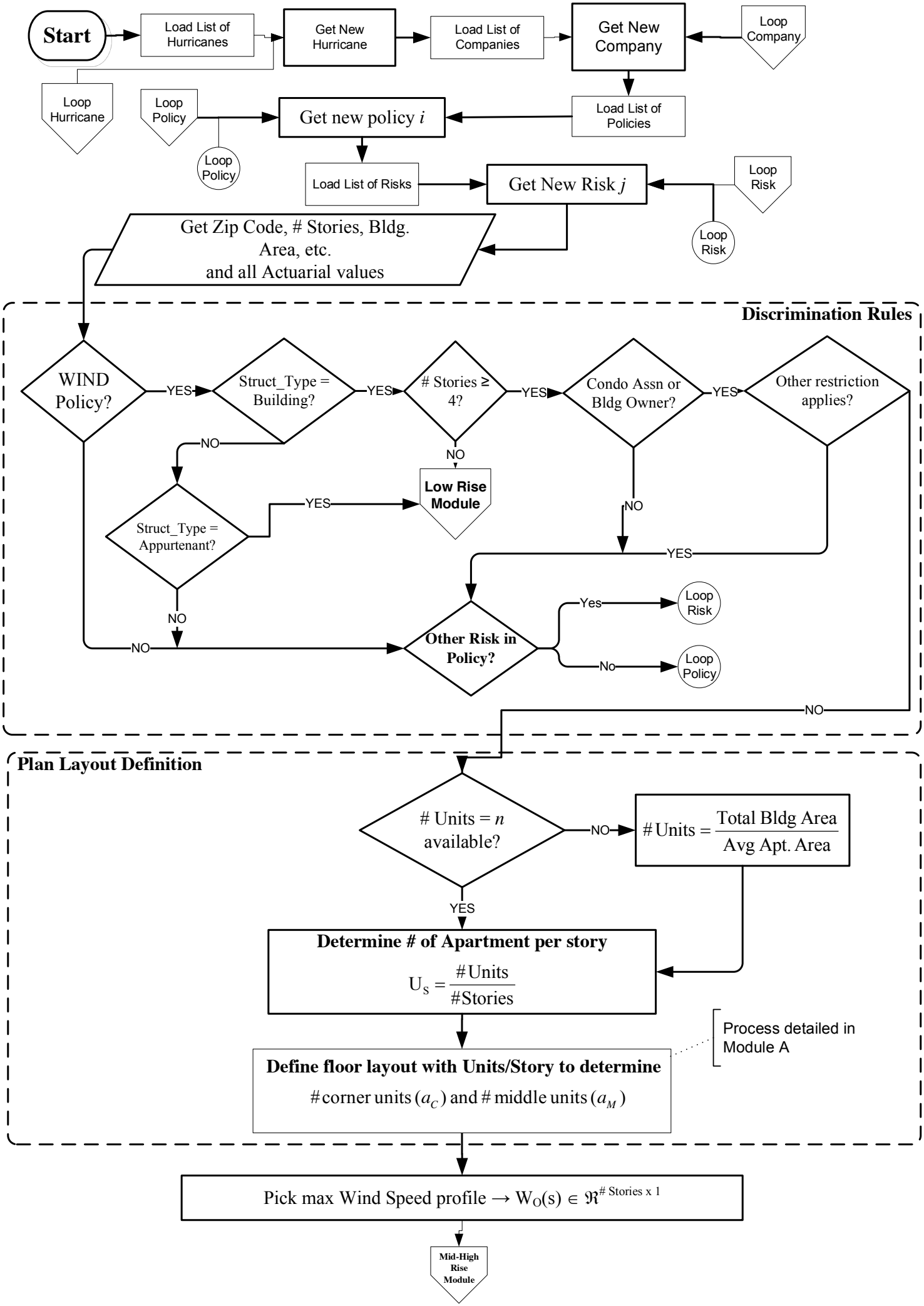
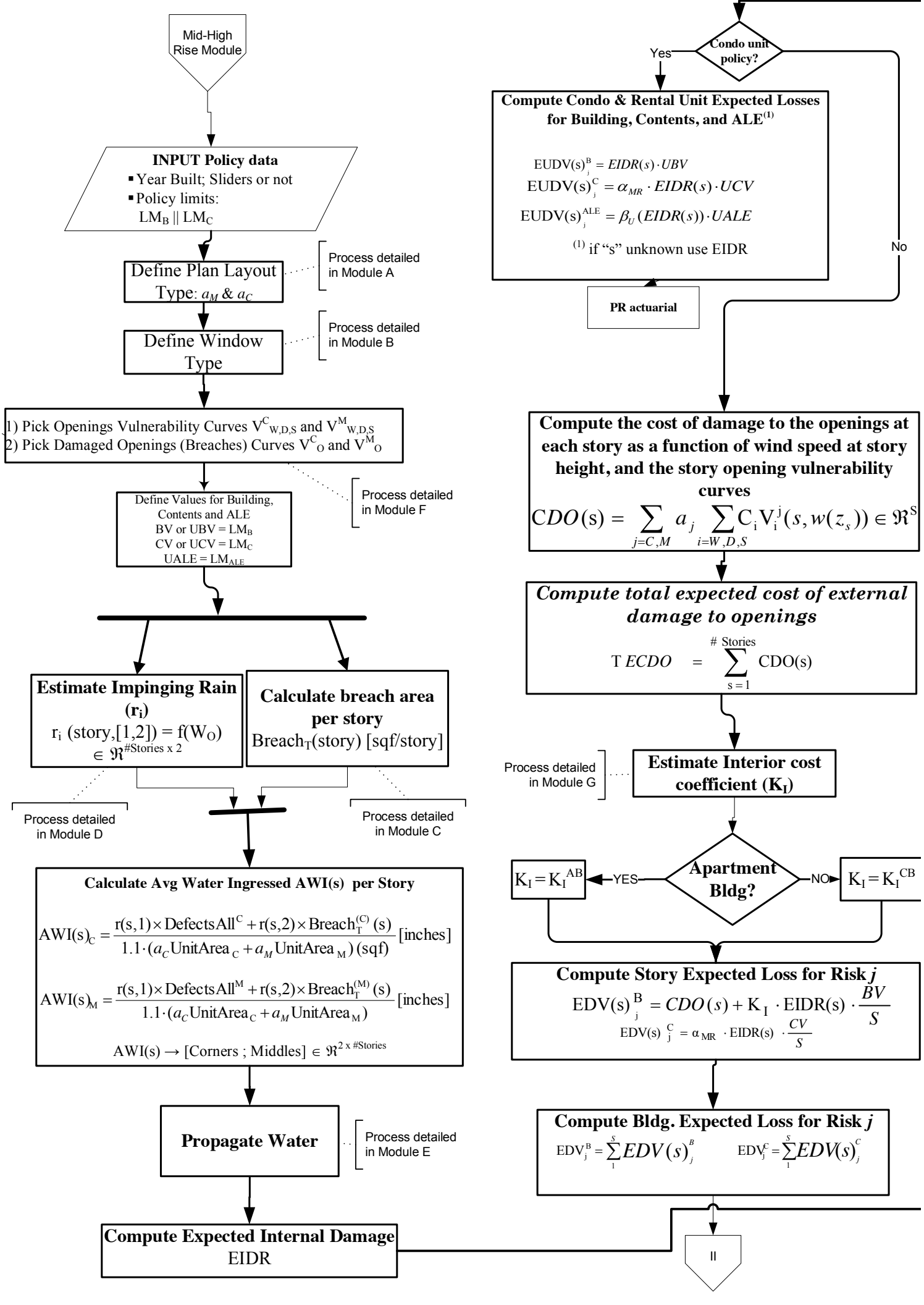
