ASSOCIATION FOR LEARNING ENVIRONMENTS

Enhancing the Educational Experience

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PLANNING GREAT EDUCATIONAL ENVIRONMENTS

2019 Southern Regional Conference

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Stantec

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Course Description

Planning for Storm Shelters

Designing schools today with recent requirements for storm shelters has brought a number of considerations and concerns when planning great educational environments. School districts will need to consider cost, size, location, and emergency planning, in addition to operations and maintenance. Early planning with the design team will aid in bond planning, programming, and a design that aligns with the vision and goals of the district. This presentation will also dive into code compliance and strategies for determining storm shelter size and location and application of the ICC 500 Standard for Design and Construction of Storm Shelters.

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Learning Objectives

- Evaluate considerations for storm shelter planning.
- Interpret storm shelter code requirements for Group E occupancies.
- Strategies for determining shelter location.
- Applying the ICC 500 Standard for Design and Construction of Storm Shelters.

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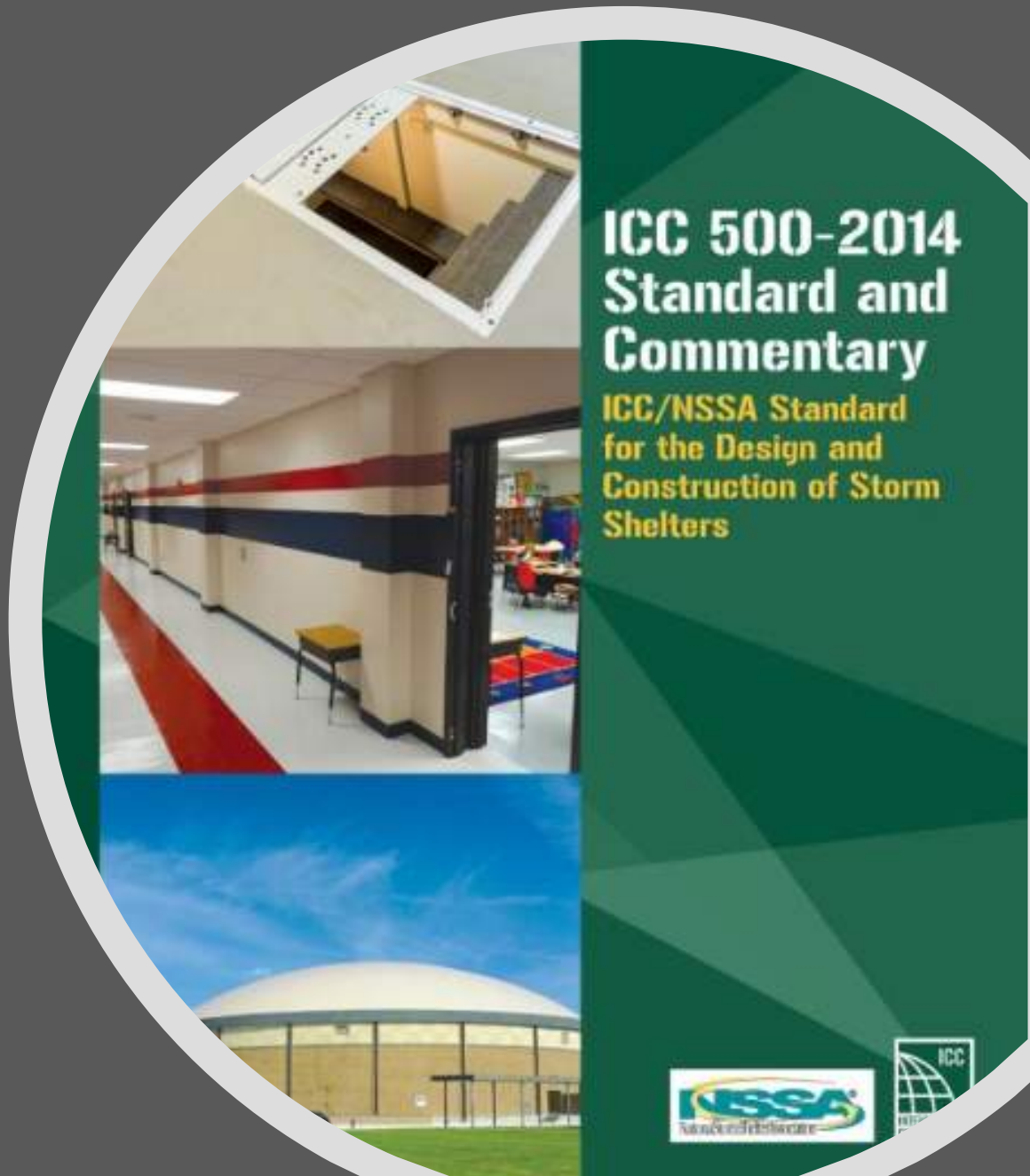
ICC 500 - 2014

ICC/NSSA Standard for the Design and Construction of Storm Shelters



5 key points

Community shelter vs.

Emergency shelter

Community shelter vs.

Residential shelter

Residential Storm Shelter: Serving dwelling units with

16 occupants or less.

Community Storm Shelter: Any storm shelter not defined as a residential storm shelter.

Shelter floor must be above flood zone elevation

2 hour fire separation from non-shelter areas

Tornado shelter must provide 2 hours of protection for

Critical Support Systems

Life safety systems, lighting, HVAC

2015 IBC

International Building Code

2015 International Building Code

423.4 Group E Occupancies. In areas where the shelter design wind speed for tornadoes is 250 MPH in accordance with Figure 304.2(1) of ICC 500,

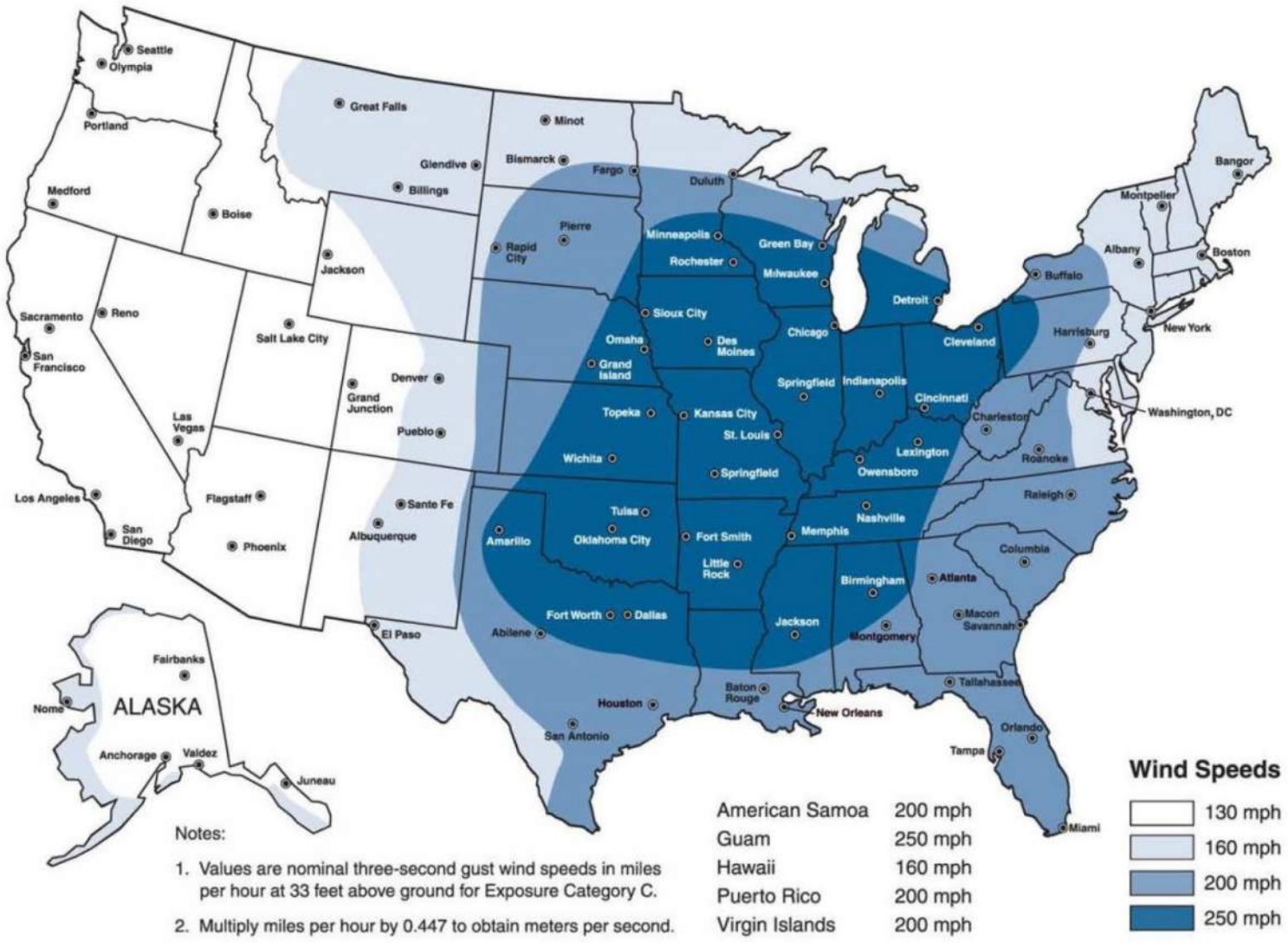
all Group E occupancies with an aggregate occupant load of 50 or more shall have a storm shelter constructed in accordance with ICC 500.

