

WA State Cascadia Subduction Zone (CSZ) Tsunami Loss Estimate Study: Hazus User Guide

July 30, 2025

Washington Emergency Management Division, Camp Murray, Washington

Background

In July 2021, Washington Emergency Management Division (WA EMD), of the Washington Military Department, hired John M. Bauer of Bauer GIS Solutions, Portland, Oregon, to conduct Hazus-based impact estimates for buildings and people in the Cascadia Subduction Zone tsunami zone, for all 15 Washington state coastal counties that will likely be significantly impacted by a tsunami.

This is a methods document, with the intent for WA EMD or others to duplicate the work we have done - either with the intent to refine the initial estimates provided by the contractor, or to adapt their usage for understanding earthquake impacts outside of the tsunami zone.

The tsunami inundation zone is defined by Washington Geological Survey's (WGS) detailed tsunami modeling of a Cascadia Subduction Zone (CSZ) Extended L1 M9.0 Tsunami (Washington Geological Survey, 2024) which has been quantified in raster format for all affected Washington counties.

This document assumes a user has prepared the User-defined Facilities (UDF) pointfile for use in Hazus, as defined by the accompanying document *WA State Cascadia Subduction Zone (CSZ) Tsunami Loss Estimate Study: Dataset Development Guide*. This is a user guide for running the UDF through the Hazus Comprehensive Data Management System (CDMS) and in the Hazus earthquake and tsunami modules. This document does not summarize loss estimate study results, nor does it provide commentary or recommendations. Rather, it is intended to be a guide for use by others on the detailed mechanics of working with the Hazus tool chain.

Assumptions

- Users have access to ArcGIS 10.8.1, ArcGIS Spatial Analyst extension, Hazus 5.0, CDMS, and SQL Server Management Studio.
- Users are adept at making inquiries and database updates in the ArcGIS database and exporting out and summarizing tables for their own reporting purposes.
- Users have access to the “median scenario” and “84th Percentile scenario” grids from the CSZ 2020 update published by United States Geological Survey ([link](#)). FYI: for convenience, these grids in xml form are supplied as part of the GIS package delivered to WA EMD.
- Users have training in CDMS and Hazus and are aware of the terminology, tool limitations, and requirements.

Importing into CDMS

When constructing or updating the UDF file, the UDF file may be in a projection not usable by CDMS. This is due to various geoprocessing needs. Prior to import into CDMS, the point file projection **must** be in WGS84:

- GCS_WGS_1984
- WKID: 4326 Authority: EPSG

A good method for reprojection to create a feature dataset with this projection, is to export the UDF library into that feature dataset (using a different name), then exporting the file geodatabase feature dataset/feature class into a temporary personal geodatabase. (shapefile format, also acceptable to CDMS, truncates column names to 10 characters.)

For processing efficiency purposes, be strategic about how many UDF points you try to import at the same time. **Do not try to import the entire state of Washington!**

CDMS => Import into CMDS Repository. Select both Earthquake and Flood, as there are flood-related attributes needed for the tsunami model (first floor height). You only need to click on Flood if you are using the tsunami module.

Browse to find the personal geodatabase that has the UDF file. Next.

Select the specific UDF file (CDMS calls it a Table) - again, be smart about file size and number of records!

Comprehensive Data Management System (CDMS)

File Tools Help

FEMA

Welcome to the Hazus-MH Comprehensive Data Management System

Please select one of the following:

- Import into CDMS Repository from File
- Import into CDMS Repository from Hazus-MH Study Region
- Building-Specific Data
- Query/Export Statewide Datasets
- Current State
 - Washington

Import into CDMS Repository

☒ Point ☐ Line For Tsunami select both Earthquake and Flood

Select a file for Import:

Specify hazards importing data for: ☒ Earthquake ☒ Flood ☐ Hurricane Wind

Fields corresponding to the hazards selected will be displayed in the Field Matching options if available.
If importing an excel document, please make sure the first row contains field names
If importing a mdb file, please make sure file names have four (4) or more characters

Select Hazus-MH Inventory Category:
User Defined Facilities

Select Hazus-MH Inventory Dataset (Layer):
User Defined Facilities

Required Fields:
* The following fields are required for updating inventory information. Please make sure your data contains all the required fields below:
Area (Sq feet)
Occupancy

Exit CDMS Back Continue CDMS Home

Comprehensive Data Management System (CDMS)

File Tools Help

FEMA

**Welcome to the Hazus-MH
Comprehensive Data Management System**

Please select one of the following:

- Import into CDMS Repository from File
- Import into CDMS Repository from Hazus-MH Study Region
- Building-Specific Data
- Query/Export Statewide Datasets

Current State
Washington

Exit CDMS

Import into CDMS Repository

Input File Name: **CDMS_Import.mdb**
 Data Category: **User Defined Facilities**
 Dataset Name: **User Defined Facilities**
 Data Import Type: **Site Specific**

Select Import Table:
 UDF_Compilation2

Select HAZUS-ID Field ** (if available):
 UserDefinedFtyId

**** The HAZUS-ID is the field utilized by Hazus-MH to uniquely identify inventory data for performing aggregation and analysis tasks. This field must be unique and must have the format XX000000. (2 alpha 6 numeric)**

Additionally when transferring data, the HAZUS-ID is used to match source data records to existing records in the statewide database. The values contained in this field must meet the required format (XX000000) or have empty values.

Records not found in the statewide database will be added and given a HAZUS-ID if an empty value or a value which does not meet the required format was provided.

Back Continue CDMS Home

The “Select Import Table” will auto-fill. For the “Select HAZUS-ID Field” you want to select the field that contains the unique identification numbers (see text in right side box). For example, we used the “comment” field for where we put the unique identification numbers. Click “Continue.”

Now comes the mapping.

Comprehensive Data Management System (CDMS)

File Tools Help

U.S. DEPARTMENT OF HOMELAND SECURITY **FEMA**

Welcome to the Hazus-MH Comprehensive Data Management System

Please select one of the following:

- Import into CDMS Repository from File
- Import into CDMS Repository from Hazus-MH Study Region
- Building-Specific Data
- Query/Export Statewide Datasets

Current State: **Washington**

Input File Name: CDMS_Import.mdb
Data Import Type: Site Specific
Data Category: User Defined Facilities
Dataset Name: User Defined Facilities

Exit CDMS

Import into CDMS Repository - Data Field Matching

Define Source(from) and Destination (to) Field Matches

Source (from) Fields (click to select): Bedrooms, CB, CB_2020, CB_SRate, CBG, CBG_2020, COUNTYFIPS

Destination (to) Fields (click to select):

Field Name	Field Type	Field Length	Default Value
Address	Text	40	
Back-up Power ...	Yes/No		
City	text	40	
Contact	text	40	
Name	text	40	
PhoneNumber	text	14	

LEGEND: ■ Earthquake ■ Flood ■ Hurricane Wind

Fields marked in GREEN are required. A default value will be provided if the field is not matched. Fields marked in RED are required fields from the user. Default building and content replacement costs will be provided based on RS Means tables and building area when not provided by user.

Add Match

Field Matches

Source	Destination	Field Type	Field Length	Default Value
Area	Area (Sq feet)	real	40	
Comment	Comment	text	40	
ContentCost	Content Repla...	Money		0
Cost	Building Repl...	Currency		0
eqUdsClass	eqUdsClass	text	5	UDS1
FirstFloorHt	First Floor Hei...	float	4	1
LndSusCat	Landslide Sus...	int		0
LafSusCat	Liquefaction ...	int		0

Load **Save** **Remove**

Back **Continue** **CDMS Home**

Now you need to manually match up the “Source” and “Destination” fields by clicking on the correct field in the “Source (from) Fields” box and the matching field in the “Destination (to) Fields” box. Then click the “Add Match” button below. Do this for each field that needs to be matched up. **VERIFY ALL MAPPINGS.**

CDMS will automatically map fields that have the same name in the source and destination tables (Figure 3-10). The remaining fields must be mapped. Fields shown in red text in the destination table are required and must be supplied by the user. If the fields in green are not supplied by the user, CDMS will enter standard Hazus default values. Typically, the more data the user supplies, the more accurate the resulting dataset. To map the fields, select a value in the source and destination tables and click Add Match. Once the field mapping process is complete, click the Save button. If a mapping scheme has already been saved, it can be used by clicking the Load button. All mappings will be moved to the Field Matches table. Click Continue when finished.

Define Source(from) and Destination (to) Field Matches

Source (from) Fields (click to select)

- CensusTrac
- CONTENTCOS**
- COUNTY
- eqAEBMId
- fd_id
- found_ht
- FOUNDATION

Destination (to) Fields (click to select)

Field Name	Field Type	Field	Default
Comment	text	40	
Contact	text	40	
Content Replacement Value (\$)	Money		0
Name	text	40	
PhoneNumber	text	14	
ShelterCapacity	int		

LEGEND: Earthquake Flood Hurricane Wind

Fields marked in GREEN are required. A default value will be provided if the field is not matched. Fields marked in RED are required fields from the user.

Default building and content replacement costs will be provided based on RS Means tables and building area when not provided by user.

Add Match

Field Matches

As an FYI, mapping a text field with more than 40 characters into the Comments field will result in a rejection by CDMS.

Source (from) Fields (click to select)

- found_ht
- LATITUDE
- LONGITUDE
- OBJECTID_1
- Pop2AM
- Pop2PM

Destination (to) Fields (click to select)

Field Name	Field Type	Field	Default
PhoneNumber	text	14	
ShelterCapacity	int		
Zipcode	text	10	
eqUdsClass	text	5	UDS1
WaterDepth	real		5

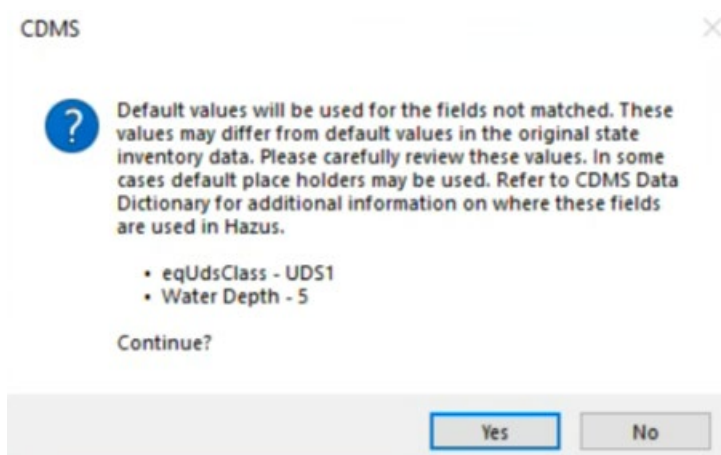
LEGEND: Earthquake Flood Hurricane Wind

Field Matches

Source	Destination	Field Type	Field Length	Default Value
AREA	Area (Sq feet)	real	40	
COST	Building Repl...	Currency		0
LNDUSCAT	Landslide Sus...	int		0
LQFSUSCAT	Liquefaction ...	int		0
NUMSTORIES	NumStories	int	40	1
OCCUPANCY	Occupancy	text	5	
SOILTYPE	SoilType	text	1	D
STATE	State	text	2	

Field Matches				
Source	Destination	Field Type	Field Length	Default Value
STATE	State	text	2	
YEARBUILT	Year Built (Bet...	Number		
eqdl	Earthquake D...	text	2	LC
bldgtype	Earthquake B...	text	4	URML
CONTENTCOS	Content Repla...	Money		0
CensusTrac	Census Tract	text	11	
FOUNDATION	EQFoundation...	text	1	

Continue results in this popup. Hit 'Yes'.

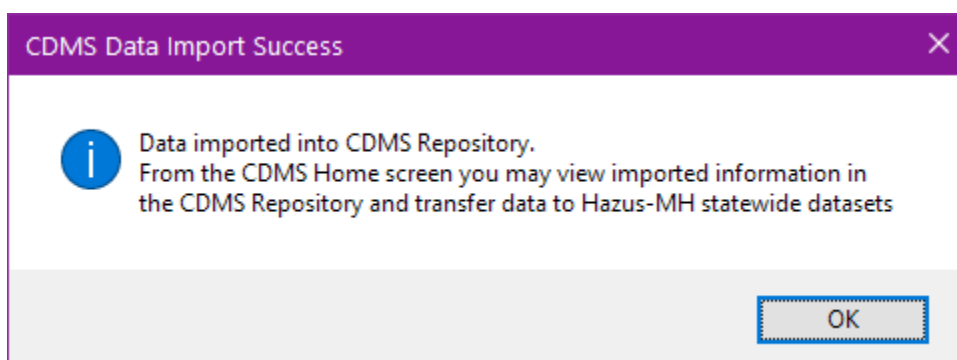


Proceed with OK, Continue, etc.