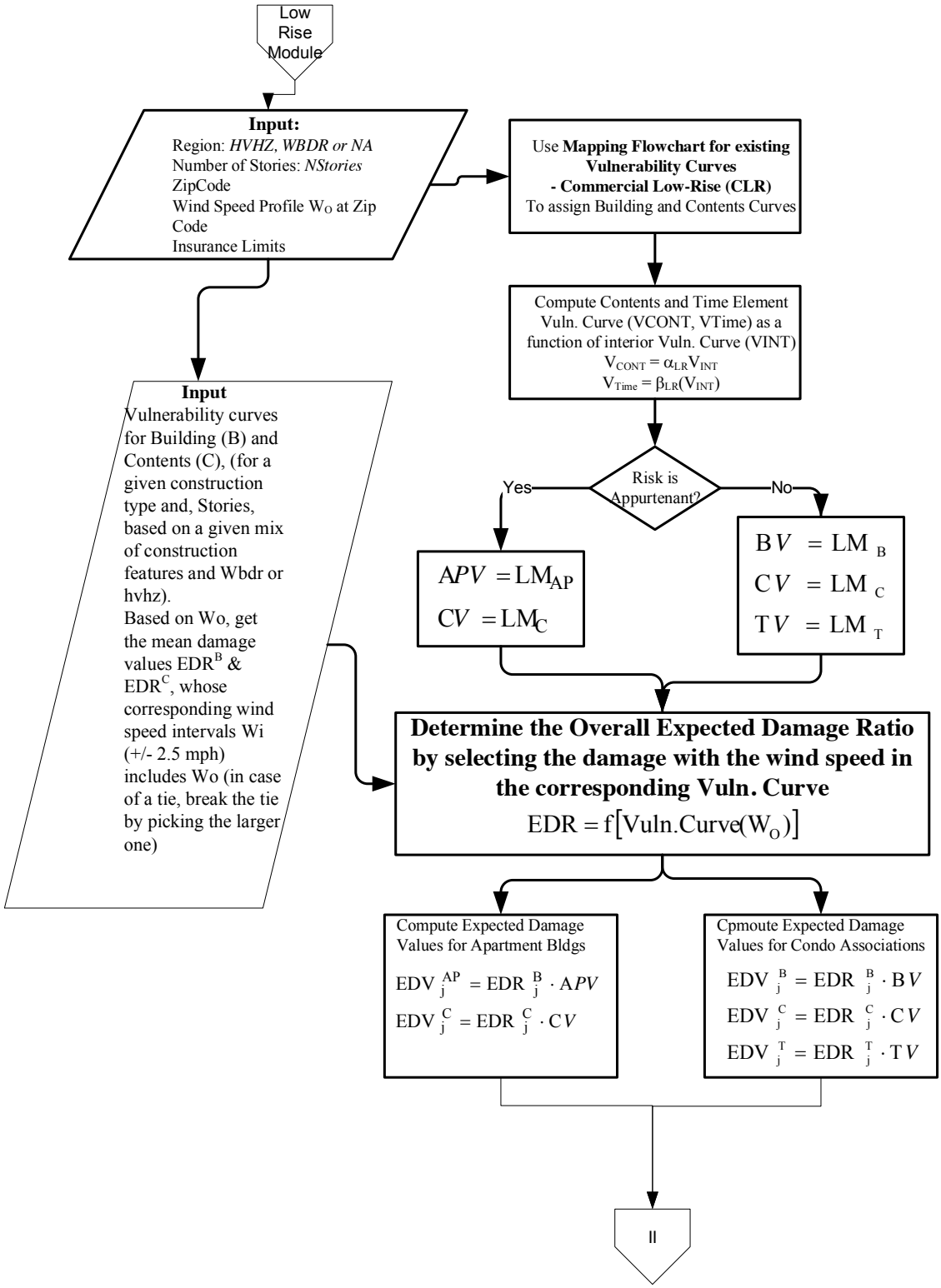
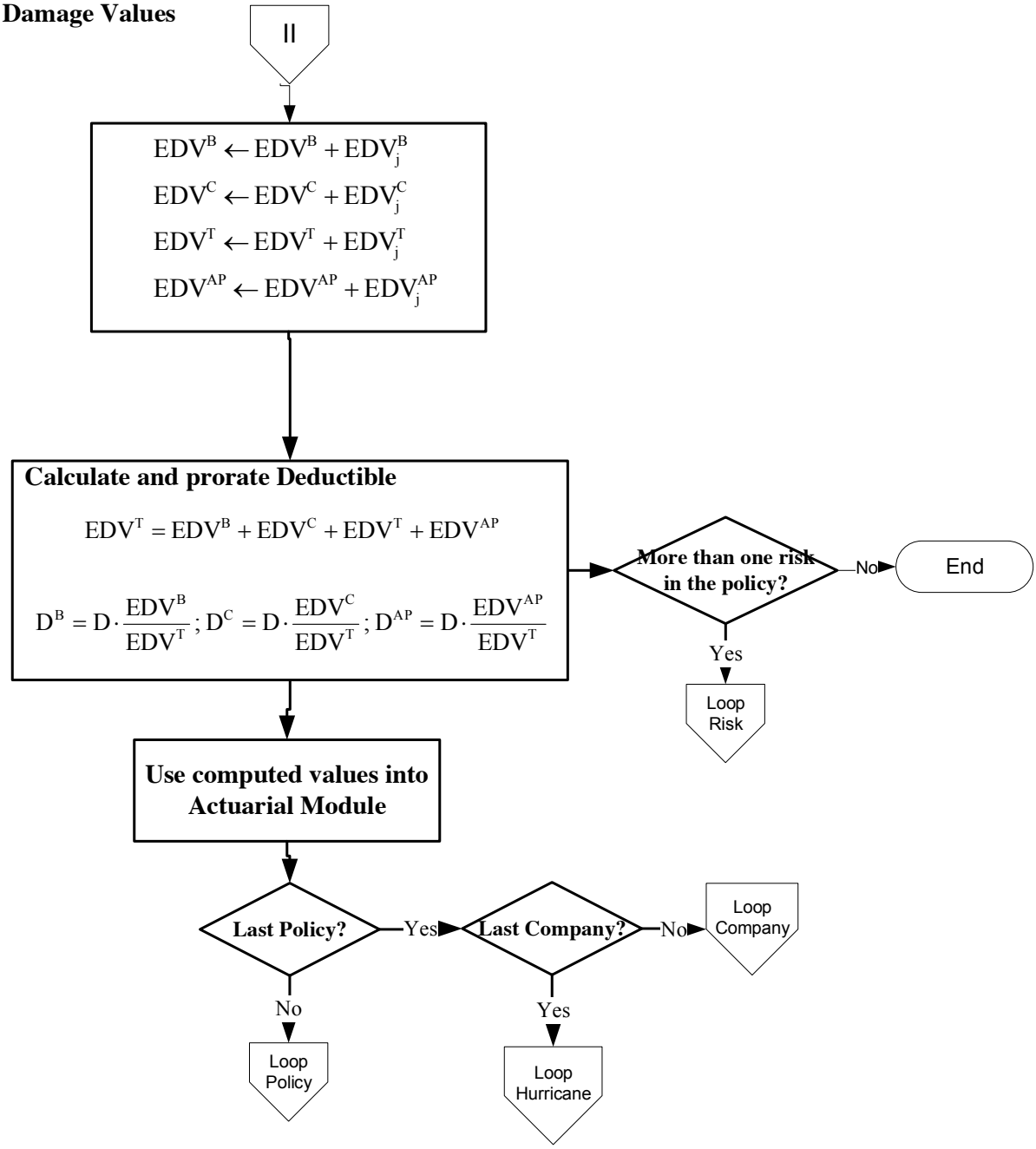

