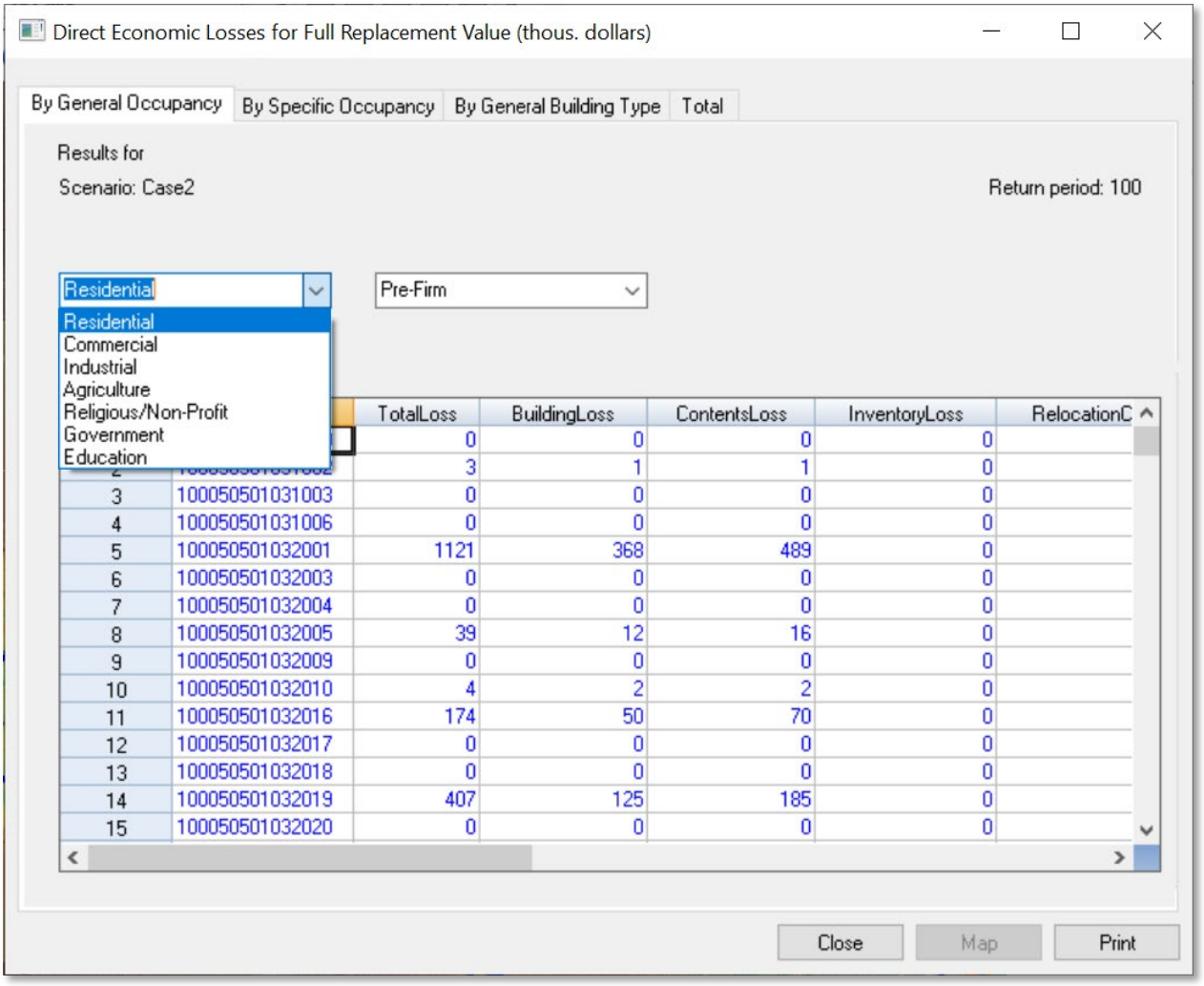
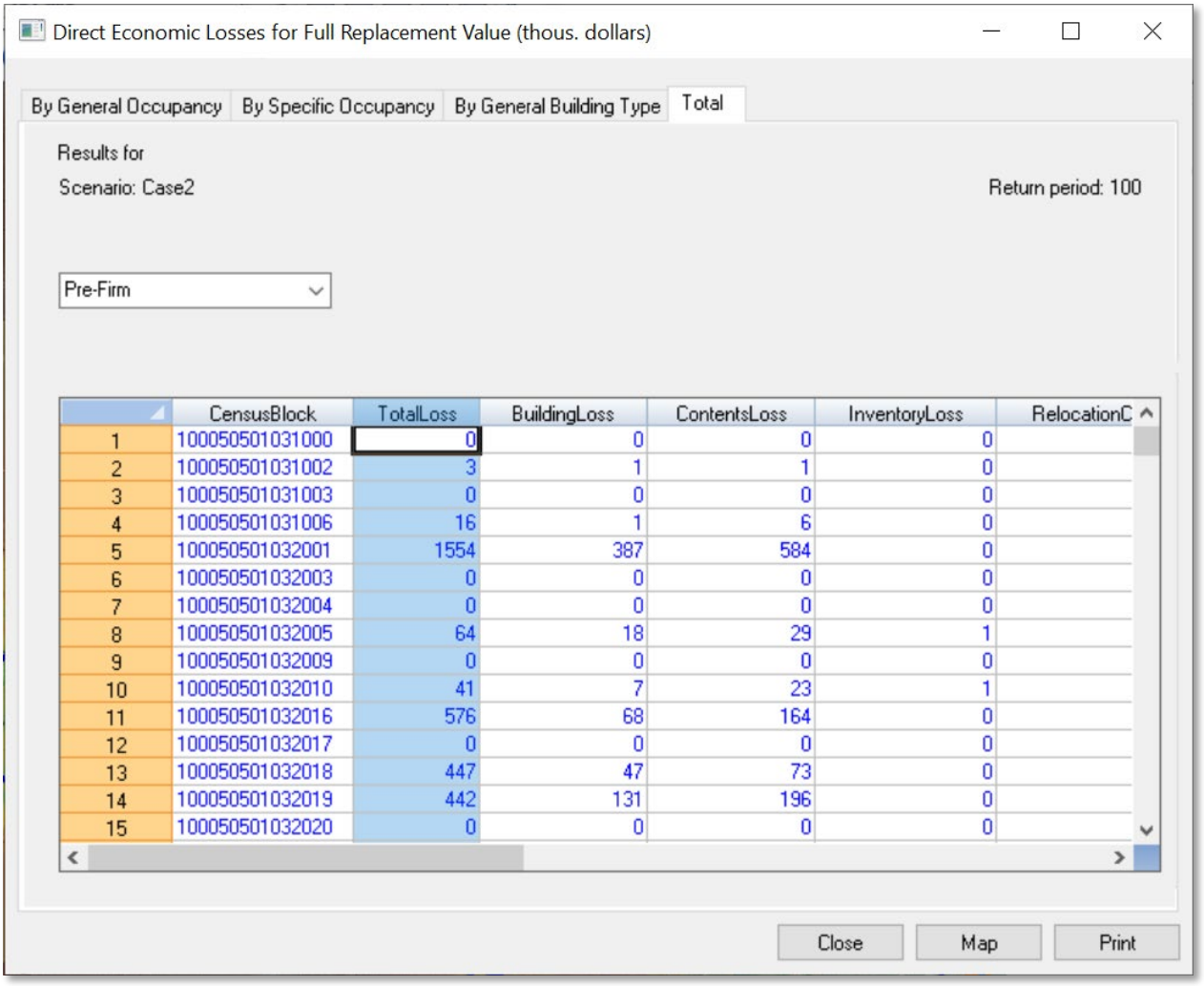


Figure 8-9 General Building Stock Direct Economic Losses for Full Replacement Value (By General Occupancy) Table

8.3.5 Viewing and Exporting Data from Building Stock Damage Menus

To view the damage results spatially, click on one of the columns with loss values, such as the TotalLoss field (Figure 8-10) on the desired tab of the Direct Economic Losses table and click the Map button at the bottom right-hand corner. The data will appear a new data layer within the Hazus project and Esri shapefile format. Once the data are listed in the Flood Map Table of Contents, right click on the data layer, and export the data to a shapefile, which can be imported into database and spreadsheet programs for further analysis.

To view the damage results only in a tabular format, right click within the table and select Export (Figure 8-11).



	CensusBlock	TotalLoss	BuildingLoss	ContentsLoss	InventoryLoss	RelocationC
1	100050501031000	0	0	0	0	
2	100050501031002	3	1	1	0	
3	100050501031003	0	0	0	0	
4	100050501031006	16	1	6	0	
5	100050501032001	1554	387	584	0	
6	100050501032003	0	0	0	0	
7	100050501032004	0	0	0	0	
8	100050501032005	64	18	29	1	
9	100050501032009	0	0	0	0	
10	100050501032010	41	7	23	1	
11	100050501032016	576	68	164	0	
12	100050501032017	0	0	0	0	
13	100050501032018	447	47	73	0	
14	100050501032019	442	131	196	0	
15	100050501032020	0	0	0	0	

Figure 8-10 General Building Stock Direct Economic Losses for Full Replacement Value (Total) Results

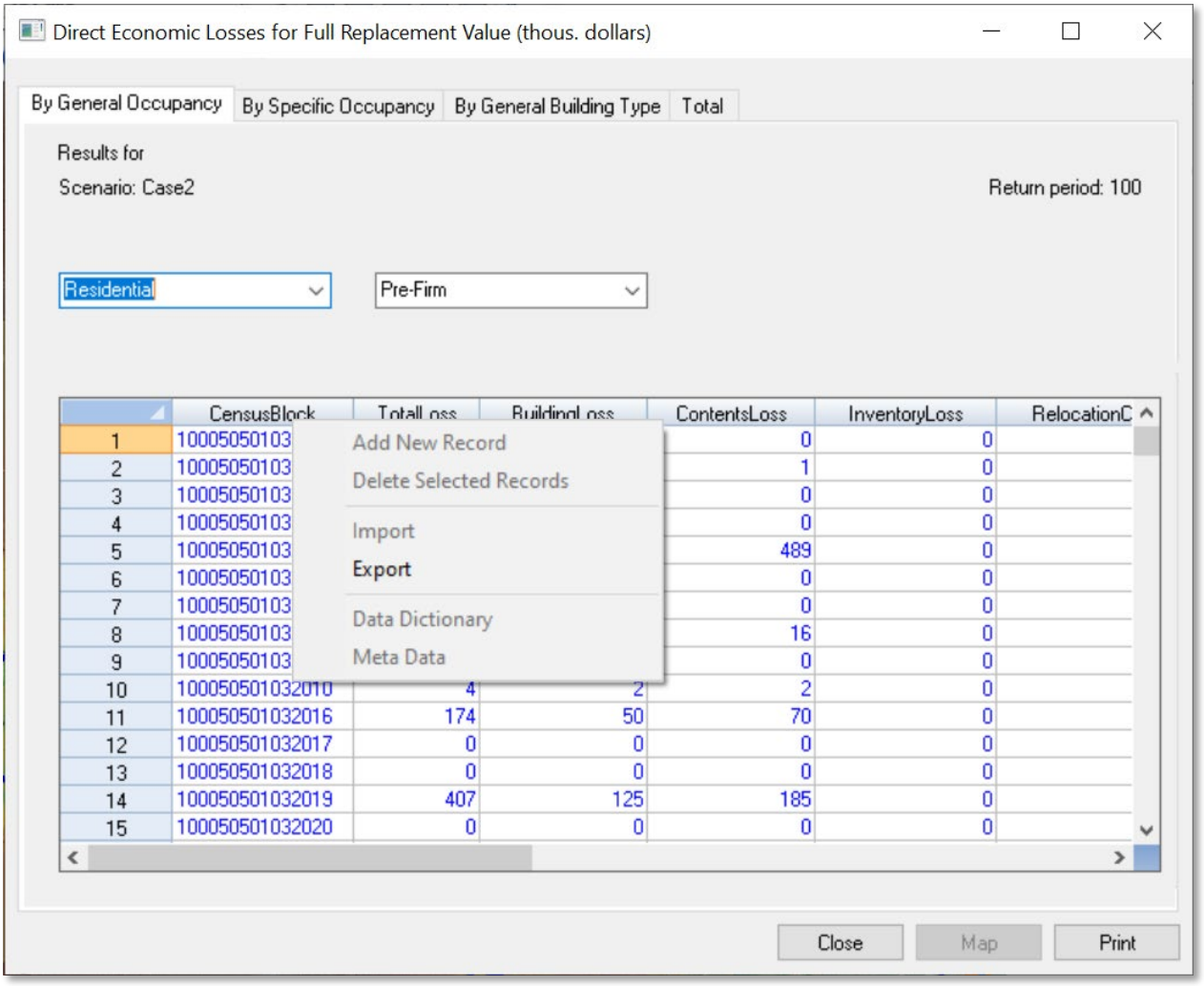


Figure 8-11 Export General Building Stock Direct Economic Losses for Full Replacement Value (By Occupancy) Results

8.4 Combined Wind and Flood Loss

When a storm surge analysis has been performed (see Section 11 for all steps in that type of analysis), the user can show results from the combined wind flood loss analysis with the **Combined Wind and Flood Loss** menu (Figure 8-12). Selecting that menu will bring up the window shown in Figure 8-13, which includes some of the fields that Hazus calculated when a combined hurricane wind and flood surge analysis was conducted, where results are shown for each hazard type individually and the weighted combination. The combined losses are weighted based on how each hazard type contributes to overall damages, with flood hazards typically damaging the lower portions of a structure (foundation, lower floors) and hurricane wind hazards typically damaging upper portions of a structure (roof, upper floors). Refer to the Hazus Flood and Hurricane Technical Manuals for more details on how the combined results are calculated.

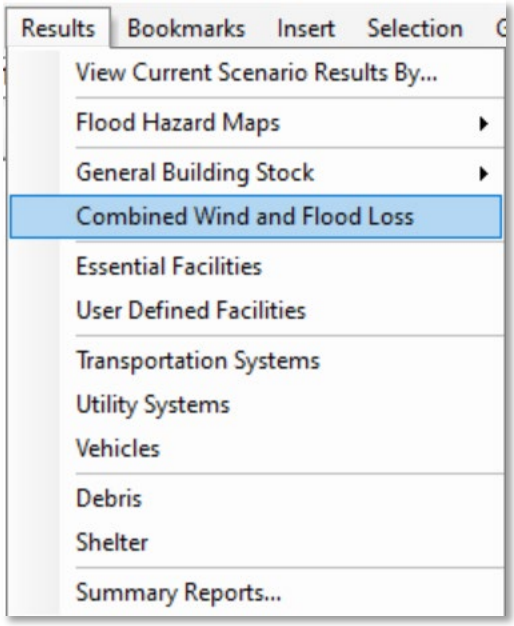
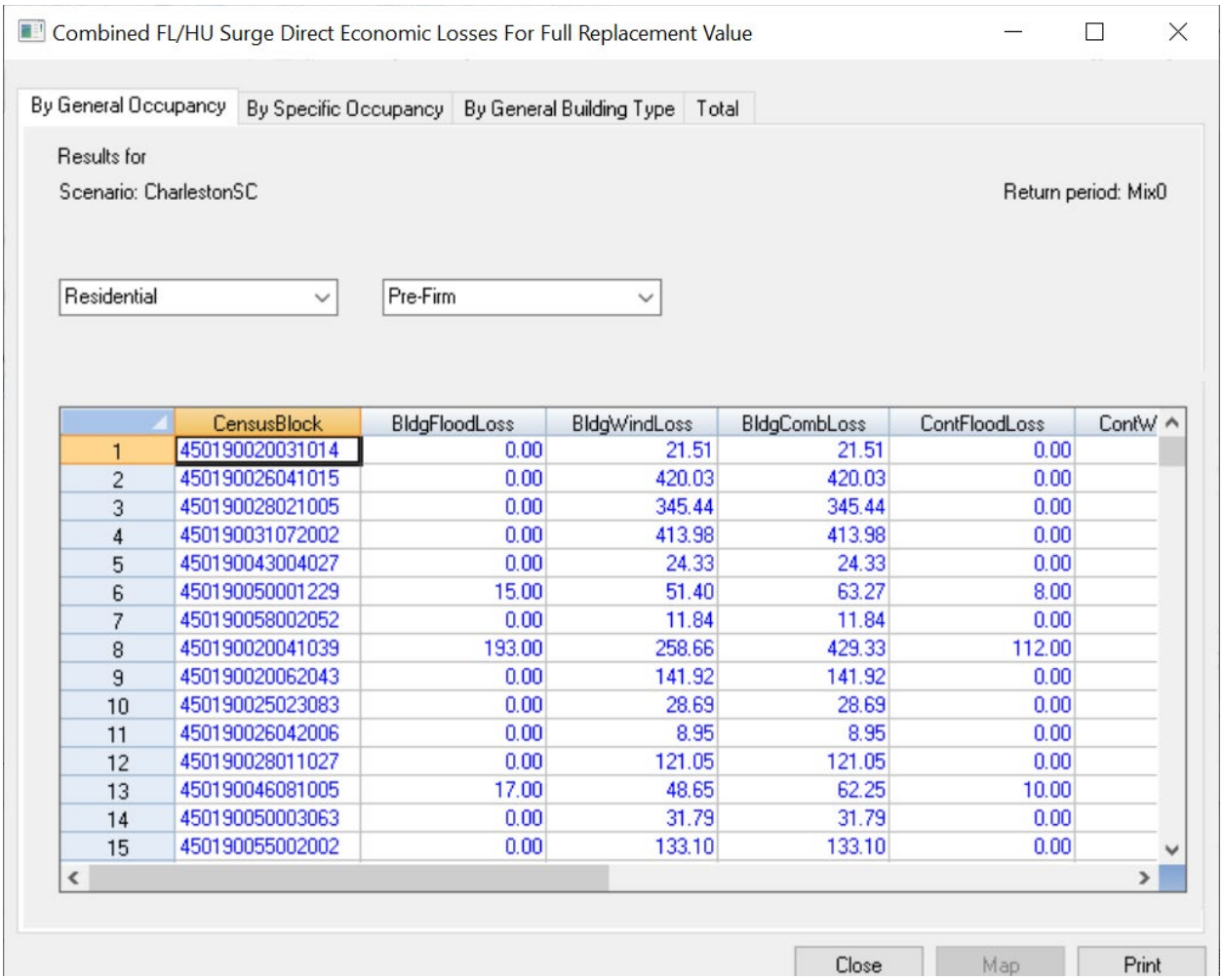


Figure 8-12 Results > Combined Wind and Flood Loss Menu



	CensusBlock	BldgFloodLoss	BldgWindLoss	BldgCombLoss	ContFloodLoss	ContW
1	450190020031014	0.00	21.51	21.51	0.00	
2	450190026041015	0.00	420.03	420.03	0.00	
3	450190028021005	0.00	345.44	345.44	0.00	
4	450190031072002	0.00	413.98	413.98	0.00	
5	450190043004027	0.00	24.33	24.33	0.00	
6	450190050001229	15.00	51.40	63.27	8.00	
7	450190058002052	0.00	11.84	11.84	0.00	
8	450190020041039	193.00	258.66	429.33	112.00	
9	450190020062043	0.00	141.92	141.92	0.00	
10	450190025023083	0.00	28.69	28.69	0.00	
11	450190026042006	0.00	8.95	8.95	0.00	
12	450190028011027	0.00	121.05	121.05	0.00	
13	450190046081005	17.00	48.65	62.25	10.00	
14	450190050003063	0.00	31.79	31.79	0.00	
15	450190055002002	0.00	133.10	133.10	0.00	

Figure 8-13 Combined FL/HU Surge Direct Economic Losses for Full Replacement Value (By General Occupancy) Table

8.5 Essential Facilities

Essential Facilities results, selected in Figure 8-14 and shown in Figure 8-15, allow the user to view and map losses and damages to Essential Facilities, including **Medical Care Facilities**, **Emergency Centers**, and **Schools**. See Section 8.3.5 for general methods to create maps and export data from the Flood Model results.

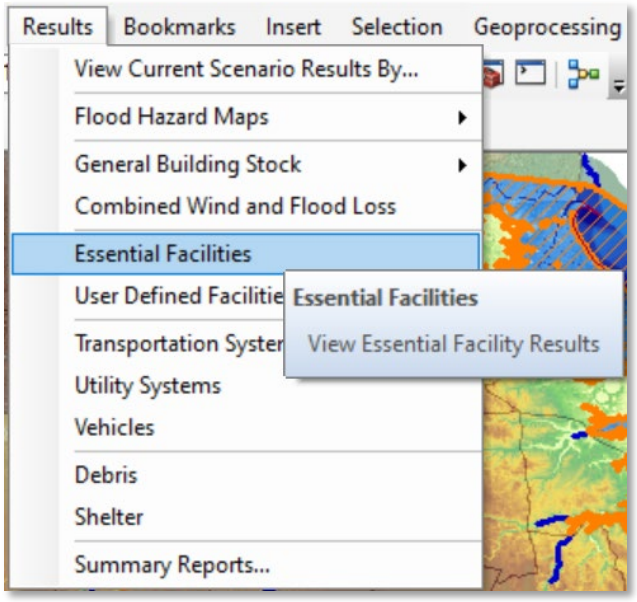


Figure 8-14 Results > Essential Facilities Menu

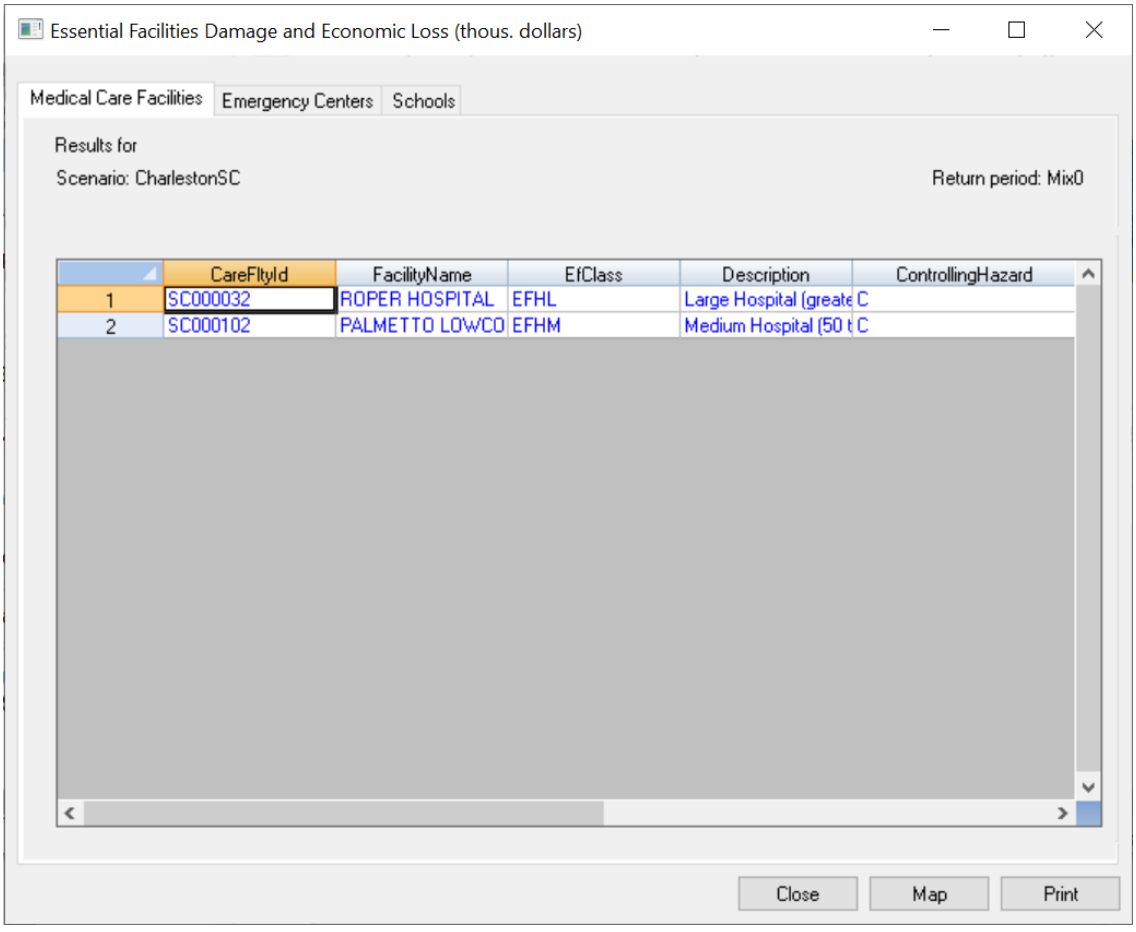


Figure 8-15 Essential Facilities (Medical Care Facilities) Table

8.6 User-Defined Facilities

User-Defined Facilities results, selected in Figure 8-16 and shown in Figure 8-17, allow the user to view and map losses and damages to individual UDFs. See Section 8.3.5 for general methods to create maps and export data from the Flood Model results.