The shelter shall be capable of housing the total occupant load of the Group E occupancy.

Exceptions:

1. Group E day care facilities.
2. Group E occupancies accessory to places of religious worship.
3. Buildings meeting the requirements for shelter design in ICC 500.

Figure 304.2(1) of ICC 500 – Shelter Design Wind Speeds for Tornados

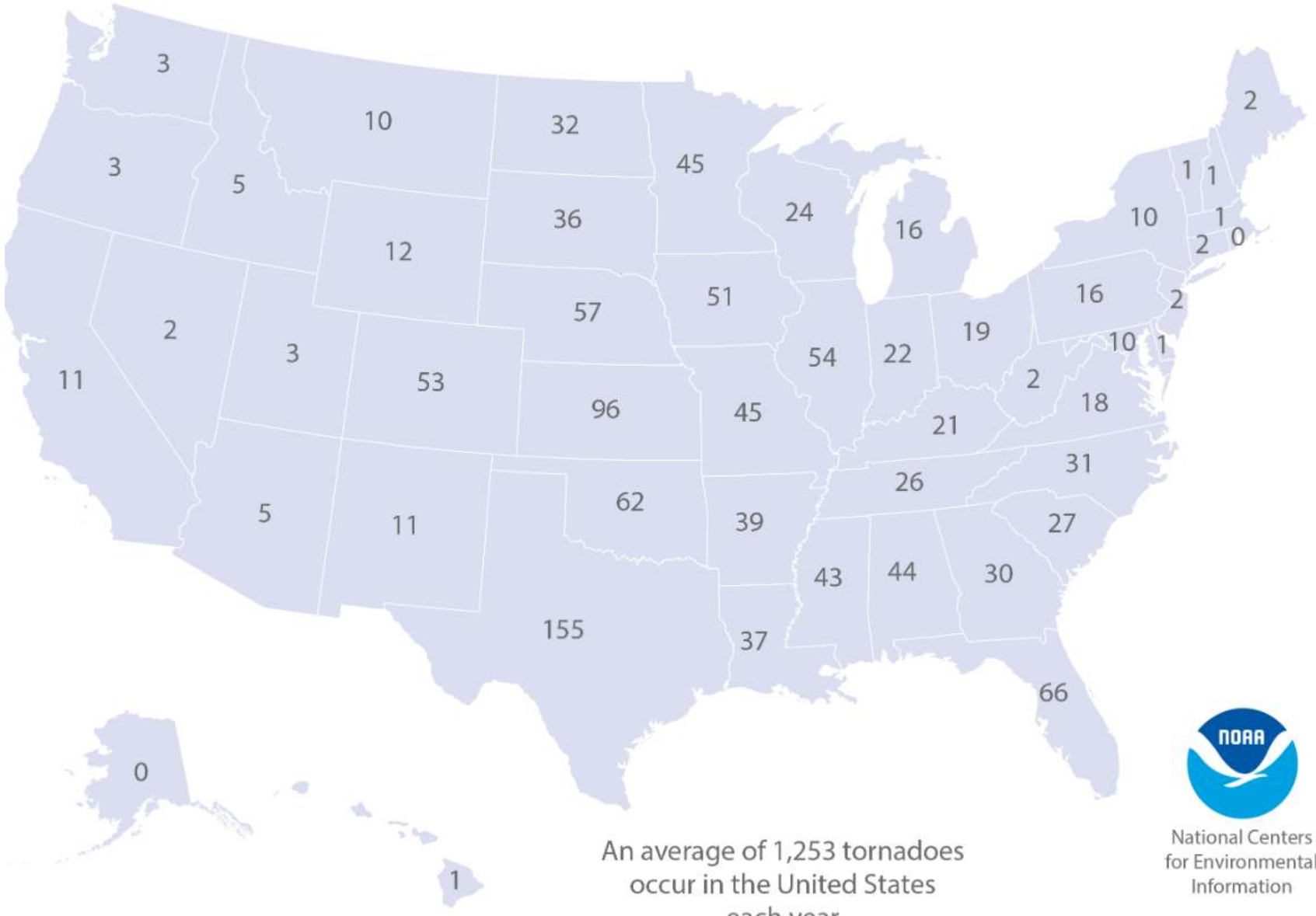


Enhanced Fujita Scale - ICC 500 Requires Resistivity up to 250 MPH

Scale	Wind speed		Relative frequency	Potential damage	
	mph	km/h			
EF0	65–85	105–137	53.5%	Minor damage. Peels surface off some roofs; some damage to gutters or siding; branches broken off trees; shallow-rooted trees pushed over. Confirmed tornadoes with no reported damage (i.e., those that remain in open fields) are always rated EF0.	
EF1	86–110	138–178	31.6%	Moderate damage. Roofs severely stripped; mobile homes overturned or badly damaged; loss of exterior doors; windows and other glass broken.	
EF2	111–135	179–218	10.7%	Considerable damage. Roofs torn off well-constructed houses; foundations of frame homes shifted; mobile homes completely destroyed; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.	
EF3	136–165	219–266	3.4%	Severe damage. Entire stories of well-constructed houses destroyed; severe damage to large buildings such as shopping malls; trains overturned; trees debarked; heavy cars lifted off the ground and thrown; structures with weak foundations blown away some distance.	
EF4	166–200	267–322	0.7%	Extreme damage to near-total destruction. Well-constructed houses and whole frame houses completely leveled; cars thrown and small missiles generated.	
EF5	>200	>322	<0.1%	Massive Damage. Strong frame houses leveled off foundations and swept away; steel-reinforced concrete structures critically damaged; high-rise buildings have severe structural deformation. Incredible phenomena will occur.	

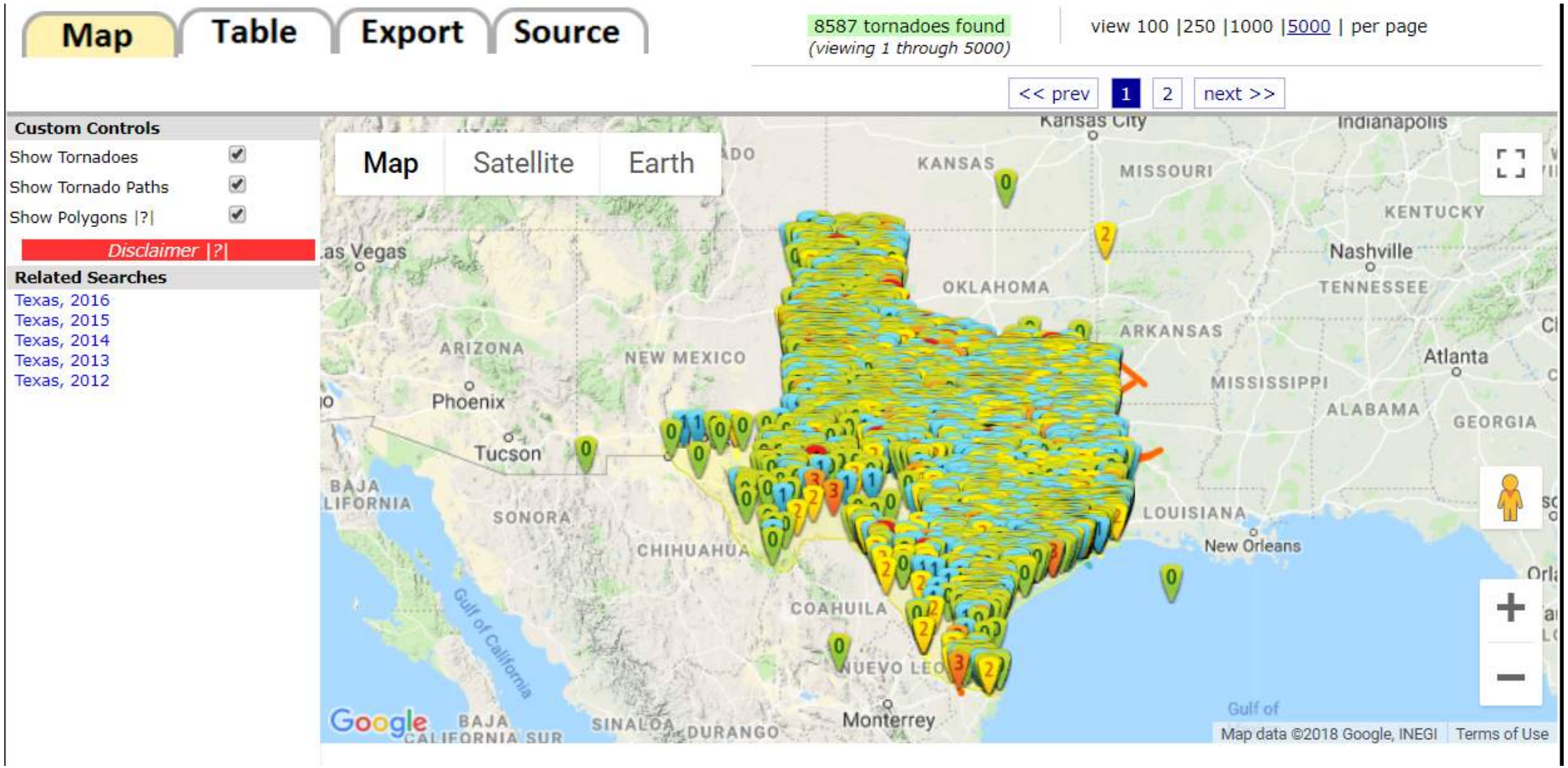
Average Annual Number of Tornados: 1991-2010

