FLOOD RISK MANAGEMENT – PLANNING CENTER OF EXPERTISE (FRM-PCX)

FRM-PCX WEBINAR SERIES

IMPLEMENTING NONSTRUCTURAL MEASURES IN HEC-FDA

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FRM-PCX – WE'RE HERE TO HELP!!!

...BUT WE NEED YOUR HELP TOO!

The Goal:

- Timely webinars on specific topics that can help you and your FRM study RIGHT NOW!
- Provide individual presentations/training to teams on specific topics relevant for your FRM study
- Provide individual support to teams to help work through specific FRM challenges



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OVERVIEW OF PRESENTATION – WHY IS THIS IMPORTANT?



- Defining nonstructural measures
- Modeling of nonstructural measures using the HEC-FDA model
 - Using modules to adjust the structure inventory for nonstructural plans
- Providing results for nonstructural plans using risk-based methods
- Incorporating sensitivity analyses for the participation rates of nonstructural plans
- Bonus Technical!
 - Using structure detail output file information to evaluate increments of a nonstructural plan



NONSTRUCTURAL MEASURES DEFINED

Nonstructural measures are permanent or contingent measures applied to a structure and/or its contents that prevent or provide resistance to damage from flooding. Nonstructural measures differ from structural measures in that they focus on reducing the CONSEQUENCES of flooding instead of focusing on reducing the PROBABILITY of flooding.

Changing the CONSEQUENCES not the HAZARD

Typically only need without project H&H for nonstructural alternatives!

Two types of nonstructural measures: physical and nonphysical measures that provide resistance to damage from flooding





PHYSICAL NONSTRUCTURAL MEASURES



Elevation

Relocation

Acquisition (buyouts)

Wet floodproofing

Dry floodproofing



Figure 6-6. Wet floodproofing with a wet floodproofed subgrade basement

(Source: FEMA 312)



Figure 7-1. A typical dry floodproofed structure (Source: FEMA 312)



NON-PHYSICAL NONSTRUCTURAL MEASURES

Flood warning systems

Flood insurance

Floodplain mapping

Flood emergency preparedness plans

Land use regulation

Zoning

Evacuation plans

Risk communication





HEC-FDA MODEL VERSION 1.4.2

Configure is the configuration of the study area into Streams and Reaches, and providing the Study Analysis Years and Plans

HydEng is for entering Water Surface Elevations, Exceedance Probability Relationships with Uncertainty, the Stage-Discharge Function with Uncertainty, and Levee Features

Economics is for addressing Structure Categories and Occupancies, Modules and their assignment and the Structure Inventory information



STRUCTURE INVENTORY

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Struc_Name	Cat_Name	Stream_Name	Occ_Name	Station	Bank	Year	Struc_Val	Grnd_Stage	Found_Ht	Num_Struct	Mod_Name
158	RES	Styx	2SNB	26776	Left	2001	191.36	6.506	2.5	1	Base
159	RES	Styx	1SNB	26776	Left	2000	200.521	6.266	2.5	1	Base
158A	AUTO	Styx	AUTO RES	26776	Left	2001	9.496	6.506	0	1	Base
159A	AUTO	Styx	AUTO RES	26776	Left	2000	9.496	6.266	0	1	Base
25092A	AUTO	Styx	AUTO RES	26776	Right	1962	9.496	6.321	0	1	Base
24910A	AUTO	Styx	AUTO RES	26776	Left	1963	9.496	5.4	0	1	Base
40972	RES	Styx	2SNB	3512	Left	1983	209.94	4.103	2	1	Base
40972A	AUTO	Styx	AUTO RES	3512	Left	1983	9.496	4.103	0	1	Base
46542	APT	Styx	A-3SNB	26776	Left	1980	759.144	7.209	0.5	1	Base
46542A	AUTO	Styx	AUTO RES	26776	Left	1980	75.972	7.209	0	1	Base
24910	RES	Styx	1SNB	26776	Left	1963	197.541	5.4	0.6	1	Base
25092	RES	Styx	2SNB	26776	Right	1962	217.947	6.321	0.5	1	Base
611	COM	Styx	OFFICE	3512	Left	1973	356.518	8.654	0.5	1	Base
13457	COM	Styx	OFFICE	26776	Left	1980	163.999	7.505	0.5	1	Base

NONSTRUCTURAL MEASURES IN HEC-FDA

All nonstructural measures in HEC-FDA are implemented through manipulation of the module function. Each structure is assigned a module. The modules are then assigned to plans by year. If a module is active for a plan, all structures assigned to that module will be able to receive damages.