Start
Load List of Hurricanes
Get New Hurricane
Load List of Companies
Get New Company
Loop Company
Loop Hurricane
Loop Policy
Get new policy i
Load List of Policies
Loop Policy
Load List of Risks
Get New Risk j
Loop Risk
Loop Risk
Get Zip Code, # Stories, Bldg. Area, etc. and all Actuarial values
Discrimination Rules
WIND Policy?
YES
Struct_Type = Building?
YES
Stories ≥ 4?
YES
Condo Assn or Bldg Owner?
YES
Other restriction applies?
NO
NO
Low Rise Module
Struct_Type = Appurtenant?
YES
NO
NO
YES
Other Risk in Policy?
Yes
Loop Risk
No
Loop Policy
NO
Plan Layout Definition
Units = n available?
NO
Units = Total Bldg Area / Avg Apt. Area
YES
Determine # of Apartment per story
U_S = #Units / #Stories
Process detailed in Module A
Define floor layout with Units/Story to determine
corner units (a_C) and # middle units (a_M)
Pick max Wind Speed profile → W_O(s) ∈ ℜ^(# Stories x 1)
Mid-High Rise Module


Mid-High Rise Module
INPUT Policy data
▪ Year Built; Sliders or not
▪ Policy limits: LM_B || LM_C
Define Plan Layout Type: a_M & a_C
Process detailed in Module A
Define Window Type
Process detailed in Module B
1) Pick Openings Vulnerability Curves V^C_W,D,S and V^M_W,D,S
2) Pick Damaged Openings (Breaches) Curves V^C_O and V^M_O
Process detailed in Module F
Define Values for Building, Contents and ALE
BV or UBV = LM_B
CV or UCV = LM_C
UALE = LM_ALE
Estimate Impinging Rain (r_i)
r_i (story,[1,2]) = f(W_O) ∈ ℜ^#Stories x 2
Calculate breach area per story
Breach_T(story) [sqf/story]
Process detailed in Module D
Process detailed in Module C
Calculate Avg Water Ingressed AWI(s) per Story
AWI(s)_C = r(s,1)×DefectsAll^C + r(s,2)×Breach_T^(C)(s) / 1.1·(a_C UnitArea_C + a_M UnitArea_M) (sqf) [inches]
AWI(s)_M = r(s,1)×DefectsAll^M + r(s,2)×Breach_T^(M)(s) / 1.1·(a_C UnitArea_C + a_M UnitArea_M) [inches]
AWI(s) → [Corners ; Middles] ∈ ℜ^2 x #Stories
Propagate Water
Process detailed in Module E
Compute Expected Internal Damage EIDR
Yes
Condo unit policy?
No
Compute Condo & Rental Unit Expected Losses for Building, Contents, and ALE(1)
EUDV(s)^B_j = EIDR(s)·UBV
EUDV(s)^C_j = α_MR · EIDR(s)·UCV
EUDV(s)^ALE_j = β_U(EIDR(s))·UALE
(1) if "s" unknown use EIDR
PR actuarial
Compute the cost of damage to the openings at each story as a function of wind speed at story height, and the story opening vulnerability curves
CDO(s) = Σ_{j=C,M} a_j Σ_{i=W,D,S} C_i V_i^j(s, w(z_s)) ∈ ℜ^S
Compute total expected cost of external damage to openings
T ECDO = Σ_{s=1}^{# Stories} CDO(s)
Process detailed in Module G
Estimate Interior cost coefficient (K_I)
Apartment Bldg?
YES
K_I = K_I^AB
NO
K_I = K_I^CB
Compute Story Expected Loss for Risk j
EDV(s)^B_j = CDO(s) + K_I · EIDR(s) · BV/S
EDV(s)^C_j = α_MR · EIDR(s) · CV/S
Compute Bldg. Expected Loss for Risk j
EDV^B_j = Σ_1^S EDV(s)^B_j
EDV^C_j = Σ_1^S EDV(s)^C_j
II