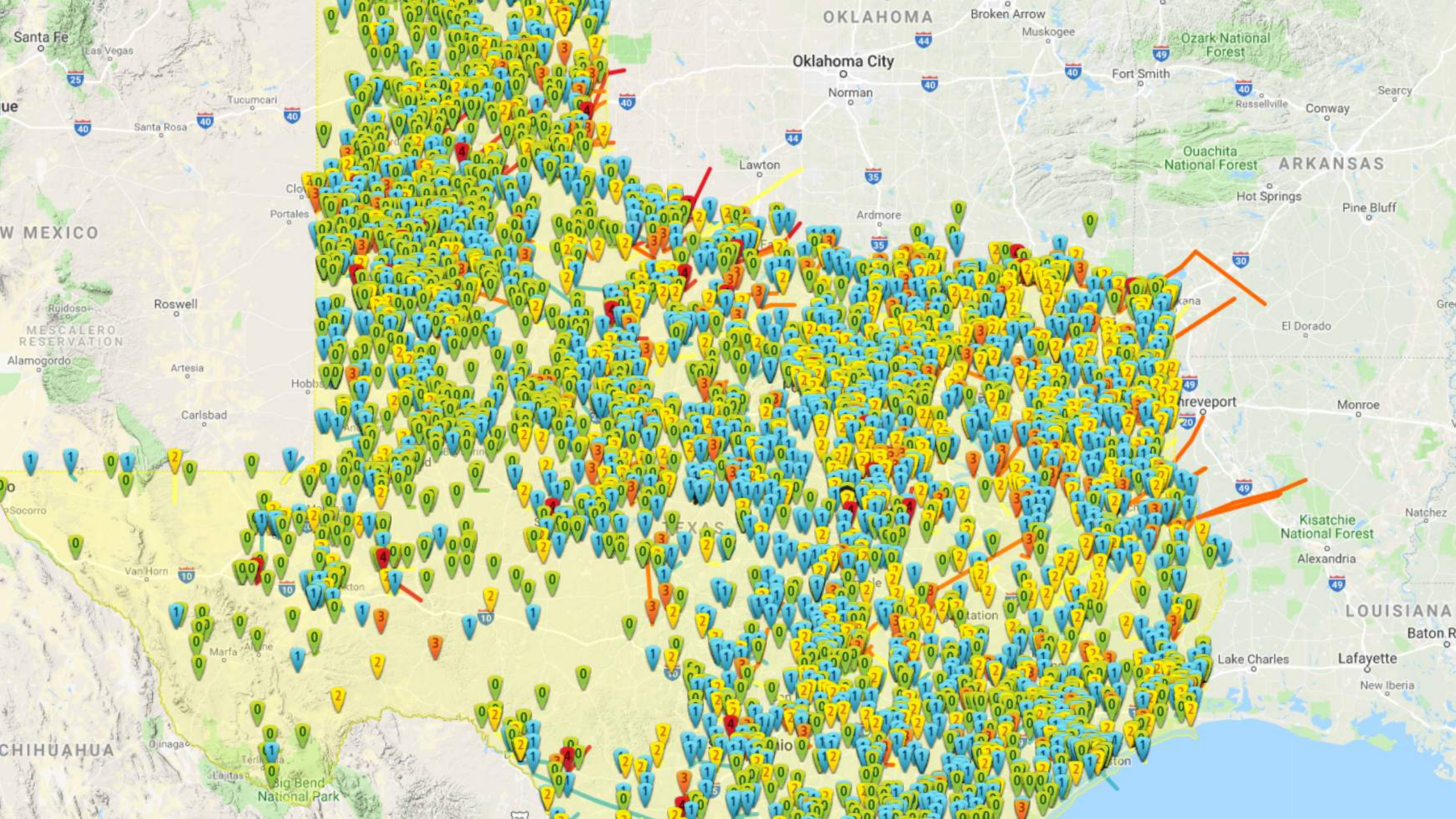
Source: https://www.ncdc.noaa.gov/climate-information/extreme-events/us-tornado-climatology