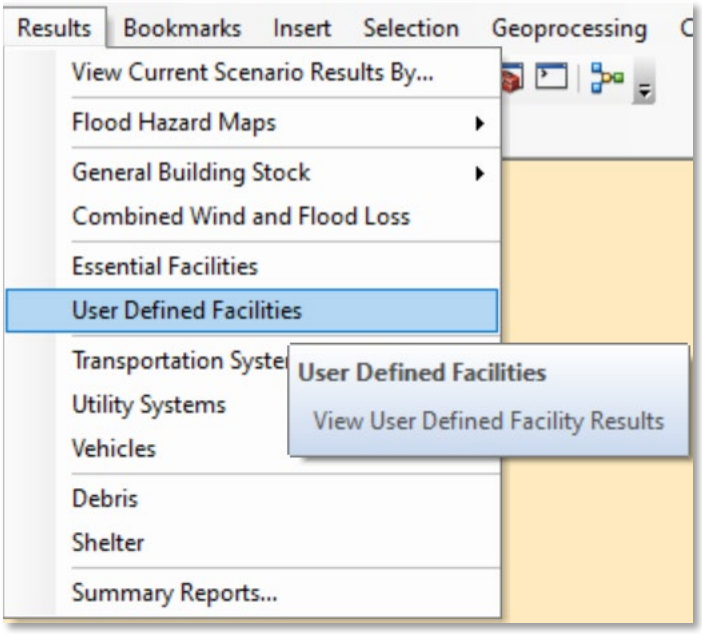
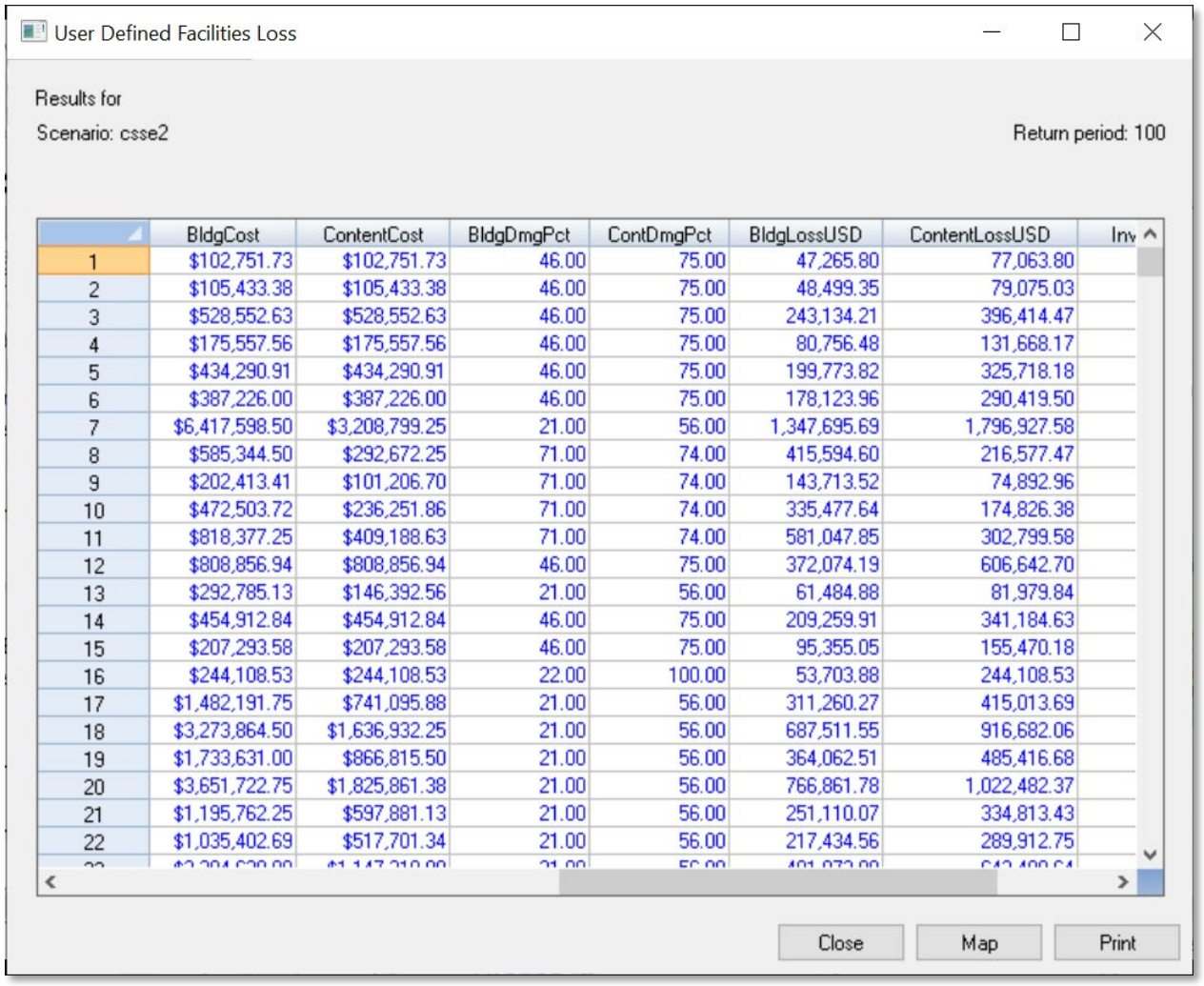


Figure 8-16 Results > User-Defined Facilities Menu



	BldgCost	ContentCost	BldgDmgPct	ContDmgPct	BldgLossUSD	ContentLossUSD	Inv
1	$102,751.73	$102,751.73	46.00	75.00	47,265.80	77,063.80	
2	$105,433.38	$105,433.38	46.00	75.00	48,499.35	79,075.03	
3	$528,552.63	$528,552.63	46.00	75.00	243,134.21	396,414.47	
4	$175,557.56	$175,557.56	46.00	75.00	80,756.48	131,668.17	
5	$434,290.91	$434,290.91	46.00	75.00	199,773.82	325,718.18	
6	$387,226.00	$387,226.00	46.00	75.00	178,123.96	290,419.50	
7	$6,417,598.50	$3,208,799.25	21.00	56.00	1,347,695.69	1,796,927.58	
8	$585,344.50	$292,672.25	71.00	74.00	415,594.60	216,577.47	
9	$202,413.41	$101,206.70	71.00	74.00	143,713.52	74,892.96	
10	$472,503.72	$236,251.86	71.00	74.00	335,477.64	174,826.38	
11	$818,377.25	$409,188.63	71.00	74.00	581,047.85	302,799.58	
12	$808,856.94	$808,856.94	46.00	75.00	372,074.19	606,642.70	
13	$292,785.13	$146,392.56	21.00	56.00	61,484.88	81,979.84	
14	$454,912.84	$454,912.84	46.00	75.00	209,259.91	341,184.63	
15	$207,293.58	$207,293.58	46.00	75.00	95,355.05	155,470.18	
16	$244,108.53	$244,108.53	22.00	100.00	53,703.88	244,108.53	
17	$1,482,191.75	$741,095.88	21.00	56.00	311,260.27	415,013.69	
18	$3,273,864.50	$1,636,932.25	21.00	56.00	687,511.55	916,682.06	
19	$1,733,631.00	$866,815.50	21.00	56.00	364,062.51	485,416.68	
20	$3,651,722.75	$1,825,861.38	21.00	56.00	766,861.78	1,022,482.37	
21	$1,195,762.25	$597,881.13	21.00	56.00	251,110.07	334,813.43	
22	$1,035,402.69	$517,701.34	21.00	56.00	217,434.56	289,912.75	

Figure 8-17 User-Defined Facilities Loss Table

8.7 Transportation Systems

Transportation Systems results, selected in Figure 8-18 and shown in Figure 8-19, allow the user to view and map losses and damages to transportation systems, including **Highway**, **Railway**, **Light Rail**, **Bus**, **Port**, **Ferry**, and **Airport**. However, losses from flood will only be calculated for bridges and only as they relate to scour. See Section 8.3.5 for general methods to create maps and export data from the Flood Model results.

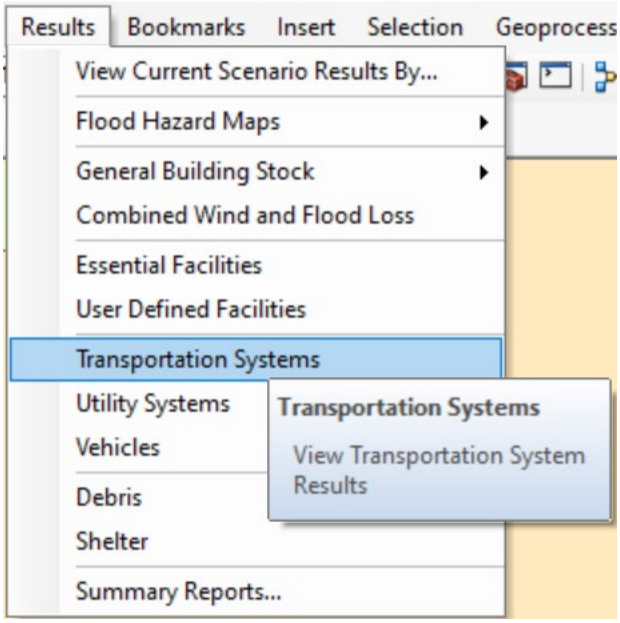


Figure 8-18 Results > Transportation Systems Menu

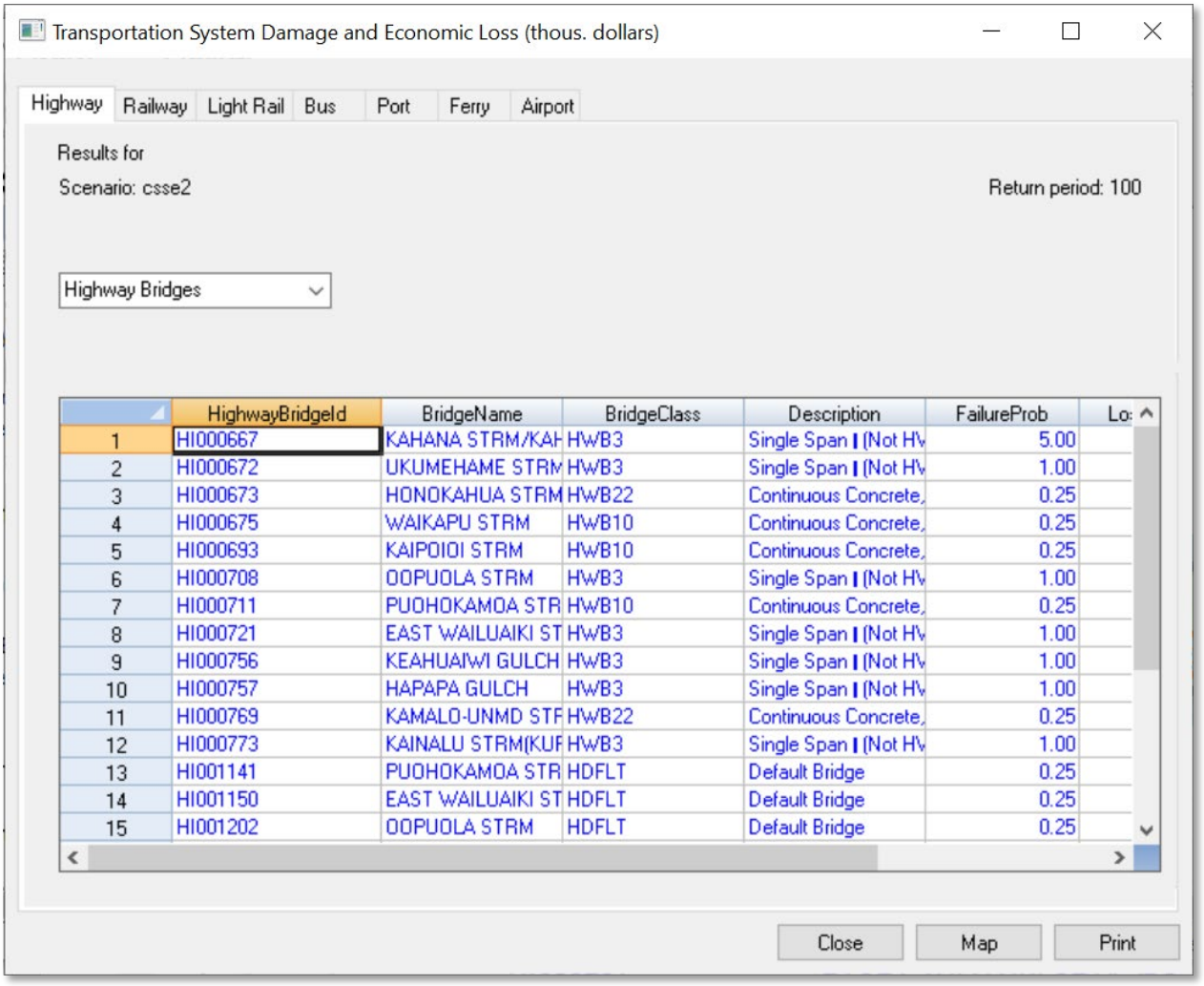


Figure 8-19 Transportation Systems Damage/Economic Loss (Highway) Table

8.8 Utility Systems

Utility Systems results, selected in Figure 8-20 and shown in Figure 8-21, allow the user to view and map losses and damages to utility systems, including **Potable Water**, **Wastewater**, **Oil**, **Natural Gas**, **Electric Power**, and **Communications**. See Section 8.3.5 for general methods to create maps and export data from the Flood Model results.

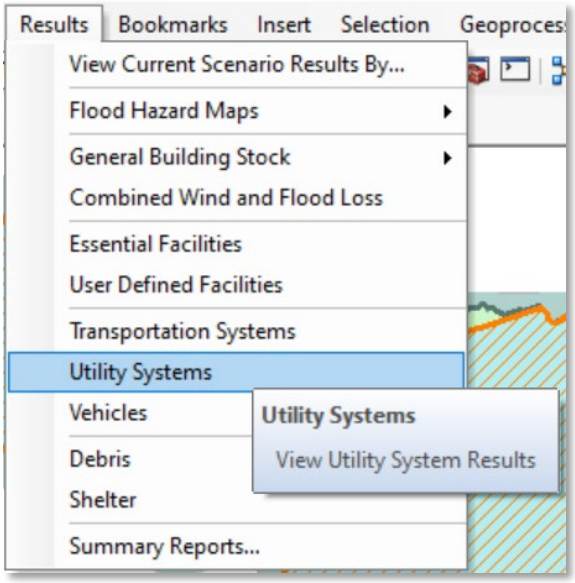


Figure 8-20 Results > Utility Systems Menu

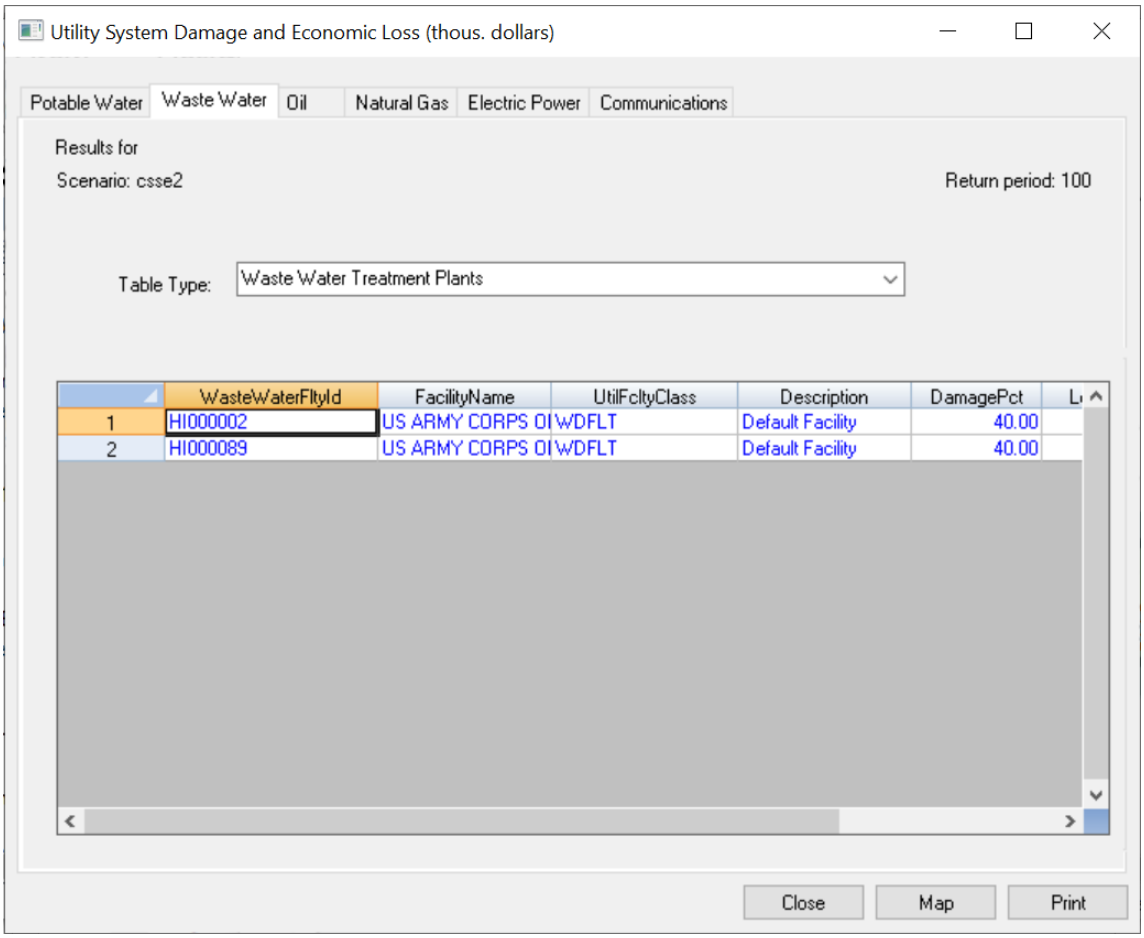


Figure 8-21 Utility Systems Damage/Economic Loss (Waste Water Treatment Plants) Table

8.9 Vehicles

Vehicles results, selected in Figure 8-24 and shown in Figure 8-25, allow the user to view and map losses and damages to vehicles by Census block and for either night or day times. See Section 8.3.5 for general methods to create maps and export data from the Flood Model results.

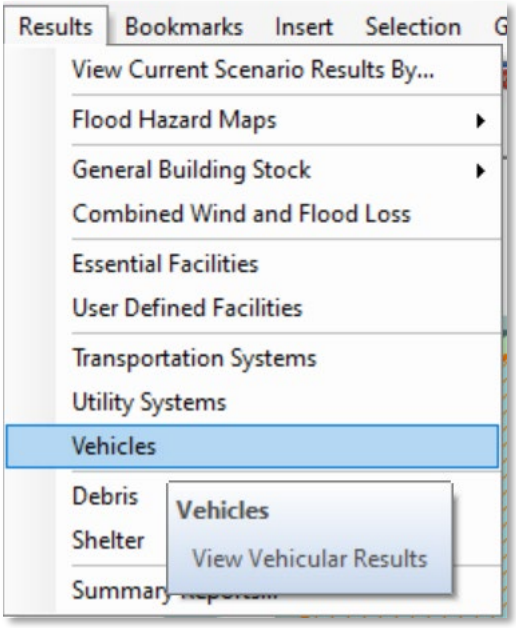
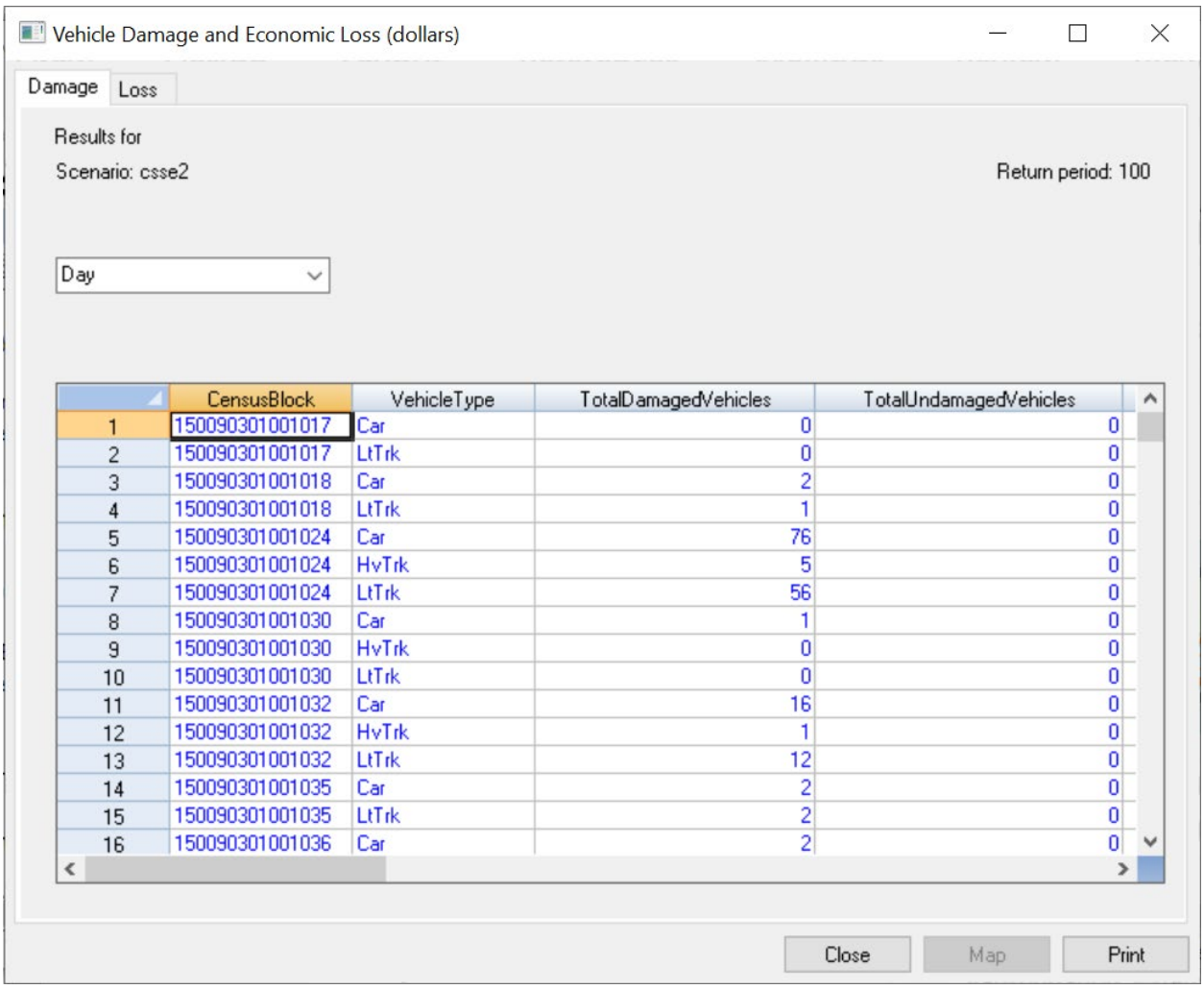


Figure 8-22 Results > Vehicles Menu



	CensusBlock	VehicleType	TotalDamagedVehicles	TotalUndamagedVehicles
1	150090301001017	Car	0	0
2	150090301001017	LtTrk	0	0
3	150090301001018	Car	2	0
4	150090301001018	LtTrk	1	0
5	150090301001024	Car	76	0
6	150090301001024	HvTrk	5	0
7	150090301001024	LtTrk	56	0
8	150090301001030	Car	1	0
9	150090301001030	HvTrk	0	0
10	150090301001030	LtTrk	0	0
11	150090301001032	Car	16	0
12	150090301001032	HvTrk	1	0
13	150090301001032	LtTrk	12	0
14	150090301001035	Car	2	0
15	150090301001035	LtTrk	2	0
16	150090301001036	Car	2	0

Figure 8-23 Vehicle Damage and Loss (Damage) Table

8.10 Debris

Debris results, selected in Figure 8-26 and shown in Figure 8-27, allow the user to view and map finish, structural, and foundation building debris results by Census block. See Section 8.3.5 for general methods to create maps and export data from the Flood Model results.

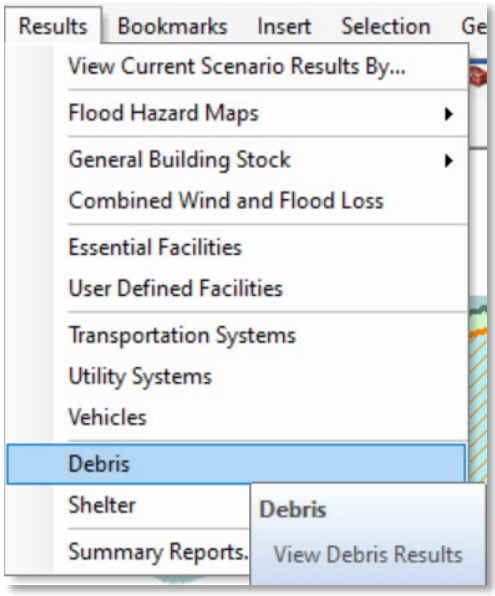


Figure 8-24 Results > Debris Menu

Debris Generation

Results for
Scenario: csse2
Return period: 100

	CensusBlock	TotalTons	FinishTons	StructureTons	FoundationTons
1	150090301001017	97.02	27.30	42.73	26.99
2	150090301001018	582.73	162.43	257.60	162.70
3	150090301001024	4,268.31	1,499.67	1,696.91	1,071.73
4	150090301001027	132.50	37.07	58.49	36.94
5	150090301001030	634.90	179.45	279.15	176.30
6	150090301001031	59.49	21.97	23.00	14.52
7	150090301001032	1,235.40	351.10	541.99	342.31
8	150090301001035	105.24	31.36	45.28	28.60
9	150090301001036	203.08	56.47	89.86	56.75
10	150090301001039	101.03	30.10	43.47	27.46
11	150090301001043	1,143.98	665.47	293.28	185.23
12	150090301001044	872.27	247.17	383.12	241.97
13	150090301001045	514.47	148.02	224.60	141.85
14	150090301001046	965.43	266.41	428.43	270.59
15	150090301001056	183.93	110.05	45.28	28.60
16	150090301001064	59.49	21.97	23.00	14.52
17	150090301001066	59.49	21.97	23.00	14.52
18	150090301001069	150.99	40.74	67.57	42.68
19	150090301001070	59.49	21.97	23.00	14.52
20	150090301001072	0.00	0.00	0.00	0.00
21	150090301001073	922.25	259.60	406.14	256.51
22	150090301001078	398.93	177.28	135.85	85.80
23	150090301001086	150.99	40.74	67.57	42.68

Close Map Print

Figure 8-25 Debris Generation Table

8.11 Shelter

Shelter results, selected in Figure 8-30 and shown in Figure 8-31, allow the user to view and map the estimated displaced population and the short-term shelter needs by Census block. See Section 8.3.5 for general methods to create maps and export data from the Flood Model results.