A Categorize Fields message will appear (Figure 3-12). Some of the fields that were supplied with data will need to be categorized into Hazus-specific data. If the data that have been imported already use Hazus-compatible attributes, the categorization will be automatic. Click OK to continue.

Hit Continue and be prepared to wait. You may have to wait a long time.

Finally - if all goes well:



But, it has yet to be transferred into the official Hazus inventory stored on your machine.

Comprehensive Data Management System (CDMS)

File Tools Help

FEMA

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Comprehensive Data Management System

Please select one of the following:

- Import into CDMS Repository from File
- Import into CDMS Repository from Hazus-MH Study Region
- Building-Specific Data
- Query/Export Statewide Datasets
- Update Study Region with Hazus-MH Data
- Exit CDMS

CDMS Repository (Not yet transferred into Statewide Layers)

	Category	Layer	Records	Upload Date	Uploaded By
View/ Edit	Remove	User Defined Facilities	User Defined Facilities	9241	11/9/2021 PUMAJohn M Bauer

[Transfer to Statewide Dataset](#)

Statewide Layer Modification History (Only last 10 updates are displayed below. To view all records run the report on the right)

State	Category	Layer	Records	Upload Date	Uploaded By
-------	----------	-------	---------	-------------	-------------

Current State: **Washington**

Hit “Transfer to Statewide Dataset”. To minimize confusion, Replace Data

Comprehensive Data Management System (CDMS)

Statewide Data Transfer Options:

Please select one of the options below:

☐ Append / Update Data
(all new data will be added and existing/duplicate information will be updated based on Hazus ID)

☒ Replace Data
(all existing data in the Statewide datasets with matching census tracts will be deleted and replaced with the current data being transferred.)

*** It is highly recommended to package the statewide dataset before selecting this option by going to Tools Menu.**

Submit Cancel

Then hit Submit. This process should be pretty quick. A record of your transaction will then appear in the “Statewide Layer Modification History” section.

Repeat the above for populating the UDF Inventory Category (UDF is required for combined Hazus Earthquake-Tsunami. If you are doing only an earthquake run, depending on your plans, a UDF import may not be needed.) You need 2am/2pm population in order to conduct casualty estimates for earthquake runs.

Comprehensive Data Management System (CDMS)

File Tools Help

FEMA

Welcome to the Hazus-MH
Comprehensive Data Management System

Please select one of the following:

- Import into CDMS Repository from File
- Import into CDMS Repository from Hazus-MH Study Region
- Building-Specific Data
- Query/Export Statewide Datasets

Current State: Washington

Exit CDMS

Import into CDMS Repository

☒ Point ☐ Line For Tsunami select both Earthquake and Flood

Select a file for Import:
H:\GIS\Projects\WAEMD\Tsunami_2022\geodata\CDMS_Import.mdb Browse

Specify hazards importing data for: ☒ Earthquake ☒ Flood ☐ Hurricane Wind
Fields corresponding to the hazards selected will be displayed in the Field Matching options if available.
If importing an excel document, please make sure the first row contains field names.
If importing a mdb file, please make sure file names have four (4) or more characters.

Select Hazus-MH Inventory Category:
AEBM

Select Hazus-MH Inventory Dataset (Layer):
Advanced Engineering Building Module

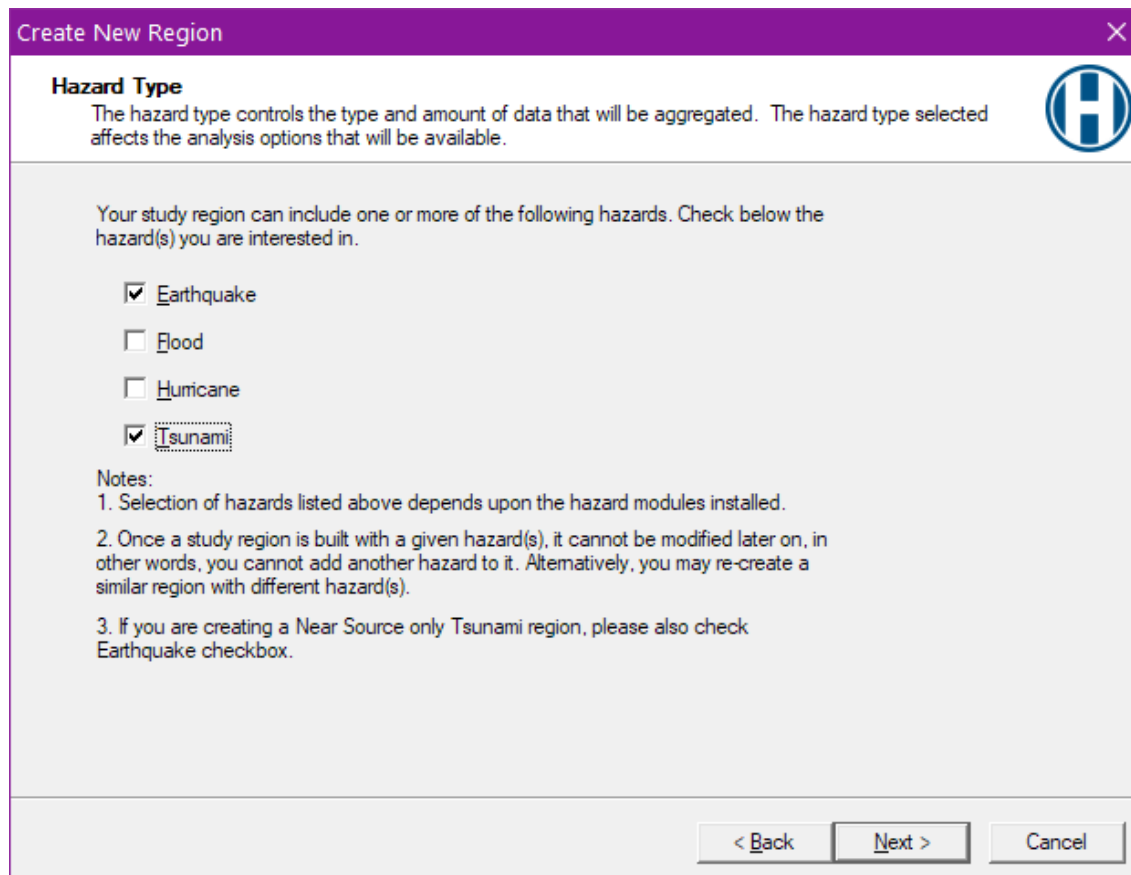
Required Fields:
* The following fields are required for updating inventory information. Please make sure your data contains all the required fields below:
Area (Sq feet)
Earthquake Building Type
Earthquake Design Level
Occupancy Type

Back Continue CDMS Home

Running the Hazus Earthquake-Tsunami model

[If earthquake-only is desired, then ignore the tsunami model references below]

Open Hazus and “Create a new region”. For efficiency’s sake, we advise that this be run at a county level. The tsunami model becomes very slow with two or more counties. For tsunami, make sure both earthquake and tsunami are selected:



Create New Region

Hazard Type
The hazard type controls the type and amount of data that will be aggregated. The hazard type selected affects the analysis options that will be available.

Your study region can include one or more of the following hazards. Check below the hazard(s) you are interested in.

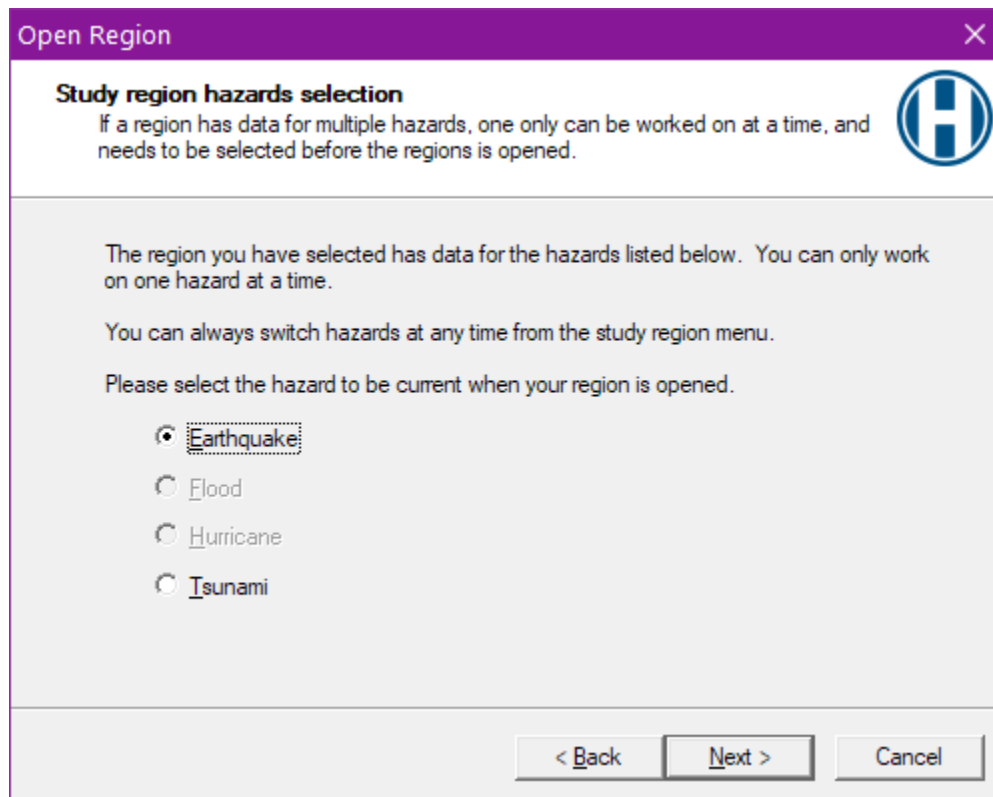
☒ Earthquake
☐ Flood
☐ Hurricane
☒ Tsunami

Notes:
 1. Selection of hazards listed above depends upon the hazard modules installed.
 2. Once a study region is built with a given hazard(s), it cannot be modified later on, in other words, you cannot add another hazard to it. Alternatively, you may re-create a similar region with different hazard(s).
 3. If you are creating a Near Source only Tsunami region, please also check Earthquake checkbox.

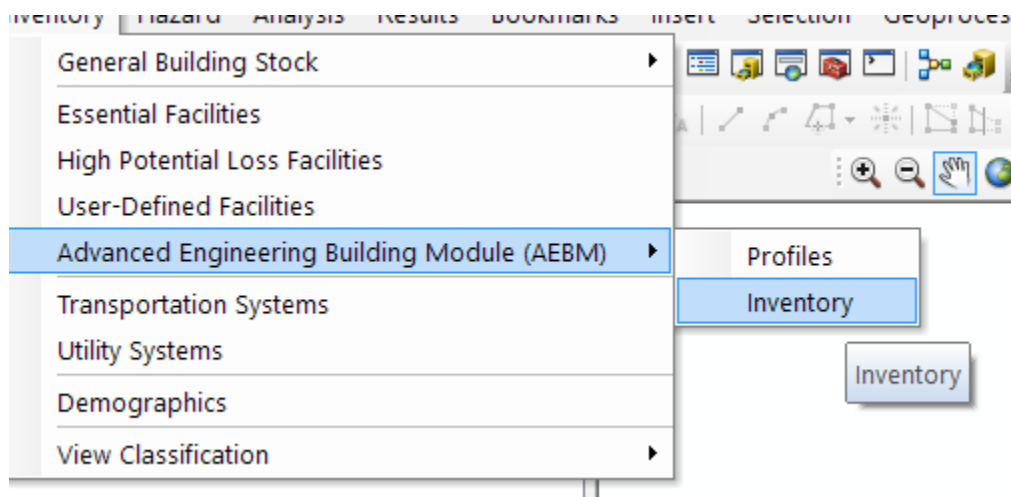
< Back Next > Cancel

Depending on the county, this can take several minutes.

Open the region that was just created. For combined tsunami-earthquake analysis, open the Earthquake first, before proceeding with the tsunami.



Verify the inventory that was imported into CDMS is present in the Hazus database: (this example is for AEBM; for tsunami/earthquake, you want to view the User-Defined Facilities).