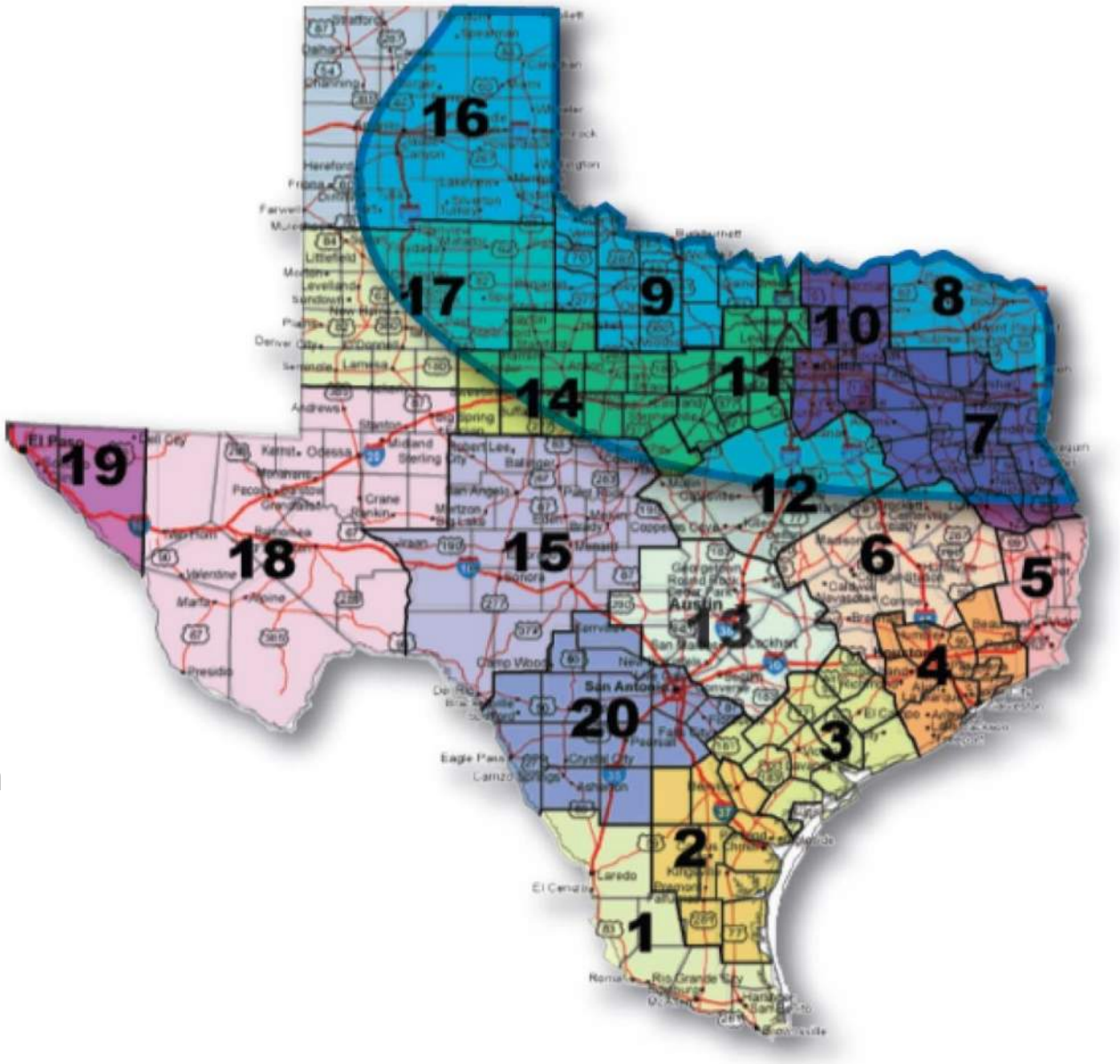
Texas Tornado Occurrences 1950-2016

Source: http://www.tornadohistoryproject.com/tornado/texas/map




OKLAHOMA
Oklahoma City
Norman
Lawton
Ardmore
Broken Arrow
Muskogee
Fort Smith
Ozark National Forest
Russellville
Conway
Searcy
Ouachita National Forest
ARKANSAS
Hot Springs
Pine Bluff
El Dorado
Monroe
Shreveport
Kisatchie National Forest
Alexandria
Natchez
LOUISIANA
Lake Charles
Lafayette
New Iberia
Baton R
Santa Fe
Las Vegas
Tucumcari
Santa Rosa
Portales
W MEXICO
Roswell
Ruidoso
MESCALERO RESERVATION
Alamogordo
Artesia
Hobbs
Carlsbad
Socorro
Van Horn
Marfa
Alpine
TEXAS
CHIHUAHUA
Ojinaga
Big Bend National Park
Terlingua
Lajitas

Corresponding Map to Texas ESC Regions



- Region 10: Richardson
- Region 11: Fort Worth
- Region 12: Waco

All of:

- Region 8
- Region 9
- Region 10

Most of:

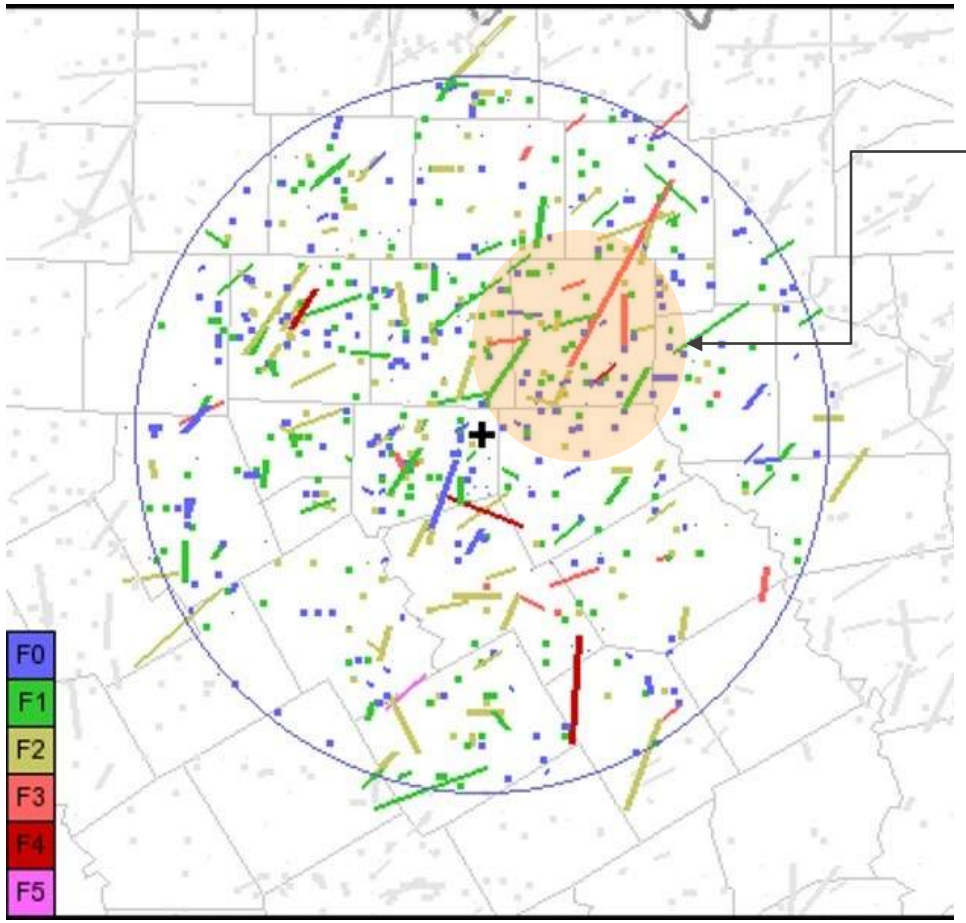
- Region 7
- Region 11

Portions of:

- Region 6
- Region 12
- Region 14
- Region 15
- Region 16
- Region 17

Tornado Occurrences 1962-2011

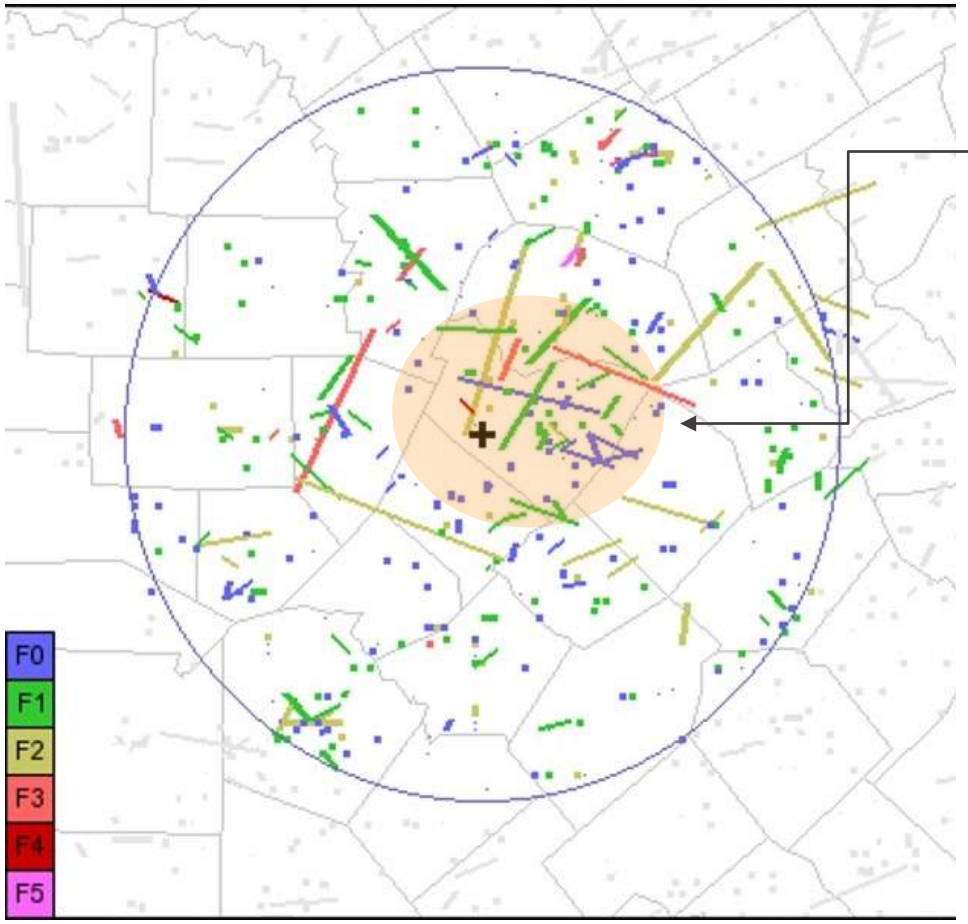
Source: NOAA/NWS Storm Prediction Center, Norman OK



Dallas County (**Dallas**)