Structures without nonstructural measures are generally assigned to the "Base" module.

AfterNonstructural	Structure Module Assignment	×	AfterNonstructural - Structure Module Assignment	>
J Structure Module Name:	Base Buyout Roodproof Raise WOP	<u>S</u> ave <u>C</u> ancel	Structure Module Name: Base Buyout Floodproof Raise WOP	<u>S</u> ave <u>C</u> ancel
	-	J		Ŀ

ACQUISITION (BUYOUTS)

Buyouts are handled in FDA in a way very similar to the Base structures. The only manipulation of the structure record is the use of the "Buyout" module assignment.

Using this module allows you to either include or exclude a module in a plan/year combination. When a module is assigned, all structure records with that module are included for damages.

Since buying out a structure removes it from the inventory, not assigning the module to a specific plan/year will effectively remove those structures from the inventory.

Struc Name	Struc Desc	Cat Name	Stream Name	Occ Name	Station	Bank	Year	Struc Val	Grnd Stage	Found Ht	Begin Damg	Num Struct	Mod Name
40972	_	RES	Styx	2SNB	3512	Left	1983	209.94	4.103	2		1	Base
40972A		AUTO	Styx	AUTO RES	3512	Left	1983	9.496	4.103	0		1	Base
46542		APT	Styx	A-3SNB	26776	Left	1980	759.144	7.209	0.5		1	Base
46542A		AUTO	Styx	AUTO RES	26776	Left	1980	75.972	7.209	0		1	Base

Struc_Name	Struc_Desc	Cat_Name	Stream_Name	Occ_Name	Station	Bank	Year	Struc_Val	Grnd_Stage	Found_Ht	Begin_Damg	Num_Struct	Mod_Name
40972		RES	Styx	2SNB	3512	Left	1983	209.94	4.103	2		1	Buyout
40972A		AUTO	Styx	AUTO RES	3512	Left	1983	9.496	4.103	0		1	Buyout
46542		APT	Styx	A-3SNB	26776	Left	1980	759.144	7.209	0.5		1	Buyout
46542A		AUTO	Styx	AUTO RES	26776	Left	1980	75.972	7.209	0		1	Buvout

ELEVATION (RAISING)

Raising is implemented in FDA by duplicating structure records, manipulating foundation heights, and utilizing modules.

The original structure records are copied and then assigned the "WOP" module instead of "Base". The structure names for the new copies are adjusted to be unique ("R" after the original name). The records are then assigned the "Raise" module and given a foundation height matching how much the structures are to be raised.

These new records keep the same occupancy name, so use the same depth-damage curve.

Struc_Name	Struc_Desc	Cat_Name	Stream_Name	Occ_Name	Station	Bank	Year	Struc_Val	Grnd_Stage	Found_Ht	Begin_Dar	Num_Struct	Mod_Name
24910		RES	Styx	1SNB	26776	Left	1963	197.541	5.4	0.6		1	Base
25092		RES	Styx	2SNB	26776	Right	1962	217.947	6.321	0.5		1	Base
24910A		AUTO	Styx	AUTO RES	26776	Left	1963	9.496	5.4	0		1	Base
25092A		AUTO	Styx	AUTO RES	26776	Right	1962	9.496	6.321	0		1	Base

FLOODPROOFING

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Floodproofing is implemented in FDA by duplicating structure records, manipulating occupancies, and utilizing modules.

The original structure records are copied and then assigned the "WOP" module instead of "Base". The structure names for the new copies are adjusted to be unique ("FP" after the original name).

The records are then assigned the "Floodproof" module and given an occupancy name linked to an adjusted depth-damage curve that has damages zeroed out up to the height of the floodproofing.