This may take several minutes while Hazus produces a table. You can select a column and map it:

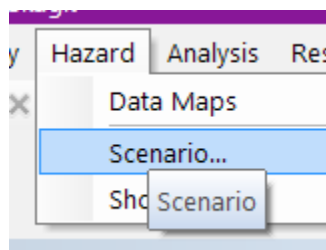
Advanced Engineering Building Model Inventory

Table

	Building Area (Sq. Ft.)	Building Value (thous. \$)	Co
1	992.000	\$143,524.00	
2	30,000.000	\$4,296,240.00	
3	1,904.000	\$272,668.00	
4	2,060.000	\$313,603.00	
5	9,244.000	\$1,323,815.00	
6	4,388.000	\$628,397.00	
7	1,608.000	\$244,793.00	
8	1,138.000	\$162,971.00	
9	2,740.000	\$417,123.00	
10	1,858.000	\$282,852.00	
11	1,264.000	\$192,424.00	
12	3,240.000	\$493,240.00	
13	2,165.000	\$329,588.00	
14	722.000	\$109,913.00	
15	30,000.000	\$4,296,240.00	
16	1,421.000	\$216,325.00	
17	4,196.000	\$600,901.00	

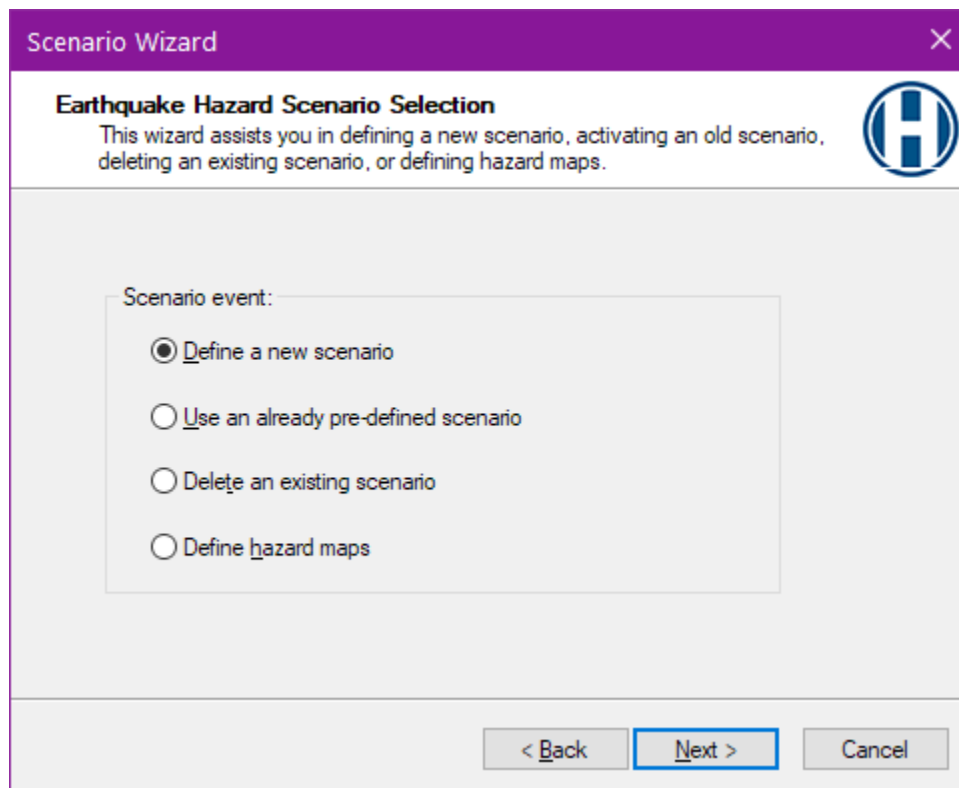
Close Map Print

To run the earthquake model, define the scenario:

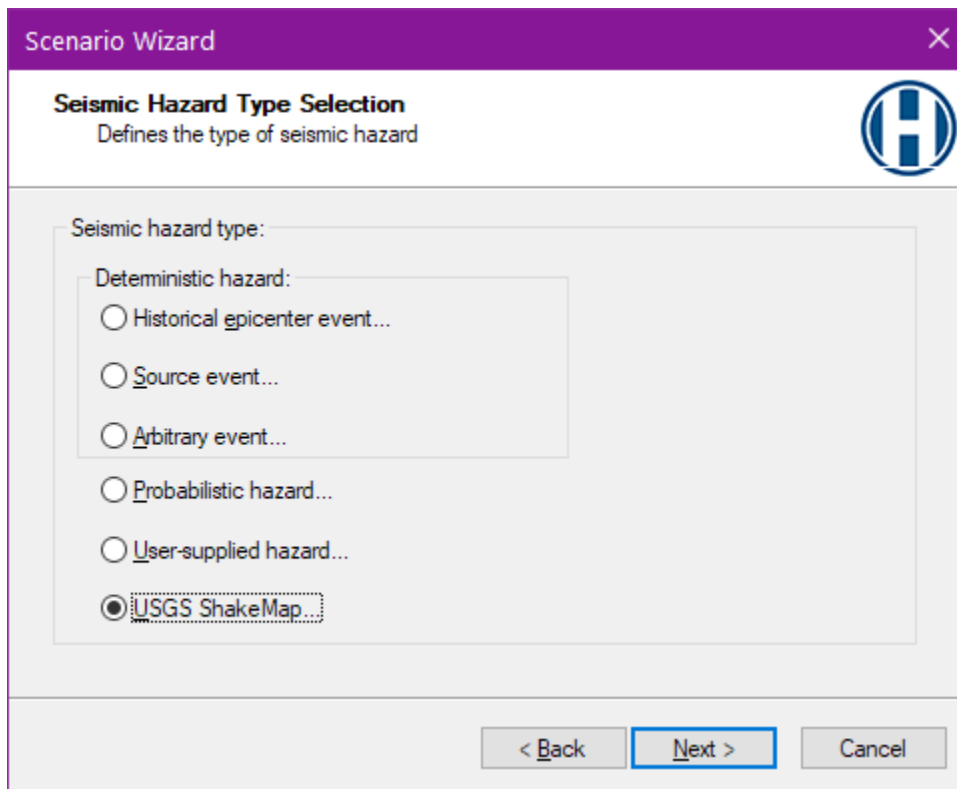




Next ->



Don't try recycling old scenarios. Just do New Scenario each time. Next



The screenshot shows a software window titled "Scenario Wizard" with a close button (X) in the top right corner. Below the title bar, the main heading is "Seismic Hazard Type Selection" with a subtitle "Defines the type of seismic hazard". To the right of the text is a circular logo containing a stylized letter 'H'. The main content area is labeled "Seismic hazard type:" and contains a list of options under the heading "Deterministic hazard:". The options are: "Historical epicenter event...", "Source event...", "Arbitrary event...", "Probabilistic hazard...", "User-supplied hazard...", and "USGS ShakeMap...". The "USGS ShakeMap..." option is selected, indicated by a filled radio button. At the bottom of the window, there are three buttons: "< Back", "Next >" (which is highlighted with a blue border), and "Cancel".

Scenario Wizard

Seismic Hazard Type Selection
Defines the type of seismic hazard

Seismic hazard type:

Deterministic hazard:

- ☐ Historical epicenter event...
- ☐ Source event...
- ☐ Arbitrary event...
- ☐ Probabilistic hazard...
- ☐ User-supplied hazard...
- ☒ USGS ShakeMap...

< Back Next > Cancel

Next

Here, before proceeding, remember to uncheck the “Apply Geomean” box in the upper right

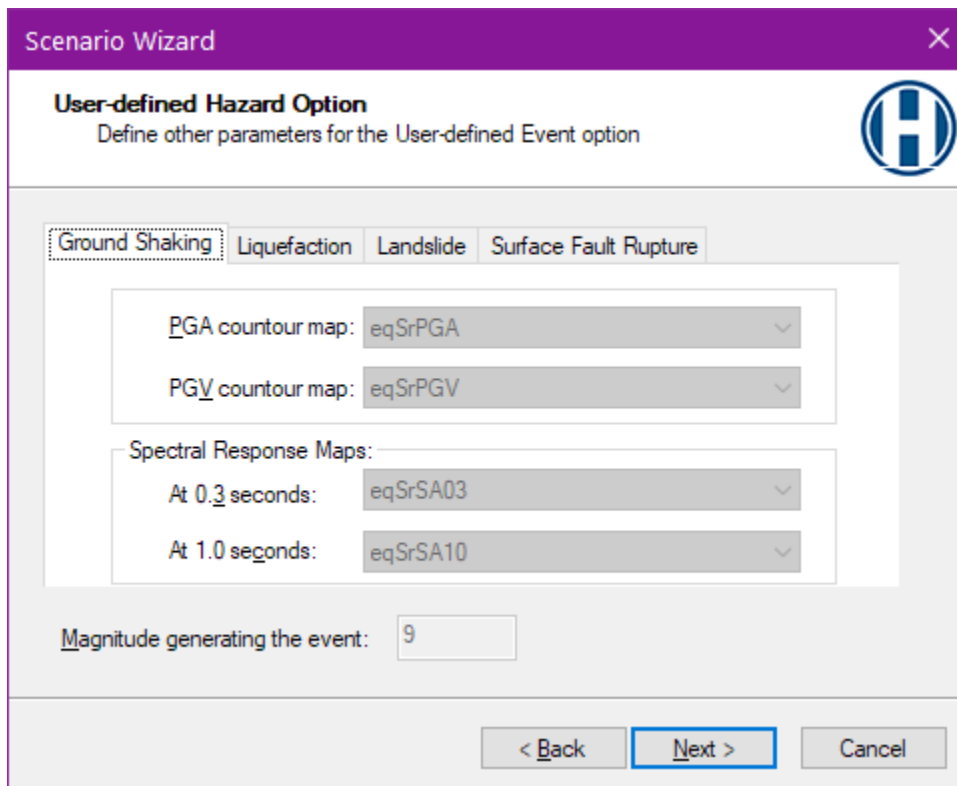
The screenshot shows the 'ShakeMap Download' dialog box. On the left, there are radio buttons for 'ShakeMap Events' (selected) and 'ShakeMap Scenarios'. Below them is a section 'Select from Available ShakeMap Events' with a list 'Available Earthquake Data'. The main area is titled 'Online ShakeMap Search Parameters' and contains several input fields: 'Max Latitude' (48.657842836), 'Min Longitude' (-122.740552203), 'Max Longitude' (-120.685396856), and 'Min Latitude' (48.295543800000). To the right, there are fields for 'Earthquake Magnitude' (Min: 5, Max: 9.5) and 'Earthquake Time Frame' (Start Time: Today Minus 90 Days). A red circle highlights the 'Apply Geomean' checkbox, which is currently unchecked. Below these fields are 'Study Region Upload Options' with checkboxes for 'Exclude Gridcells Outside Study Region' (checked) and 'Overwrite Existing ShakeMap Grid Data' (checked). At the bottom, there are two large empty boxes labeled 'Selected ShakeMap Properties' and 'Selected ShakeMap Details'. At the very bottom are three buttons: 'Download Selected ShakeMap Grid Data', 'Browse for Existing ShakeMap Grid Data', and 'Cancel'.

Then hit “Browse for Existing Shakemap Grid Data” (bottom right):

Navigate to where the USGS CSZ Shakemap median or 84th percentile file, and select the scenario of interest (folder geodata\CSZ ShakeMap):

- CSZ 2020 84th percentile.xml
- CSZ 2020 median.xml

It should return the following:



The screenshot shows the 'Scenario Wizard' dialog box with the 'User-defined Hazard Option' step selected. The title bar is purple with a close button. The main area has a white background with a blue 'H' logo in the top right. Below the title, there's a subtitle 'Define other parameters for the User-defined Event option'. A tabbed interface shows 'Ground Shaking' as the active tab, with other tabs for 'Liquefaction', 'Landslide', and 'Surface Fault Rupture'. The 'Ground Shaking' tab contains several dropdown menus: 'PGA contour map' set to 'eqSrPGA', 'PGV contour map' set to 'eqSrPGV', 'Spectral Response Maps' with two sub-sections: 'At 0.3 seconds' set to 'eqSrSA03' and 'At 1.0 seconds' set to 'eqSrSA10'. Below these is a text input field for 'Magnitude generating the event' with the value '9'. At the bottom, there are three buttons: '< Back', 'Next >', and 'Cancel'.