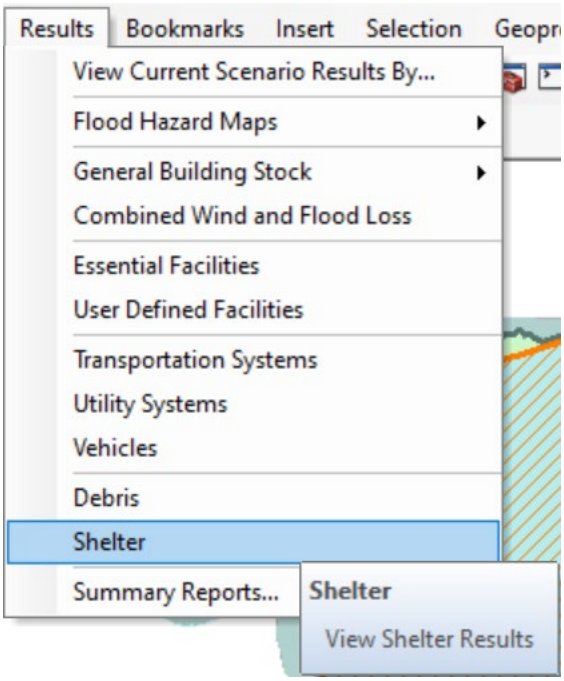
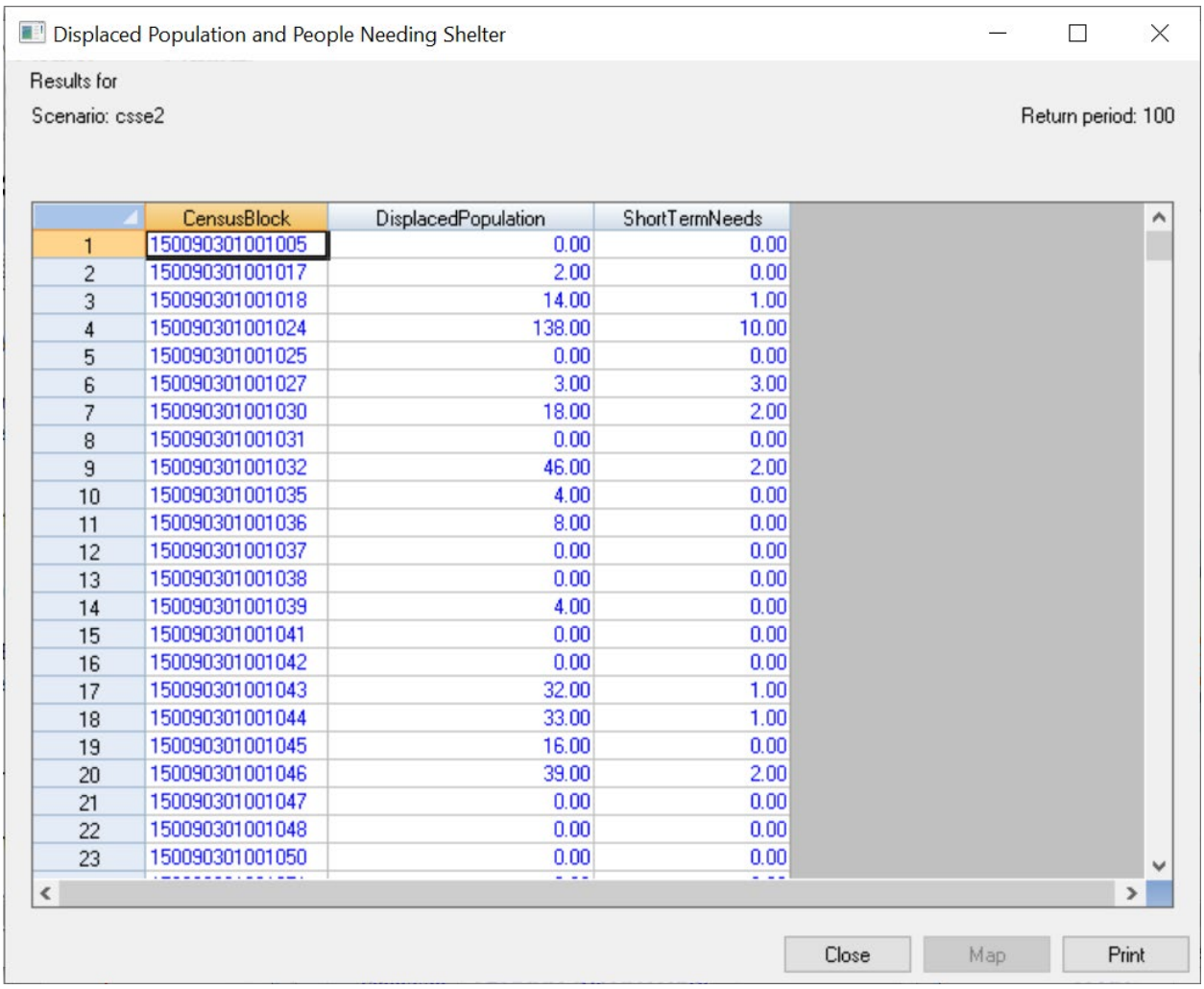


Figure 8-26 Results > Shelter Menu



	CensusBlock	DisplacedPopulation	ShortTermNeeds
1	150090301001005	0.00	0.00
2	150090301001017	2.00	0.00
3	150090301001018	14.00	1.00
4	150090301001024	138.00	10.00
5	150090301001025	0.00	0.00
6	150090301001027	3.00	3.00
7	150090301001030	18.00	2.00
8	150090301001031	0.00	0.00
9	150090301001032	46.00	2.00
10	150090301001035	4.00	0.00
11	150090301001036	8.00	0.00
12	150090301001037	0.00	0.00
13	150090301001038	0.00	0.00
14	150090301001039	4.00	0.00
15	150090301001041	0.00	0.00
16	150090301001042	0.00	0.00
17	150090301001043	32.00	1.00
18	150090301001044	33.00	1.00
19	150090301001045	16.00	0.00
20	150090301001046	39.00	2.00
21	150090301001047	0.00	0.00
22	150090301001048	0.00	0.00
23	150090301001050	0.00	0.00

Figure 8-27 Shelter Table

8.12 Summary Reports

The **Summary Reports** results, selected in Figure 8-34 and shown in Figure 8-35, allow the user to view and print a wide variety of reports on topics, including **Inventory**, **Buildings**, **Lifelines**, and **Losses**. The reports are created using the Crystal Reports engine that is included as part of Hazus installation. Figure 8-36 and Figure 8-37 show examples of the many reports available, as listed in Table 8-1. Figure 8-37 shows the report-viewing window in Hazus, which contains icons along the top to export or print reports and navigate through report pages. For example, the left-most icon (as shown in Figure 8-36) allows the user to export a report in pdf format. Figure 8-38 shows the export window for the user to select the report export format and file location.

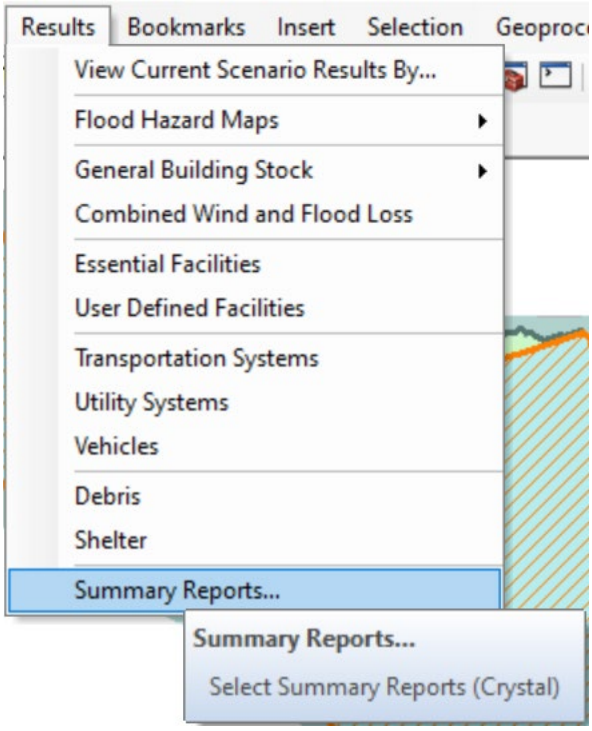


Figure 8-28 Results > Summary Reports Menu

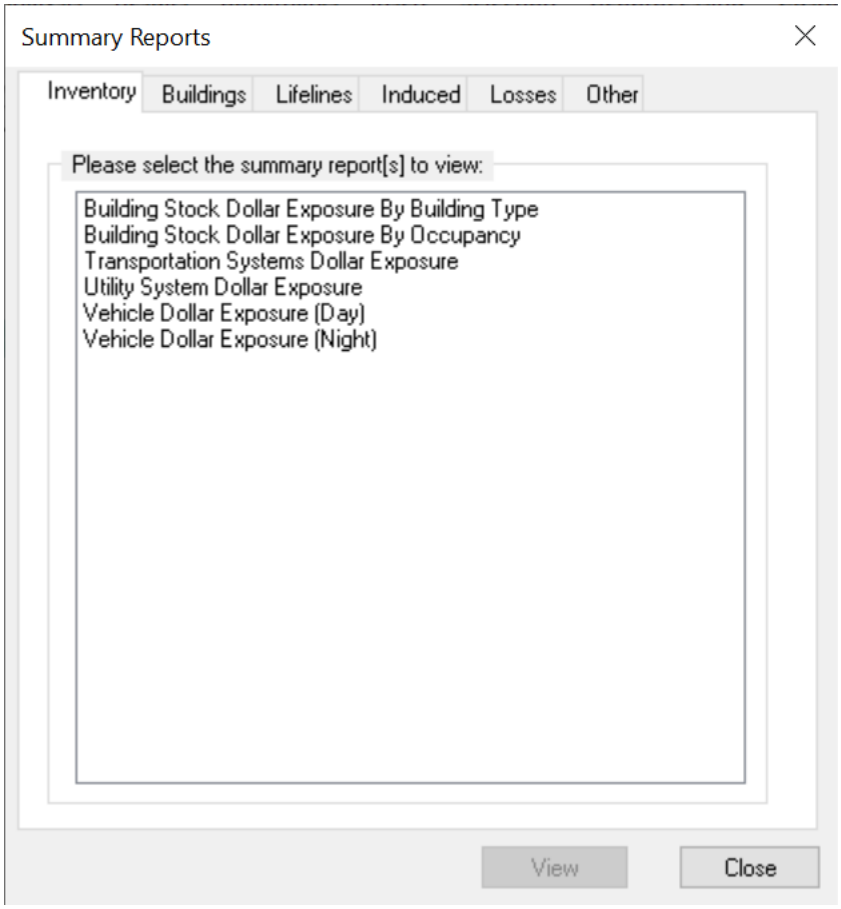
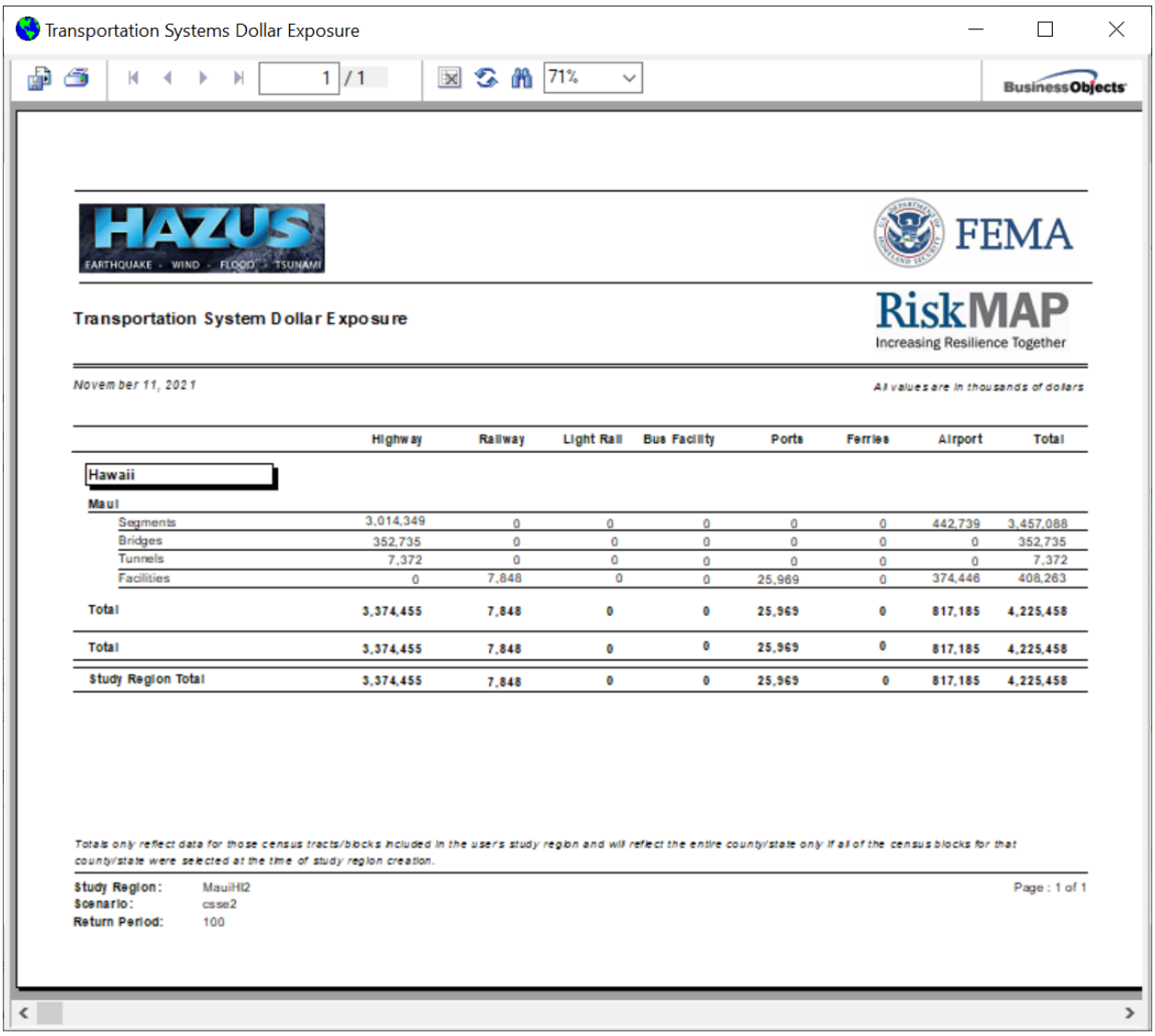
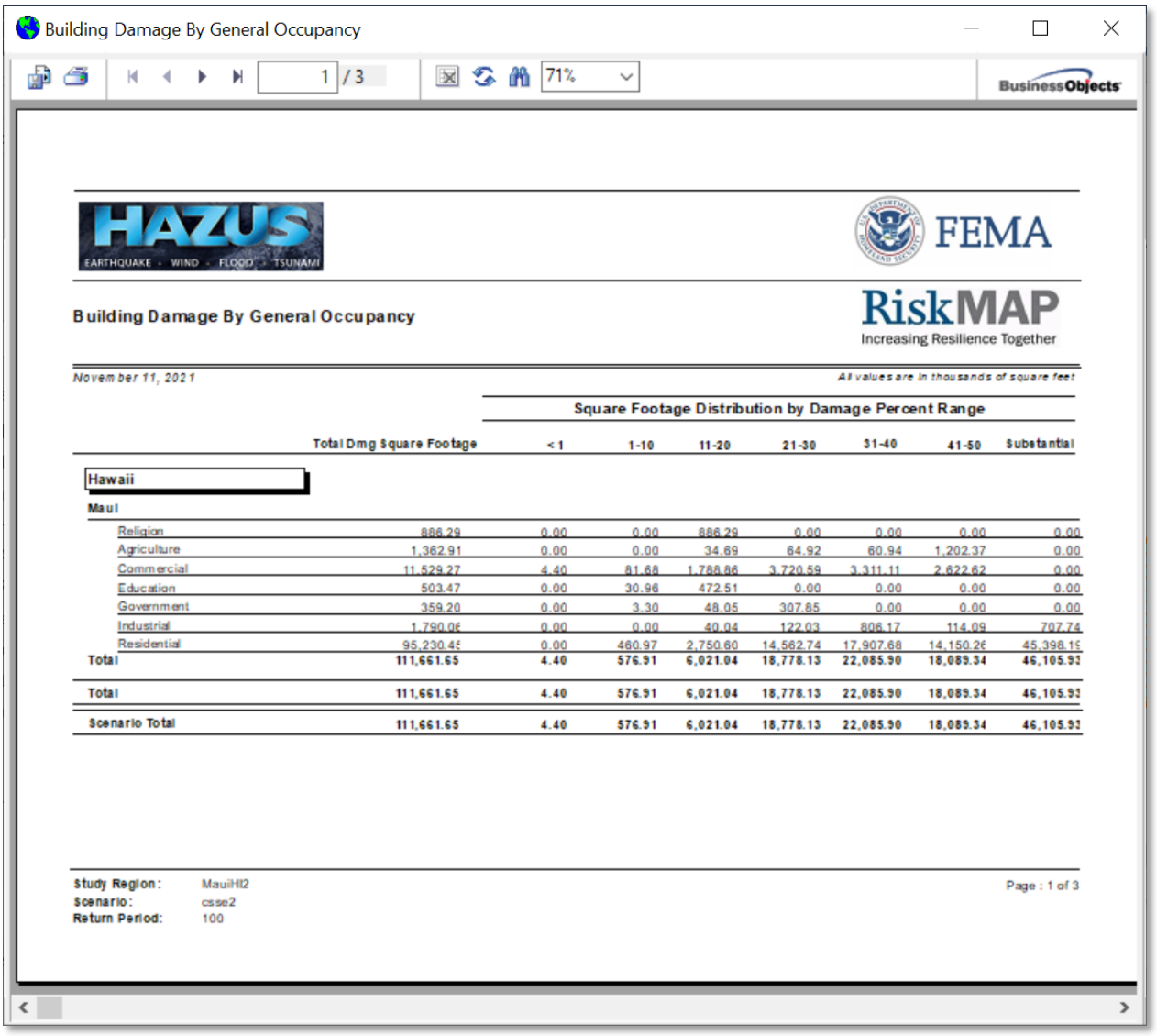


Figure 8-29 Summary Reports (Inventory) Window



	Highway	Railway	Light Rail	Bus Facility	Ports	Ferries	Airport	Total
Hawaii								
Maui								
Segments	3,014,349	0	0	0	0	0	442,739	3,457,088
Bridges	352,735	0	0	0	0	0	0	352,735
Tunnels	7,372	0	0	0	0	0	0	7,372
Facilities	0	7,848	0	0	25,969	0	374,446	408,263
Total	**3,374,455**	**7,848**	**0**	**0**	**25,969**	**0**	**817,185**	**4,225,458**
Total	**3,374,455**	**7,848**	**0**	**0**	**25,969**	**0**	**817,185**	**4,225,458**
Study Region Total	**3,374,455**	**7,848**	**0**	**0**	**25,969**	**0**	**817,185**	**4,225,458**

Figure 8-30 Example – Transportation Systems Exposure Summary Report



Building Damage By General Occupancy

1 / 3 71%

HAZUS EARTHQUAKE - WIND - FLOOD - TSUNAMI

FEMA

RiskMAP Increasing Resilience Together

Building Damage By General Occupancy

November 11, 2021

All values are in thousands of square feet

		Square Footage Distribution by Damage Percent Range						
	Total Dmg Square Footage	< 1	1-10	11-20	21-30	31-40	41-50	Substantial
Hawaii								
Maui								
Religion	886.29	0.00	0.00	886.29	0.00	0.00	0.00	0.00
Agriculture	1,362.91	0.00	0.00	34.69	64.92	60.94	1,202.37	0.00
Commercial	11,529.27	4.40	81.68	1,788.86	3,720.59	3,311.11	2,622.62	0.00
Education	503.47	0.00	30.96	472.51	0.00	0.00	0.00	0.00
Government	359.20	0.00	3.30	48.05	307.85	0.00	0.00	0.00
Industrial	1,790.06	0.00	0.00	40.04	122.03	806.17	114.09	707.74
Residential	95,230.45	0.00	460.97	2,750.60	14,562.74	17,907.68	14,150.26	45,398.19
Total	**111,661.65**	**4.40**	**576.91**	**6,021.04**	**18,778.13**	**22,085.90**	**18,089.34**	**46,105.93**
Total	**111,661.65**	**4.40**	**576.91**	**6,021.04**	**18,778.13**	**22,085.90**	**18,089.34**	**46,105.93**
Scenario Total	**111,661.65**	**4.40**	**576.91**	**6,021.04**	**18,778.13**	**22,085.90**	**18,089.34**	**46,105.93**

Study Region: MauiHI2
Scenario: csse2
Return Period: 100

Page : 1 of 3

Figure 8-31 Example – Building Damage By General Occupancy Summary Report

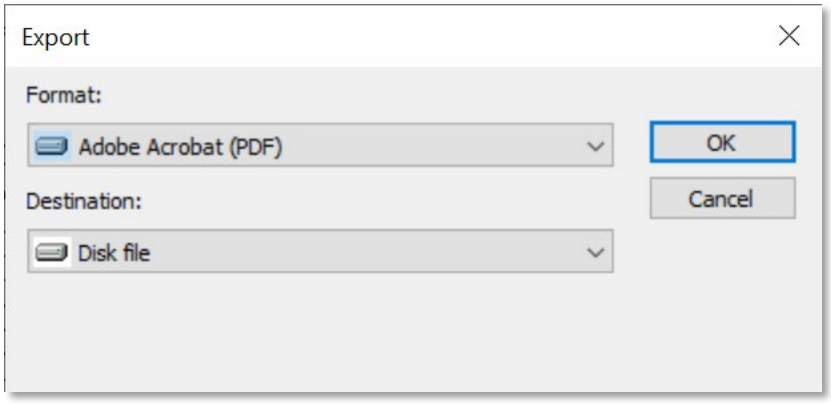


Figure 8-32 Report Export

Table 8-1: List of Summary Reports

Tab	Report	Description
Inventory	Building Stock Dollar Exposure by Building Type	Dollar exposure (in thousands of dollars) of the building stock by building type in the Study Region.
Inventory	Building Stock Dollar Exposure by Occupancy	Dollar exposure (in thousands of dollars) of the building stock by occupancy in the Study Region.
Inventory	Transportation Systems Dollar Exposure	Dollar exposure (in thousands of dollars) of the transportation systems in the Study Region.
Inventory	Utility System Dollar Exposure	Dollar exposure (in thousands of dollars) of the utility system in the Study Region.
Inventory	Vehicle Dollar Exposure (Day)	Dollar exposure (in thousands of dollars) of vehicles (during the day) in the Study Region.
Inventory	Vehicle Dollar Exposure (Night)	Dollar exposure (in thousands of dollars) of vehicles (during the night) in the Study Region.
Buildings	Building Damage by Building Type	Building damage (square footage distribution by percent damage) by building type caused by the hazard in the scenario. All values are in thousands of square feet.
Buildings	Building Damage by General Occupancy	Building damage (square footage distribution by percent damage) by general occupancy caused by the hazard in the scenario. All values are in thousands of square feet.

Tab	Report	Description
Buildings	Building Damage by General Occupancy (Post-FIRM)	Building damage (square footage distribution by percent damage) by general occupancy (Post-FIRM) caused by the hazard in the scenario. All values are in thousands of square feet.
Buildings	Building Damage by General Occupancy (Pre-FIRM)	Building damage (square footage distribution by percent damage) by general occupancy (Pre-FIRM) caused by the hazard in the scenario. All values are in thousands of square feet.
Buildings	Building Damage Count by General Building Type	Building damage (building count by percent damage) by general building type caused by the hazard in the scenario.
Buildings	Building Damage Count by General Occupancy	Building damage (building count by percent damage) by general occupancy caused by the hazard in the scenario.
Buildings	Building Damage Count by General Occupancy (Post-FIRM)	Building damage (building count by percent damage) by general occupancy (Post-FIRM) caused by the hazard in the scenario.
Buildings	Building Damage Count by General Occupancy (Pre-FIRM)	Building damage (building count by percent damage) by general occupancy (Pre-FIRM) caused by the hazard in the scenario.
Buildings	Emergency Operation Center Damage & Functionality	Damage and functionality of Emergency Operation Center caused by the hazard in the scenario.
Buildings	Fire Station Damage & Functionality	Damage and functionality of Fire Stations caused by the hazard in the scenario.
Buildings	Hospital Damage & Functionality	Damage and functionality of Hospitals caused by the hazard in the scenario.
Buildings	Police Station Damage & Functionality	Damage and functionality of Police Stations caused by the hazard in the scenario.
Buildings	School Damage & Functionality	Damage and functionality of Schools caused by the hazard in the scenario.
Lifelines	Highway Bridge Damage & Functionality	Damage and functionality of Highway Bridges caused by the hazard in the scenario.
Lifelines	Light Rail Bridge Damage & Functionality	Damage and functionality of Light Rail Bridges caused by the hazard in the scenario.
Lifelines	Potable Water Facility Damage	Damage to Potable Water Facilities caused by the hazard in the scenario.