		Struc_Name	Struc_Desc	Cat_Name	Stream_Nam	e Occ_Name	Station	Bank	Year	Struc_Val	Grnd_Stage	Found_Ht	Begin_Damg	Num_Struct	Mod_Nam
		611		COM	Styx	OFFICE	3512	Left	1973	356.518	8.654	0.5	i i	1	Base
		13457		COM	Styx	OFFICE	26776	Left	1980	163.999	7.505	0.5	i l	1	Base
	_	Struc Name	Struc_Desc	Cat_Name	Stream_Nam	e Occ_Name	Station	Bank	Year	Struc_Val	Grnd_Stage	Found_Ht	Begin_Damg	Num_Struct	Mod_Nam
New	-	Struc Name 13457FP	Struc_Desc	Cat_Name COM	Stream_Nam Styx	e Occ_Name OFFICE_FP	Station 26776	Bank Left	Year 1980	Struc_Val 163.999	Grnd_Stage 7.505	Found_Ht 0.5	Begin_Damg	Num_Struct	Mod_Nam Floodproo
New Records		Struc Name 13457FP 611FP	Struc_Desc	Cat_Name COM COM	Stream_Nam Styx Styx	e Occ_Name OFFICE_FP OFFICE_FP	Station 26776 3512	Bank Left Left	Year 1980 1973	Struc_Val 163.999 356.518	Grnd_Stage 7.505 8.654	Found_Ht 0.5 0.5	Begin_Damg	Num_Struct 1 1	Mod_Nam Floodproo Floodproo
New tecords		Struc Name 13457FP 611FP 611	Struc_Desc	Cat_Name COM COM COM	Stream_Nam Styx Styx Styx	e Occ_Name OFFICE_FP OFFICE_FP OFFICE	Station 26776 3512 3512	Bank Left Left Left	Year 1980 1973 1973	Struc_Val 163.999 356.518 356.518	Grnd_Stage 7.505 8.654 8.654	Found_Ht 0.5 0.5 0.5	Begin_Damg	Num_Struct 1 1 1	Mod_Nam Floodproo Floodproo WOP

NOTE: New records must be given different structure names. The FDA model will overwrite any structures with the same name. It will not give an error message.

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FLOODPROOFING (CONT.)

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Below are the depth-damage curves for an office building without (occupancy "OFFICE") and with floodproofing (occupancy "OFFICE_FP"). In this case, floodproofing does not allow damages up to 3'.

Occ_Name	Occ_Description	Cat_Name	Parameter	Start_Data															
OFFICE	Office	COM	Stage	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10	
OFFICE			S	0	0	0	9.2	12.8	15.6	18.4	25.6	25.6	30.63	36.7	45.3	56.8	62.4	62.4	
OFFICE			STL	0	0	0	3.5	7.6	10.2	12.6	18.9	20.2	25.2	27.7	35.5	43.1	50.63	55.6	
OFFICE			STU	0	0	2.1	12.9	17.9	22.9	27.9	34.6	37.9	42.9	55.5	62.9	78.6	84.3	88.6	
OFFICE			Stage	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10	
OFFICE			С	0	0	0	10	20	25	30	40	57.5	70	81	95	100	100	100	
OFFICE			CTL	0	0	0	5	12.2	20	28	35	45	54	65	70	78	80	87.5	
OFFICE			СТU	0.1	0.9	0.9	20	25	32.2	42.5	55	65	72.5	80	83.8	100	100	100	
OFFICE			Struct	N		0.49		т		92	108	Т	18.1	14	24				

	Occ_Name	Occ_Description	Cat_Name	Parameter	Start_Data														
	OFFICE_FP	Office with 3' floodproofing	COM	Stage	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
New	OFFICE_FP			S	0	0	0	0	0	0	0	0	25.6	30.63	36.7	45.3	56.8	62.4	62.4
supancy	OFFICE_FP			STL	0	0	0	0	0	0	0	0	20.2	25.2	27.7	35.5	43.1	50.63	55.6
Гуре	OFFICE_FP			STU	0	0	0	0	0	0	0	0	37.9	42.9	55.5	62.9	78.6	84.3	88.6
	OFFICE_FP			Stage	-1	-0.5	0	0.5	1	1.5	2	3	4	5	6	7	8	9	10
	OFFICE_FP			C	0	0	0	0	0	0	0	0	57.5	70	81	95	100	100	100
	OFFICE_FP			CTL	0	0	0	0	0	0	0	0	45	54	65	70	78	80	87.5
	OFFICE_FP			CTU	0	0	0	0	0	0	0	0	65	72.5	80	83.8	100	100	100
	OFFICE_FP			Struct	N		0.49		Т		92	108	Т	18.1	14	24			

PROBABILITY BENEFITS EXCEED COSTS

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Report Equivalent Annual Damage Analysis Reduced and Distributed by Plans

Study: AfterNonstructural

Monetary Units: \$1,000's

Discount Rate: 2.875

Period of Analysis: 50 years

Version 1.4.2, July 2017; Less Simple Method (0.010)

Plan	Plan Description	Total Without Proiect	Total With Proiect	Annual Damage Reduced	Prob Damg Reduced Exceeds 0.75	Prob Damg Reduced Exceeds 0.50	Prob Damg Reduced Exceeds 0.25	Annual Cost of Nonstructural Plan	Probability Benefits Exceed Costs
		,	j						
With	Nonstructural	\$73	\$10	\$63	\$39	\$59	\$83	\$37	Greater than 75%

Note: Since the annual cost (\$37k) is less than the annual benefit value at 75 percent (\$39k), there is a 75 percent chance that benefits exceed the costs.