Tornado Occurrences 1962-2011

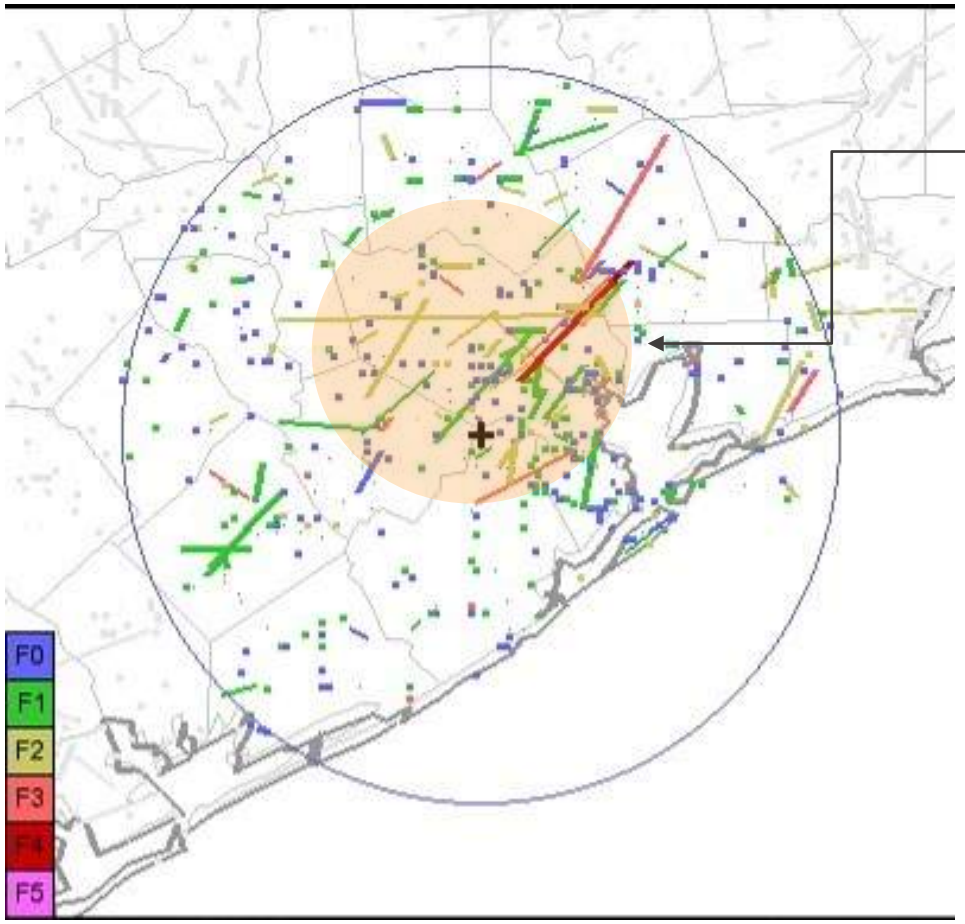
Source: NOAA/NWS Storm Prediction Center, Norman OK



Travis County (**Austin**)

Tornado Occurrences 1962-2011

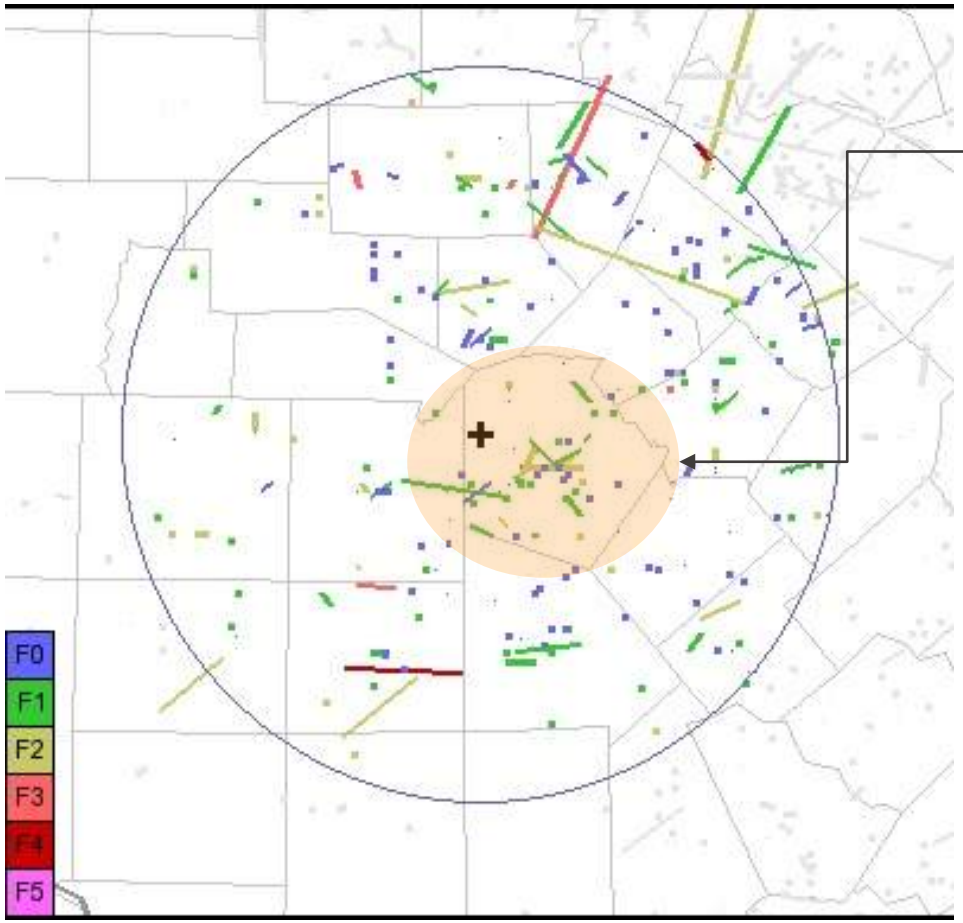
Source: NOAA/NWS Storm Prediction Center, Norman OK



Harris County (**Houston**)

Tornado Occurrences 1962-2011

Source: NOAA/NWS Storm Prediction Center, Norman OK



Bexar County (**San Antonio**)

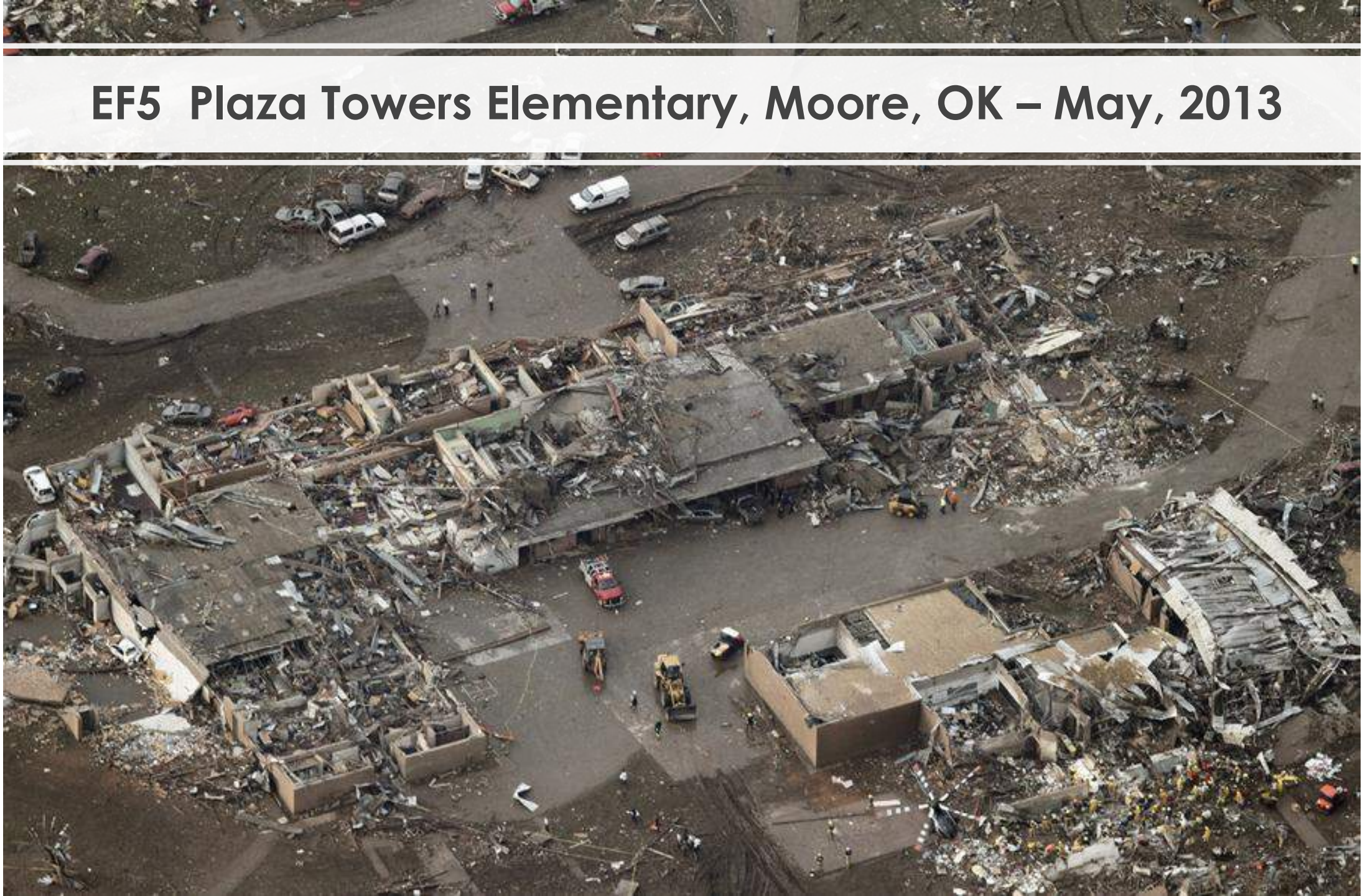
EF1 Shields Elementary, Red Oak, TX - December, 2015