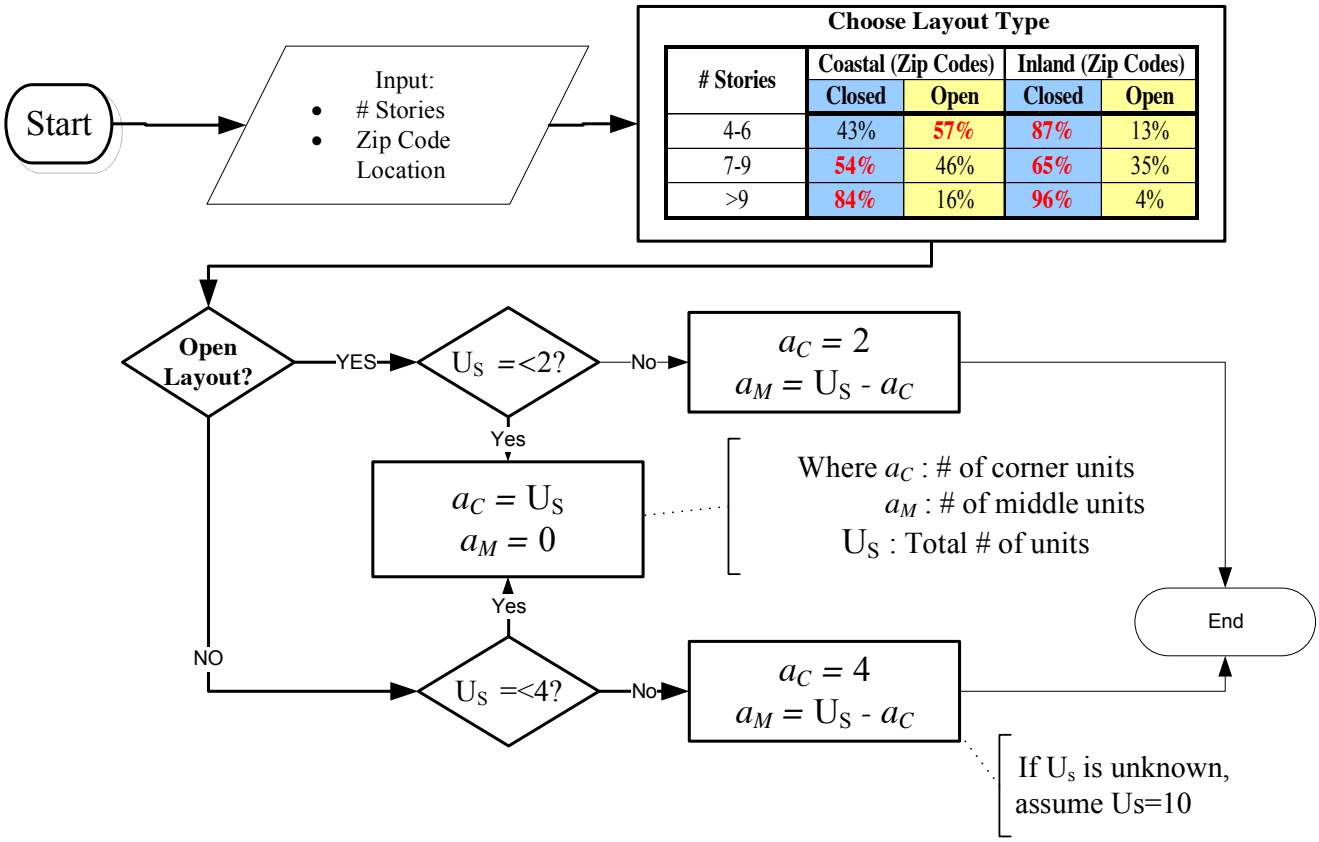
Low-Rise Module



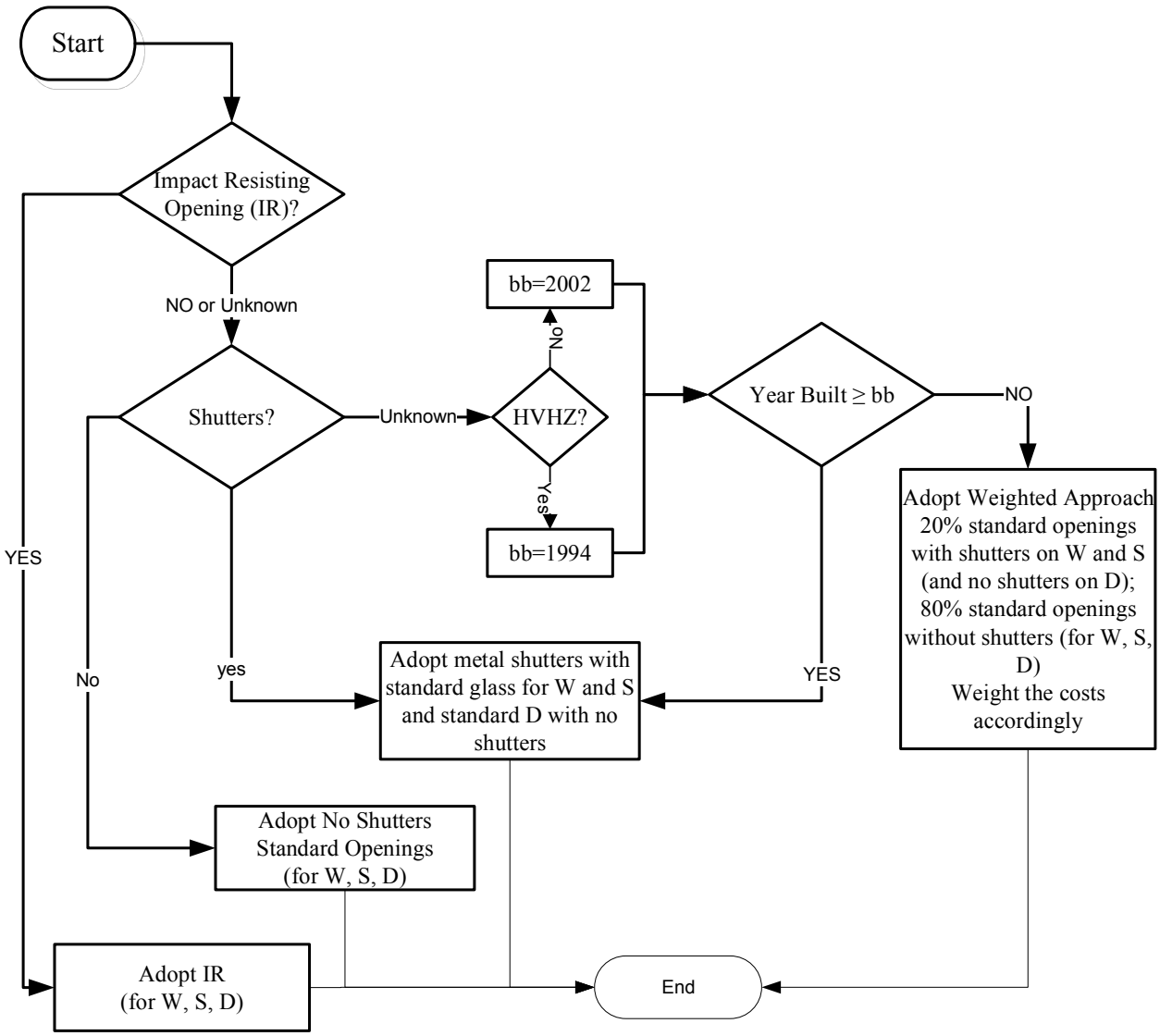
Aggregation of Damage Values



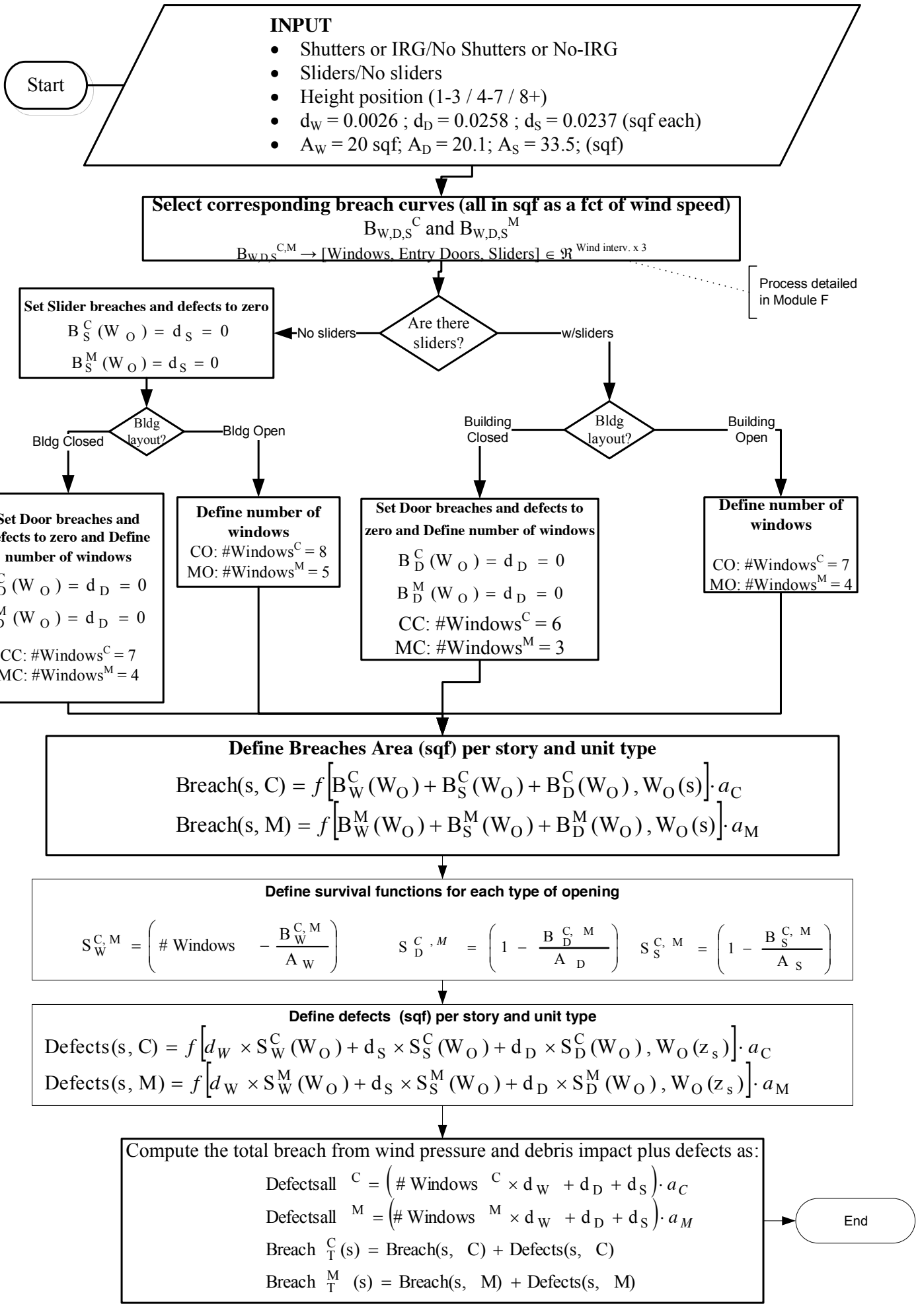
Plan Layout: module a



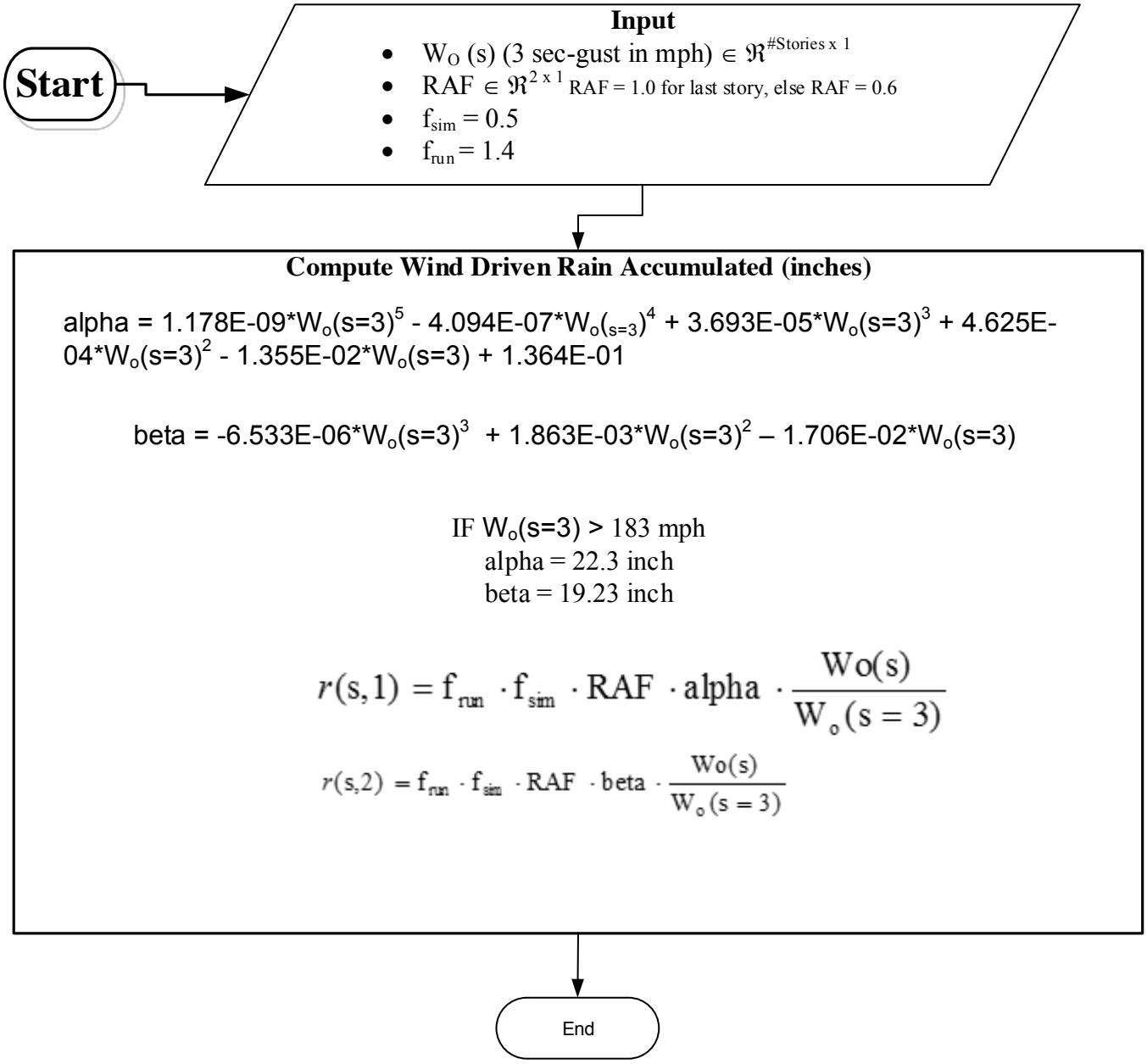
Opening Type: module b



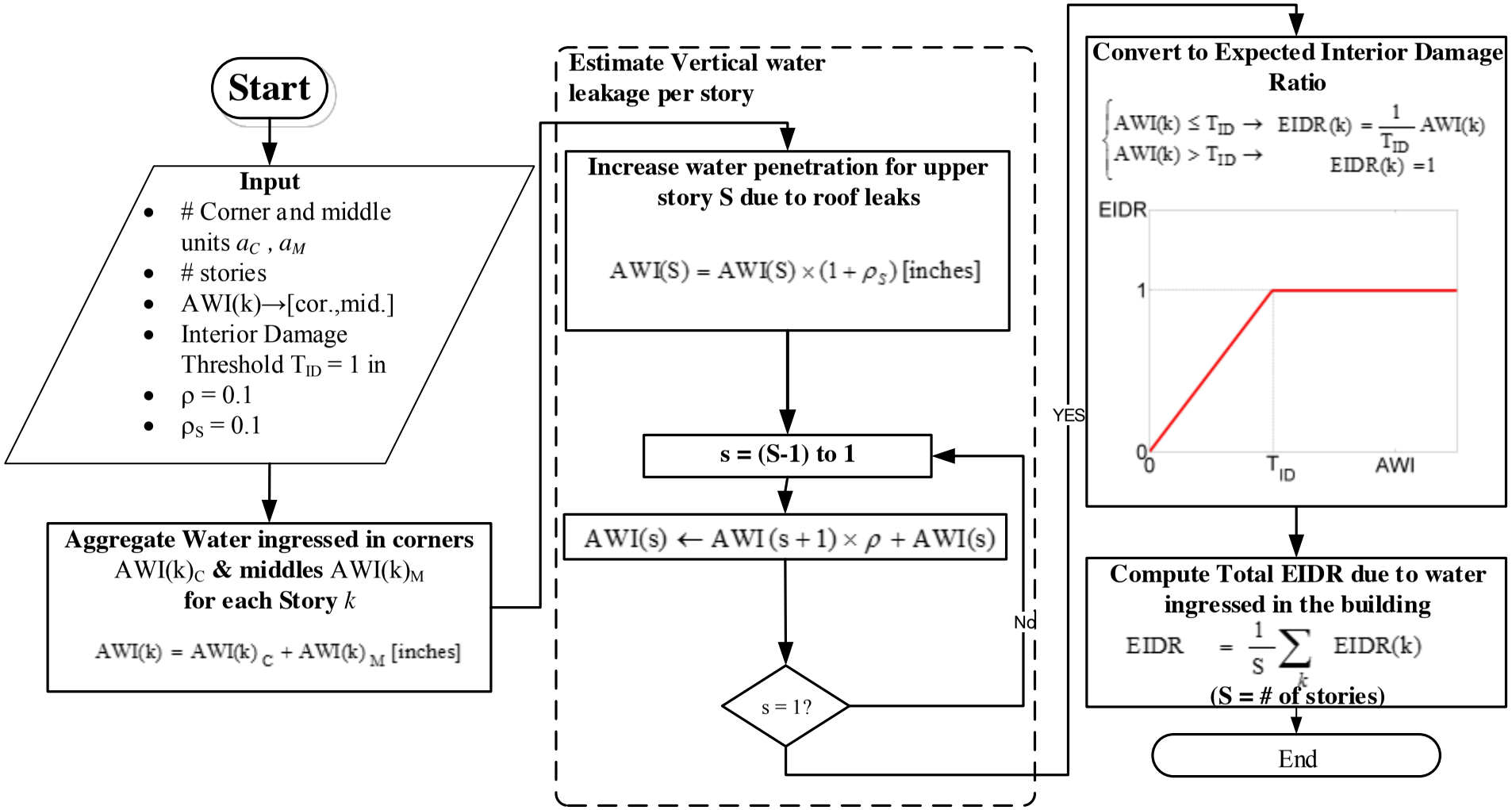
Openings Breach Area: module c



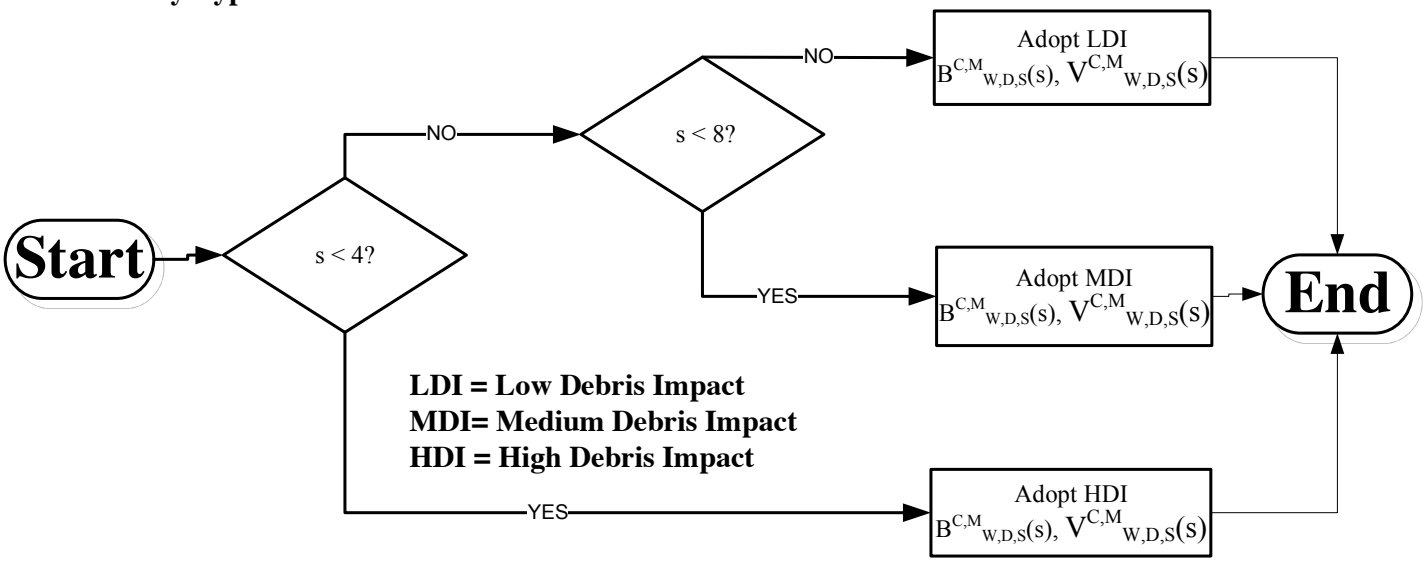
Computation of impinging rain: Module d



Propagation Engine: Module e



Vulnerability Type: module f



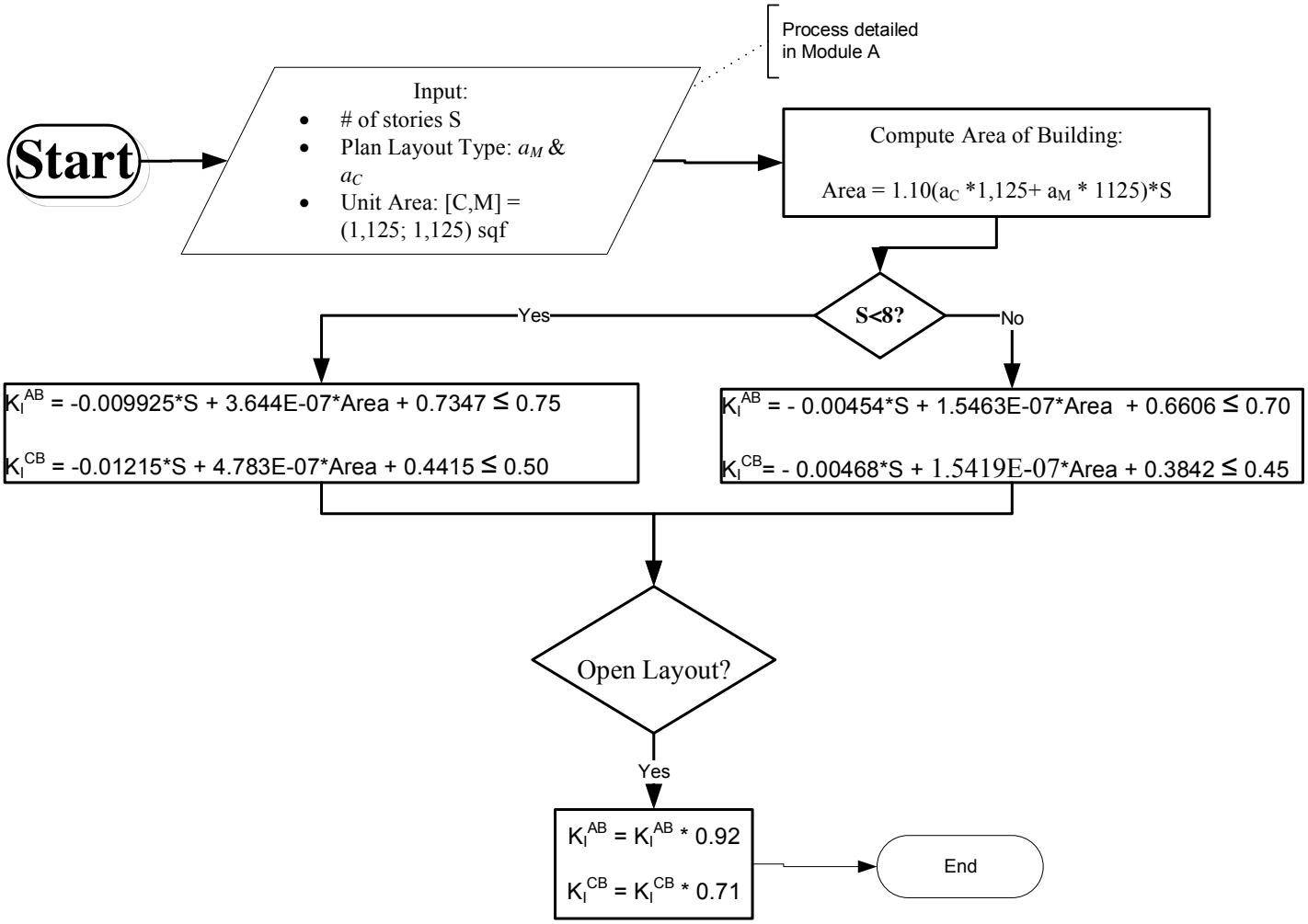
1) Pick Openings Vulnerability Curves $V^{C}_{W,D,S}$ and $V^{M}_{W,D,S} \in \Re^{1x41}$ ($\Re^{S \text{ x Wind intervals}}$)
2) Pick Damaged Openings (Breaches) Curves V^{C}_{O} and $V^{M}_{O} \in \Re^{3x41}$ ($\Re^{SxWind\ intervals}$)

Openings Unit Replacement Costs:

- $C_{W\text{-}IR}$= \$780
- $C_{W\text{-}Standard}$= \$430
- $C_{W\text{-}StandardShutter}$= \$700
- $C_{S\text{-}IR}$= \$1530
- $C_{S\text{-}Standard}$=\$935
- $C_{S\text{-}StandardShutter}$=\$1300
- $C_{D\text{-}IR}$= \$1650
- $C_{D\text{-}Standard}$= \$900

Note: if the openings are weighted, weight the costs accordingly
Reference: section 3.3.2 of Steven Bell Thesis

Interior Cost Coefficient: module g



Openings Unit Replacement Costs:

- $C_{W\text{-}IR}$= \$780
- $C_{W\text{-}Standard}$= \$430
- $C_{W\text{-}StandardShutter}$= \$700
- $C_{S\text{-}IR}$= \$1530
- $C_{S\text{-}Standard}$=\$935
- $C_{S\text{-}StandardShutter}$=\$1300
- $C_{D\text{-}IR}$= \$1650
- $C_{D\text{-}Standard}$= \$900

Note: if the openings are weighted, weight the costs accordingly
Reference: section 3.3.2 of Steven Bell Thesis

Glossary

a_C : # of corner units per story

a_M : # of middle units per story

a,b,c,d: linear regression coefficients of impinging rainfall as a function of 3 sec gust at 10m

APV : Appurtenant Value [$]

AWI : Average water ingressed [inches of rain]

A_W, A_D, A_S: Size of individual windows, doors, sliders. (sqf)

α_{LR}, α_{MR} : Contents coeff. as proportion of Interior Dam. (Low-Rise and Mid-Rise). Currently set to 1.

β_{LR}, β_U : time element coverage function of Interior Damage. (Low-Rise; apartment unit renter and condo unit policy). Currently set to $2x^2+x$ with x= interior damage.

bs: Average breach area

B_i^C : Breach curve for openings i=W,S, or D (windows-sliders-doors) - corner units (ft^2 as a fct of wind speed)

B_i^M : Breach curve for openings i=W,S, or D (windows-sliders-doors) - middle units (ft^2 as a fct of wind speed)