SENSITIVITY ANALYSIS ON PARTICIPATION RATE

To test the nonstructural plan's sensitivity to participation rates, the model was duplicated to produce results reflecting 25% participation, 50% participation, and 75% participation. The inventory records in these additional models were manipulated to delete nonstructural records and reassign the without project module to base.

The alteration for 50% participation is shown below. Structures 611 and 25092 were no longer participating, so the raise and floodproof records were deleted and the module for the without project records was changed to base.

Struc_Name Cat_Name Occ_Name Station Struc_Val Grnd_Stage Found_Ht Mod_Name

_	—	_		_		_	—
158	RES	2SNB	26776	191.36	6.506	2.5	Base
159	RES	1SNB	26776	200.521	6.266	2.5	Base
158A	AUTO	AUTO RES	26776	9.496	6.506	0	Base
159A	AUTO	AUTO RES	26776	9.496	6.266	0	Base
40972	RES	2SNB	3512	209.94	4.103	2	Buvout
40972A	AUTO	AUTO RES	3512	9,496	4.103	0	, Buvout
46542	APT	A-3SNB	26776	759,144	7.209	0.5	Buyout
46542A	AUTO	AUTO RES	26776	75.972	7.209	0	Buyout
13457FP	COM	OFFICE FP	26776	163 999	7 505	05	Floodproof
611FP	COM		3512	356 518	8 654	0.5	Floodproof
24910R	RES	15NR	26776	197 541	5.4	7	Raise
25092R	RES	25NB	26776	217 947	6 3 2 1	65	Raise
2/910	RES	15NR	26776	197 541	5.4	0.5	WOP
25092	RES		26776	217 Q//7	6 3 2 1	0.0	
611	COM	OFFICE	20770	256 518	8 654	0.5	WOP -
12/157	COM		26776	162 000	7 505	0.5	WOR
250020			26776	0 /06	6 2 2 1	0.5	Base
23092A	AUTO		20770	9.490	0.521	0	Base
24910A	AUTU	AUTO KES	20//0	9.490	5.4	0	Base

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Report Equivalent Annual Damage Analysis Reduced and Distributed by Plans

Diam	Dian Description	Total Without	Total With	Annual Damage	Annual Cost of	Net Decelia	Benefit/Cost
Plan	Plan Description	Project	Project	Reduced	Nonstructural Plan	Net Benefits	Ratio
	Nonstructural 25%						
With	Participation	\$73	\$31	\$42	\$30	\$12	1.40
	Nonstructural 50%						
With	Participation	\$73	\$18	\$55	\$33	\$22	1.67
	Nonstructural 75%						
With	Participation	\$73	\$10	\$62	\$36	\$26	1.72
	Nonstructural 100%						
With	Participation	\$73	\$10	\$63	\$37	\$26	1.70

THINGS TO REMEMBER

- Without project H&H are used to analyze nonstructural measures
- Modules are very useful in the HEC-FDA modeling of nonstructural measures
- Incorporate risk and uncertainty and sensitivity analysis regarding participation rates into all nonstructural evaluations

USING THE STRUCTURE DETAIL OUTPUT

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The HEC-FDA model has an output option that can be toggled on or off in the "Compute Reach Stage-Damage Function with Uncertainty..." section of the model. When toggled on, the "Write Structural Details" option will generate a Structure Detail Output file with damage data by probability event for each individual structure. This file can be found in the study folder under the name "FDA_StrucDetail.out", which can be opened in Excel.

NOTE: This output is an intermediary product. At this point in the model, risk and uncertainty have not been fully calculated. Also, structural alternatives such as levees are not taken into account. If your nonstructural measures are combined with a levee, damages in the detail file will need to be zeroed out for probability events mitigated by the levee.