EF3 Caledonia High School, MS – January, 2008

EF3 Caledonia High School, MS - January, 2008

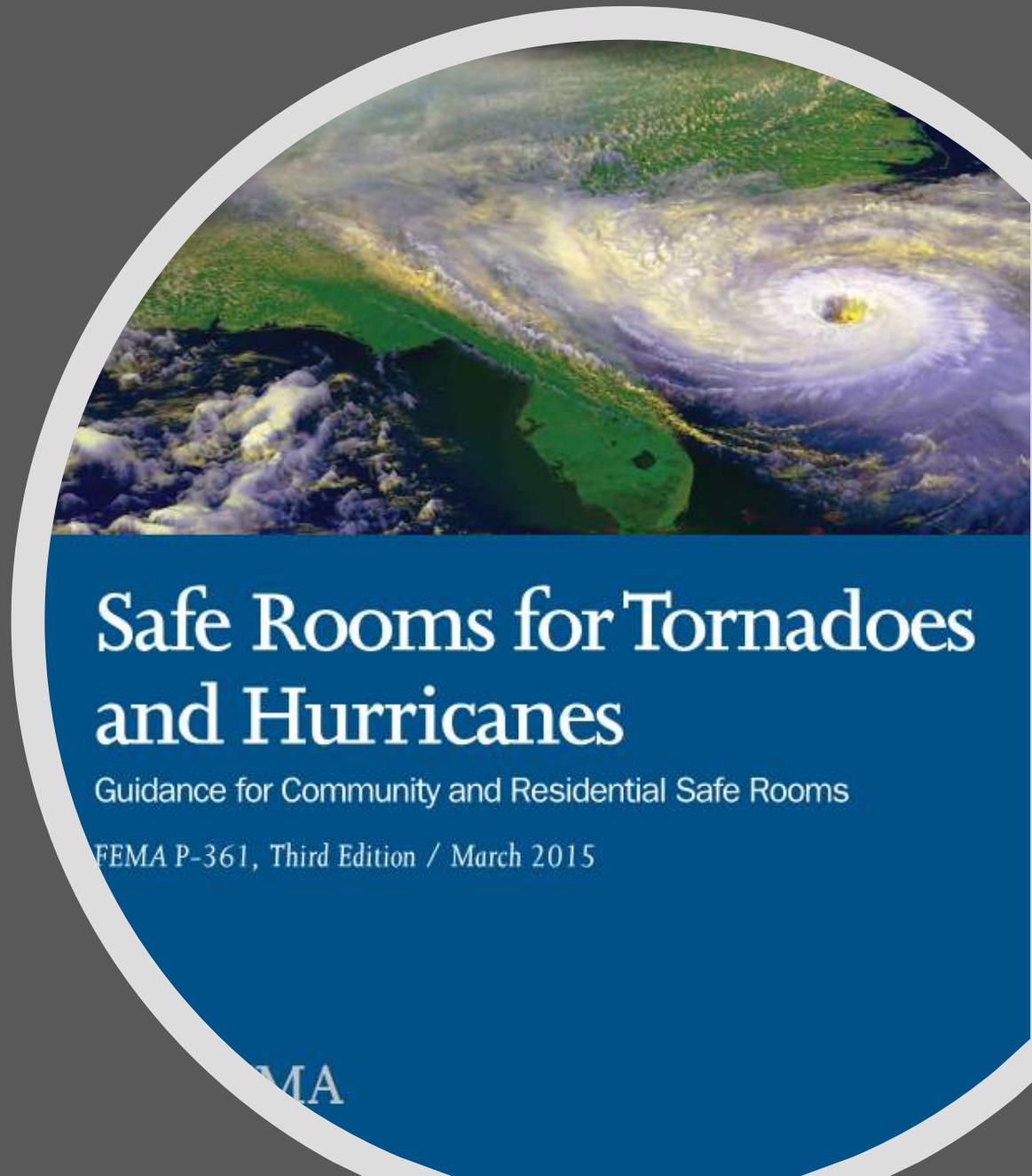

EF4
Sunnyvale,
Rowlett,
Garland, TX
– December,
2015

EF5 Plaza Towers Elementary, Moore, OK – May, 2013



FEMA P-361

Safe Rooms for Tornados and Hurricanes



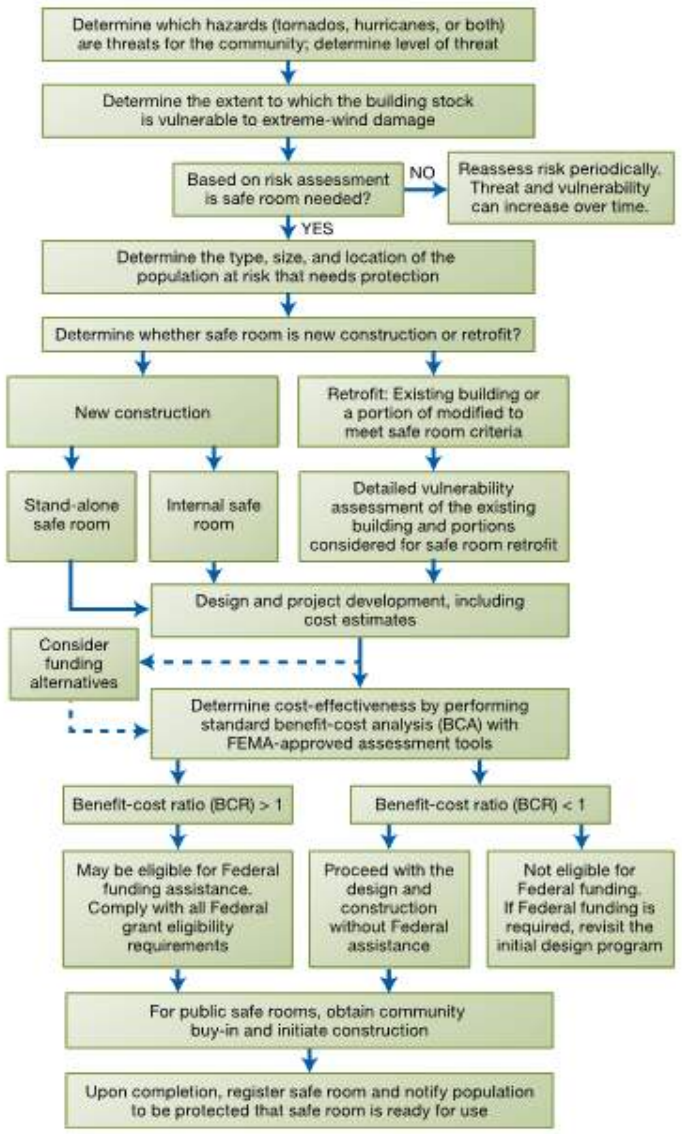


Figure A1-2. Safe room decision-making flowchart

Risk assessment and analysis

FEMA vs. code required vs. optional

- Site specific
- Type of threat
  - Hurricane, tornado, both, or other
- Assessing Vulnerability
  - Building
  - Population

Risk assessment and analysis

Building

- New vs retrofit
- Level of protection
  - Best Available Refuge Area (BARA)
  - ICC 500
  - FEMA P-361