Tab	Report	Description
Lifelines	Railroad Bridge Damage & Functionality	Damage and functionality of Railroad Bridges caused by the hazard in the scenario.
Lifelines	Wastewater Facility Damage	Damage to Wastewater Facilities caused by the hazard in the scenario.
Induced	Debris Generated	Estimated total of debris generated (in tons) by the hazard in the scenario.
Losses	Annualized Direct Economic Losses for Buildings	Annualized direct economic losses (in thousands of dollars) for buildings resulting from the hazard in the scenario.
Losses	Combined Wind and Surge Loss	Direct economic losses (in thousands of dollars) for the combined results from wind and flood hazards in a storm surge scenario.
Losses	Depreciated Direct Economic Losses for Buildings	Depreciated direct economic losses (in thousands of dollars) for buildings resulting from the hazard in the scenario.
Losses	Direct Economic Losses for Buildings	Direct economic losses (in thousands of dollars) for buildings resulting from the hazard in the scenario.
Losses	Direct Economic Losses for Transportation	Direct economic losses (in thousands of dollars) for transportation resulting from the hazard in the scenario.
Losses	Direct Economic Losses for UDFs	Direct economic losses for user-defined facilities (UDFs) resulting from the hazard in the scenario.
Losses	Direct Economic Losses for Utilities	Direct economic losses (in thousands of dollars) for utilities resulting from the hazard in the scenario
Losses	Direct Economic Losses for Vehicles (Day)	Direct economic losses (in thousands of dollars for vehicles (during the day) resulting from the hazard in the scenario.
Losses	Direct Economic Losses for Vehicles (Night)	Direct economic losses (in thousands of dollars) for vehicles (during the night) resulting from the hazard in the scenario.
Losses	Shelter Requirements	Estimated number of persons to seek temporary shelter in public shelters as a result of the hazard in the scenario.

Tab	Report	Description
Other	Flood Global Risk Report	Includes general description of the region, building exposure by occupancy type (one for the Study Region and another for the scenario), expected building damage by occupancy and expected building damage by building type, expected damage to Essential Facilities, debris generated, shelter requirements, building-related economic loss estimates, and regional population and building value data.
Other	Quick Assessment	Includes regional statistics (area in square miles, number of Census blocks, number of buildings, number of people in the region, building exposure) and scenario results (shelter requirements and economic loss)

Section 9. Model Menu: Other Items

This section addresses the **File** menu, the **Help** menu, and the **Customize** menu. The primary focus is on any menu items that are different in the Hazus version of ArcMap compared with a typical ArcMap instance.

9.1 File Menu

The **File** menu, shown in Figure 9-1, is largely the same as the usual ArcMap File menu. The only two differences are the first two items: **Switch Hazard...** and **Study Region Wizard...**.

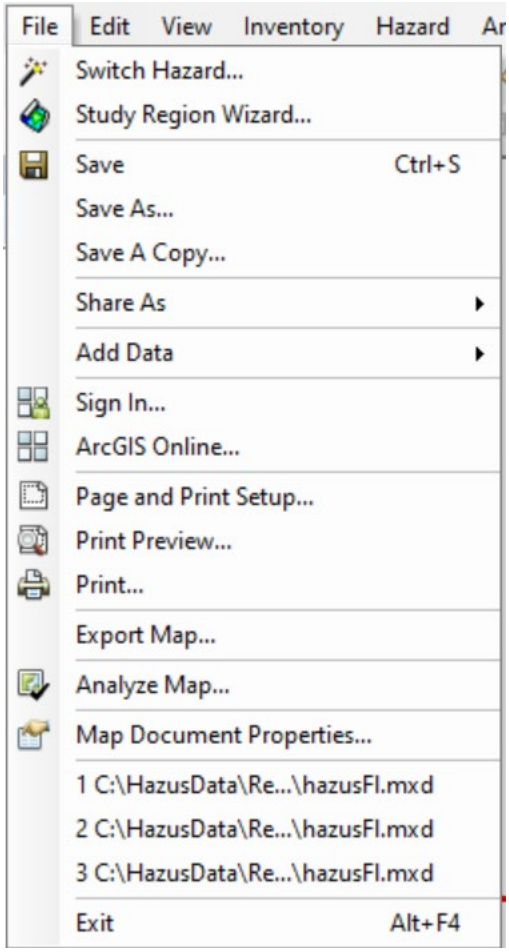


Figure 9-1 Hazus File Menu

The **Switch Hazard** option opens the **Select Hazard** dialog (Figure 9-2), which allows the user to switch between hazard types if the region was created with multiple hazards. Figure 9-2 shows an example related to storm surge where the Study Region has data and analyses for both the Hurricane Model and the Flood Model. When the user selects a new hazard, ArcMap will close and re-open with the selected hazard.

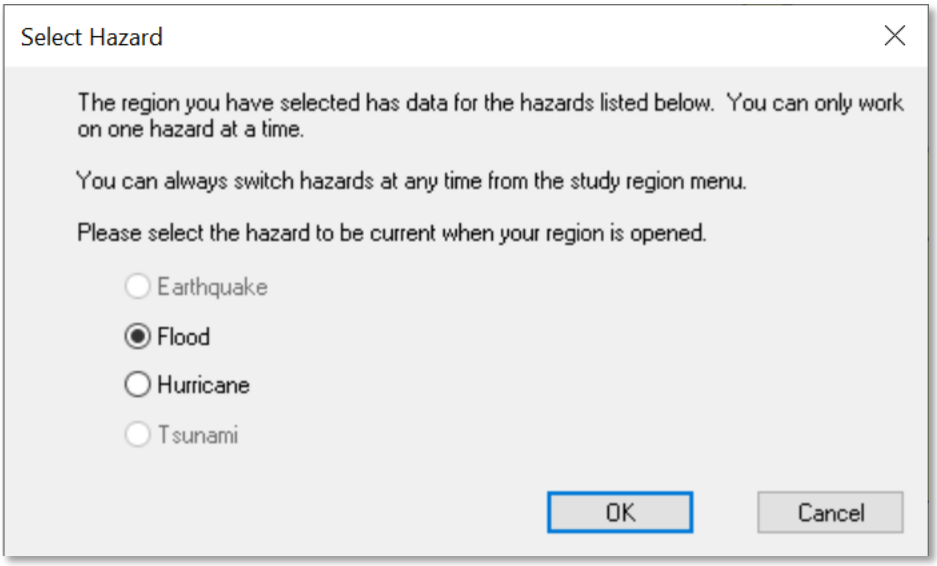


Figure 9-2 Select Hazard Dialog

The **Study Region Wizard...** option opens the Hazus startup screen (Figure 9-3). The only option available is **Open a region**. Click **OK** to select from any of the previously created regions and launch ArcMap.

Figure 9-3 Study Region Wizard

The remaining File menu options are the same as those normally found in ArcMap. Please refer to Esri documentation for any questions regarding these options.

9.2 Help Menu

The **Help** menu, shown in Figure 9-4, is largely the same as the usual ArcMap Help menu. The only two differences are the **Obtaining Technical Support...** and **About Hazus-MH** options.

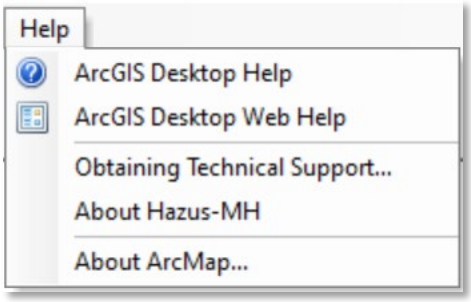


Figure 9-4 Hazus Help Menu

Selecting the **Obtaining Technical Support...** option will open the **Technical Support** window (Figure 9-5), which provides a phone number and email address for the user to refer any technical questions regarding Hazus.

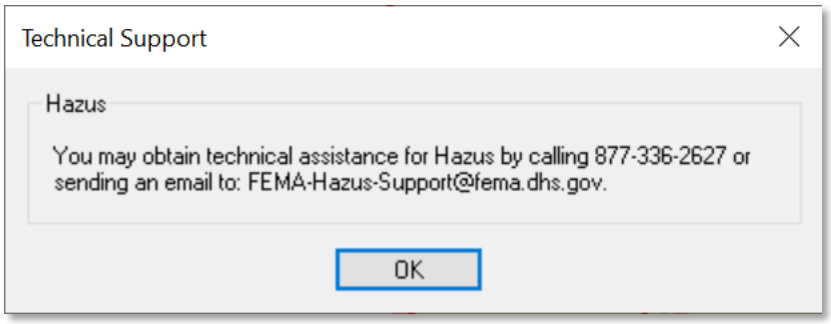


Figure 9-5 Technical Support Window

Selecting the **About Hazus-MH** option will open the **About Hazus** window (Figure 9-6), which shows the copyright information for Hazus.

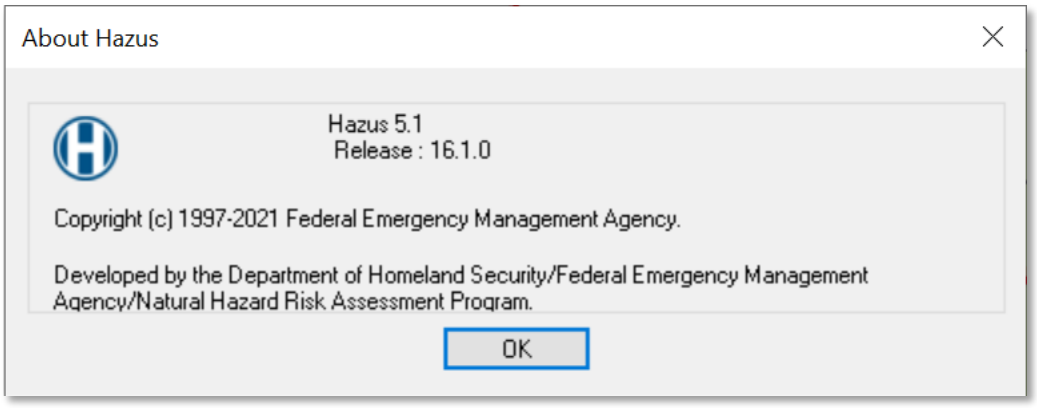


Figure 9-6 About Hazus Window

The remaining options on the Help menu are the same as those normally found in ArcMap. Please refer to Esri documentation for any questions regarding these options.

9.3 Customize Menu

The **Customize** menu, shown in Figure 9-7, is largely the same as the usual ArcMap Customize menu. The only addition to the menu is **Flood Options...**.

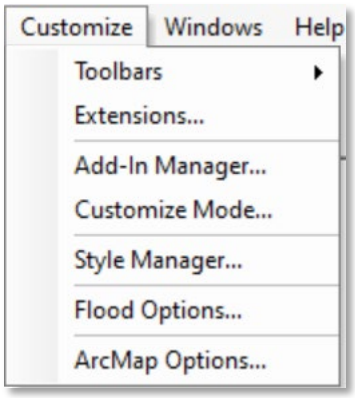


Figure 9-7 Hazus Customize Menu

Selecting **Flood Options...** will open the **Flood Options** window (Figure 9-8), which has four tabs: **Startup Options** (Figure 9-8), **Raster Options** (Figure 9-9), **Automation** (Figure 9-10), and **Repository** (Figure 9-11). The **Startup Options** tab gives the user some choices of what will appear when a Hazus ArcMap document is launched.

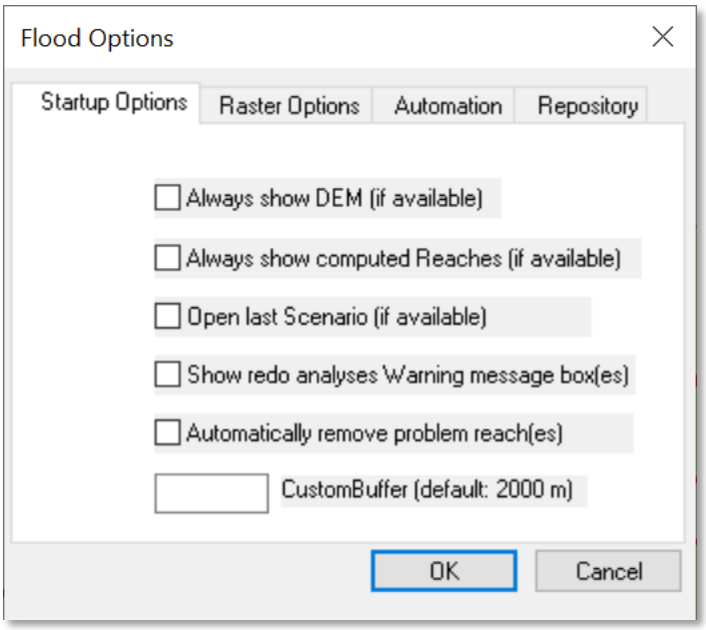


Figure 9-8 Flood Options (Startup Options) Window

The **Raster Options** tab gives the user control over how rasters will be symbolized and displayed in the Table of Contents.

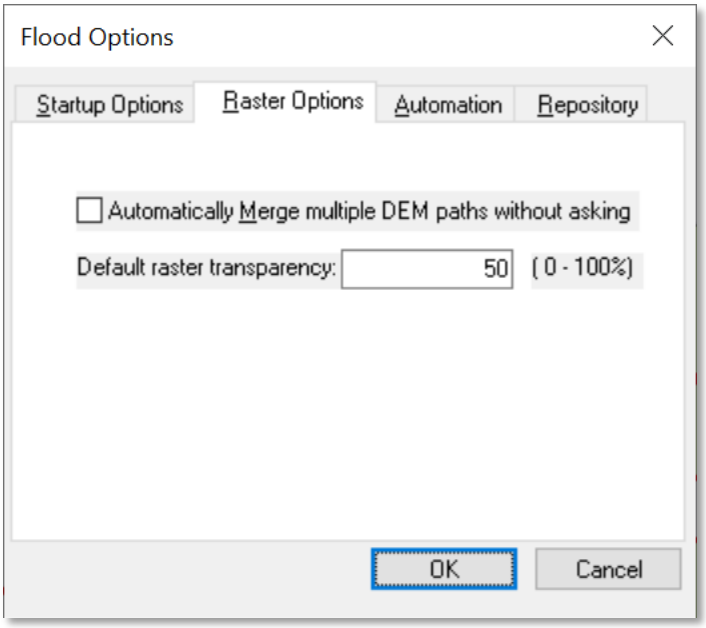


Figure 9-9 Flood Options (Raster Options) Window

The **Automation** tab (**Figure 9-10**) allows the user the set the parameters for a scenario to run from stream networks. To run:

1. Select the **Run Automation** checkbox.
2. Enter the **Drainage Area** for the Study Region.
3. **DEM Path** is automatically included based on the previous DEM analysis. Editing the path will have no effect on the DEM or **DEM Path**.
4. Enter a **Scenario Name** (the name must be unique). All reaches that are developed by the stream network will be selected and included in the scenario.
5. Select a **Return Period**. If the user selects the **Single** return period, Hazus will run through the GBS analysis. If the user selects the **Suite** option, Hazus will run through the GBS analysis *and* the AAL analysis.
6. Click **OK.**

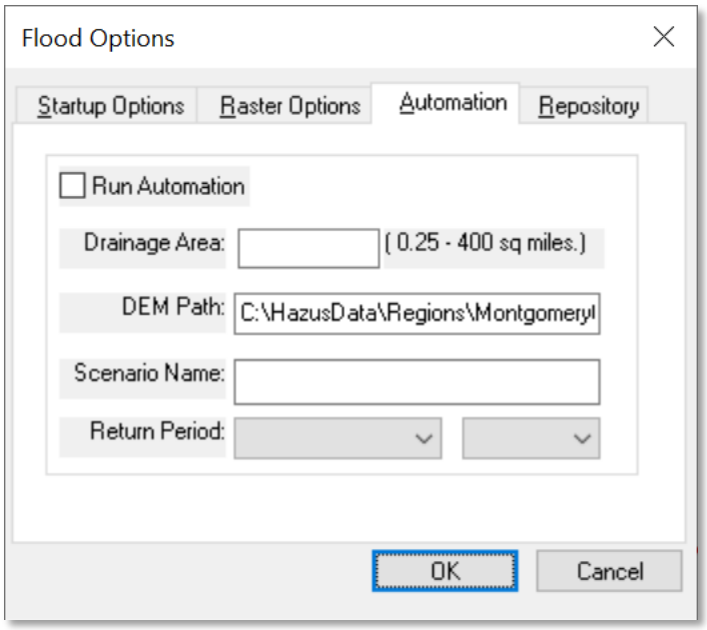


Figure 9-10 Flood Options (Automation) Window

The **Repository** tab allows the user to control where output data is stored.

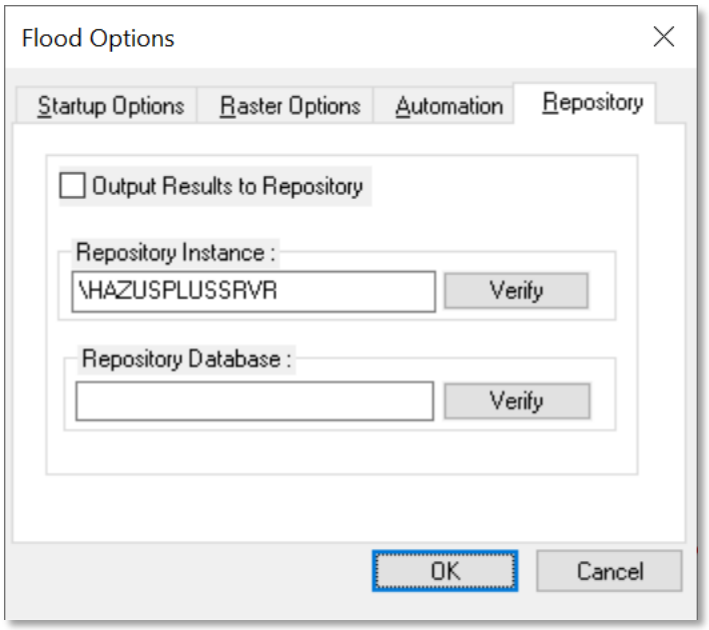


Figure 9-11 Flood Options (Repository) Window

The remaining items on the **Customize** menu are the same as those normally found in ArcMap. Please refer to Esri documentation for any questions regarding these options.

Section 10. Advanced Hazus Analysis: User-Defined Inventory Data

The Hazus baseline data inventory provides many datasets that support analysis, but in certain areas, a custom dataset may be more relevant to the Study Region being analyzed. Although Hazus data for a given location includes default inventory data for most data types, users may want to edit existing data or input their own data for certain type of analysis. Users should perform all data editing and entry using the Hazus Comprehensive Data Management System (CDMS) (Figure 10-1). CDMS will use Hazus Flood Model default values when critical attributes have not been populated (see Section 10.1 for baseline values). When CDMS is used to update the user-defined inventory data at the state level, these updated data will automatically be included in any Hazus Study Regions for that state. Details on using CDMS to import UDF and data requirements can be found in the *Hazus Comprehensive Data Management System User Guidance*.

Figure 10-1 Hazus Comprehensive Data Management System

10.1 UDF Required Attributes

Table 10-1 presents the attributes required for analysis of UDFs within the Flood Model. If any of the attributes are not imported (i.e., mapped), Hazus will populate them with baseline values. Although those values can be edited later through the Hazus interface, doing so is not practical for such a large number of records. Therefore, having the correct values in the imported file is more efficient

than editing them later. Note that the minimum required attributes for UDF analysis in Hazus are indicated by “Yes”, however, the minimum required attributes for CDMS are only Occupancy Type and Building Area. More detailed information about preparing UDF for import via CDMS is available in the CDMS User Guide.

Table 10-1 UDF Attribute Descriptions

Attribute	Description	Minimum Requirement	Field Type	Comments
ID	Hazus-assigned unique identifier for each record	Yes (generated by Hazus)	Text, Length: 8	If the user wants to include their own unique identifier for each structure, suggested fields are “Name” and “Comment.”
Name	Structure name	No	Text, Length: 40	This field can be used for user’s unique identifier for each structure, which may be local parcel ID if available.
Address	Structure street address	No	Text, Length: 40	
City	Structure city	No	Text, Length: 40	
State	Structure state	No	Text, Length: 2	
ZipCode	Structure zip code	No	Text, Length: 10	
Contact	Structure additional contact	No	Text, Length: 40	
Phone	Structure phone	No	Text, Length: 14	

Attribute	Description	Minimum Requirement	Field Type	Comments
Occupancy	Hazus-specific occupancy type	Yes	Text, Length: 5	CDMS requires that occupancy type is defined by the user. See Hazus technical manuals or Hazus Inventory menu for detailed list of Hazus-specific occupancies.
Cost	Building replacement value = cost to replace the building in case of damage in whole dollars (not thousands)	Yes	Currency,	Primary source should be cost-estimating guides, such as RSMeans ($/sq.ft). CDMS will use Area, Occupancy and RSMeans tables to estimate Cost if not provided by the user.
YearBuilt	Year structure was built	No	Number	User should provide the year built between 1500 and 2100
Area	Building finished floor area in square feet	Yes	Real, Length: 40	Required from user. CDMS will use Area, Occupancy and RSMeans tables to estimate Cost if not provided by the user.
NumStories	Number of stories in the building	Yes	Int Length: 40	CDMS will assume 1 if not populated. See Table 10-2 for acceptable values.

Attribute	Description	Minimum Requirement	Field Type	Comments
FoundationType	Foundation type of the structure	Yes	Text, Length: 1	CDMS will assume 7 (slab on grade) if not populated. See Table 10-4 for acceptable values. Used to determine with or without basement for RES1 occupancies.
FirstFloorHt	First floor height above grade	No	Float, Length: 4 Default: 1	Value should be locally derived. CDMS will assume 1 if not populated. See Table 10-4 for acceptable values.
ContentCost	Contents replacement value	No	Money, Default: 0	If not populated, CDMS will assume default value based on Cost and standard Hazus default contents value multiplier assumptions. See Hazus technical manuals or Hazus Analysis menu for specific multipliers.

Attribute	Description	Minimum Requirement	Field Type	Comments
BldgDamageFnId	Building Damage Function ID	No	Number, Length: 10	If not populated, Hazus will assume the GBS default value based on Occupancy, Number of stories, and Foundation Type. See Hazus technical manuals or Hazus Analysis menu for specific values.
ContDamageFnId	Contents Damage Function ID	No	Number, Length: 10	If not populated, Hazus will assume the GBS default value based on Occupancy, Number of stories, and Foundation Type. See Hazus technical manuals or Hazus Analysis menu for specific values.
InvdamageFnId	Inventory Damage Function ID	No	Number, Length: 10	If not populated, Hazus will assume the GBS default value based on Occupancy, Number of stories, and Foundation Type. See Hazus technical manuals or Hazus Analysis menu for specific values.

Attribute	Description	Minimum Requirement	Field Type	Comments
FloodProtection	Level of protection provided by a dam or levee in Return Period)	No	Int	Hazus will assume 0 if not populated. If near dam or levee, set value for level of protection in Return Period (e.g., 100 for protection behind a 100-year flood rated levee
ShelterCapacity	Capacity, in number of people, for structure providing shelter	No	Smallint, Length: 2 Precision: 5	Not used in Hazus.
BUPower	Is backup power available?	No	Bit, Length: 1	No (default) = 0, Yes = 1. Not used in Hazus.
Latitude/Longitude	The location of the structure	Yes	Decimal, Length: 9, Precision: 11, Scale: 6	Importing data in CDMS will pull location from spatial attributes of each structure point; manually entered data with Hazus user interface will require entering values when adding a UDF point.
Census Tract	The Census Tract where the UDF is located	No	Text, Length: 11	
Comment	Open text field	No	Text, Length: 40	Text field for additional information.

Table 10-2 NumStories Field Description

Occupancy	Number of Stories from Parcel Data	NumStories Value
RES1	1	1
RES1	2	2
RES1	3	3
RES1	Split-Level	4
RES2	1	1
RES2	2	2
RES2	3	3
RES3	1–2	1
RES3	3–4	3
RES3	5+	5
All other occupancies	1–3	1
All other occupancies	4–7	4
All other occupancies	8+	8

Table 10-3 DesignLevel Field Description

Year Built	Design Level Value
Prior – 1950	1
1950 – 1970	2
Post 1970	3
0 (set to Null)	0

Table 10-4 FoundationType Field and FirstFloorHt Field Description

Foundation Type from Parcel Data	FoundationType Value	Default FirstFloorHt (feet) Value
Pile	1	7
Pier	2	5
Solid Wall	3	7
Basement/Yard	4	4

Foundation Type from Parcel Data	FoundationType Value	Default FirstFloorHt (feet) Value
Crawl Space	5	3
Fill	6	2
Slab on Grade	7	1
These values are based on Pre-FIRM construction for Riverine, Great Lakes, and Coastal Construction Census blocks as defined through the Flood Specific Occupancy Mapping table.		

10.2 UDF User-Supplied Inventory

The creation of user-supplied inventory can require varying levels work to prepare. The extent of preparation and data compilation work involved depends on the condition and completeness of existing information, required data conversions, and the contributions of subject expertise. The greatest impact from enhanced inputs is produced by editing both the default inventory.

The most detailed type of analysis incorporates the results from completed loss studies. For example, the output of loss estimates performed using locally developed traffic models that have identified the bridges most susceptible to damage can be included. Similar analyses can provide information on water distribution or other pipeline systems. Updates to the vulnerability ratings for each model building type will also produce more accurate analysis results.

Running a baseline analysis for comparison with results after introduction of user-supplied data is recommended. Sensitivity of the loss estimation methodology under local conditions is measured best by review of outputs after inclusion of each enhanced inventory. Good record-keeping and inventory of documentation are essential.

In some cases, data collected will have to be adjusted so that the inventory is classified according to the systems defined in the methodology. For example, a school may have two building wing additions that were constructed over the 40-year lifetime of the structure. Each era of construction used improved materials, but the best materials were used to construct the smallest addition. The individual responsible for assigning the building type of the school according to the Hazus methodology will need to define and document the criteria applied to classify the structure. The easiest approach is to break the facility into different entries (i.e., records).

Consult the *Hazus Comprehensive Data Management System User Guidance* for specific information on use of that tool for data editing and entry.

Section 11. Advanced Hazus Analysis: Hurricane Surge Scenario

The Hazus tool can run a combined hurricane and flood hazard analysis for coastal areas. To run a combined hurricane and flood hazard, a multi-hazard (flood and hurricane) Study Region that includes a shoreline must be built. To build the Study Region, follow the workflow shown in Table 11-1. The inputs will be used to determine the extent of flooding due to a wind-driven storm and estimate the flood losses associated with the hurricane.