BaseArea: total area of story in sqft

Breaches: breaching square footage per story

$Breach_T^C$: total breach size of corner units. (includes defects)

$Breach_T^M$: total breach size of middle units. (includes defects)

BV : Bldg. Value [$]

BV_{AB} : Apt. Bldg. Value [$]

BV_{CB} : Condo Bldg. Value [$]

C_i : unit replacement cost for openings i=W,S, or D (windows-sliders-doors)

CCT : Closed Corridor Type

CV : Contents Value [$]

CDO(s): cost of damage to the openings at story s [$]

D : Deductible

D^{AP} : Appurtenant deductible

D^B : Building deductible

D^C : Contents deductible

DefectsAll: area of all the defects for a given unit

d_W, d_D, d_S: defects area for windows, door and slider (sqf)

EEDR : Expected Exterior Damage Ratio [%]

EDR_S : Exterior Damage Ratio vector per Story [%]

$EDR_j^{B,C,T}$: Expected Dam. Ratio Bldg, Contents, Time resp.

EDV_j^B : Expected Damage Value of Risk j – Building [$]

EDV_j^C : Expected Damage Value of Risk j – Contents [$]

EDV_j^{AP} : Expected Damage Value of Risk j – Appurtenant [$]

EDV^B : Overall Expected Damage Value – Building [$]

EDV^C : Overall Expected Damage Value – Contents [$]

EDV^T : Overall Expected Damage Value – Time Element [$]

EDV^{AP} : Overall Expected Damage Value – Appurtenant [$]