STRUCTURE DETAIL OUTPUT EXAMPLES

Study:

AfterNonstructural

Without nonstructural project plan in the base year

Plan:	Without															
Year:	2026															
									Total							
									Damage at							
Structure	Damage	Occupancy		Structure	Content	Total	Ground	Foundation	0.5	0.2	0.1	0.04	0.02	0.01	0.004	0.002
Name	Category	Туре	Module	Value	Value	Value	Flevation	Height	Probability	Brobability						
Name	Category	Type	Wiodule	value	value	value	Lievation	neight		0.2	∩ 1	0.04	0.02	0.01	0.004	0.002
150	DEC	2CND	Raco	101.26	05.69	207.04	6 5 1	25	0.0	0.2	0.1	0.04	0.02	19.20	61 50	0.002
150	RES		Dase	191.50	95.00	207.04	0.51	2.5	0.00	0.00	0.00	0.00	0.00	10.59	104.42	91.52
159	RES	15NB	ваѕе	200.52	100.26	300.78	6.27	2.5	0.00	0.00	0.00	0.00	0.00	29.74	104.43	150.37
158A	AUTO	AUTO RES	Base	9.50	0.00	9.50	6.51	0	0.00	0.00	0.00	0.48	3.46	5.34	/.1/	8.80
159A	AUTO	AUTO RES	Base	9.50	0.00	9.50	6.27	0	0.00	0.00	0.00	1.01	3.88	5.70	7.44	9.02
40972	RES	2SNB	Buyout	209.94	104.97	314.91	4.10	2	0.00	9.11	47.93	76.78	104.83	118.27	151.80	185.77
40972A	AUTO	AUTO RES	Buyout	9.50	0.00	9.50	4.10	0	0.79	3.97	5.60	7.10	8.75	9.43	9.50	9.50
46542	APT	A-3SNB	Buyout	759.14	75.16	834.30	7.21	0.5	0.00	0.00	0.00	0.00	54.49	190.25	230.45	284.77
46542A	AUTO	AUTO RES	Buyout	75.97	0.00	75.97	7.21	0	0.00	0.00	0.00	0.00	13.86	34.01	49.99	65.15
24910	RES	1SNB	WOP	197.54	98.77	296.31	5.40	0.6	0.00	0.00	2.73	63.69	113.39	146.00	164.53	190.53
25092	RES	2SNB	WOP	217.95	108.97	326.92	6.32	0.5	0.00	0.00	0.82	17.05	63.18	88.46	110.60	132.18
611	СОМ	OFFICE	WOP	356.52	64.53	421.05	8.65	0.5	0.00	0.00	0.00	0.00	34.23	77.46	117.37	145.17
13457	СОМ	OFFICE	WOP	164.00	29.68	193.68	7.51	0.5	0.00	0.00	0.00	0.00	0.00	28.45	45.95	59.59
25092A	AUTO	AUTO RES	Base	9.50	0.00	9.50	6.32	0	0.00	0.00	0.00	0.80	3.78	5.62	7.38	8.97
24910A	AUTO	AUTO RES	Base	9.50	0.00	9.50	5.40	0	0.00	0.00	1.15	3.42	5.25	6.86	8.38	9.40
Study:	AfterNons	structural														
Plan:	With															
Year:	2026															
									Total							
									Damage at							
Structure	Damage	Occupancy		Structure	Content	Total	Ground	Foundation	0.5	0.2	0.1	0.04	0.02	0.01	0.004	0.002
Name	Category	Туре	Module	Value	Value	Value	Elevation	Height	Probability							
	υ,	<i>"</i>						U	, 0.5	, 0.2	0.1	, 0.04	. 0.02	0.01	0.004	0.002
158	RES	2SNB	Base	191.36	95.68	287.04	6.51	2.5	0.00	0.00	0.00	0.00	0.00	18.39	61.50	91.32
159	RES	1SNB	Base	200.52	100.26	300.78	6.27	2.5	0.00	0.00	0.00	0.00	0.00	29.74	104.43	150.37
158A	AUTO	AUTO RES	Base	9.50	0.00	9.50	6.51	0	0.00	0.00	0.00	0.48	3.46	5.34	7.17	8.80
159A	AUTO	AUTO RES	Base	9.50	0.00	9.50	6.27	0	0.00	0.00	0.00	1.01	3.88	5.70	7.44	9.02
13457EP	COM	OFFICE FP	Floodproof	164.00	29.68	193.68	7 51	05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	59 59
611FP	COM	OFFICE FP	Floodproof	356 52	64 53	421.05	8 65	0.5	0.00	0.00	0.00	0.00	0.00	0.00	3 2/	145 17
24910R	RES	1SNR	Raise	197 5/	97.35	206 21	5.05	0.J	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50
25002P	RES		Raico	217.05	108 07	230.31	5.40 6.22	65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
250521			Paco	217.95	100.97	320.92	6.32	0.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00
23092A	AUTO	AUTO RES	Dase	9.50	0.00	9.50	0.32	0	0.00	0.00	0.00	0.80	3.78	5.62	/.38	8.97
24910A	AUTO	AUTU KES	Dase	9.50	0.00	9.50	5.40	U	0.00	0.00	1.15	3.42	5.25	0.80	8.38	9.40