Table 11-1 Workflow to Build Multi-Hazard Study Region

Model	Inputs
Hurricane	▪ Define/Select Hurricane Scenario ▪ Run Analysis with Surge-Only or Surge and Waves ▪ Display Wind-Only Losses
Flood	▪ Select Storm Surge ▪ Define Topography ▪ Define Scenario ▪ Delineate Floodplain ▪ Run Flood-Only Analysis ▪ Run Combined Loss Analysis
Hurricane or Flood	▪ Display Combined Losses

11.1 Storm Surge Scenario Options

The storm surge scenario options are available for four hurricane scenario types:

- Historic (It is recommended when selecting from the historic data to run storm surge is applicable. These include observed data from recent events and additional files to improve the reliability of the surge data)
- User- defined
- Hazus import
- Hurrevac Hurricane Hazard Import Tool (HHIT) or .stm file library import; also see the Hazus Hurricane Model Technical Manual

The storm surge scenario options are not available for:

- Hurricane surface wind file (.dat file format)
- Probabilistic

To run a storm surge analysis, the Study Region must have been created for both Hurricane and Flood Hazard analysis. As shown in Section 3, start with create a New Region Wizard (Figure 11-1). Check both **Flood** and **Hurricane** hazard boxes and click **Next**.

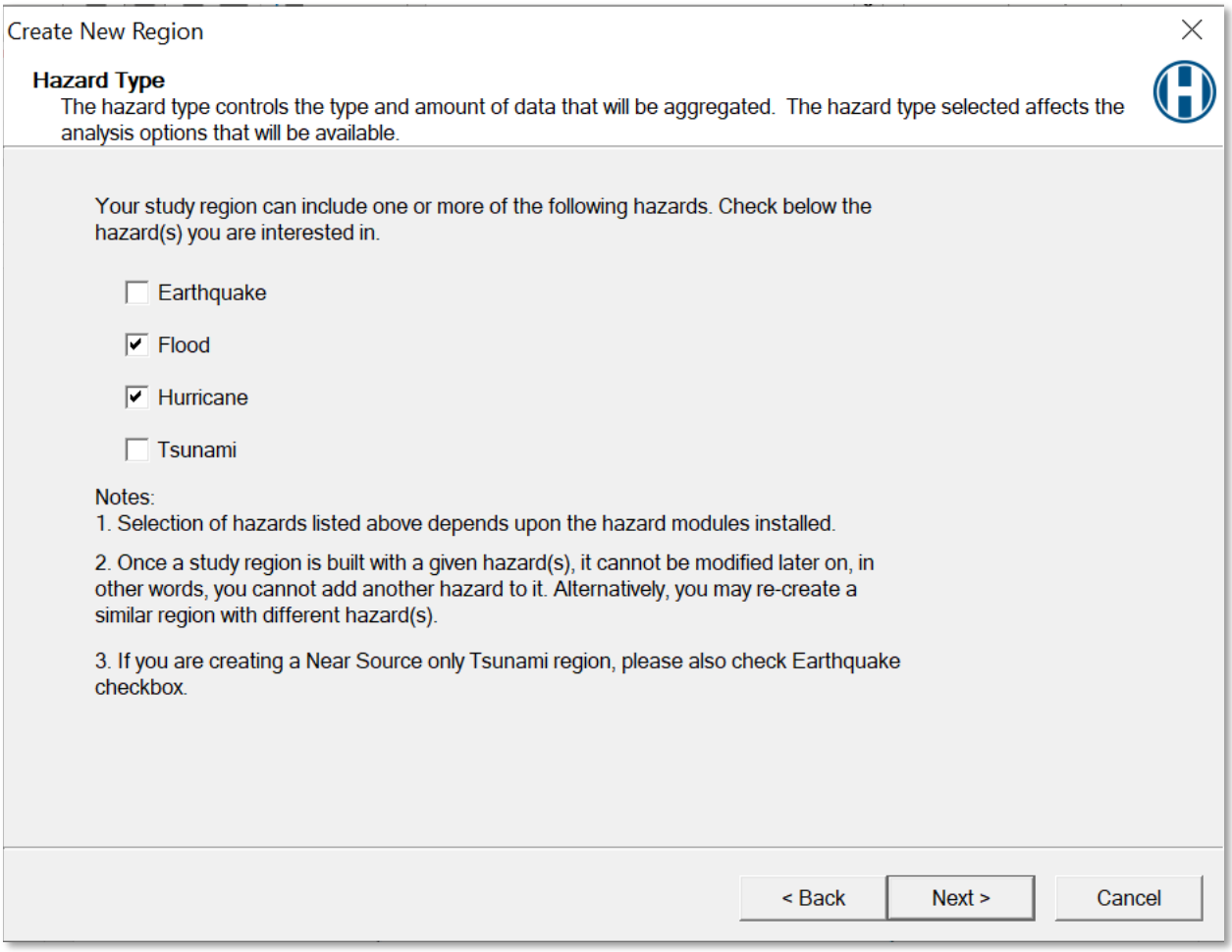


Figure 11-1 Select Hazards for New Region

Specify the Study Region and finish the Create New Region wizard.

NOTE: Limiting storm surge Study Regions to a single county is recommended. In some cases, a very large single county may need to be split into two regions.

Open a region and select the new multi-hazard. When prompted, select the Hurricane Model to open first, as shown in Figure 11-2. Click **Next** and then click **Finish** to open the region.

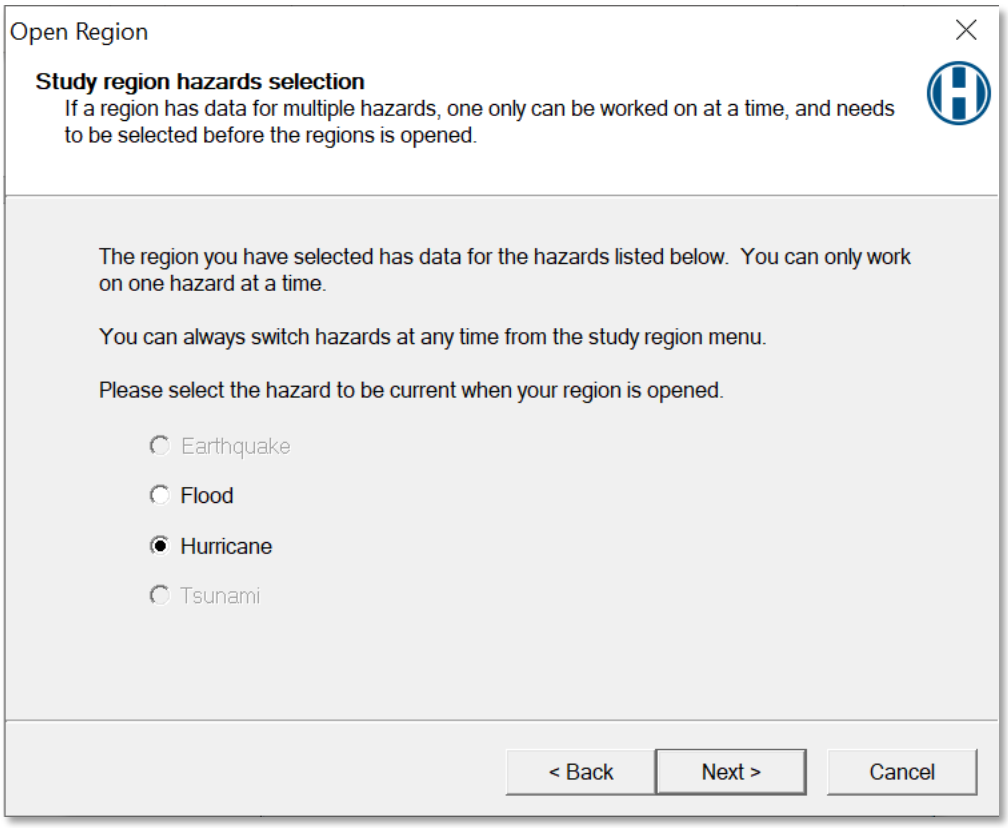


Figure 11-2 Select Hurricane Model First in Study Region

Analysis > Set Optimized Analysis Mode must be "Off," as shown in Figure 11-3.

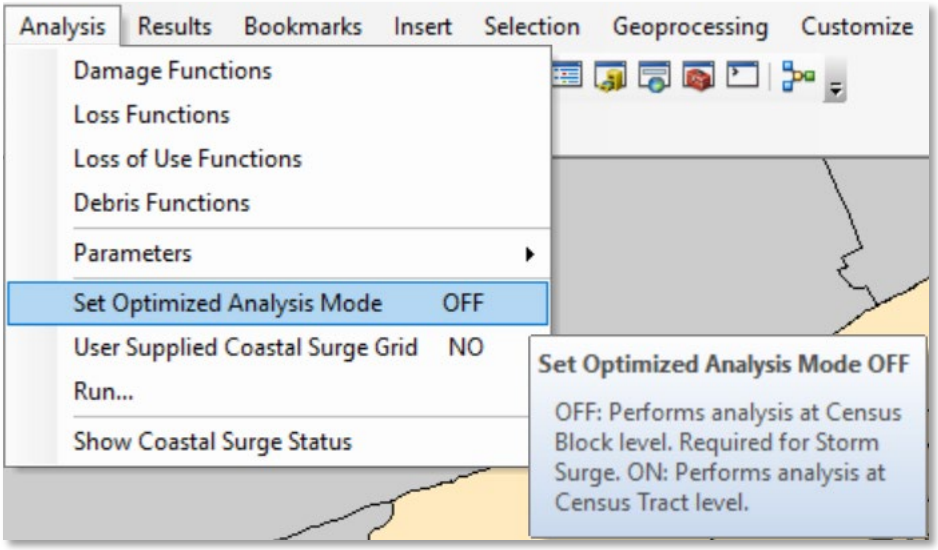


Figure 11-3 Ensure Optimized Analysis Mode is Off

Check **Hazard > Show Current** to make sure the scenario is set to manual, Hazus import, historical, or Hurrevac import (Figure 11-4). If the scenario needs to be changed, use **Hazard > Scenario** to open the Scenario Management Wizard discussed previously (Figure 11-5).

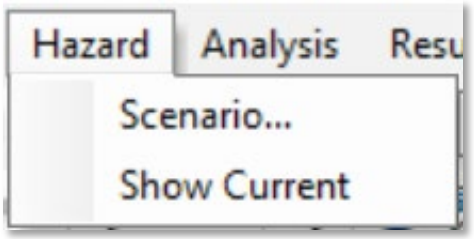


Figure 11-4 Review Scenario in Hazard > Show Current

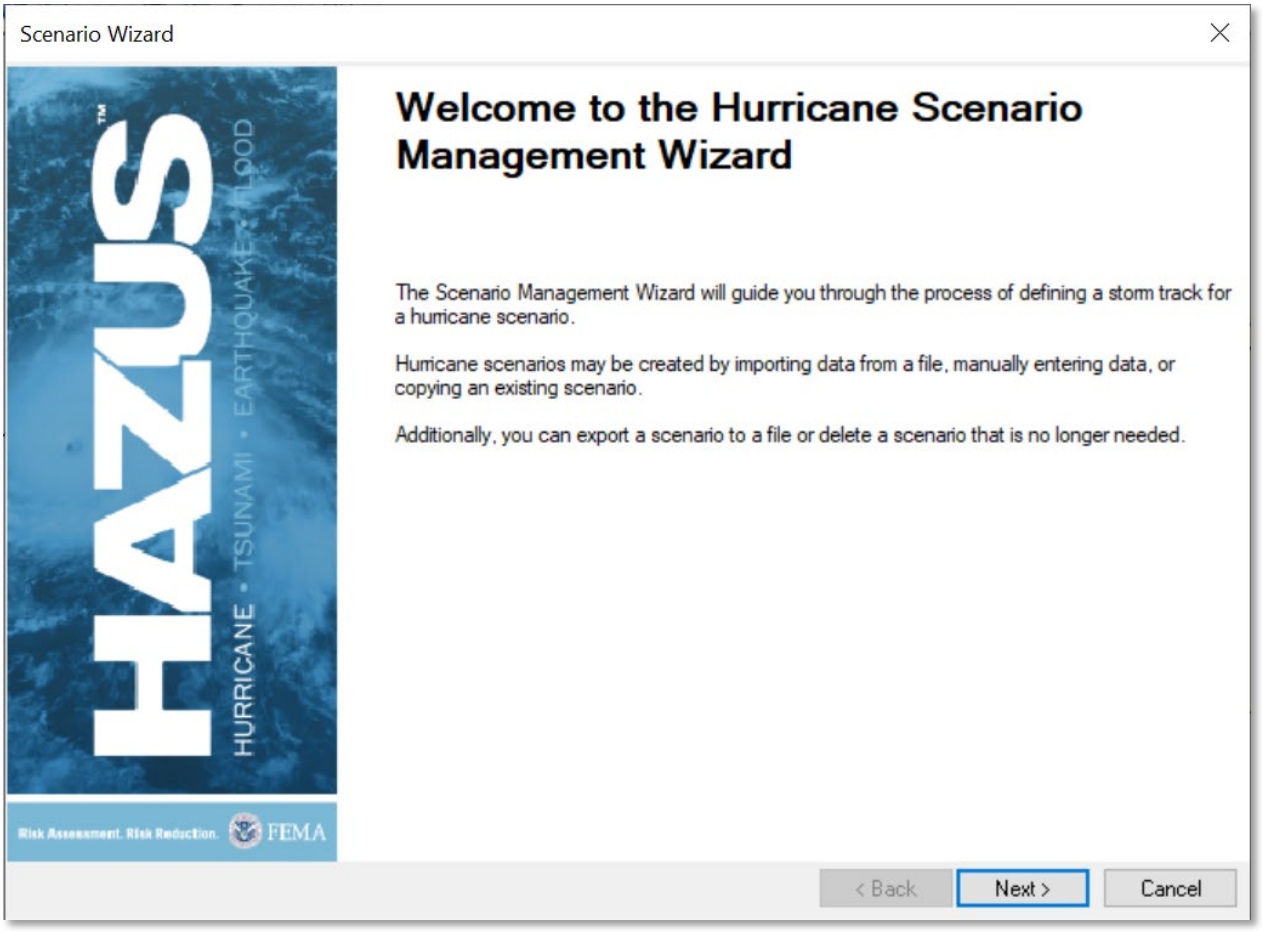


Figure 11-5 Scenario Management Wizard

11.2 Run Storm Surge Analysis

Open the **Analysis Options** from the **Analysis > Run** menu (Figure 11-6). When storm surge is selected, as shown in Figure 11-7, a storm surge analysis using the National Oceanic and Atmospheric Administration (NOAA) Sea, Lake, and Overland Surges from Hurricanes (SLOSH) model is executed in the Hurricane Model to produce estimates of coastal still water elevations. Note that the storm track that is used should extend beyond the outer boundary of the applicable SLOSH basin grids.

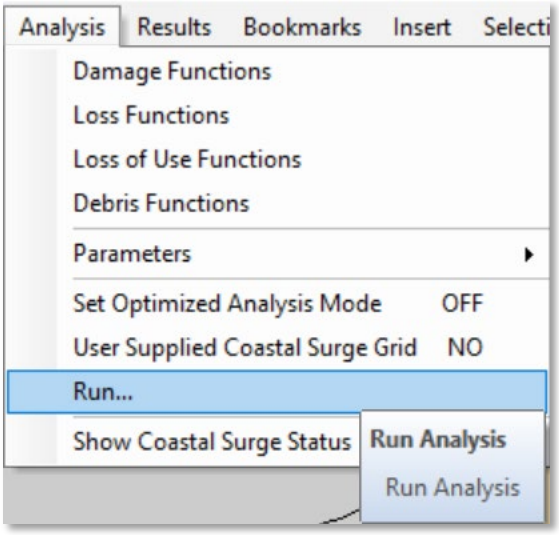


Figure 11-6 Analysis Run Storm Surge Menu

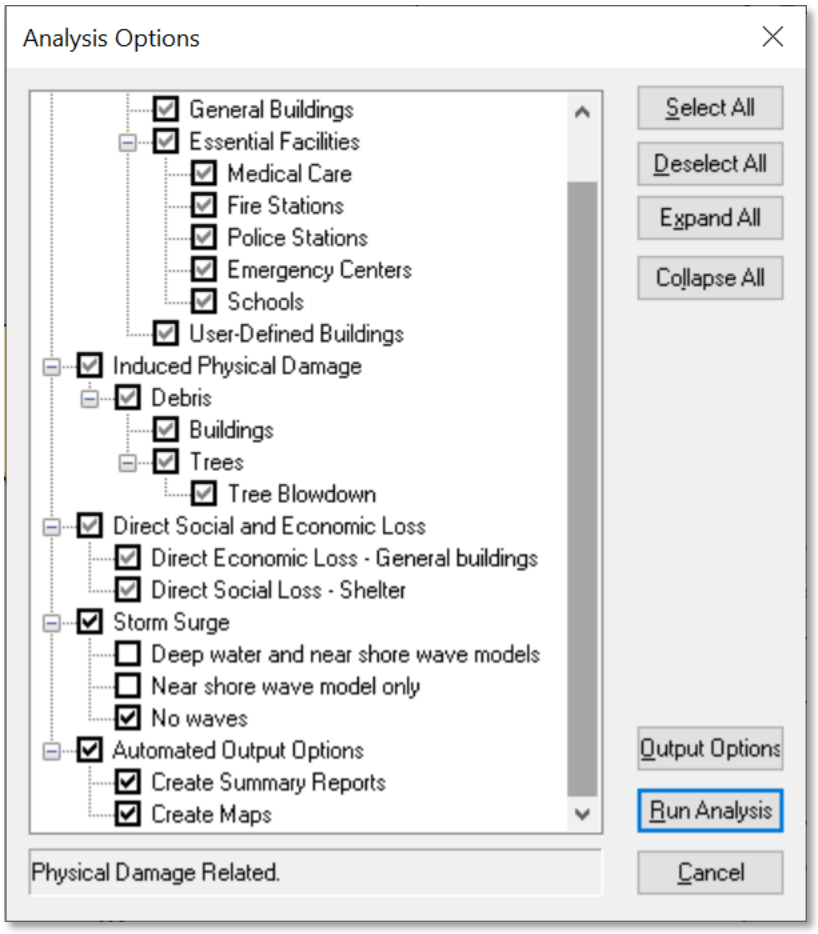


Figure 11-7 Analysis Options for Storm Surge

In addition, there are options for running coupled surge and wave analysis using the Delft University Simulating WAves Nearshore (SWAN) model if checked (refer to the Technical Manual for more details on the modeling approaches used for SWAN and SLOSH):

- *Deep water and near shore wave models.* A coarse analysis of the entire northwest Atlantic basin is run, and the results are then coupled into one or more nearshore wave grids, which are superimposed on the relevant SLOSH basin(s). This option is the most detailed and slowest running. The storm track used should also extend all the way out to 60 degrees west longitude when this option is selected.

- *Near shore wave model only.* This option runs a coupled surge and wave analysis within the relevant SLOSH basin(s) only. This option is faster than the first option but still significantly slower running than the "no waves" option.

- *No waves*. This option skips the SWAN model entirely. For this case, the Flood Model assumes depth-limited waves at the coastline rather than using significant wave heights produced by SWAN. This is the fastest option.

When appropriate boxes have been checked in the Analysis Options, click **Run Analysis**.

At the start of the analysis, the Hurricane Model prompts the user for an **initial water level** in feet with respect to the North American Vertical Datum (NAVD) 1988 datum shown in Figure 11-8. This represents the water level along the coast that would have been expected (in the absence of the hurricane) near the center of the Study Region at the time of hurricane landfall. The initial water level can be estimated by using NOAA tide forecasts plus the pre-storm tidal anomaly (i.e., the difference between the forecast and observed water level 2 days before landfall).

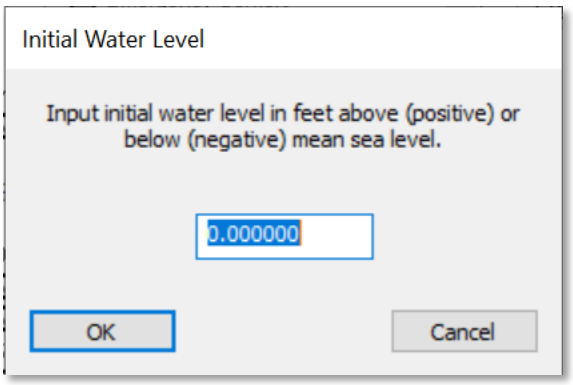


Figure 11-8 Provide Initial Water Level

When running a coastal surge hazard analysis (Figure 11-9) in the Hurricane Model, a second progress dialog will appear after the wind-only damage and loss calculations are completed (Figure 11-10).

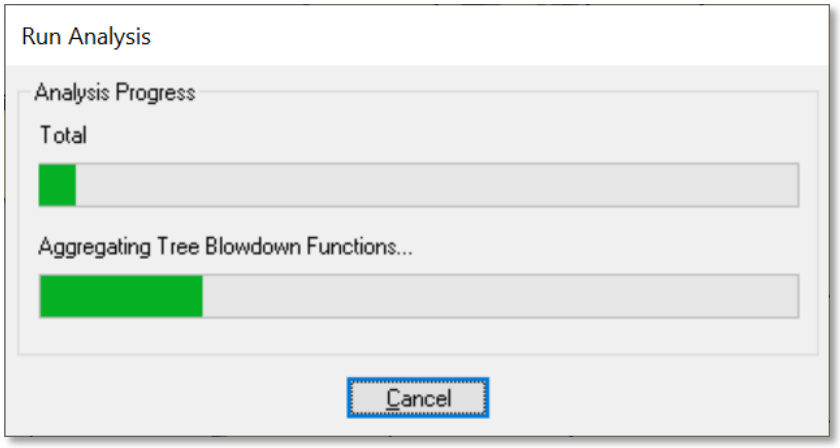


Figure 11-9 Run Analysis Progress Status Window

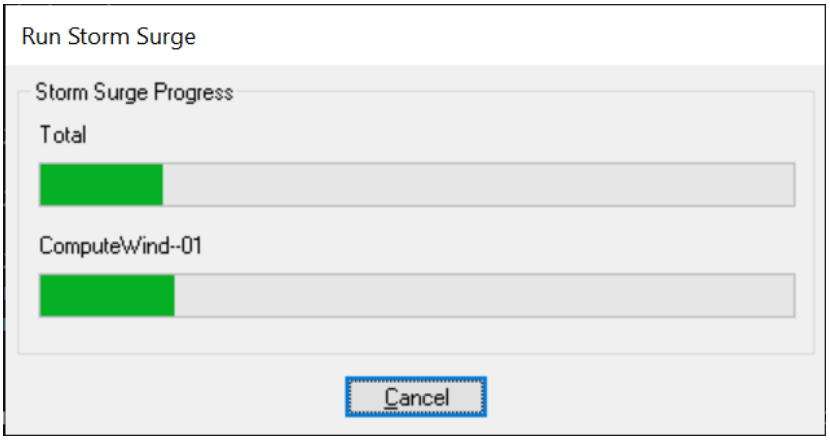


Figure 11-10 Run Storm Surge Progress Status Window

When a hurricane coastal storm surge analysis is run, two sets of direct building losses are produced: one set for the wind damage by itself and a second set for the combined wind and surge damage. When the coastal surge analysis is complete, click the **Analysis > Show Coastal Surge Status** to confirm that the analysis was successful, as shown by the status box in Figure 11-11.

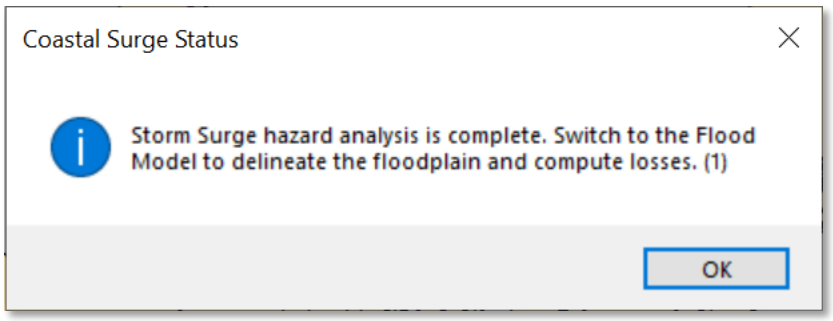


Figure 11-11 Coastal Surge Status Window

To obtain the combined wind and surge losses, users must run a Coastal Surge analysis and calculate the combined losses in the Flood Model. See further instructions in the Hazus Flood Model Manual.

11.3 Storm Surge

After the Hurricane Model has been run, reopen the Study Region in the Flood Model.

View as **Flood**, shown in Figure 11-12. Click **Next** and then click **Finish** to open region.

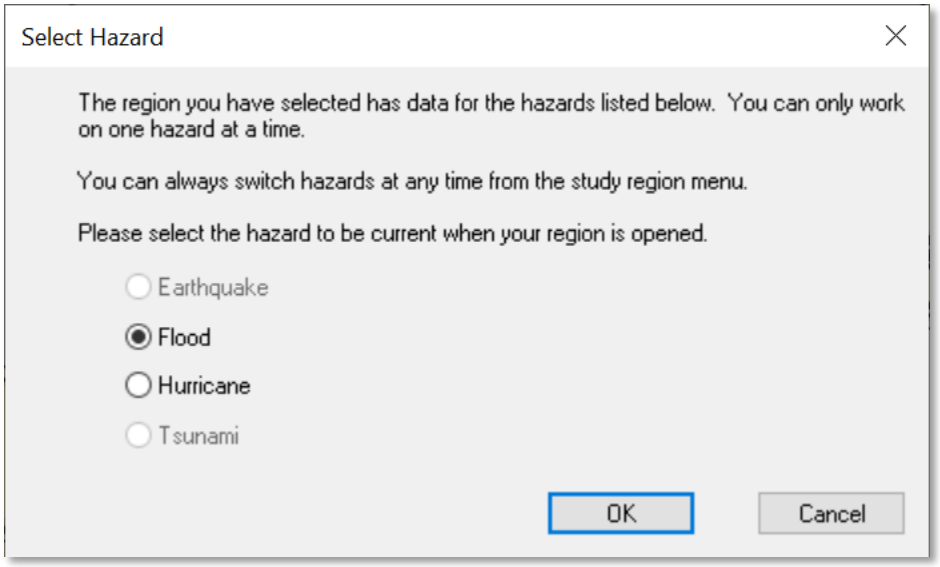


Figure 11-12 Select Flood Model in Study Region

Open the **Hazard** menu and select **Flood Hazard Type** (Figure 11-13).