Scenario Wizard

User-defined Hazard Option
Define other parameters for the User-defined Event option

Ground Shaking | Liquefaction | Landslide | Surface Fault Rupture

PGA contour map: eqSrPGA

PGV contour map: eqSrPGV

Spectral Response Maps:

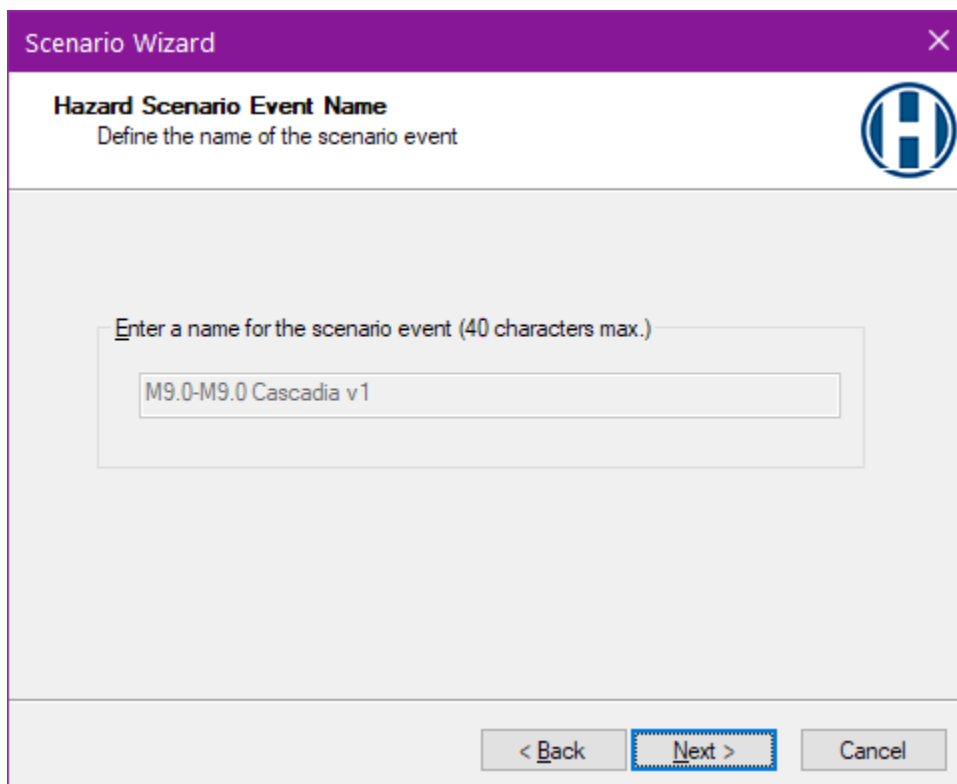
At 0.3 seconds: eqSrSA03

At 1.0 seconds: eqSrSA10

Magnitude generating the event: 9

< Back | Next > | Cancel

Next -> Nothing to select here below:



The screenshot shows the 'Scenario Wizard' dialog box with the 'Hazard Scenario Event Name' step selected. The title bar is purple with a close button. The main area has a white background with a blue 'H' logo in the top right. Below the title, there's a subtitle 'Define the name of the scenario event'. A large text input field is present with the placeholder text 'Enter a name for the scenario event (40 characters max.)'. The input field contains the text 'M9.0-M9.0 Cascadia v1'. At the bottom, there are three buttons: '< Back', 'Next >', and 'Cancel'.

Scenario Wizard

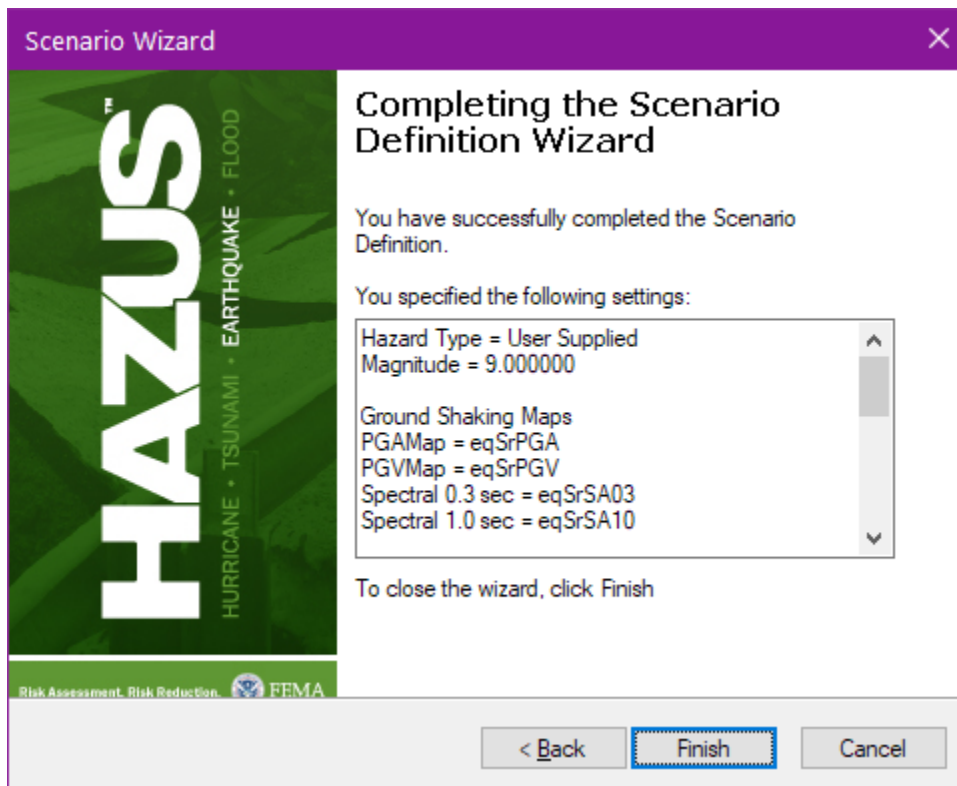
Hazard Scenario Event Name
Define the name of the scenario event

Enter a name for the scenario event (40 characters max.)

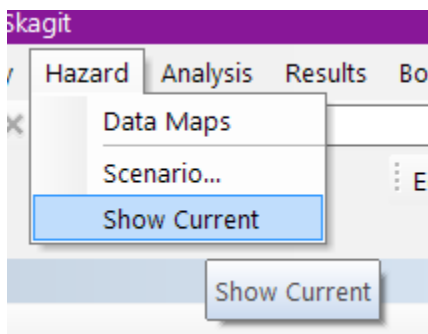
M9.0-M9.0 Cascadia v1

< Back | Next > | Cancel

Next ->



Finish. And there it is. To verify the grids are ready to go, do the following:



This should return the following:

Current Hazard Selection

Current Scenario | Current Hazard Maps |

Scenario Description

Name:

M9.0-M9.0 Cascadia v1

Type:

User Supplied

Attenuation Function:

[NA]

Magnitude:

9

Event Id:

[NA]

Contour Maps:

Map	Map Name	Layer/Value	Geo-Database
PGA:	eqSrPGA	eqSrPGA	user id=hazuspuser;Password:
PGV:	eqSrPGV	eqSrPGV	user id=hazuspuser;Password:
SA03:	eqSrSA03	eqSrSA03	user id=hazuspuser;Password:
SA10:	eqSrSA10	eqSrSA10	user id=hazuspuser;Password:
PGD Settlement:	[NA]	[NA]	[NA]
Lateral Soreading:	[NA]	[NA]	[NA]

To map any layer, highlight the layer in the Map column and press Map button

Map

Close

Click on “PGA” and hit “Map”

WA State Cascadia Subduction Zone (CSZ) Tsunami Loss Estimate Study: Hazus User Guide

July 2025

Current Hazard Selection

Current Scenario | Current Hazard Maps

Scenario Description

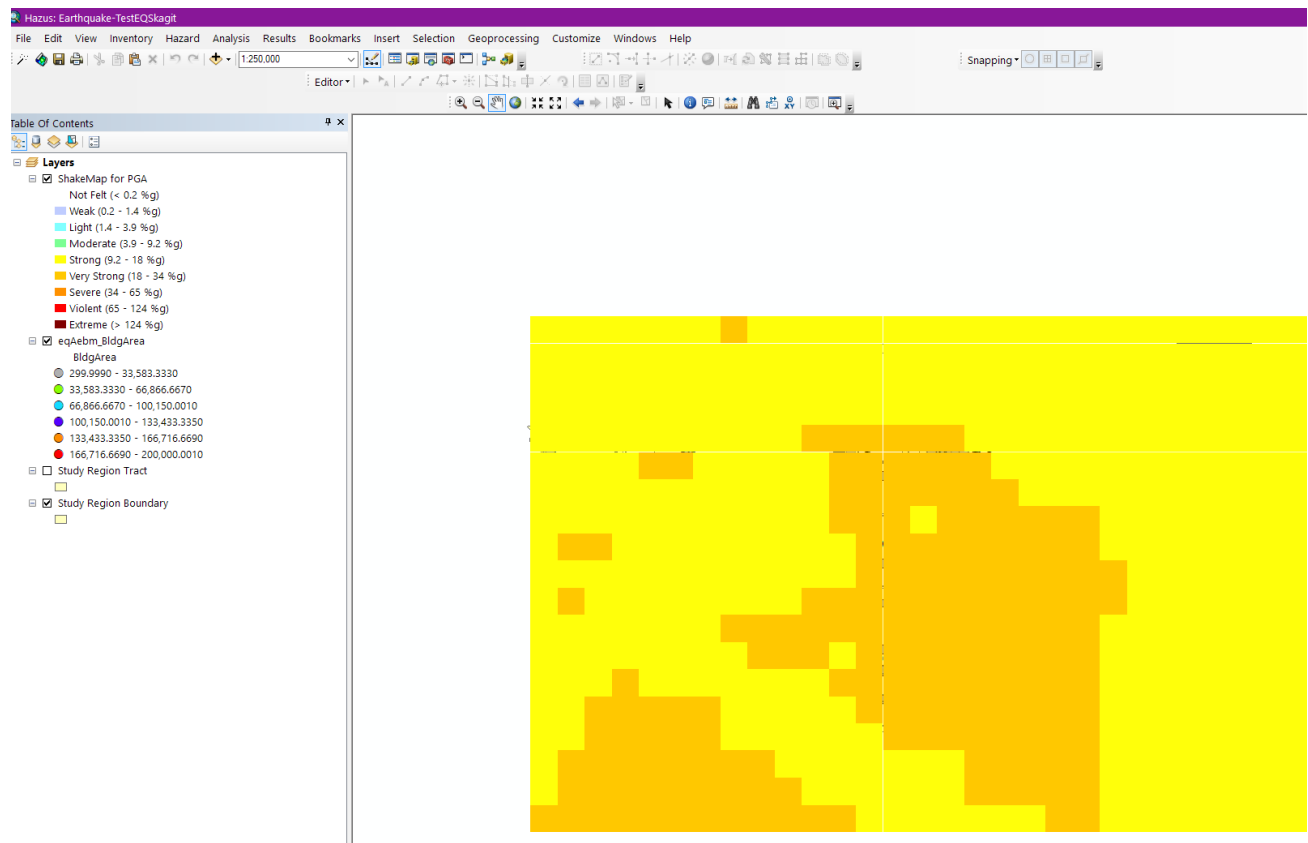
Name: M9.0-M9.0 Cascadia v1
 Type: User Supplied
 Attenuation Function: [NA]
 Magnitude: 9 Event Id: [NA]
 Contour Maps:

Map	Map Name	Layer/Value	Geo-Database
PGA:	eqSrPGA	eqSrPGA	user id=hazuspuser;Password:
PGV:	eqSrPGV	eqSrPGV	user id=hazuspuser;Password:
SA03:	eqSrSA03	eqSrSA03	user id=hazuspuser;Password:
SA10:	eqSrSA10	eqSrSA10	user id=hazuspuser;Password:
PGD Settlement:	[NA]	[NA]	[NA]
Lateral Spreading:	[NA]	[NA]	[NA]

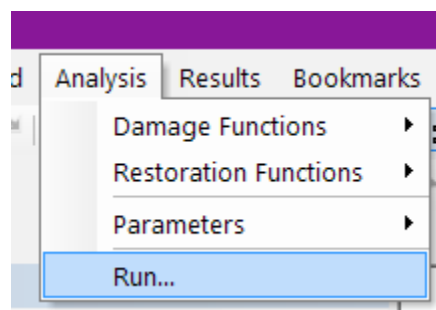
To map any layer, highlight the layer in the Map column and press Map button