EDV^T : Total Expected Damage Value [$]

EIDR(s) : Expected Interior Damage Ratio per story s [%]

$EDV_j^B(s)$: Expected Story Damage Value of Risk j –Building [$]

$EDV_j^C(s)$: Expected Story Damage Value of Risk j–Contents [$]

$EUDV_j^B(s)$: Expected Condo Unit Damage Value , at story s – Building [$]

$EUDV_j^{C/ALE}(s)$: Expected Condo Unit Story Damage Value, at story s – Contents [$] or ALE [$]

EIDR : Expected Interior Damage Ratio for entire building [%]

f_{sim}: Simultaneity factor that accounts for the walls that actually have rain intrusion due to wind angle.

f_{run}: Runoff factor that accounts for the runoff water on the facades

i : Policy Counter / Other counter

IDR(k) : Interior Damage Ratio vector [%]

IDR_C^U : Interior Damage Ratio of a corner unit [%]

IDR_M^U : Interior Damage Ratio of a middle unit [%]

IDR_{VERT} : Interior Damage Ratio due to vert. propagation [%]

IDR_U : Interior Damage Ratio [%]

IR : Impinging rain on bldg façade [in/hr]

IRW: Impact Resistant Window

j : Risk counter

k: story index

k_E^{AB}, k_E^{CB} : Ratio of Exterior Value to total Value for Apt bldgs and Condo Bldgs.

k_I^{AB}, k_I^{CB} : Ratio of Interior Value to total Value for Apt bldgs and Condo Bldgs.