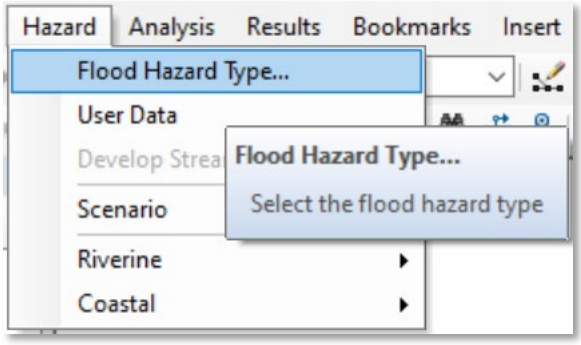


Figure 11-13 Select Flood Hazard Type

Select the **Flood Hazard** type **Storm Surge** and click **OK** (Figure 11-14).

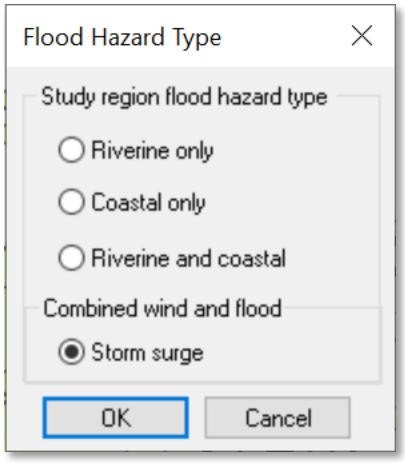


Figure 11-14 Select Storm Surge

After the hazard type is set, the user must import a DEM for the Study Region by opening the **Hazard** menu and selecting the **User Data** dialog (Figure 11-15).

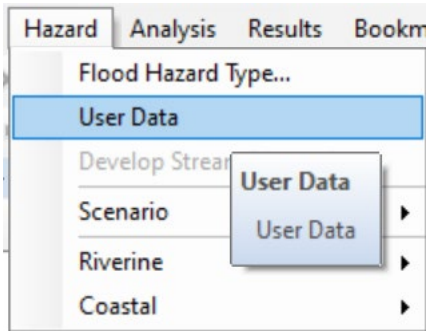


Figure 11-15 Select User Data to Import DEM

The **User Data** dialog will only contain two tabs, **DEM** and **Storm Surge**. Use the **Browse** button to add the DEM to the Model (Figure 11-16). Figure 11-17 shows the **Storm Surge** tab, where the Surge Elevation Grid (SLOSH) and Significant Wave Height Grid (SWAN) that were produced by the Hurricane Model are in the Study Region folder as surge.flt, surge.hdr (SLOSH), and waveht.flt, waveht.hdr (SWAN). When the DEM is uploaded, click **OK**. See the Hazus Flood Model Manual for more details about obtaining DEM data.

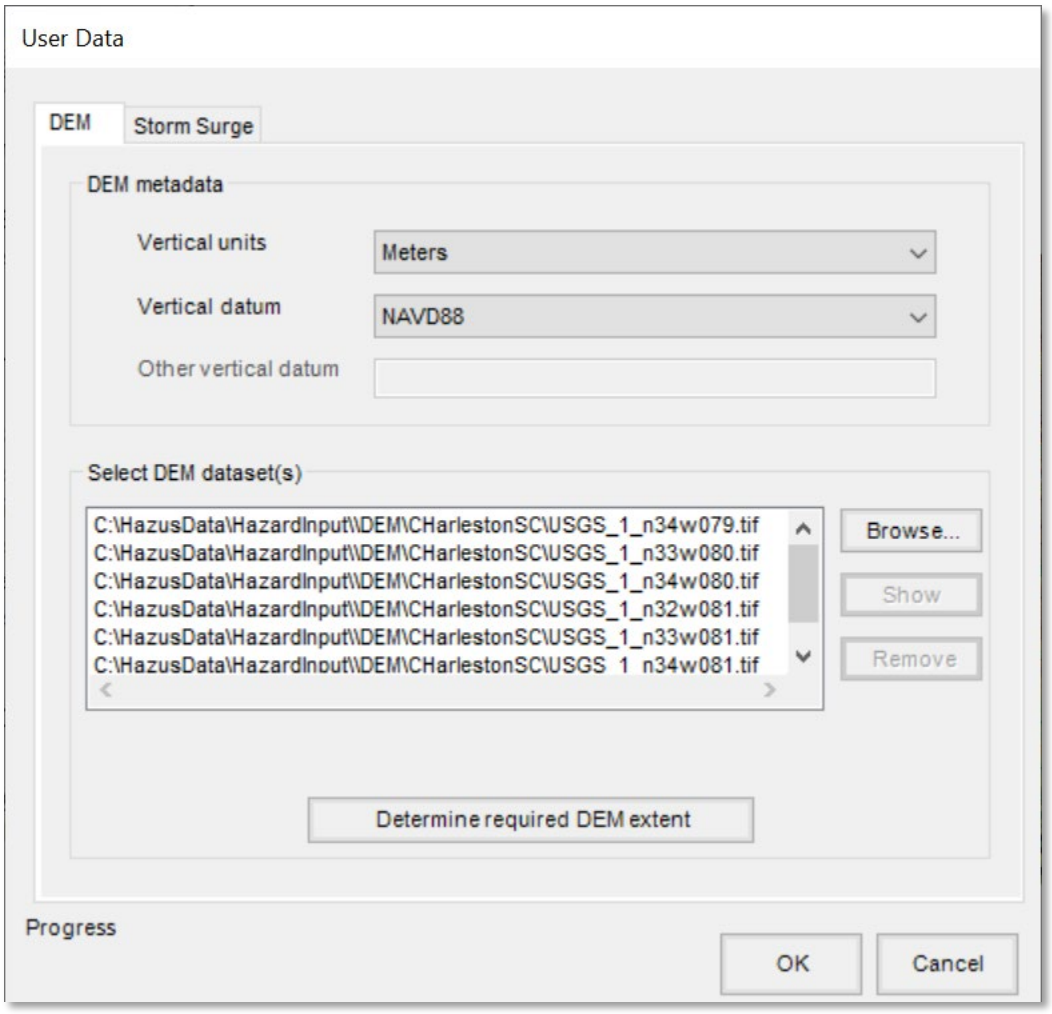


Figure 11-16 Add User Data DEM to Model

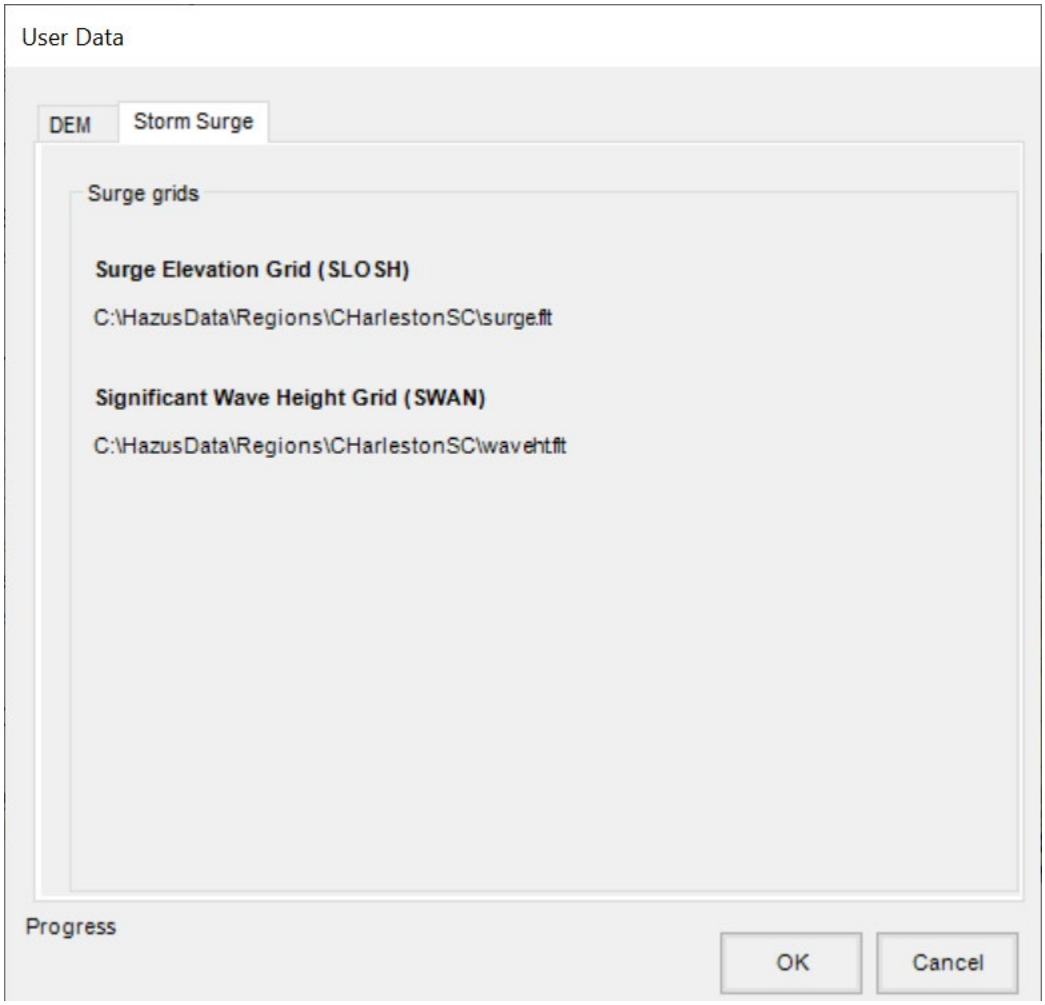


Figure 11-17 Review User Data in Storm Surge Tab

When the DEM uploads successfully, the user needs to create a new scenario next, using **Hazard > Scenario > New** (Figure 11-18). Enter a unique name for the scenario and click **OK** (Figure 11-19). In the storm surge scenarios, the surge and wave height files are automatically selected, and users do not need to select or save any features because the Hurricane Model supports only one scenario per Study Region.

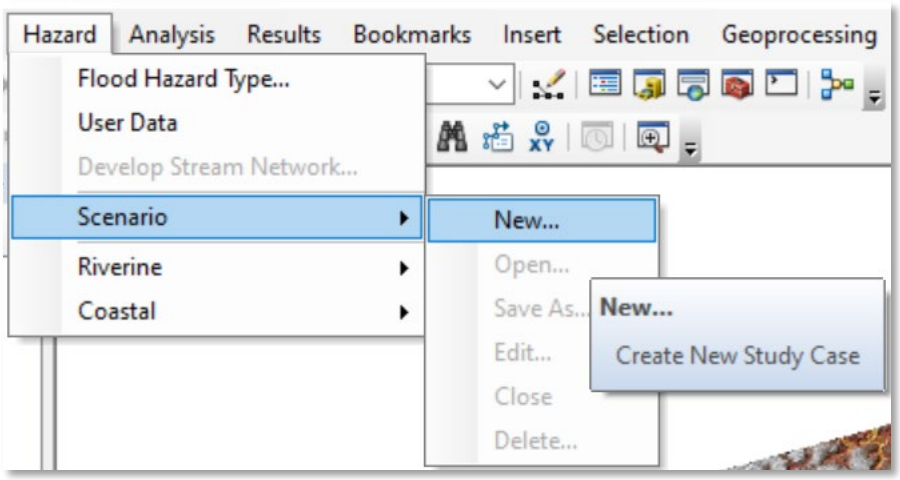


Figure 11-18 Select New Scenario in Hazard Menu

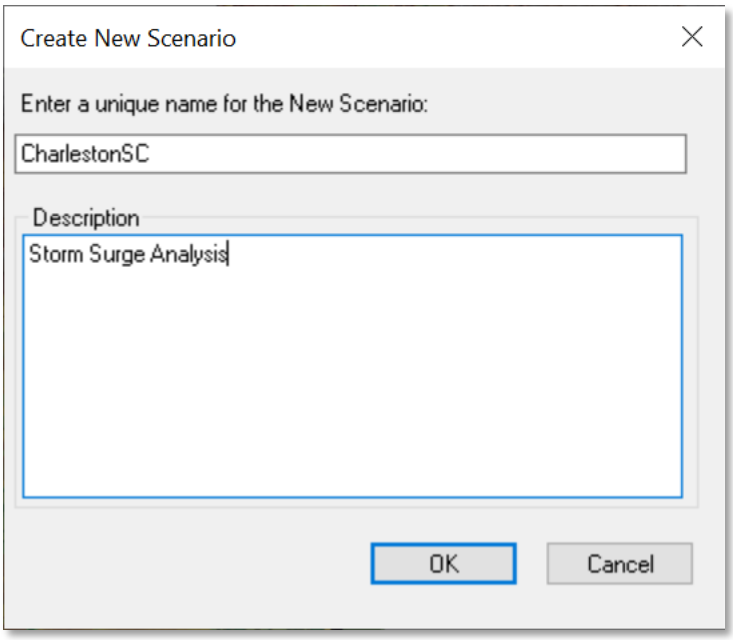


Figure 11-19 Provide Name for New Scenario

If the user selected **No Waves** in the Storm Surge analysis for the Hurricane Model, only the surge elevation grid was created for the Study Region. The wave height grid (waveht.flt) was not produced and the shoreline needs to be characterized. In this case, after creating a new scenario, the shoreline limits dialog will pop up, as shown in Figure 11-20.

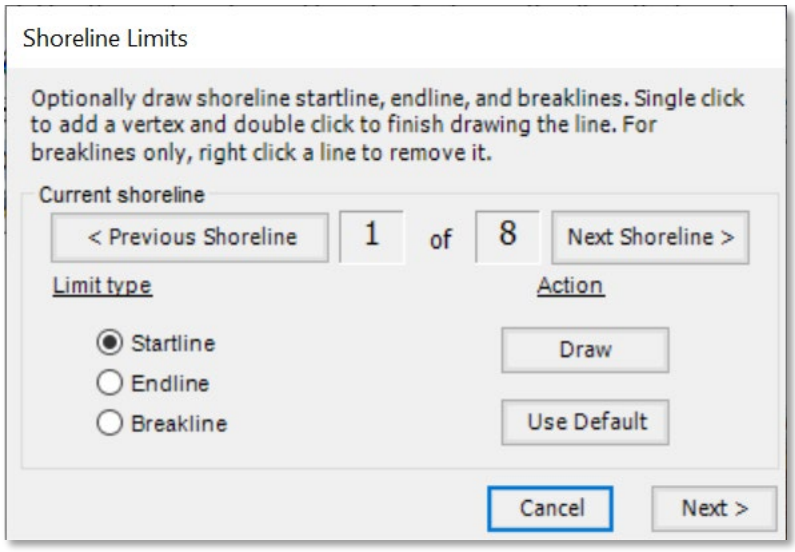


Figure 11-20 Input Shoreline Limits

After clicking **Next**, there will be an additional shoreline characterization dialog, as shown in Figure 11-21. The **Shoreline Type** tab has one required input (wave exposure).

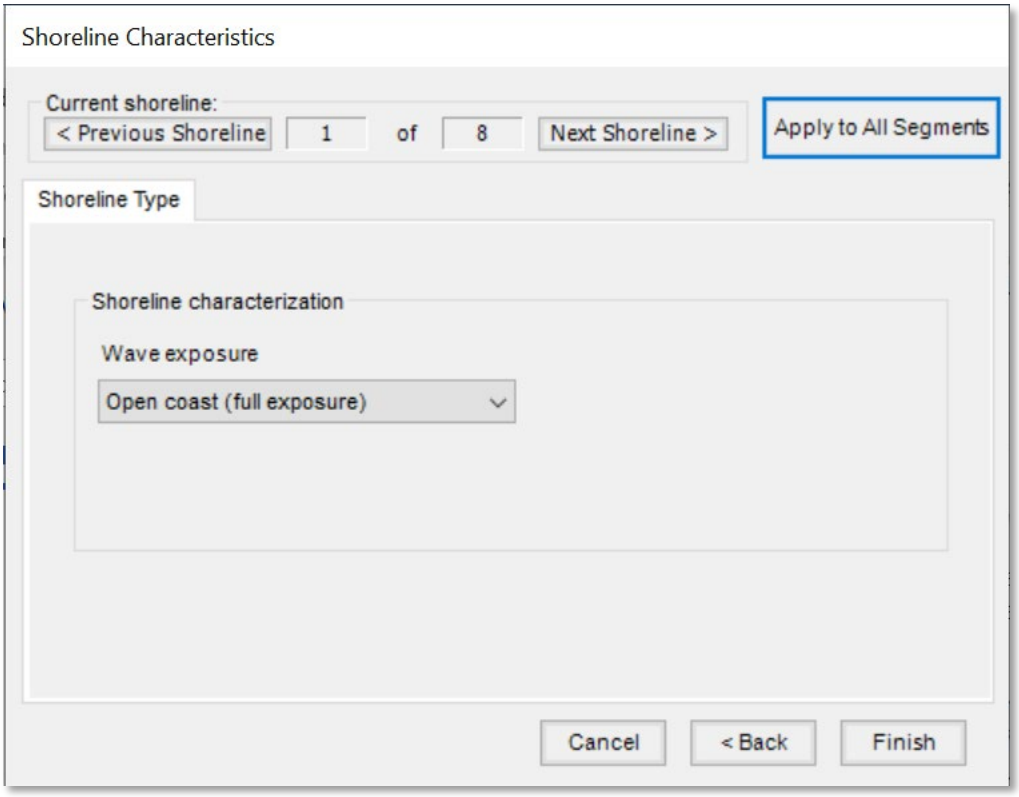


Figure 11-21 Select Shoreline Characteristics

The options for the wave exposure include:

- *Open coast (full exposure):* Any shoreline where the storm surge and waves come directly off open waters without the benefit of barrier islands or other land mass protection. Think in terms of lines of waves marching directly onto the shoreline uninterrupted. Full exposure is the Hazus default.

- *Moderate exposure:* Best represented by a shoreline that is slightly protected from the storm surge and associated waves. Moderate exposure might be a shoreline that has small islands or a low-lying sandbar that help break the direct force of the waves on the shoreline. A shoreline with moderate exposure might be angled to the direct line of the waves and will therefore receive a portion of the wave front.

- Minimal exposure: Best represented by a shoreline that is not in direct line with the storm surge or the waves. Minimal exposure might include an exposed shoreline that is running close to parallel to the storm surge and is therefore not bearing the brunt of the wave fronts.

- *Sheltered:* Best represented by the shoreline within a bay or protected by a larger barrier island. Sheltered could also be a shoreline along a large river inlet. The shoreline is sheltered from the wave front and is most likely subjected to stillwater flooding.

The default parameter is **Open coast (full exposure)**. At the top of the screen, the user can switch from one shoreline segment (if more than one) to another and back. If there are multiple segments and most have a single characteristic and a few have unique characteristics, the user can save time and effort by applying the common characteristic to all segments by pressing **Apply to All Segments** and then editing the unique segments.

After selections, click **Finish**.

Proceed to **Delineate Floodplain** by going to the **Hazard** Menu and selecting **Coastal** (Figure 11-22). When it is finished, the completion window will be shown as in Figure 11-23.

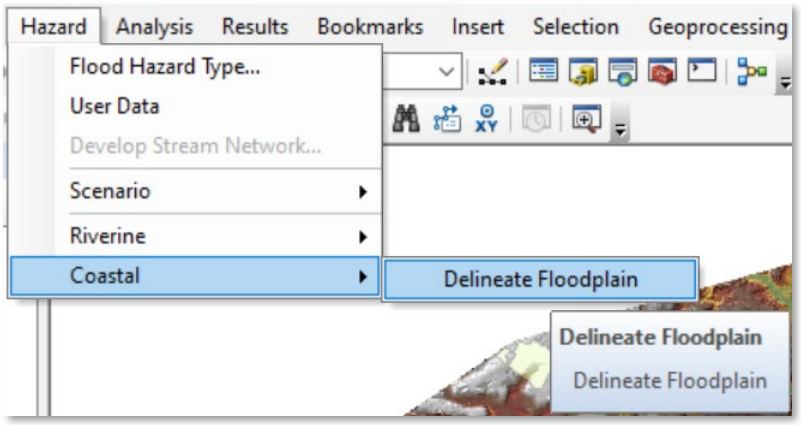


Figure 11-22 Select Coastal to Delineate Floodplain

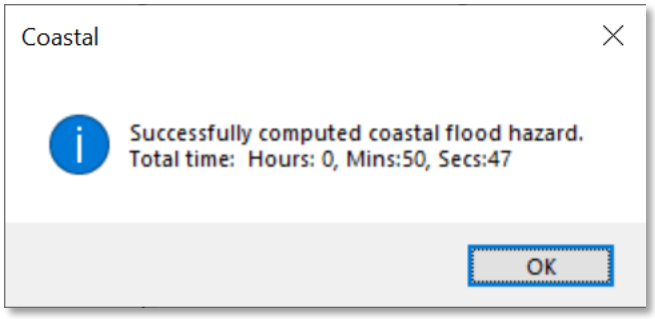


Figure 11-23 Delineate Floodplain Completion Status Window

Figure 11-24 displays the completed hazard portion of a storm surge model. The coastal surge model outputs a flood depth grid named “Mix0_c” to the map, which comprises SLOSH and wave height grids.

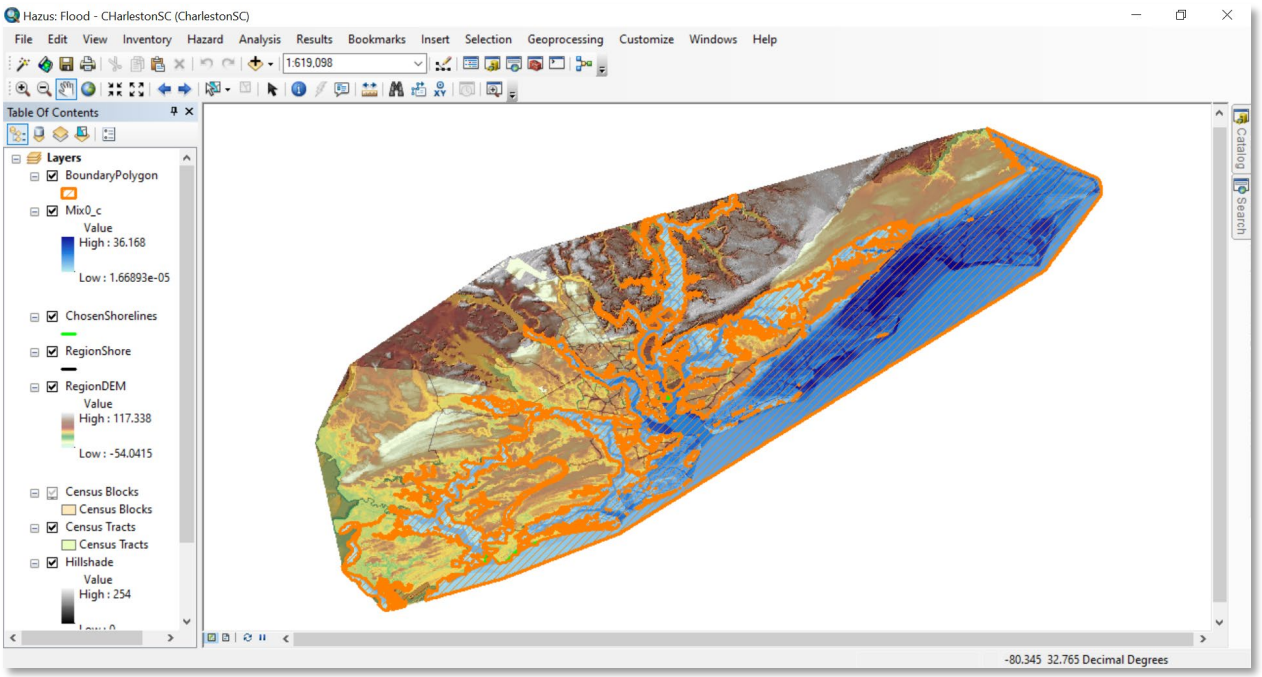


Figure 11-24 Example – Coastal Surge Floodplain Delineation

The next step to complete the analysis is by using the Analysis Menu and choose Run (Figure 11-25). Next, check the General Building Stock Damage and Loss option and click OK (Figure 11-26).