Map Close

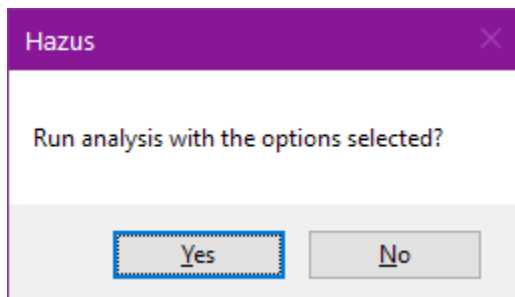
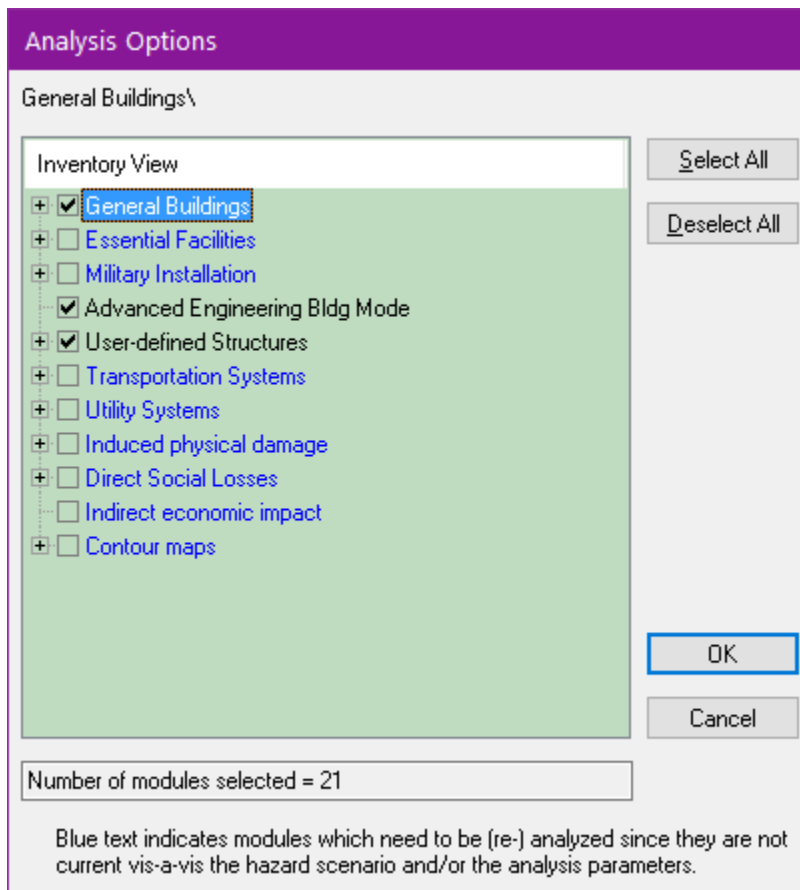
You should see a representation of “pga” (peak ground acceleration):



Then running Hazus itself:

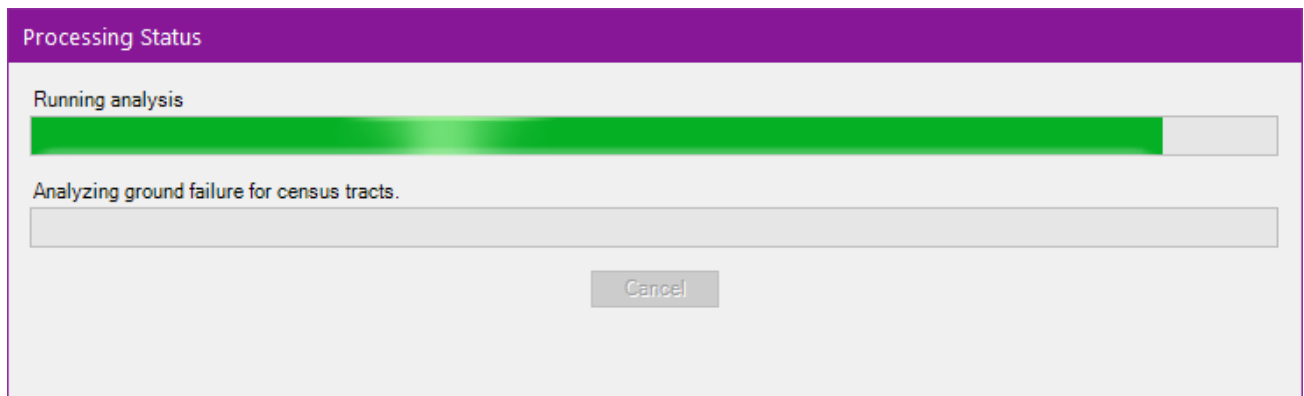


For a tsunami run, select



Select Yes

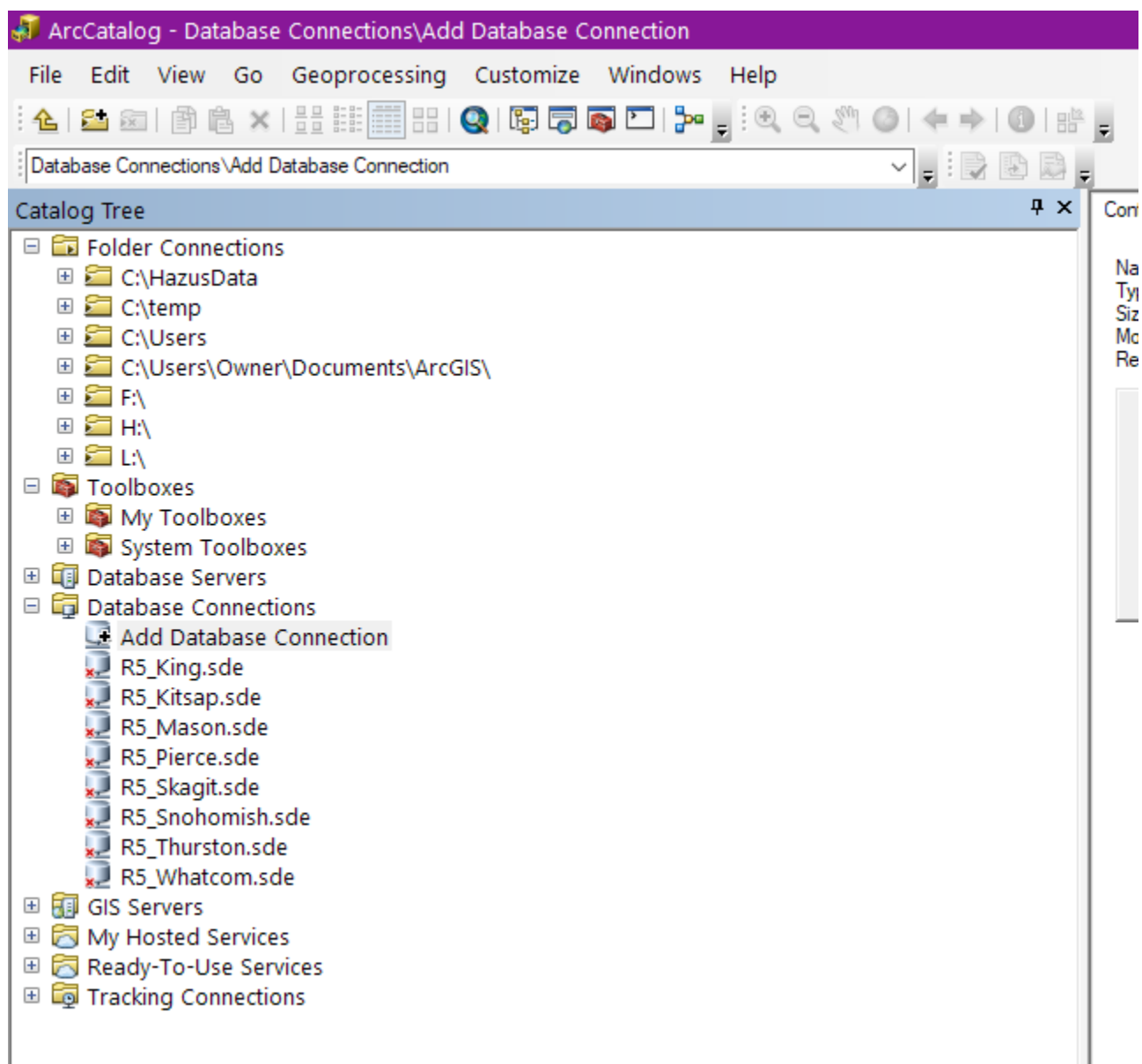
Depending on the UDF/AEBM dataset size, this step may take a while:

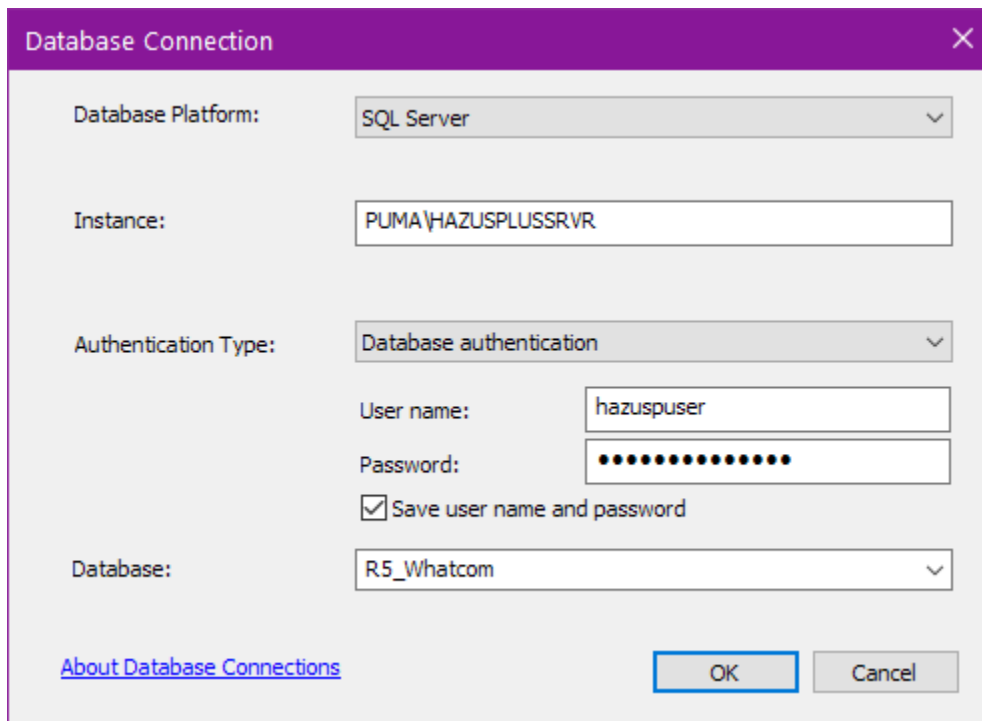


We are not reporting on earthquake-only data for buildings in the tsunami zone.

For earthquake only, exit Hazus and open ArcCatalog. If you are running the combined earthquake-tsunami, ignore the following.

Establish a connection to the SQL database. Double-click on the "Add Database Connection"





Database Connection

Database Platform: SQL Server

Instance: PUMA\HAZUSPLUSRVR

Authentication Type: Database authentication

User name: hazuspuser

Password: ●●●●●●●●●●

☒ Save user name and password

Database: R5_Whatcom

[About Database Connections](#) OK Cancel

The password is: Gohazusplus_02

Your computer name will differ from “PUMA”.

Then via the pull-down, connect to the “Database” - which is your Hazus region name.