Single vs multi-hazard

- Tornado (wind)
- Hurricane (wind & flood)
- Earthquake
- Other

Tornado Protection

Selecting Refuge Areas in Buildings

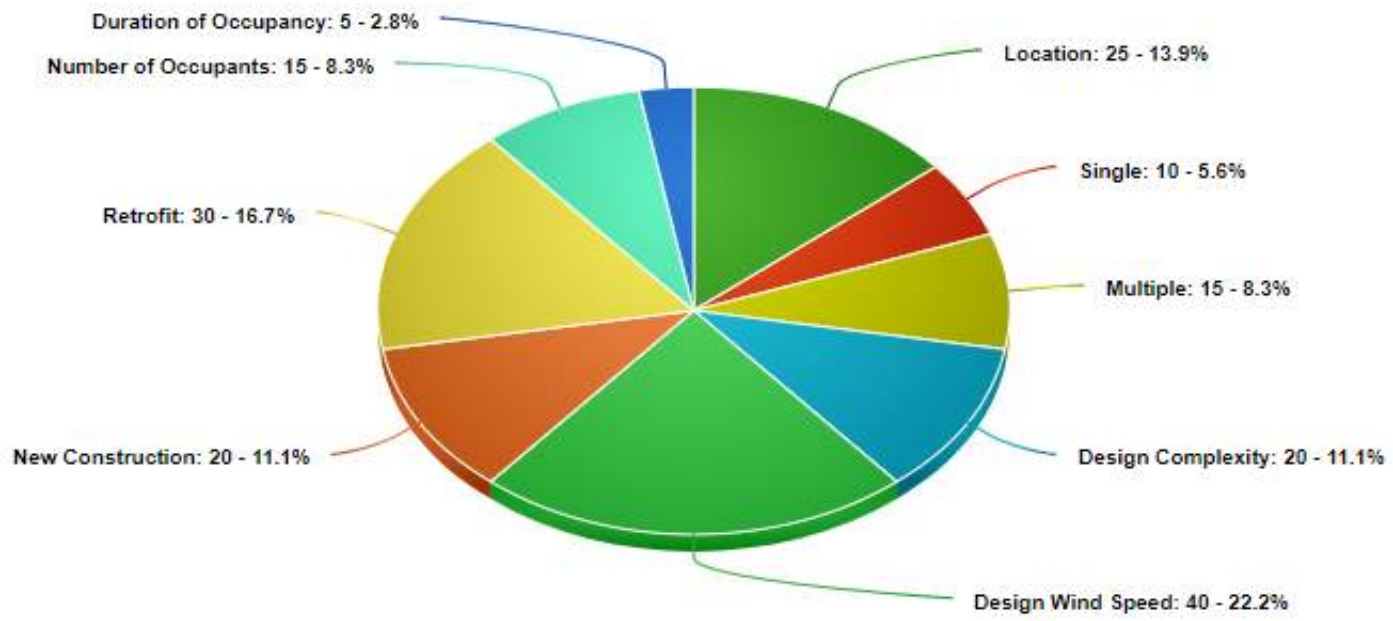
FEMA P-431, Second Edition / October 20

FEMA

Costs and Benefit-Cost Analysis (BCA)

Design Parameters

- Location
- Single vs multi-hazard
- Design complexity
- Design wind speed
- New construction vs retrofit
- Number of occupants
  - Community vs school
- Duration of occupancy
  - 2hrs vs 24hrs



- Can we afford it?
- Can we afford not to?

Emergency Operations Plan

Texas Education Code 37.108 requires districts to adopt and implement a multihazard emergency operations plan that must provide for district employee training, drills, and coordination with police, health, fire

- Sec. 37.108. MULTIHAZARD EMERGENCY OPERATIONS PLAN; SAFETY AND SECURITY AUDIT. (a) Each school district or public junior college district shall adopt and implement a multihazard emergency operations plan for use in the district's facilities. The plan must address mitigation, preparedness, response, and recovery as defined by the commissioner of education or commissioner of higher education in conjunction with the governor's office of homeland security

Emergency Operations Plan

Texas Education Code 37.109 School Safety and Security Committee

- Develop and implement emergency plans

Texas School Safety Center

School Safety and Security Standards

- Mitigation/prevention
- Preparedness
- Response
- Recovery

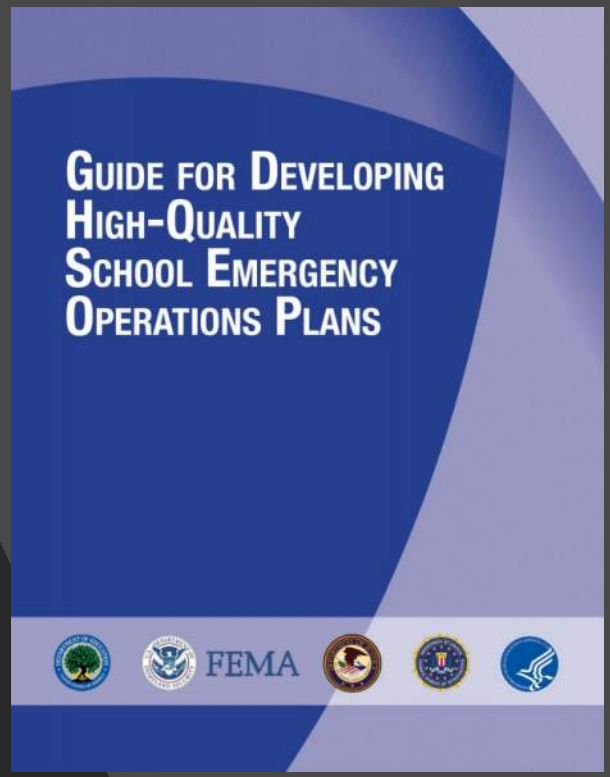
ICC 500 – Local Emergency Planning Committee (LEPC)

- County - Fire Marshal or Office of Emergency Management
- Emergency plans and hazardous chemicals
- Members – cities, red cross, medical centers (volunteers)

Emergency Operations Plan

Step 1: Form a Collaborative Planning Team

- Architects/Engineers as partners



READINESS AND EMERGENCY MANAGEMENT FOR SCHOOLS
REMS
TECHNICAL ASSISTANCE CENTER

- Prevent
- Protect
- Mitigate
- Respond
- Recover

Emergency Operations Plan

Step 3: Determine Goals and Objectives

- Before, During, After (resources)

  - Before: Shelter is ready, plan of action is understood.
  - During: Everyone is able to access safely and in a timely manner. Students are safe, calm, occupied, informed.
  - After: Assess, First Aid, stay vs. escape

Emergency Operations Plan

Step 6: Plan Implementation & Maintenance

- Exercise the Plan
- Review, Revise, and Maintain the Plan
  - TEC 37.108 - required to update every 3 years