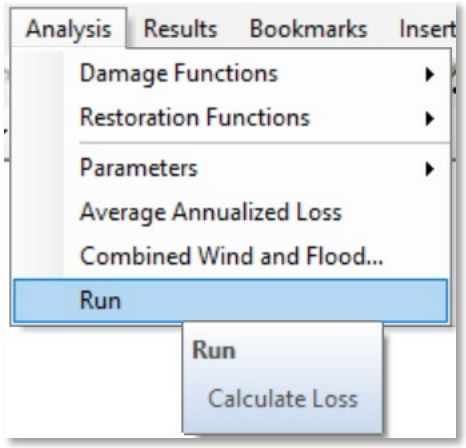


Figure 11-25 Select Run in Analysis Menu

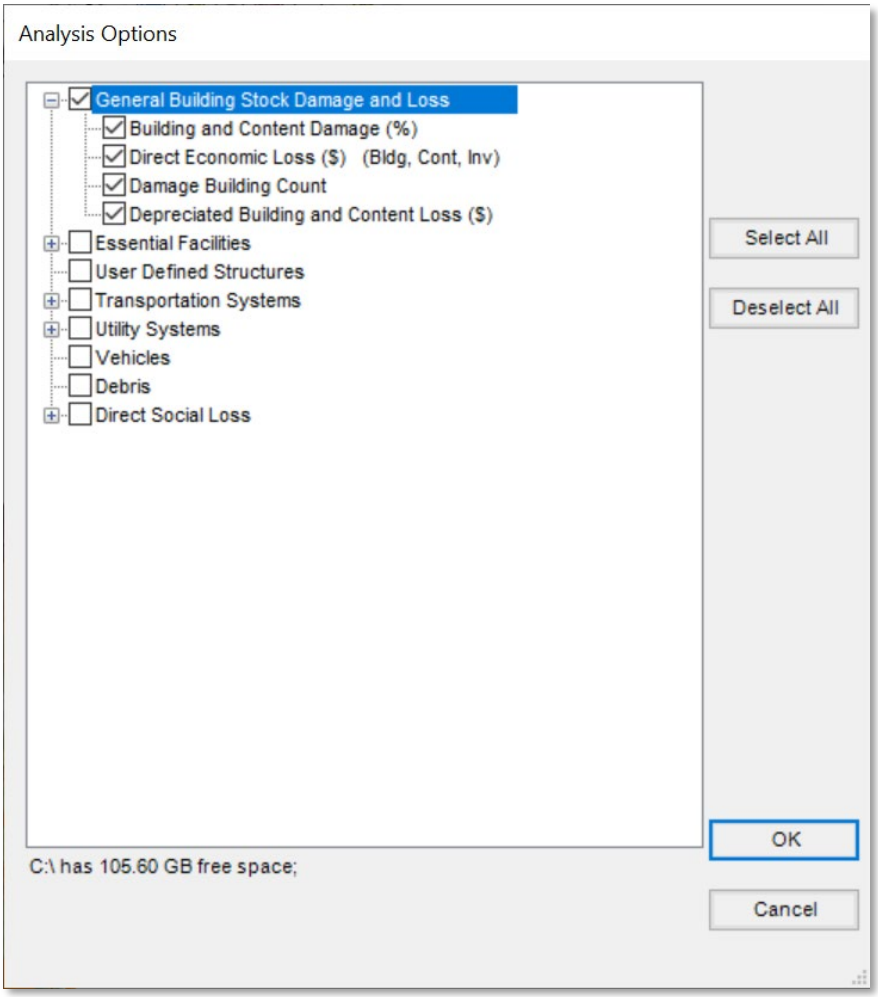


Figure 11-26 Select Preferred Analysis Options

The final step of a storm surge analysis is to calculate the combined hurricane wind and coastal storm surge losses, using the **Analysis** Menu and selecting **Combined Wind and Flood…** (Figure 11-27). When the combined losses are completed, click **OK** to the message box (Figure 11-28).

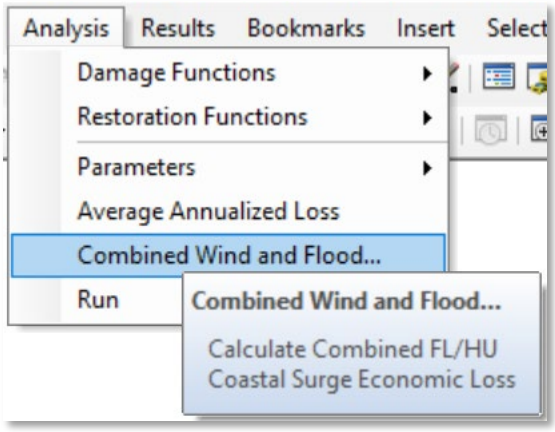


Figure 11-27 Select Combined Wind and Flood to Calculate Losses

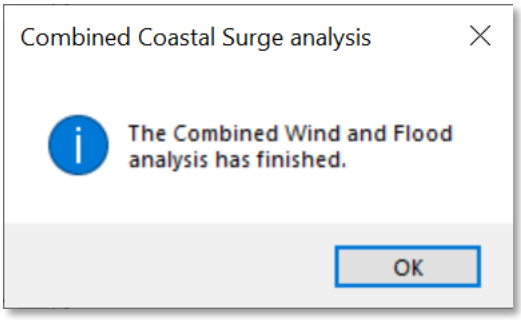


Figure 11-28 Combined Coastal Surge Status Window

When the analysis options have finished running, use the **Results Menu** (Figure 11-29) to **View Current Scenario Results By…**, select the scenario in the drop-down, and click **OK,** as shown in Figure 11-30.

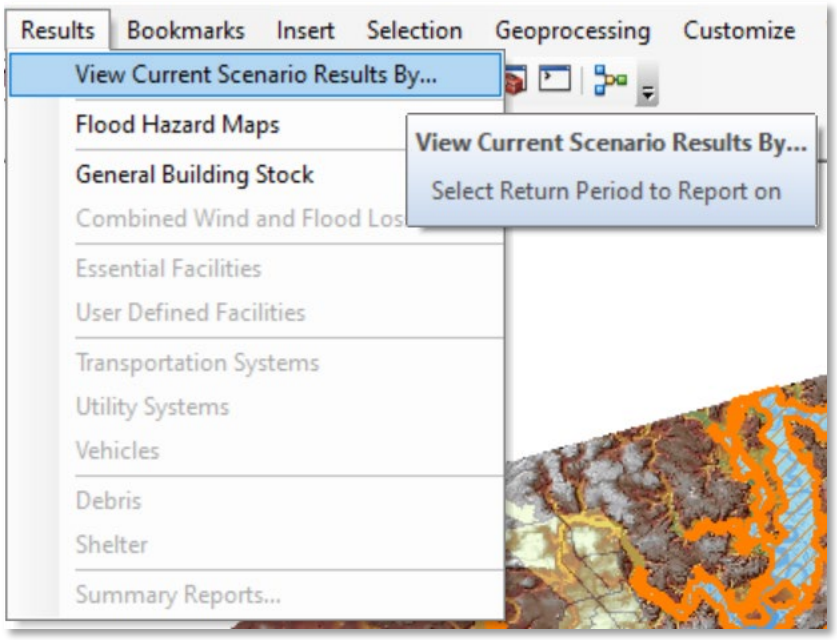


Figure 11-29 Select View Current Scenario Results

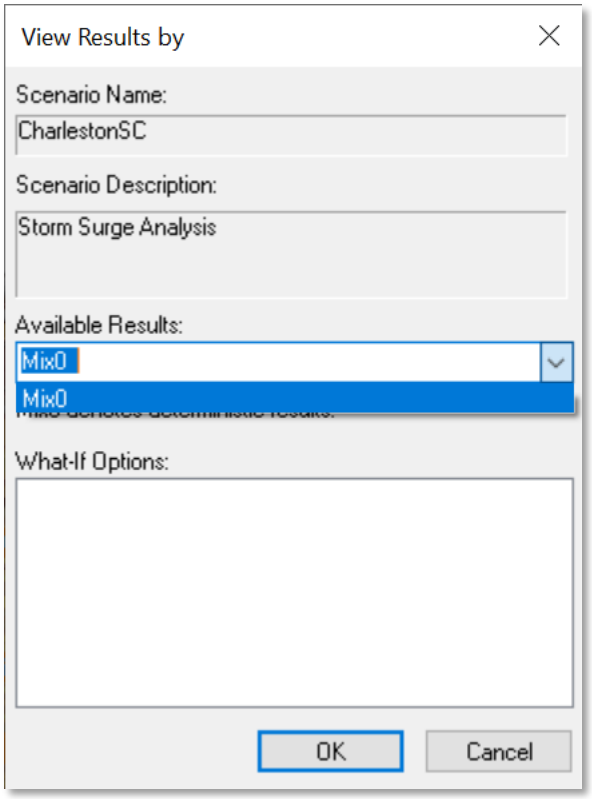


Figure 11-30 Select Available Results for Surge Analysis

The combined losses can be viewed either in the Flood Model or in the Hurricane Model using either the **Results** > **Combined Wind and Surge Loss** menu (Figure 11-31 and Figure 11-32) or the **Results** > **Summary Reports** > **Direct Losses** – **Combined Wind and Surge Loss** summary report. An example results table is shown in Figure 11-33.

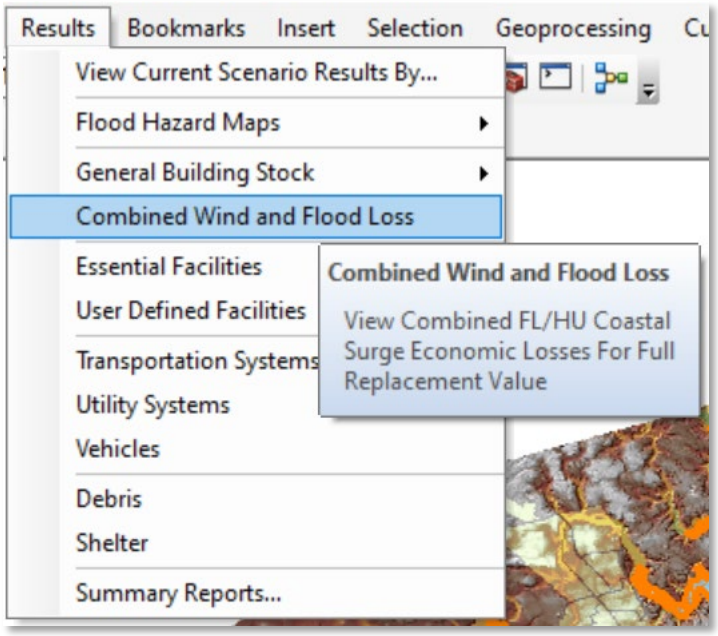


Figure 11-31 Select Combined Wind and Flood Loss Results (Flood Model)

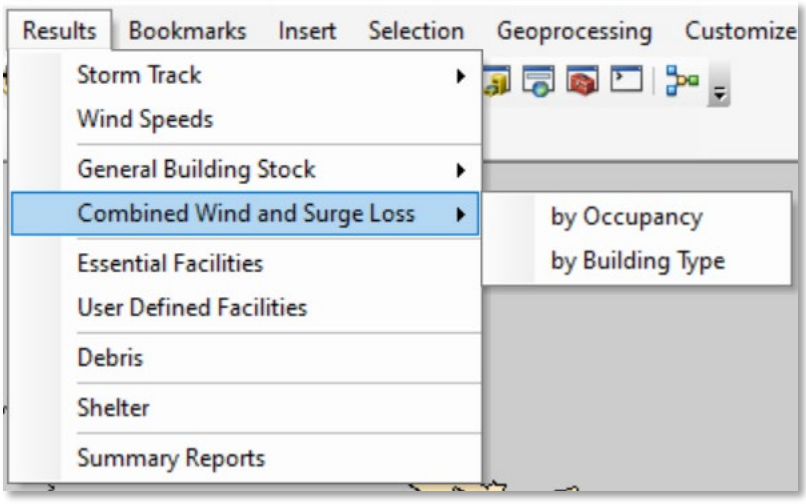
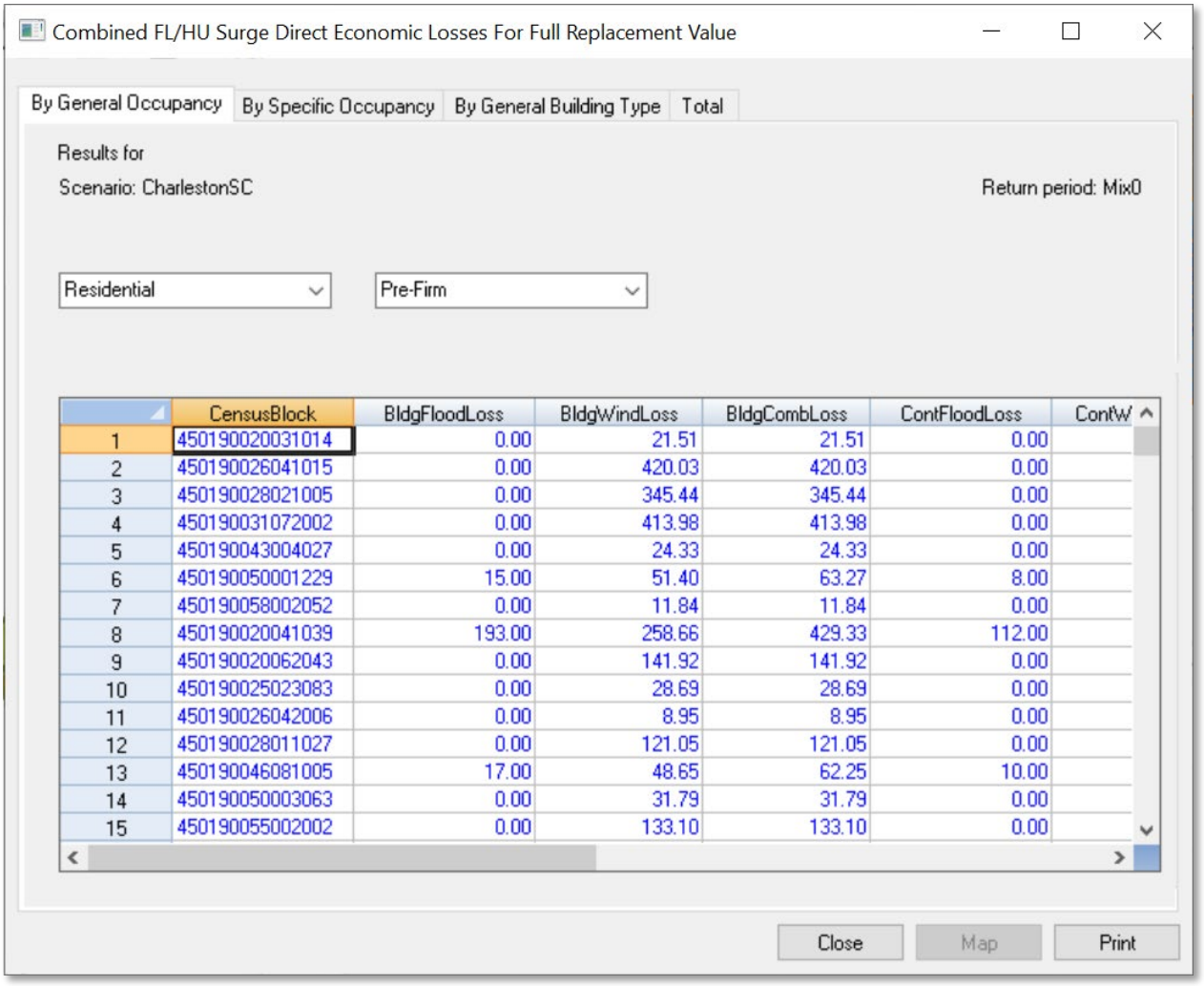


Figure 11-32 Select Combined Wind and Surge Loss (Hurricane Model)



	CensusBlock	BldgFloodLoss	BldgWindLoss	BldgCombLoss	ContFloodLoss	ContW
1	450190020031014	0.00	21.51	21.51	0.00	
2	450190026041015	0.00	420.03	420.03	0.00	
3	450190028021005	0.00	345.44	345.44	0.00	
4	450190031072002	0.00	413.98	413.98	0.00	
5	450190043004027	0.00	24.33	24.33	0.00	
6	450190050001229	15.00	51.40	63.27	8.00	
7	450190058002052	0.00	11.84	11.84	0.00	
8	450190020041039	193.00	258.66	429.33	112.00	
9	450190020062043	0.00	141.92	141.92	0.00	
10	450190025023083	0.00	28.69	28.69	0.00	
11	450190026042006	0.00	8.95	8.95	0.00	
12	450190028011027	0.00	121.05	121.05	0.00	
13	450190046081005	17.00	48.65	62.25	10.00	
14	450190050003063	0.00	31.79	31.79	0.00	
15	450190055002002	0.00	133.10	133.10	0.00	

Figure 11-33 Example – Combined Surge Result Table

Note that combined wind and surge results are available for building, content, and inventory losses but not for relocation, income, rental, or wage losses. The radio buttons and drop-down boxes allow the user to filter the losses by occupancy or building type.

Hazus has a limit of one scenario for the Coastal Surge flood hazard type. If the user already completed the coastal surge model in a Study Region and decides to re-run the Hurricane Model, the user must delete the previous flood scenario and re-input the DEM in the **User Data** dialog in the Flood Model.

11.4 User-supplied Storm Surge Depth Grid Analysis

The user also has the option of importing their own coastal surge grid created outside of Hazus. To do this, from the **Analysis** menu in the Hurricane Model ensure **User Supplied Coastal Surge Grid** is

set to "**YES**" (Figure 11-34), then run a hurricane wind analysis for the Study Region. Once the hurricane analysis has completed, reopen the Study Region in the Flood Model.

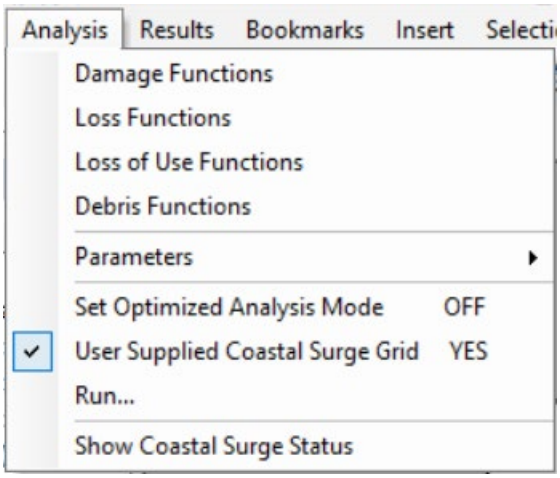


Figure 11-34 User Supplied Coastal Surge Grid Set to YES

With the Study Region Flood Model open go to **Hazard > Flood Hazard Type** and select **Storm surge** (Figure 11-35). Click **OK**.

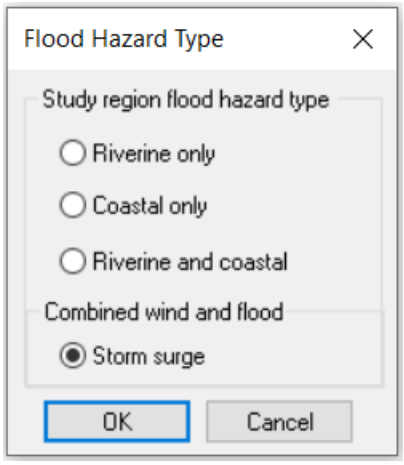


Figure 11-35 Flood Hazard Type Storm Surge

Next go to the **Hazard > User Data** menu and the **User Data > Storm Surge** dialog box will open as shown in Figure 11-36. Click **Browse** to navigate to your user-supplied storm surge grid and click **OK**.

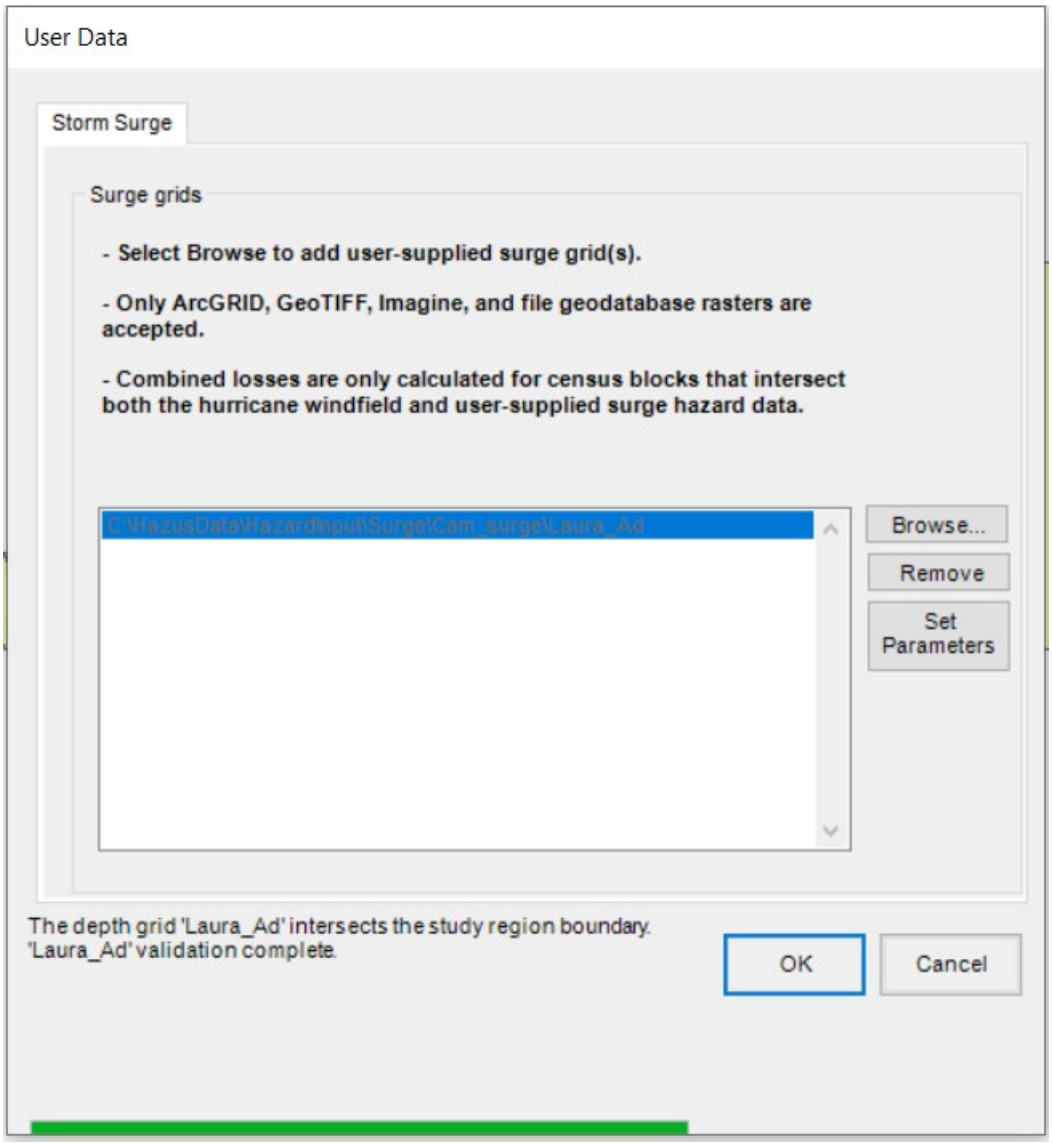


Figure 11-36 Storm Surge Data Import Dialog Box

Click **Yes** to Overwrite and Process your storm surge data (Figure 11-37). The storm surge data is now ready to be brought in a **New Scenario** and processed in the Coastal Flood Model.

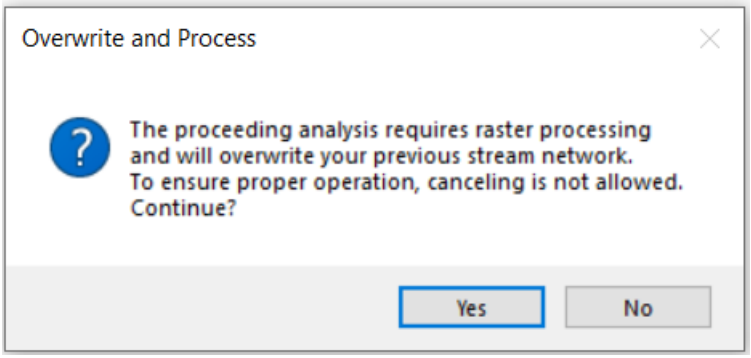


Figure 11-37 Overwrite and Process User-Supplied Storm Surge Data

Go to **Hazard > Scenario > New...** and name your **New Scenario**. The **New Scenario** window will open as shown in Figure 11-38. Click the **Plus** button and with the mouse drag a box around the coastal surge grid. Then click the **Save** button and click **OK**. Note that there is not an option to characterize a shoreline as seen in Section 12.3. All shoreline characterization steps are skipped when bringing in a user-supplied storm surge depth grid. The grid is simply selected in the **User Data** dialog.

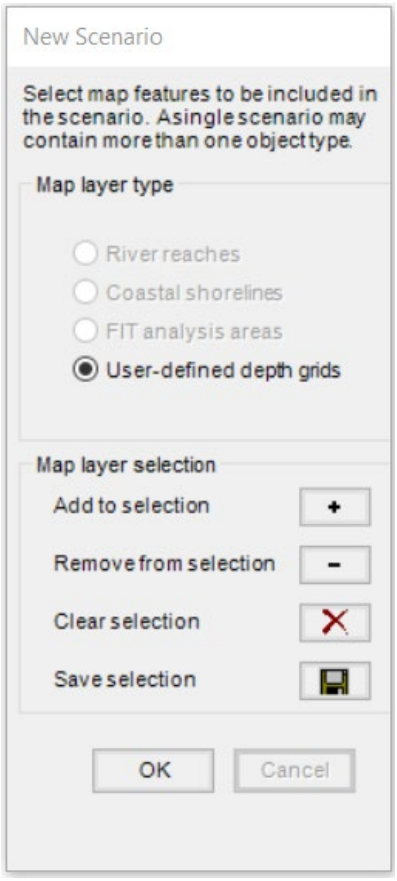


Figure 11-38 New Scenario Window

Next go to **Hazard > Coastal > Delineate Floodplain** (Figure 11-39). Click **OK** (Figure 11-40) and click **Yes** on the next screen (Figure 11-41). Processing will take a few minutes. Click **OK** on the Successfully Completed Coastal Flood Hazard dialog box (Figure 11-42).