Database Connection

Database Platform: SQL Server

Instance: PUMA\HAZUSPLUSSRVR

Authentication Type: Database authentication

User name: hazuspuser

Password:

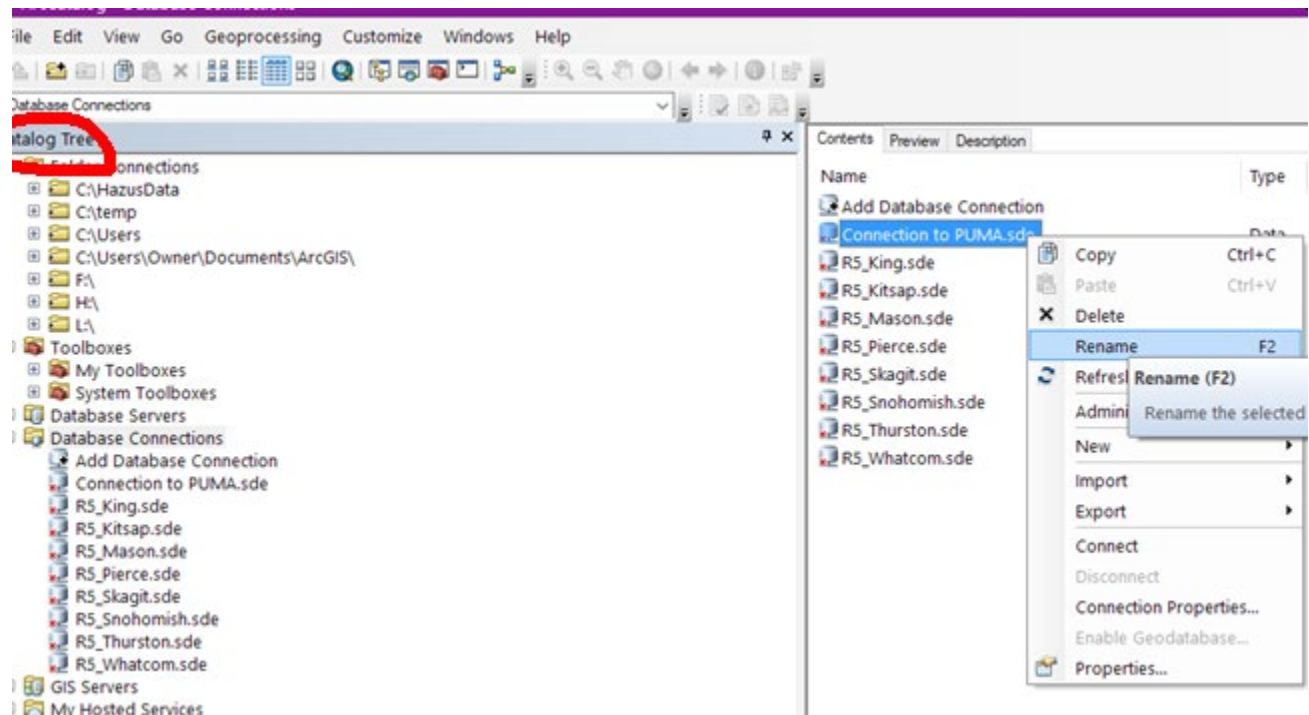
☒ Save user name and password

Database: R5_Whatcom

[About Database Connections](#)

- CDMS
- fTmpDB
- OR
- R1_King
- R1_Kitsap
- R1_Mason
- R1_Pierce
- R1_Skagit
- R1_Snohomish
- R1_Thurston
- R1_Whatcom
- R5_King
- R5_Kitsap
- R5_Mason
- R5_Pierce
- R5_Skagit
- R5_Snohomish
- R5_Thurston
- R5_Whatcom
- syHazus
- TestEQSkagit
- testInventory
- WA

Hit “OK”. Immediately rename the “Connection to COMPUTER.sde” database connection to (ideally) the same region name you used in Hazus, so as to not avoid future confusion. Right-click on the item to rename it:



It will have a suffix of “.sde”.

Then in the Catalog Tree window (circled in red, above), double click on the renamed connection, and have it expanded in full. There are a lot of files. The table you want for UDF loss is:

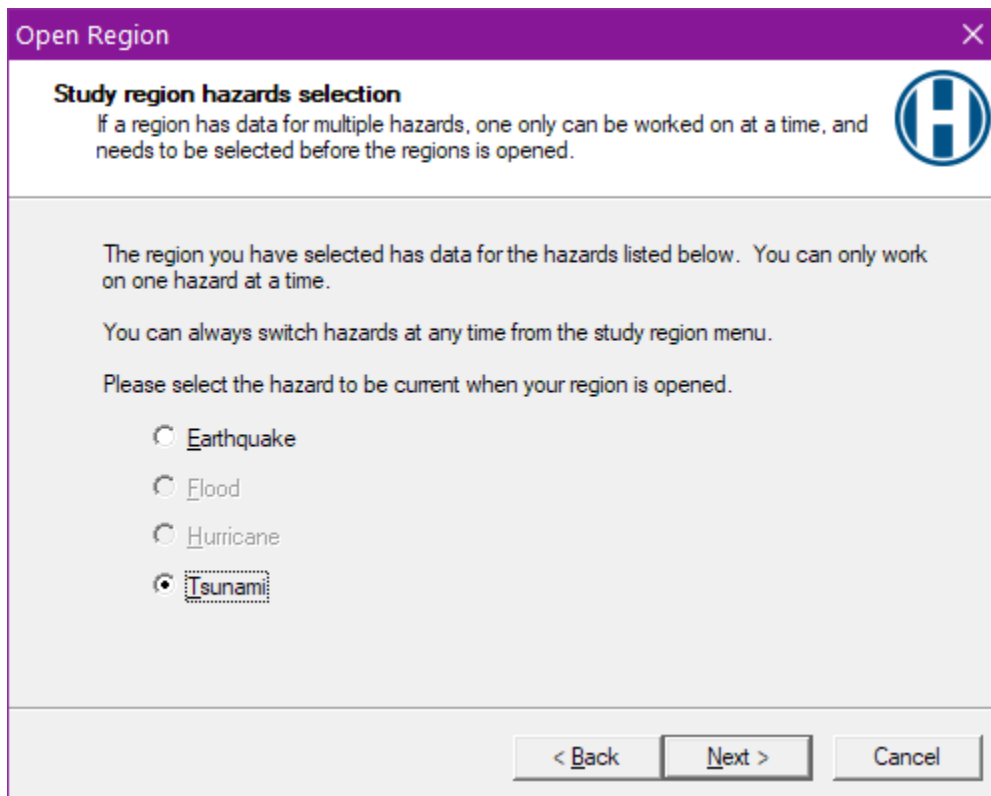
Database Connections\TestWhatcomEQ.sde\TestEQSkagit.dbo.eqUserDefinedFlty

To simplify future summaries, export this table to a standalone file geodatabase for use elsewhere.

The UDF earthquake economic loss numbers file for reference, and also to correct a major bug with the manufactured housing type (discussed below).

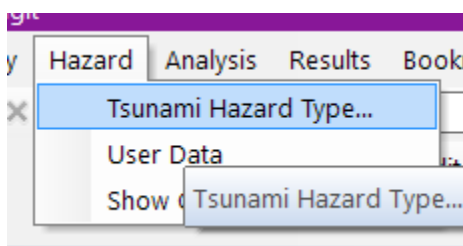
Combined Earthquake-Tsunami Building Loss

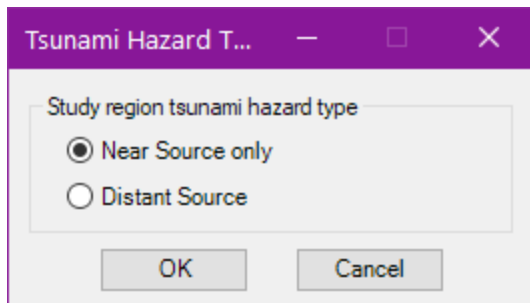
After running the earthquake analysis, quit Hazus (if you have not done so), open Hazus, select your region, and select Tsunami



Next, Finish. A Hazus/ArcMap should open. Note this warning window. Do not click buttons when these warning windows are displayed. Be patient.

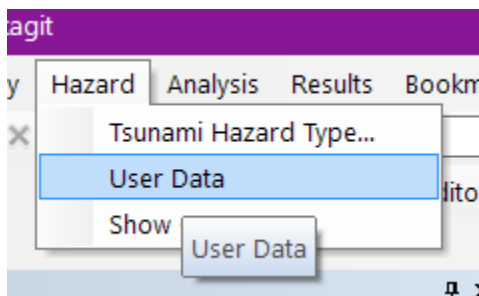
Define the Hazard as local. Hazard ->



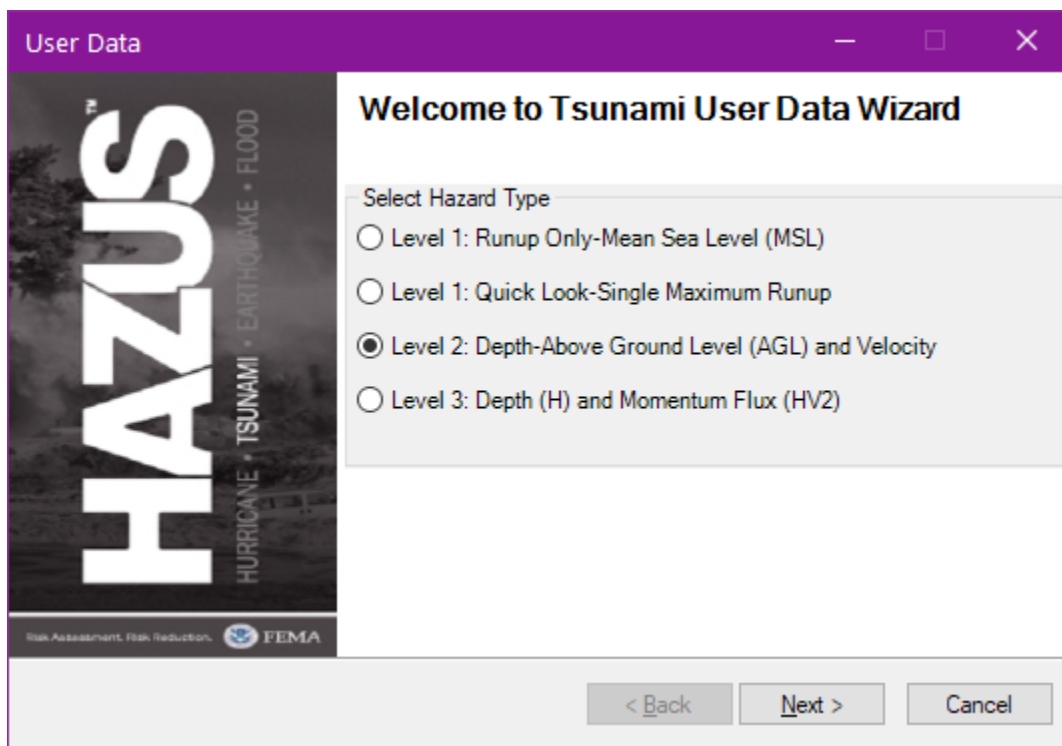


OK.

Provide the tool with the tsunami hazard data. Note that the derivation of these grids is discussed in the appendix.



WGS has provided Level 2 data in meters and maximum units



The screenshot shows a software window titled "User Data" with a purple header bar. Below the header, the title "Level 2: Tsunami Depth and Velocity" is displayed next to a circular logo containing a stylized 'H'. The main area is divided into two sections. The top section, "Select Input Format and Units", contains two radio buttons: "Rasters" (selected) and "NetCDF NOAA SIFT". To the right of these are two dropdown menus: "Depth Units:" set to "m" and "Velocity Units:" set to "m/sec". The bottom section, "Select dataset(s)", features a large empty list box with scrollbars. To the right of the list box are five buttons: "Browse Depth", "Browse Velocity", "Show Selected", "Remove", and "OK". At the bottom of the window are three buttons: "< Back", "Next >", and "Cancel".