With nonstructural project plan in the base year Note that structures with the

note that structures with the module "Buyout" have been removed from the plan.

EXPECTED ANNUAL DAMAGES FOR EACH INDIVIDUAL STRUCTURE

Below is an abbreviated structure detail output file for one plan/year computation. The columns showing the "Total Damage at XX Probability" (TD) can be used to calculate an expected annual damage for each individual structure. This expected annual damage (EAD) is an incremental sum of damages by probability event.

$$EAD = \left((0.5 - 0.2) \times \frac{TD \ at \ 0.5 \ Prob + TD \ at \ 0.2 \ Prob}{2} \right) + \left((0.2 - 0.1) \times \frac{TD \ at \ 0.2 \ Prob + TD \ at \ 0.1 \ Prob}{2} \right) + \left((0.1 - 0.04) \times \frac{TD \ at \ 0.1 \ Prob + TD \ at \ 0.04 \ Prob}{2} \right) + \dots + ((0.002) \times TD \ at \ 0.002 \ Prob)$$

Saving the Structure Detail Output file as an Excel document allows you to insert this formula directly into the detail file. This is what the formula looks like in Excel.

-	В	E	Н	I	Q	S	V	AB	AE	AF	BB	BC	BD	BE	BF	BG	BH	BI	CH	CI	CJ	CK [
											Total				-							
											Damage at	Expected										
S	tructure		Damage	Occupancy		Structure	Content	Total	Ground	Foundation	0.5	0.2	0.1	0.04	0.02	0.01	0.004	0.002	Annual			
10 N	ame	Station	Category	Туре	Module	Value	Value	Value	Elevation	Height	Probability	Damages										
11											0.5	0.2	0.1	0.04	0.02	0.01	0.004	0.002				
12 1	58	26776	RES	2SNB	Base	191,36	95.68	287.04	6.51	2.5	0.00	0.00	0.00	0.00	0.00	18.39	61.50	91,32	=(((BC12+B	B12)/2)*(\$	BB\$11-\$BC	\$11))
13																			+(((BD12+B	C12)/2)*(\$	BC\$11-\$BD	(\$11))
14																			+(((BE12+B	D12)/2)*(\$	BD\$11-\$BE	\$11))
15																			+(((BF12+B	E12)/2)*(\$	BE\$11-\$BF\$	511))
16																			+(((BG12+B	F12)/2)*(\$	BF\$11-\$BG	\$11))
17																			+(((BH12+B	G12)/2)*(\$	BG\$11-\$BH	1\$11)
18)+(((BI12+B	H12)/2)*(\$	BH\$11-\$BI	\$11))
19																			+(BI12*\$BI	511)		

MAXIMUM CONSTRUCTION COST SUPPORTED

Once the Expected Annual Damages are calculated for the base year without project condition, an maximum construction cost supported can be estimated. This is done by multiplying the Expected Annual Damage by a project support factor. This estimated project supported cost assumes all damages are mitigated with project and includes interest during construction.

In Excel, the Interest and Amortization (I&A) Factor can be calculated using the payment function (= PMT(0.02875,50,-1))