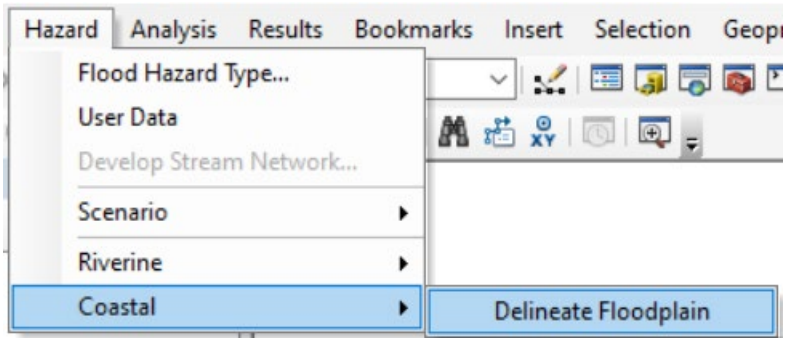


Figure 11-39 Delineate Floodplain

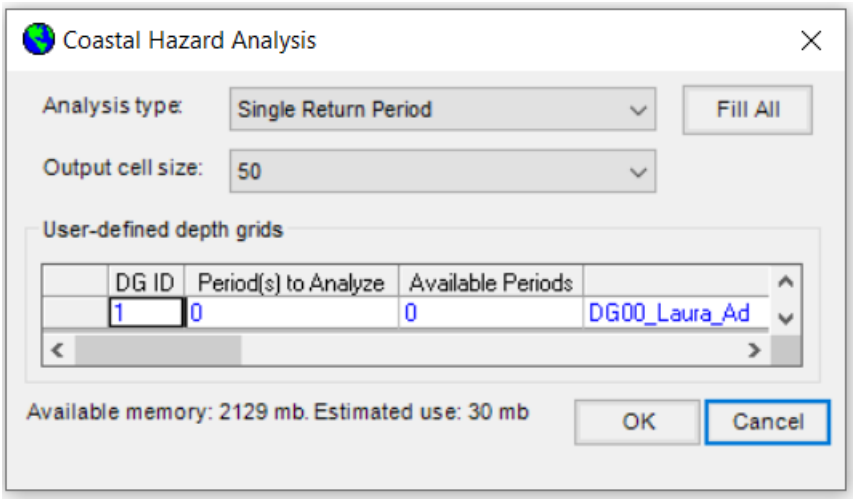


Figure 11-40 Coastal Hazard Analysis

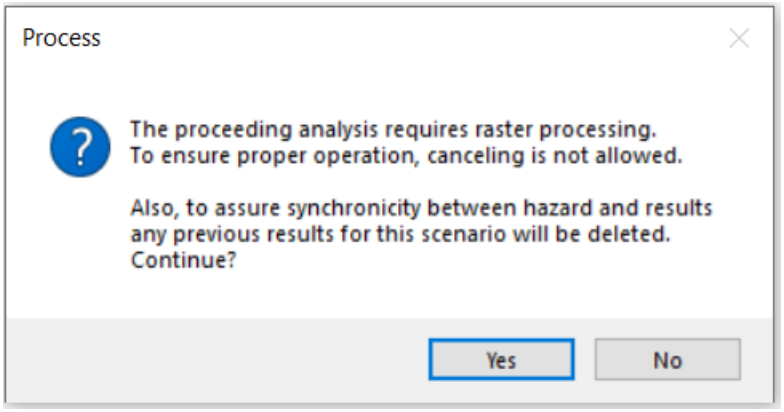


Figure 11-41 Process Coastal Hazard

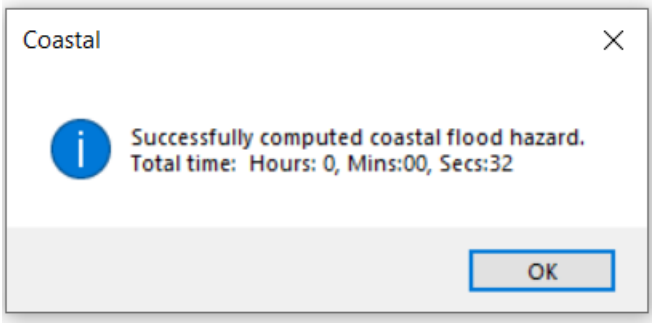


Figure 11-42 Successfully Completed Coastal Flood Hazard

Now the user can **Run > Analysis** to calculate losses. It is critical to run the storm surge flood-only losses first, before running storm surge flood and hurricane combined losses.

Section 12. Advanced Hazus Analysis: Import User-Defined Data

Users have the option to bypass processing the DEM if they plan to run a scenario that only includes the flood depth grids and/or USACE Hydrologic Engineering Center's River Analysis System (HEC-RAS) .FLT grids. The Hazus Program recommends users import their specific flood hazard information from external sources via depth grids, HEC-RAS, or other hydrologic and hydraulic model. Note that the Flood Information Tool (FIT) is no longer supported, however, the FIT User Data tab can still be used to import existing FIT projects.

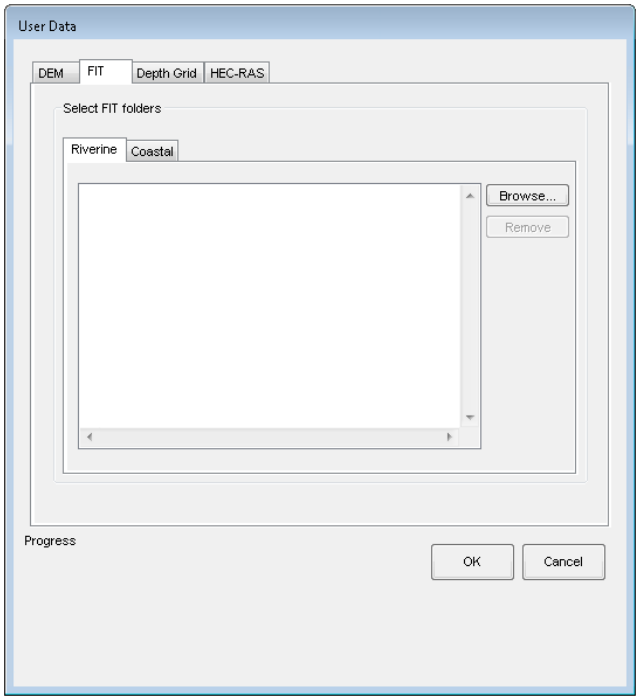


Figure 12-1 Select FIT Tab to Import FIT Data

12.1 Import Flood Depth Grid Results (preferred method for importing flood hazard information)

While Hazus can perform hydrology and hydraulic analysis to produce flood depth rasters, engineering-based depth grids provide more detailed analysis and results. Users are encouraged to research if depth grids from engineering-based studies are available to use in the advanced analysis. Examples of common depth grid sources include the following:

- FEMA's Map Service Center MSC https://msc.fema.gov/portal/home FEMA Risk MAP program risk databases that include high resolution lidar based return period depth grids for many communities based on FEMA approved hydraulic models.

- Coastal Emergency Risks Assessment (CERA): https://cera.coastalrisk.live/ ADCIRC based current and historic storm surge data.
- USGS Flood Inundation Mapper (FIM): https://fim.wim.usgs.gov/fim/
- FEMA/USGS Base Flood Elevation Viewer: https://webapps.usgs.gov/infrm/estbfe/ return period depth grids by watershed for FEMA Region VI.
- FEMA Geoplatform: https://disasters.geoplatform.gov/publicdata/NationalDisasters/ depth grids for significant disaster events from 2012 to present developed by FEMA to support disaster response and recovery

12.1.1 Obtaining Data to Import Into Hazus From the Map Service Center

The following steps demonstrate how to locate and download data from FEMA's Map Service Center to import into Hazus.

To obtain depth grids from the FEMA MSC flood Risk MAP databases use the following steps:

1. Go to FEMA's Flood Map Service Center: https://msc.fema.gov/portal/home, and select Search All Products

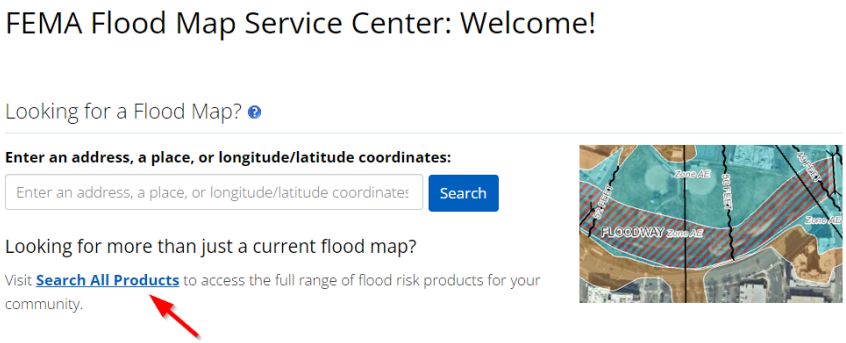


Figure 12-2 FEMA Map Service Center

2. Users can search by the drop-down menus, jurisdiction name, or product id.

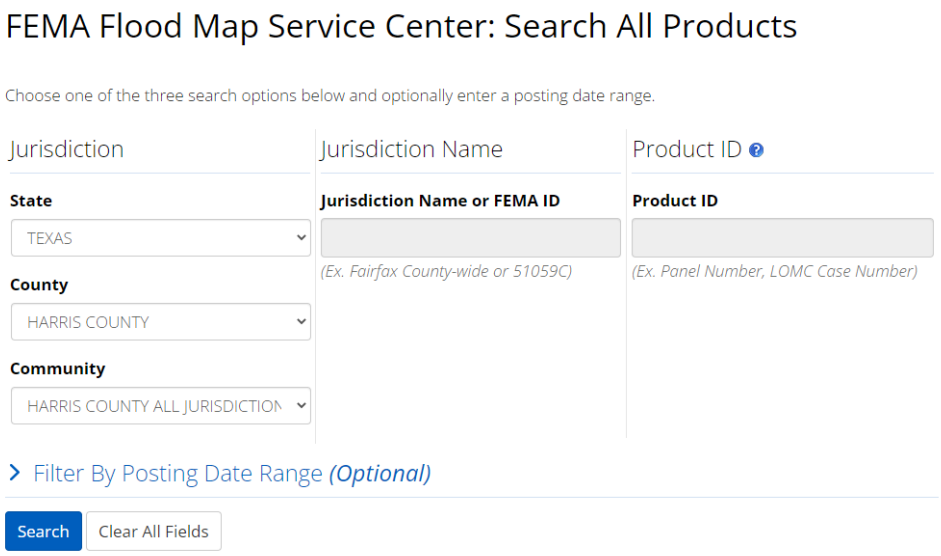
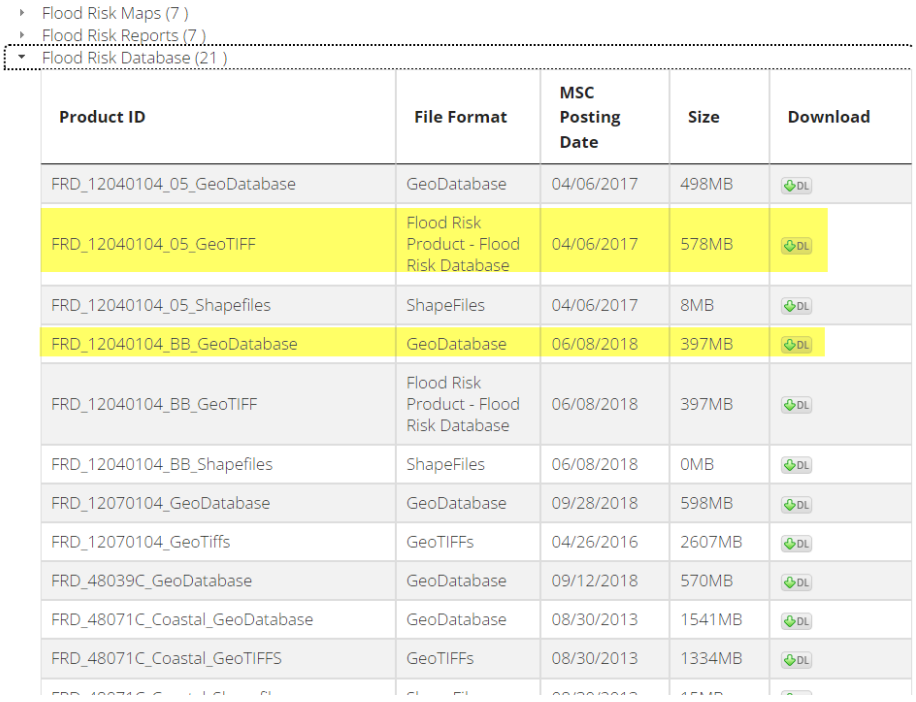


Figure 12-3 Map Service Center Search Options

3. The search results will appear in a list. When you click on the arrow, a table with the items available to download appears. Each item's Product ID (name) is listed, as well as the file format, date, and size. To download click on the download link that is indicated by the green arrow with DL icon.



Product ID	File Format	MSC Posting Date	Size	Download
FRD_12040104_05_GeoDatabase	GeoDatabase	04/06/2017	498MB	DL
FRD_12040104_05_GeoTIFF	Flood Risk Product - Flood Risk Database	04/06/2017	578MB	DL
FRD_12040104_05_Shapefiles	ShapeFiles	04/06/2017	8MB	DL
FRD_12040104_BB_GeoDatabase	GeoDatabase	06/08/2018	397MB	DL
FRD_12040104_BB_GeoTIFF	Flood Risk Product - Flood Risk Database	06/08/2018	397MB	DL
FRD_12040104_BB_Shapefiles	ShapeFiles	06/08/2018	0MB	DL
FRD_12070104_GeoDatabase	GeoDatabase	09/28/2018	598MB	DL
FRD_12070104_GeoTiffs	GeoTIFFs	04/26/2016	2607MB	DL
FRD_48039C_GeoDatabase	GeoDatabase	09/12/2018	570MB	DL
FRD_48071C_Coastal_GeoDatabase	GeoDatabase	08/30/2013	1541MB	DL
FRD_48071C_Coastal_GeoTIFFS	GeoTIFFs	08/30/2013	1334MB	DL

Figure 12-4 Jurisdiction Search Results

Most study results will have a GeoTiff and a Geodatabase version with the depth grids. Hazus can process both.

4. Data will download in a zipped file. An example of the data in the file is shown below.

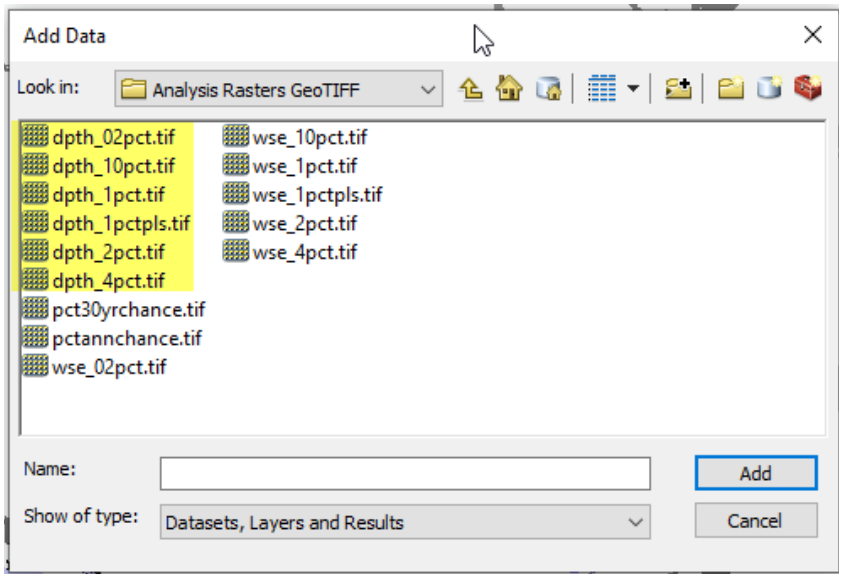


Figure 12-5 Geotiff Data from Map Service Center

Hazus uses the WGS84 UTM Zone projection. It is important to note that the available grid data may use a different projection than WGS84 UTM Zone. Hazus will convert input data into ArcGIS GRID format and the WGS84 UTM Zone projection. However, for extremely large grid data (e.g., over 1 GB) or for those in a different projection, the grids can be converted outside of Hazus to optimize processing time in Hazus, conserve drive space and prevent potential projection issues.

12.1.2 Importing Data Into Hazus

To import flood depth grid results into Hazus, select **User Data** from the **Hazard** menu. In the **User Data** window, select the **Depth Grid** tab, as shown in Figure 12-6. The format of user supplied depth grids can be Esri GRID, IMAGINE (.IMG), HEC-RAS (.FLT), tagged image file (.TIF), and file geodatabase (fGDB).

Use the **Browse...** button to navigate to the location of the flood depth grid. The browse dialog is intended to select a raster. After importing the flood depth grid, select the newly imported flood depth grid and click the **Set Parameters** button. A **Set Parameters** window will appear (Figure 12-3). Use the drop-down menu to select the **Units** (feet or meters), and then input the **Return Period** of the flood depth grid. It is important that users import the flood depth grid into the correct hazard tab. Repeat the process to import additional flood depth grids.

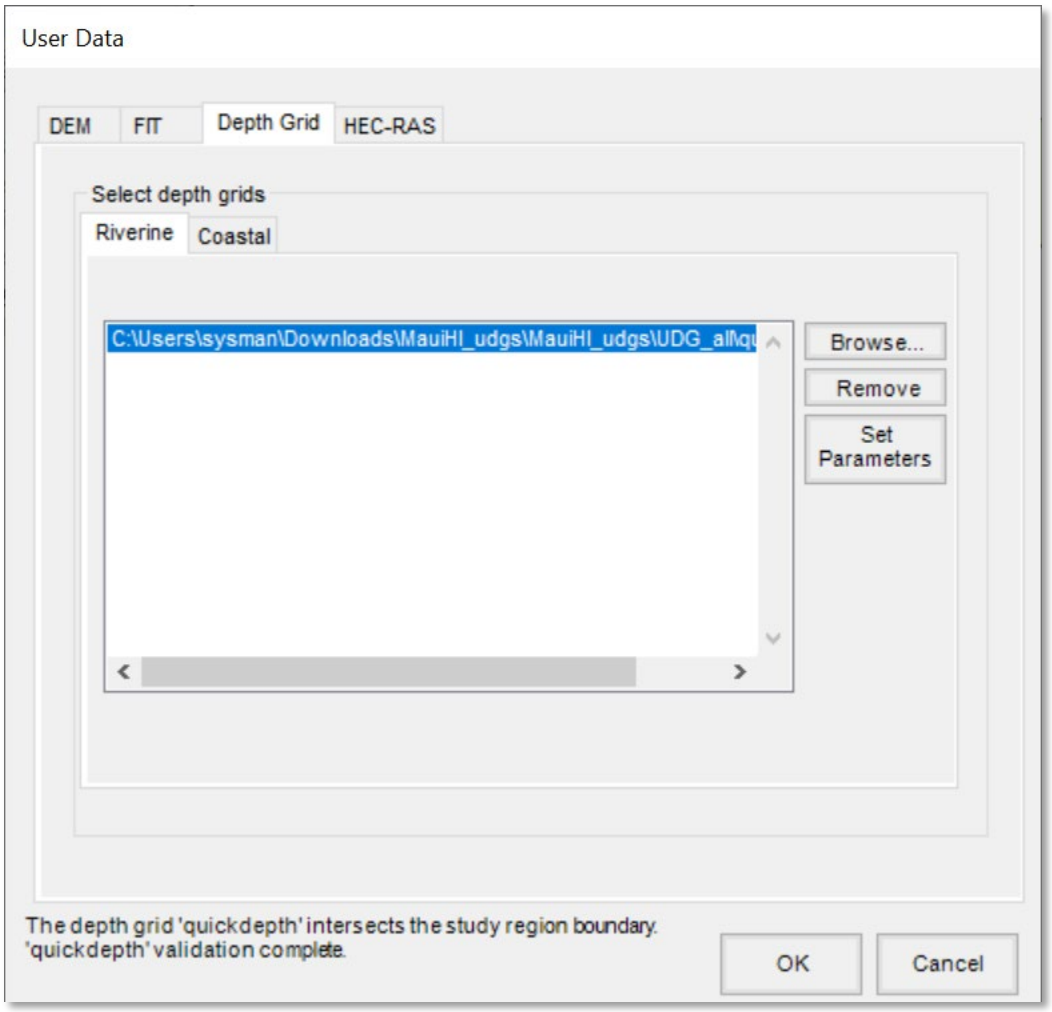


Figure 12-6 Select Depth Grid Tab to Import Depth Grid Data

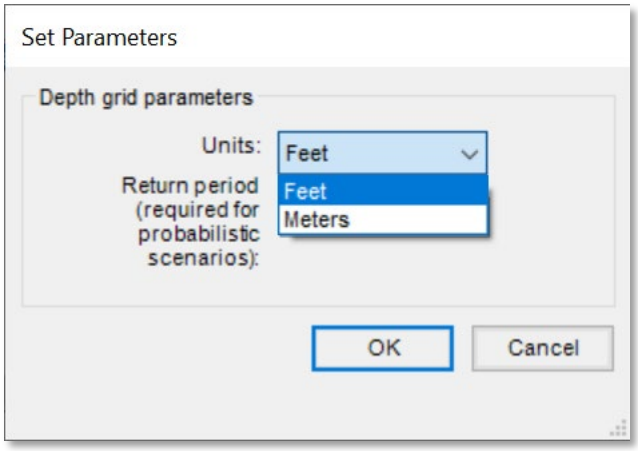


Figure 12-7 Set Parameters for Depth Grid Dialog

12.2 Import HEC-RAS .FLT Grid Results (preferred method for importing flood hazard information)

Users of HEC-RAS can import HEC-RAS (via RAS Mapper) hydraulic output .FLT grids to be used in the Flood Model. The HEC-RAS .FLT grids are implicitly treated as Riverine. To import HEC-RAS .FLT grid results into Hazus, select **User Data** from the **Hazard** menu. In the **User Data** window, select the **HEC-RAS** tab, as shown in Figure 12-8.

Use the **Browse** button to navigate to the HEC-RAS (produced via RAS Mapper) hydraulic output .FLT grid. The browse dialog is intended to select a floating-point binary file. After the .FLT grid is selected, the Flood Model validates the input by making sure the .FLT grid's associated floodplain boundary (by default, HEC-RAS saves it as FloodMap) is located partially within the Study Region (geographically) and contains projection information (prj.adf). The Flood Model does not validate the integrity between the .FLT grid and the floodplain boundary polygon (by default, HEC-RAS saves it as FloodMap). A status bar, shown at the bottom of the window in Figure 12-8, will indicate the level of progress as the data is imported and validated.

Select the newly imported .FLT grid and click the **Set Parameters** button. A **Set Parameters** window will appear (Figure 12-9). Use the drop-down menu to select the **Units** (feet or meters), and then input the **Return Period** of the flood depth grid. Repeat the process to import additional HEC-RAS .FLT grids.

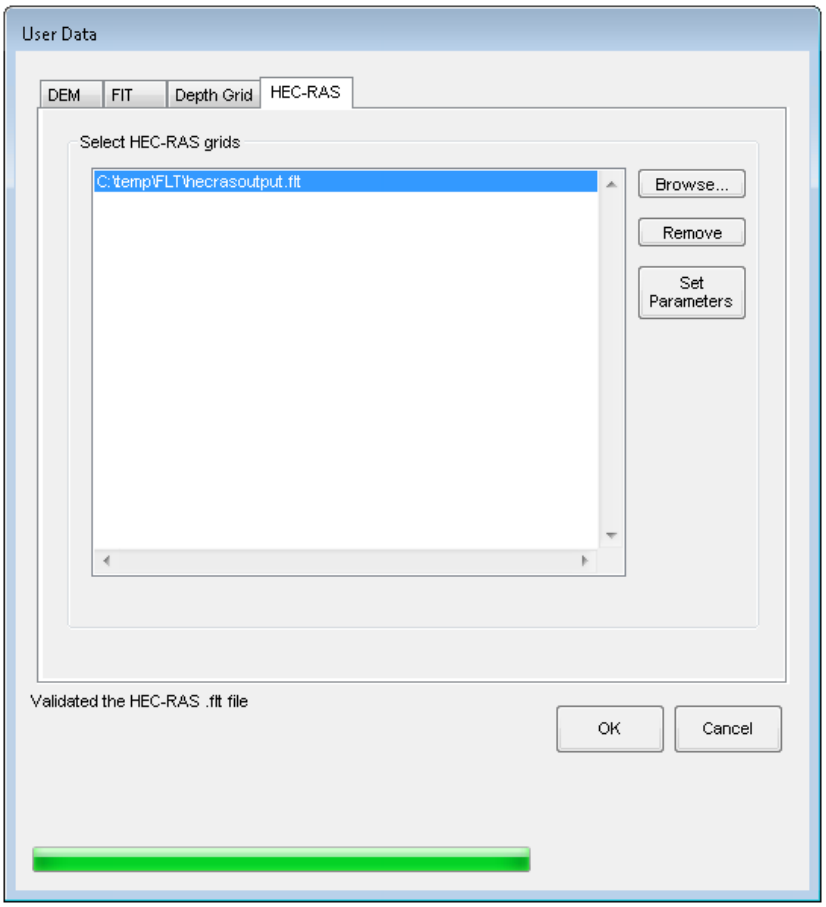


Figure 12-8 Select the HEC-RAS Tab to Import .FLT Grid Data

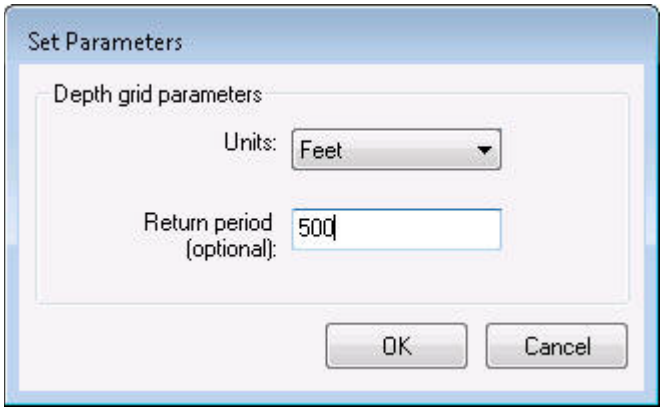


Figure 12-9 Set Parameters for .FLT Grid Dialog