Browse to the `TsuGrids_by_County.gdb` file geodatabase location. Select the `Depth_max_m_county` grid for depth, the velocity grid (`Velocity_max_ms_county`) for the velocity. These must be done in order. Do depth first, then do velocity. Set units to m, m/s:

User Data

Level 2: Tsunami Depth and Velocity

Select Input Format and Units

☒ Rasters Depth Units: m

☐ NetCDF NOAA SIFT Velocity Units: m/sec

Select dataset(s)

Browse Depth

Browse Velocity

Show Selected

Remove

OK

< Back Next > Cancel

User Data

Level 2: Tsunami Depth and Velocity

Select Input Format and Units

☒ Rasters Depth Units: m

☐ NetCDF NOAA SIFT Velocity Units: m/sec

Select dataset(s)

H:\GIS\Projects\WAEMD\Tsunami_2022\geodata\TsuGrids_by_Cour
H:\GIS\Projects\WAEMD\Tsunami_2022\geodata\TsuGrids_by_Cour

Browse Depth

Browse Velocity

Show Selected

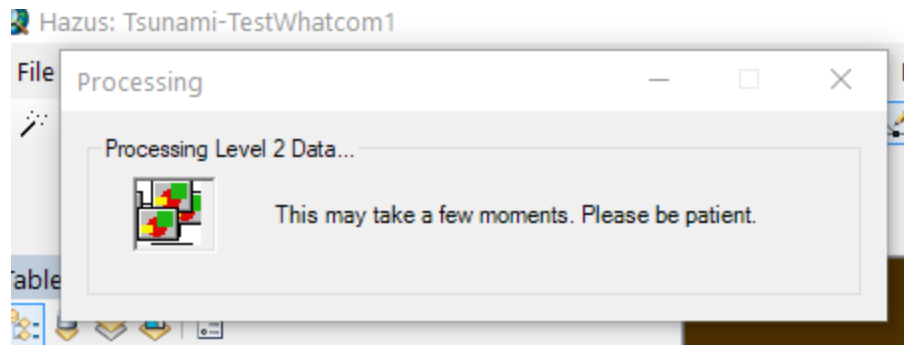
Remove

OK

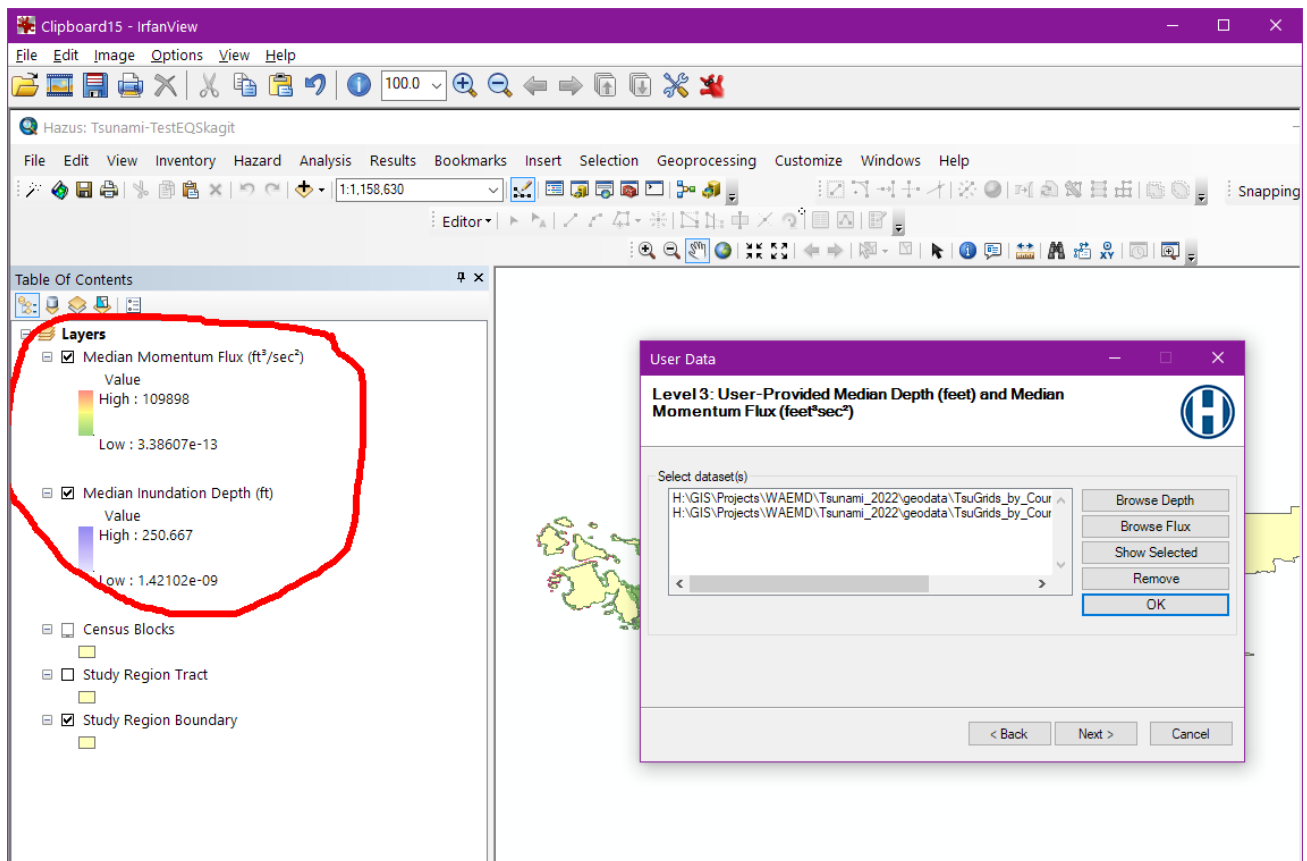
< Back Next > Cancel

Now here is where patience is rewarded. Hit “OK” NOT “Next >”

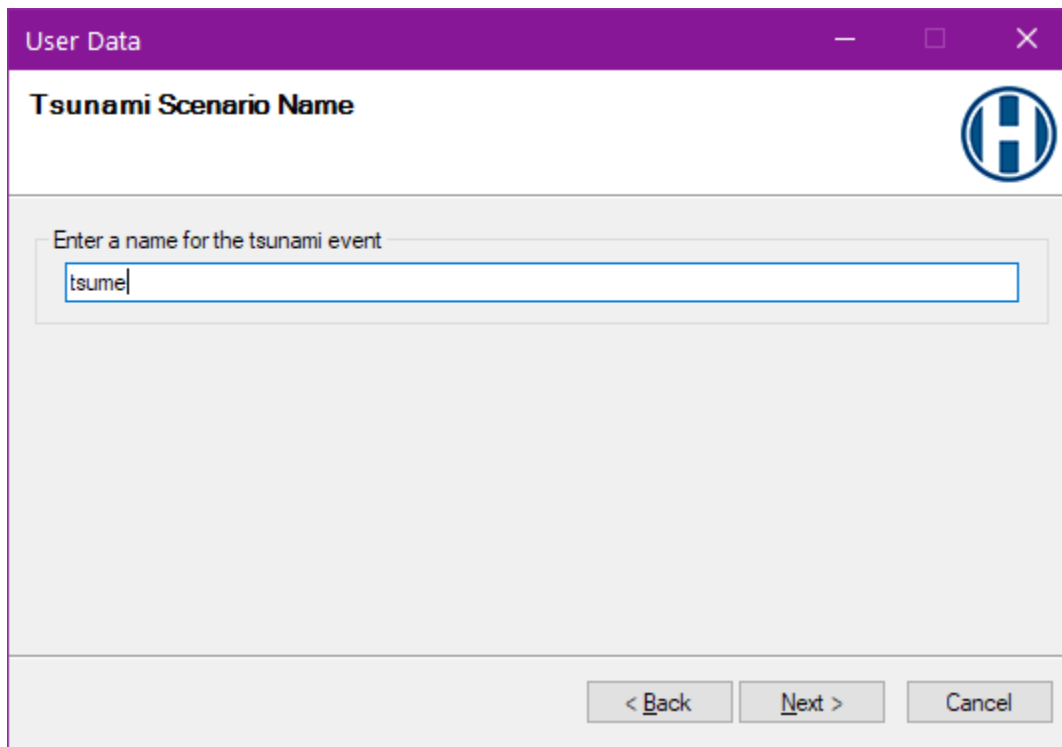
Expect this popup. Do not proceed until it goes away:



The display should show the imported depth and flux. Once you see both, then you can hit Next. Do NOT hit “OK” more than once.

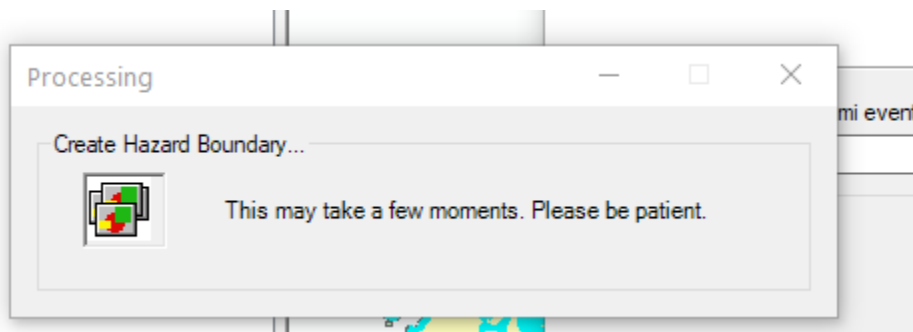


Next->

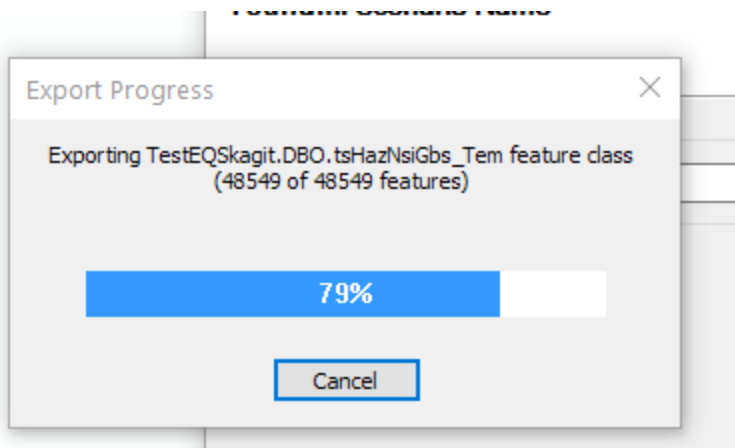


You can give it any arbitrary name. It won't impact the process. Next ->

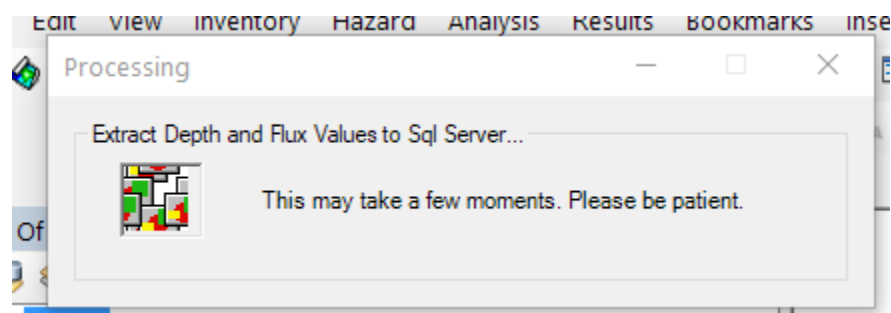
This may take some time. You will see this popup as it is doing various processing:



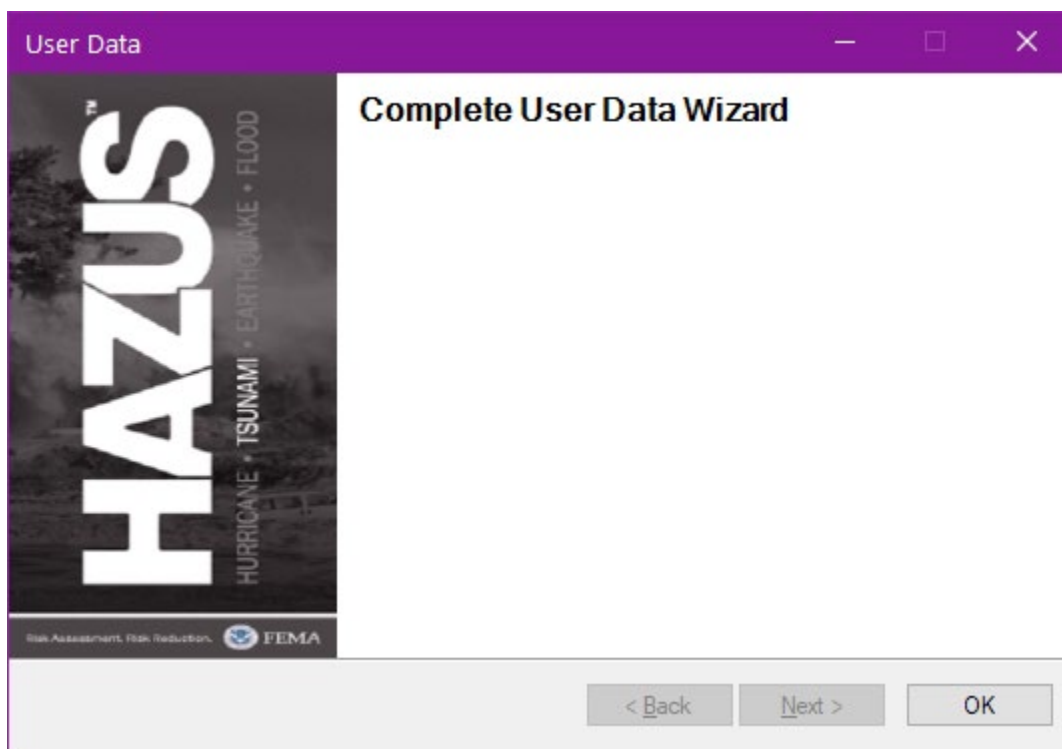
Followed by this window. Again, this can take a very long time, especially for heavily populated counties like King county.