Study:	AfterNon	structural																		
Plan:	Without																			
Year:	2026																			
																		Interest and		
									Total		Amortization		Max							
									Damage at	Expected	Factor (50	Project	Construction							
Structure	e Damage	Occupancy		Structure	Content	Total	Ground	Foundation	0.5	0.2	0.1	0.04	0.02	0.01	0.004	0.002	Annual	years,	Support	Cost
Name	Category	Туре	Module	Value	Value	Value	Elevation	Height	Probability	Damages	2.875%)	Factor	Supported							
									0.5	0.2	. 0.1	0.04	0.02	0.01	. 0.004	0.002				
158	RES	2SNB	Base	191.36	95.68	287.04	6.51	2.5	0.00	0.00	0.00	0.00	0.00	18.39	61.50	91.32	0.67	0.04	26.35	17.58
159	RES	1SNB	Base	200.52	100.26	300.78	6.27	2.5	0.00	0.00	0.00	0.00	0.00	29.74	104.43	150.37	1.11	0.04	26.35	29.16
158A	AUTO	AUTO RES	Base	9.50	0.00	9.50	6.51	0	0.00	0.00	0.00	0.48	3.46	5 5.34	7.17	8.80	0.17	0.04	26.35	4.45
159A	AUTO	AUTO RES	Base	9.50	0.00	9.50	6.27	0	0.00	0.00	0.00	1.01	3.88	3 5.70	7.44	9.02	0.20	0.04	26.35	5.29
40972	RES	2SNB	Buyout	209.94	104.97	314.91	4.10	2	0.00	9.11	. 47.93	76.78	104.83	3 118.27	151.80	185.77	12.41	0.04	26.35	327.06
40972A	AUTO	AUTO RES	Buyout	9.50	0.00	9.50	4.10	0	0.79	3.97	5.60	7.10	8.75	9.43	9.50	9.50	1.92	0.04	26.35	50.50
46542	APT	A-3SNB	Buyout	759.14	75.16	834.30	7.21	0.5	0.00	0.00	0.00	0.00	54.49	9 190.25	230.45	284.77	4.12	0.04	26.35	108.45
46542A	AUTO	AUTO RES	Buyout	75.97	0.00	75.97	7.21	0	0.00	0.00	0.00	0.00	13.86	5 34.01	49.99	65.15	0.88	0.04	26.35	23.07
24910	RES	1SNB	WOP	197.54	98.77	296.31	5.40	0.6	0.00	0.00	2.73	63.69	113.39	146.00	164.53	190.53	6.86	0.04	26.35	180.88
25092	RES	2SNB	WOP	217.95	108.97	326.92	6.32	0.5	0.00	0.00	0.82	17.05	63.18	88.46	110.60	132.18	3.24	0.04	26.35	85.44
611	СОМ	OFFICE	WOP	356.52	64.53	421.05	8.65	0.5	0.00	0.00	0.00	0.00	34.23	3 77.46	117.37	145.17	2.04	0.04	26.35	53.71
13457	сом	OFFICE	WOP	164.00	29.68	193.68	7.51	0.5	0.00	0.00	0.00	0.00	0.00	28.45	45.95	59.59	0.59	0.04	26.35	15.55
25092A	AUTO	AUTO RES	Base	9.50	0.00	9.50	6.32	0	0.00	0.00	0.00	0.80	3.78	3 5.62	7.38	8.97	0.19	0.04	26.35	5.00
24910A	AUTO	AUTO RES	Base	9.50	0.00	9.50	5.40	0	0.00	0.00	1.15	3.42	5.25	6.86	8.38	9.40	0.42	0.04	26.35	11.17

The Project Support Factor is equal to 1 over the I&A Factor.

EQUIVALENT ANNUAL DAMAGES

The Expected Annual Damages for the base year without project condition can also be used to estimate the Equivalent Annual Damage. A "back of the envelope" way to do this is to use the model's final results to calculate multiplier to get from the base year without project Expected Annual Damages to the without project Equivalent Annual Damages.

In the example below, the without project Equivalent Annual Damage is 1.51 times the base year without project Expected Annual Damages. This multiplier can be used on a structure by structure basis to provide an estimated Equivalent Annual Damage number.

EQUIVALENT ANNUAL DAMAGES REDUCED, NET BENEFITS, AND B/C RATIO

Once the Equivalent Annual Damages for without and with project have been computed for all structures, a benefit number can be calculated. Assuming cost is available on an individual structure basis, net benefit and B/C numbers can also be created. **It should be noted** that B/C ratios should not be reported or used for formulation on an individual structure basis. Nonstructural measures should be analyzed by structure groupings.