LIF : average Local intensity factor

LM_B : Building policy limit.

LM_C : Contents policy limit.

LM_T : Time element coverage policy limit.

LM_{AP} : Appurtenant policy limit.

OCT : Open Corridor Type

r(story,i) : impinging accumulated rainfall [in] per story for i = 1 time $t_{initial}$ to t_{breach} ; i=2 t_{breach} to t_{end}

ρ = percolation factor

ρ_S = roof leak factor

s = story number

S = total number of stories

S_W, S_D, S_S: Complement of the vulnerability function for MHRB, i.e. 1 – Vuln Function, for computing water intrusion due to defects.

T_{ID}= threshold water (inches) to complete interior damage.

TECDO: Total expected cost of external damage to openings [$]

TV [$]: Time element coverage value

U_S : Units per Story

UBV = Condo unit value (structure)

UCV = Condo unit value (contents)

UALE = Condo unit value (additional living expenses)

UW: Unprotected Window

V_{CONT}: Vuln. Curve Contents

V_{TIME}: Vuln. Curve Time Element Coverage

V_i^C : Vulnerability curve for openings of corner units; i= W,D,or S (window, door, or slider). Give the number or fraction of opening damaged as a function of wind speed.

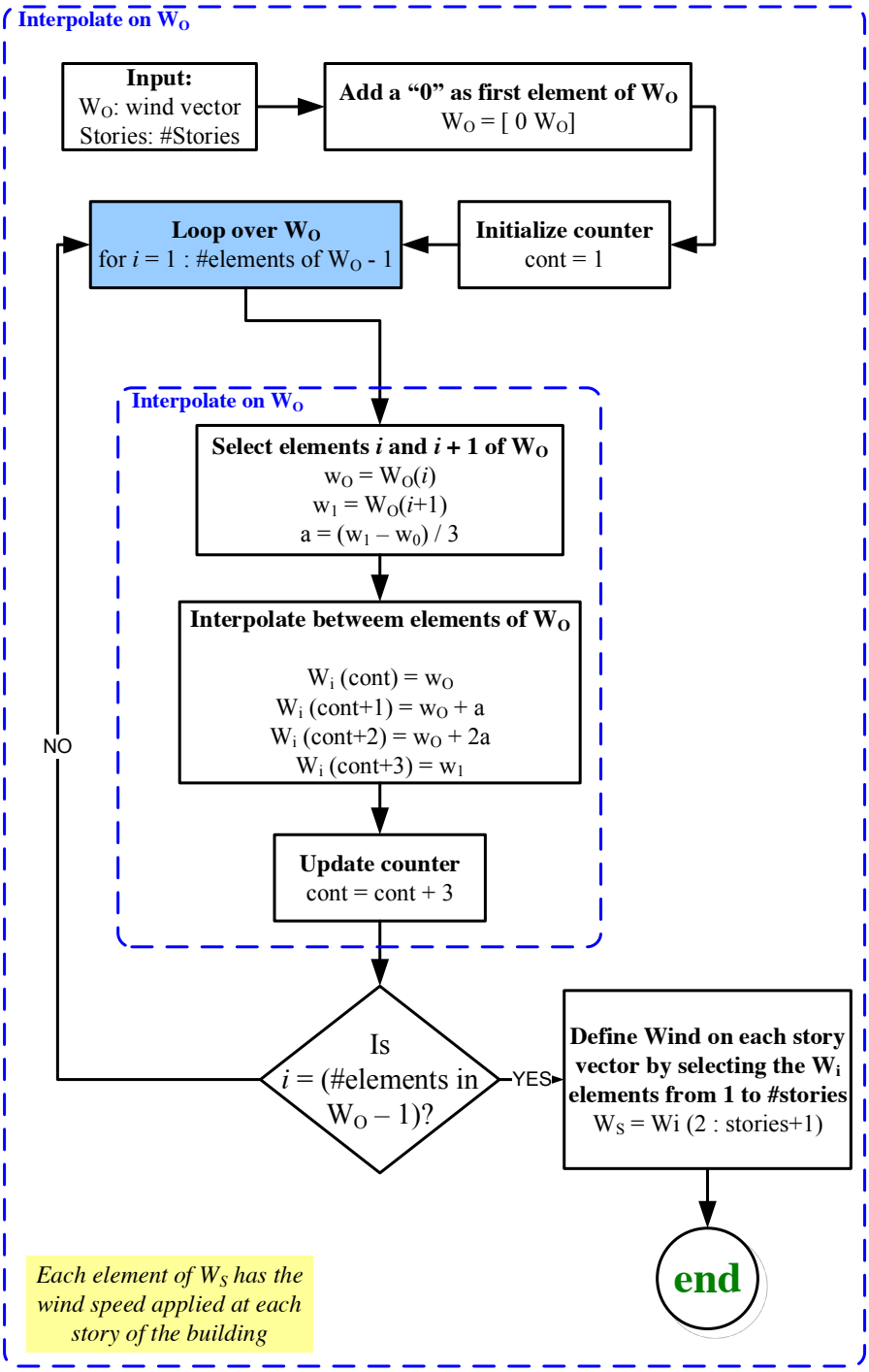
V_i^M : Vulnerability curve for openings of middle units; i= W,D,or S (window, door, or slider).

V_I : Adopted Unit's Interior Vulnerability Curve

V_{INT}: Vuln. Curve Interior

$W_O(s)$: Wind speed profile per story s

z_s = mean height of story s. For s=3, z_s is assumed to be 10 m.


Interpolate on W_O
Input:
W_O: wind vector
Stories: #Stories
Add a "0" as first element of W_O
W_O = [0 W_O]
Initialize counter
cont = 1
Loop over W_O
for i = 1 : #elements of W_O - 1
Interpolate on W_O
Select elements i and i + 1 of W_O
$w_O = W_O(i)$
$w_1 = W_O(i+1)$
$a = (w_1 - w_0) / 3$
Interpolate betweem elements of W_O
W_i (cont) = w_O
W_i (cont+1) = w_O + a
W_i (cont+2) = w_O + 2a
W_i (cont+3) = w_1
Update counter
cont = cont + 3
Is
i = (#elements in W_O – 1)?
NO
YES
Define Wind on each story vector by selecting the W_i elements from 1 to #stories
W_S = Wi (2 : stories+1)
end
Each element of W_S has the wind speed applied at each story of the building