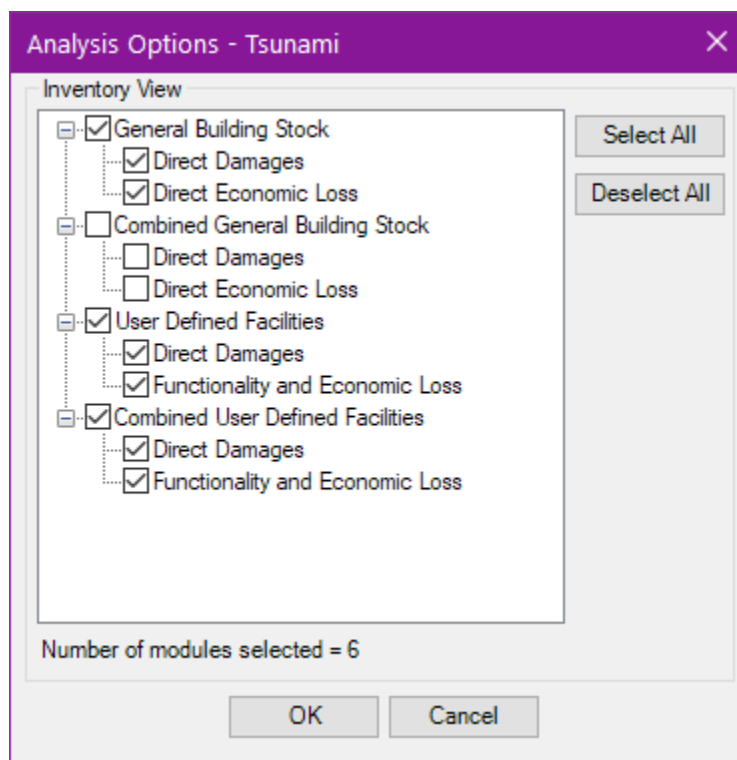
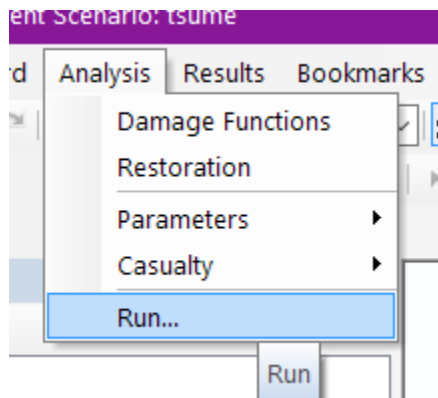
Yet another “in process” window:



Finally, you should get this:

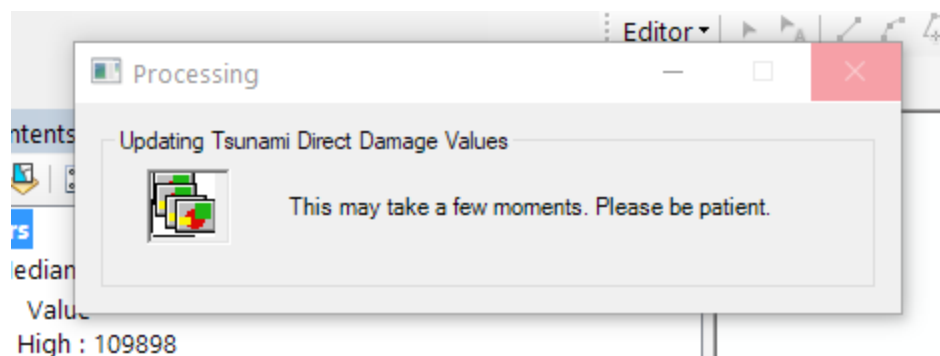


Run the combined earthquake-tsunami loss:

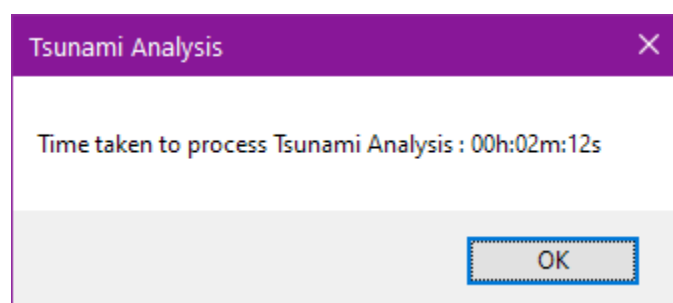


Hit OK. (the reason for running the GBS is that the tsunami casualty model sometimes does not work if the GBS was not run. There isn't a reason it shouldn't run but this is mentioned for quick reference).

Expect more processing windows:



Finally:



Hit OK.

Connect to the region SQL database as shown in the previous section. Export out the following two tables to your specific file geodatabase, for use later.

Database Connections\TestWhatcomEQ.sde\TestEQSkagit.dbo.tsCombFRUserDefinedFlty

Database Connections\TestWhatcomEQ.sde\TestEQSkagit.dbo.tsCombUserDefinedFlty

*Note the "FuncDayxx" columns are **not to be reported**. These estimates are **much too optimistic** for a regional disaster, and FEMA knows it (and has heard from me on this matter).*

Similar to earthquake loss, building repair cost = EconLossStruc + EconLossNonStruc

Optional datasets that may be of interest - if you are interested only in the tsunami damages:

- Database Connections\TestWhatcomEQ.sde\TestEQSkagit.dbo.tsUserDefinedFlty (OPTIONAL)
- Database Connections\TestClallam50.sde\TestClallam50.dbo.tsFRUserDefinedFlty (OPTIONAL)

Note the first is a point file. That is fine. #1 provides depth, velocity in structure, and PDS, but only for the tsunami damages. #2 provides economic impact and Loss Ratio for tsunami only.

With the additional field calculations, you can now join these tables with the original UDF file, and summarize losses, casualties, etc., over any spatial unit desired (typically, a county). Note, however, that **the number of buildings reported by the tsunami results may be less than earthquake results**. This is because all UDF points must intersect both tsunami grids. If neither or both are true, Hazus throws the result silently away.

Known Hazus Bugs

There are several known bugs present in Hazus 5.1. However, cumulatively, the end impact of all of these is judged to be minor on overall estimates at the state and county levels.

Restoration Times

This also influences other factors like economic impacts. The Hazus developers provided default “days to full functionality” estimates. Based on a cursory review of the estimates with experts, it was quickly determined that the Hazus estimates were simply not credible for a large-scale CSZ tsunami, and would be a major distraction if reported. We do not include these numbers or any derivatives in the final database deliverable.

Manufactured Housing

Manufactured houses (building type “MH”) in the tsunami zone are estimated to be a complete loss regardless of depth or velocity of water (an overestimation). While the MH building type is very sensitive to water velocity, there are situations where the tsunami damage should be minimal, given its first-floor height/depth-in-structure and the relatively low water velocity. About one in five MH buildings are in areas of relatively low velocity and depth. However, it should be noted that the MH building type is very sensitive to earthquake ground motions and is likely to be moderately to significantly damaged from the antecedent earthquake. They can be identified using queries:

`tsUserDefinedFlty.EqBldgTypeID=36 and tsUserDefinedFlty.EqDesignLevelID = 1 and flux <`

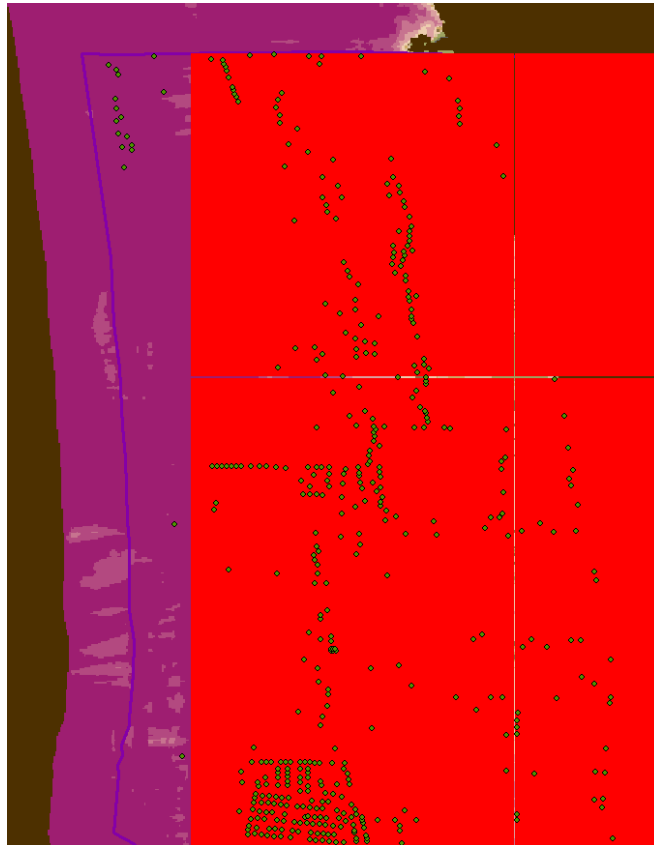
`tsUserDefinedFlty.EqBldgTypeID=36 and tsUserDefinedFlty.EqDesignLevelID <> 1`

Areas with Low Velocity (Momentum Flux) But High Depth

For buildings where the velocity is low enough that it does not cause structural damage, but the depth of water is significant (more than 3 feet of water above the first floor), the Hazus model underestimates the damage to the non-structural components of the building and to the building’s contents. Such situations could be considered, in essence, a flooding event. This results in under-reporting of building and content repair costs in probably around 1 in 10 buildings. For instance, this situation occurs throughout the Aberdeen/Hoquiam area. On the outer coast, this situation does not occur given the destructive wave velocities generally present.

Earthquake ShakeMap Boundary Issues

Hazus 5.1 does a mostly efficient job importing the USGS ShakeMap grids. However, a boundary condition occurs where the grid information gets translated into polygon rectangle form and can occasionally not completely cover the study area. A quick workaround was not identified. For example, in northwest Pacific County, about 17 buildings in the Study Area end up having zero ground motions, and thus zero damage, because the ShakeMap grid did not extend into the area. UDFs as dots, the county outline in purple, and the ShakeMap grid, interpreted from the USGS grid.xml file, is in red. Note that the grid does not fully extend westward. Hazus team knows about the bug. (The momentum flux grid is in the background. The deep magenta colors indicate where nearly no building will remain standing).



In practice, this affects relatively few points in this project. And for Pacific County, while the earthquake damage estimate for the excluded buildings will be zero, they will be completely destroyed anyway by the tsunami, and included as “completely damaged” in the final result.

Hazus County Boundary Imprecision

Hazus has an internal county boundary file, constructed from Census geometries. In some spots on Washington's rather contorted shorelines, this boundary does not quite match the reality. Any UDF point NOT within the boundary is ignored and discarded by Hazus.



In the above case, the pink line is the Hazus county boundary. We deliberately moved some of the UDF points (shown as green squares) within the boundary, to not lose the point all together. Note that they are not necessarily on the building footprint itself. It's acknowledged that moving the points so that they fall within the boundary will change the tsunami depth/velocity data, and thus may underestimate the building damage from the tsunami. This was determined to be the best course of action than to not represent the building at all. The above situation only impacts about 300 points.

Appendix D. Acronyms used in this report

AEBM	Advanced Engineering Building Module (Hazardus)
CSZ	Cascadia Subduction Zone
Hazardus	Hazards of the United States. FEMA-distributed software for estimating impacts from natural hazards.
HIFLD	Homeland Infrastructure Foundation-Level Data
PDS	Probability of Damage States
UDF	User-Defined Facility (Hazardus)
WA EMD	Washington Emergency Management Division
WGS	Washington Geological Survey