Study:	AfterNon	structural									
Plan:	Without										
Year:	2026										
Structure Name	Damage Category	Occupancy Type	Module	Structure Value	Content Value	Total Value	Ground Elevation	Foundation Height	Expected Annual Damages	Expected to Equivalent Multiplier	Equivalent Annual Damages
158	RES	2SNB	Base	191.36	95.68	287.04	6.51	2.5	0.67	1.51	. 1.01
159	RES	1SNB	Base	200.52	100.26	300.78	6.27	2.5	1.11	1.51	. 1.67
158A	AUTO	AUTO RES	Base	9.50	0.00	9.50	6.51	0	0.17	1.51	. 0.26
159A	AUTO	AUTO RES	Base	9.50	0.00	9.50	6.27	0	0.20	1.51	. 0.30
40972	RES	2SNB	Buyout	209.94	104.97	314.91	4.10	2	12.41	1.51	. 18.77
40972A	AUTO	AUTO RES	Buyout	9.50	0.00	9.50	4.10	0	1.92	1.51	. 2.90
46542	APT	A-3SNB	Buyout	759.14	75.16	834.30	7.21	0.5	4.12	1.51	6.23
46542A	AUTO	AUTO RES	Buyout	75.97	0.00	75.97	7.21	0	0.88	1.51	. 1.32
24910	RES	1SNB	WOP	197.54	98.77	296.31	5.40	0.6	6.86	1.51	. 10.38
25092	RES	2SNB	WOP	217.95	108.97	326.92	6.32	0.5	3.24	1.51	4.90
611	СОМ	OFFICE	WOP	356.52	64.53	421.05	8.65	0.5	2.04	1.51	. 3.08
13457	СОМ	OFFICE	WOP	164.00	29.68	193.68	7.51	0.5	0.59	1.51	0.89
25092A	AUTO	AUTO RES	Base	9.50	0.00	9.50	6.32	0	0.19	1.51	0.29
24910A	AUTO	AUTO RES	Base	9.50	0.00	9.50	5.40	0	0.42	1.51	0.64

Study:	AfterNon	structural									
Plan:	With										
Year:	2026										
										Expected	
									Expected	to	Equivalent
Structure	Damage	Occupancy		Structure	Content	Total	Ground	Foundation	Annual	Equivalent	Annual
Name	Category	Туре	Module	Value	Value	Value	Elevation	Height	Damages	Multiplier	Damages
158	RES	2SNB	Base	191.36	95.68	287.04	6.51	2.5	0.67	1.51	1.01
159	RES	1SNB	Base	200.52	100.26	300.78	6.27	2.5	1.11	1.51	1.67
158A	AUTO	AUTO RES	Base	9.50	0.00	9.50	6.51	0	0.17	1.51	0.26
159A	AUTO	AUTO RES	Base	9.50	0.00	9.50	6.27	0	0.20	1.51	0.30
13457FP	СОМ	OFFICE_FP	Floodproof	164.00	29.68	193.68	7.51	0.5	0.18	1.51	0.27
611FP	COM	OFFICE_FP	Floodproof	356.52	64.53	421.05	8.65	0.5	0.45	1.51	0.68
24910R	RES	1SNB	Raise	197.54	98.77	296.31	5.40	7	0.00	1.51	0.00
25092R	RES	2SNB	Raise	217.95	108.97	326.92	6.32	6.5	0.00	1.51	0.00
25092A	AUTO	AUTO RES	Base	9.50	0.00	9.50	6.32	0	0.19	1.51	0.29
24910A	AUTO	AUTO RES	Base	9.50	0.00	9.50	5.40	0	0.42	1.51	0.64

			•	•					
			Without	With	Equivalent				
			Project	Project	Annual				
			Equivalent	Equivalent	Damages	Average			
Structure	Occupancy		Annual	Annual	Reduced	Annual	Net		
Name	Type Module		Damages	Damages	(Benefits)	Cost	Benefits	B/C Ratio	
24910R	1SNB	Raise	10.38	0.00	10.38	3.00	7.38	3.46	
25092R	2SNB	Raise	4.90	0.00	4.90	3.00	1.90	1.63	
511FP	OFFICE_FP	Floodproof	3.08	0.68	2.40	1.00	1.40	2.40	
13457FP	OFFICE_FP	Floodproof	0.89	0.27	0.62	1.00	-0.38	0.62	

THINGS TO REMEMBER

- Results of nonstructural plans are only presented for a grouping of structures and are not shown on an individual structure basis
- Intermediate outputs of the HEC-FDA model such as the Structure Detail Output files can be useful in evaluating increments of a nonstructural plan

QUESTIONS / FEEDBACK?

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Please contact us with:

- > Questions?
- Comments?
- More/less helpful than a live webinar?
- Recommendations for improvement?

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