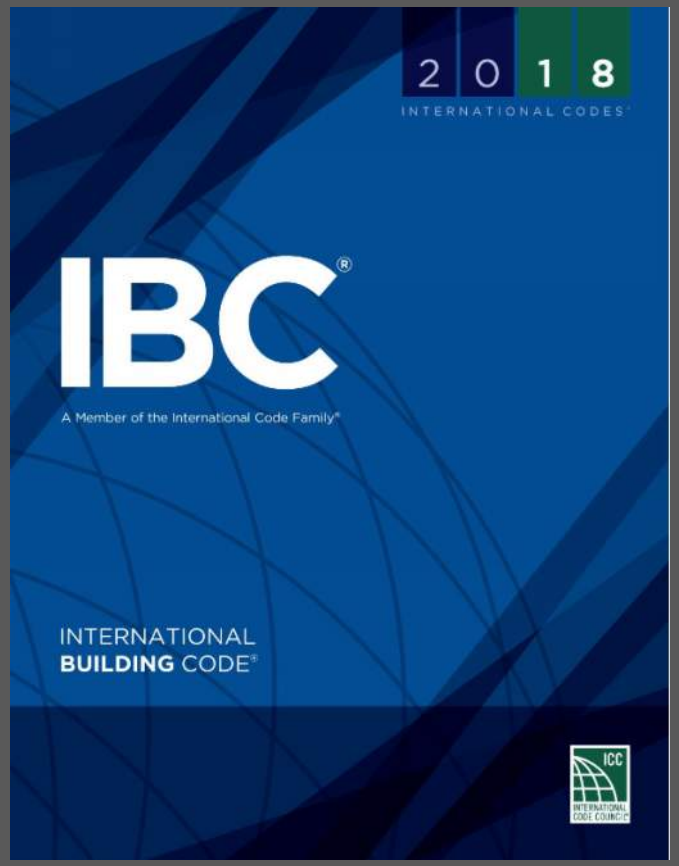
Owner Considerations

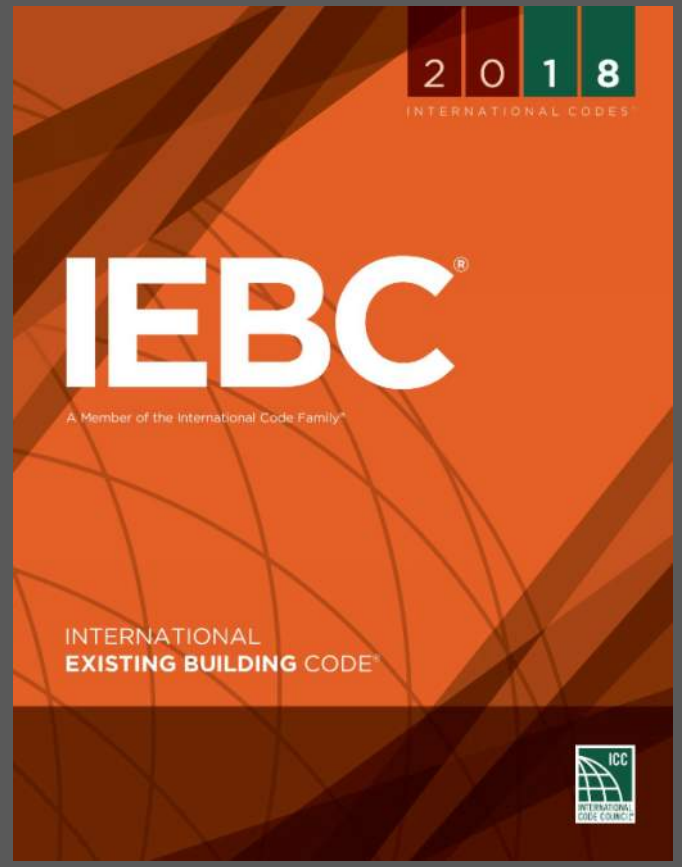
1. Operations and maintenance (Chapter A4 of FEMA P-361)
2. Standby power
3. Mechanical vs natural ventilation
4. Permanent vs temporary plumbing fixtures
5. Technology/Communications
6. Control Room
7. First Aid Kit, medical needs
8. Access and Functional Needs (AFN)

2018 IBC
2018 IEBC

International Building Code

International Existing Building Code





2015 International Building Code

The shelter shall be capable of housing the total occupant load of the Group E occupancy.

2018 International Building Code

Deleted blue text and added:

423.4.1 Required Occupant Capacity. The required occupant capacity of the storm shelter shall include all the buildings on the site, and shall be the **greater** of the following:

1. The total occupant load of the classrooms, vocational rooms, and offices in the Group E occupancy.
2. The occupant load of **any** (the largest) indoor assembly space that is associated with the Group E occupancy.

2018 International Building Code

Exceptions:

1. Where a new building is being added on an existing Group E site, and where the new building is **not of sufficient size** to accommodate the required occupant capacity of the storm shelter for all the buildings on the site, the storm shelter **shall at a minimum** accommodate the required capacity for the new building.
2. Where approved by the code official, the required occupant capacity of the shelter shall be permitted to be reduced by the occupant capacity of any existing storm shelters on site.

423.4.2 Location. Storm shelters shall be located within the buildings they serve, or shall be located where the maximum distance of travel from not fewer than one exterior door of each building to a door of the shelter serving that building does not exceed 1000 feet.

2015 International Existing Building Code

Did not address Storm Shelters

2018 International Existing Building Code

1106.1 Addition to a Group E occupancy. Where an addition is added to an existing Group E occupancy located in an area where the shelter design wind speed for tornados is 250 mph in accordance with Figure 304.2(1) of ICC 500 and the occupant load in the addition is 50 or more, the addition shall have a storm shelter constructed in accordance with ICC 500.

Exceptions:

1. Group E day care facilities.
2. Group E occupancies accessory to places of religious worship.
3. Additions meeting the requirements for shelter design in ICC 500.

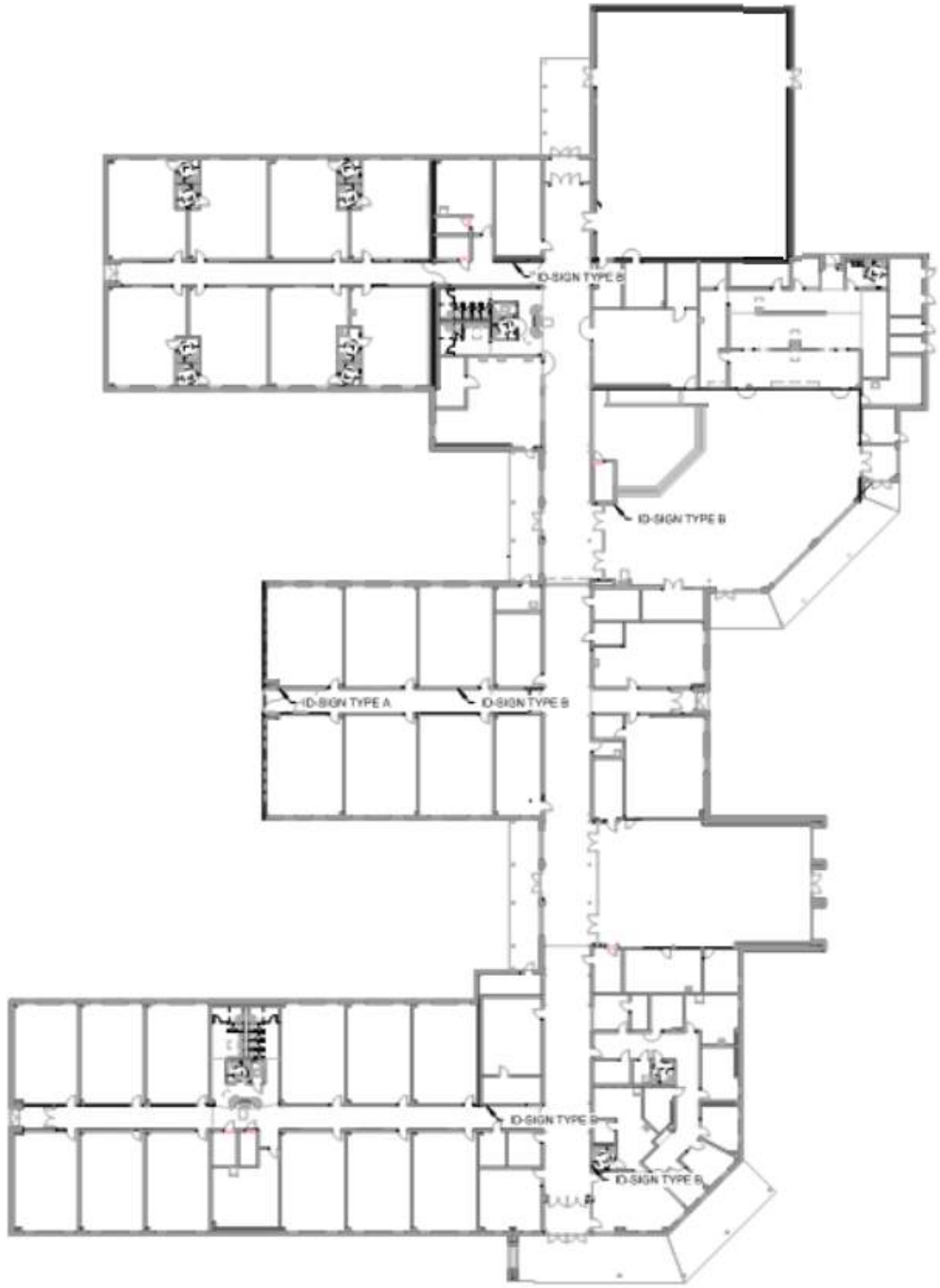
2018 International Existing Building Code

1106.1.1 Required occupant capacity. The required occupant capacity of the storm shelter shall include all buildings on the site, and shall be the **greater** of the following:

1. The total occupant load of the classrooms, vocational rooms and offices in the Group E occupancy.
2. The occupant load of **any** (the largest) indoor assembly space that is associated with the Group E occupancy.

Exceptions:

1. Where an addition is being added on an existing Group E site, and where the addition is **not of sufficient size** to accommodate the required occupant capacity of the storm shelter for all of the buildings on-site, the storm shelter **shall at a minimum** accommodate the required capacity for the addition.
2. Where approved by the code official, the required occupant capacity of the shelter shall be permitted to be reduced by the occupant capacity of any existing storm shelters on the site.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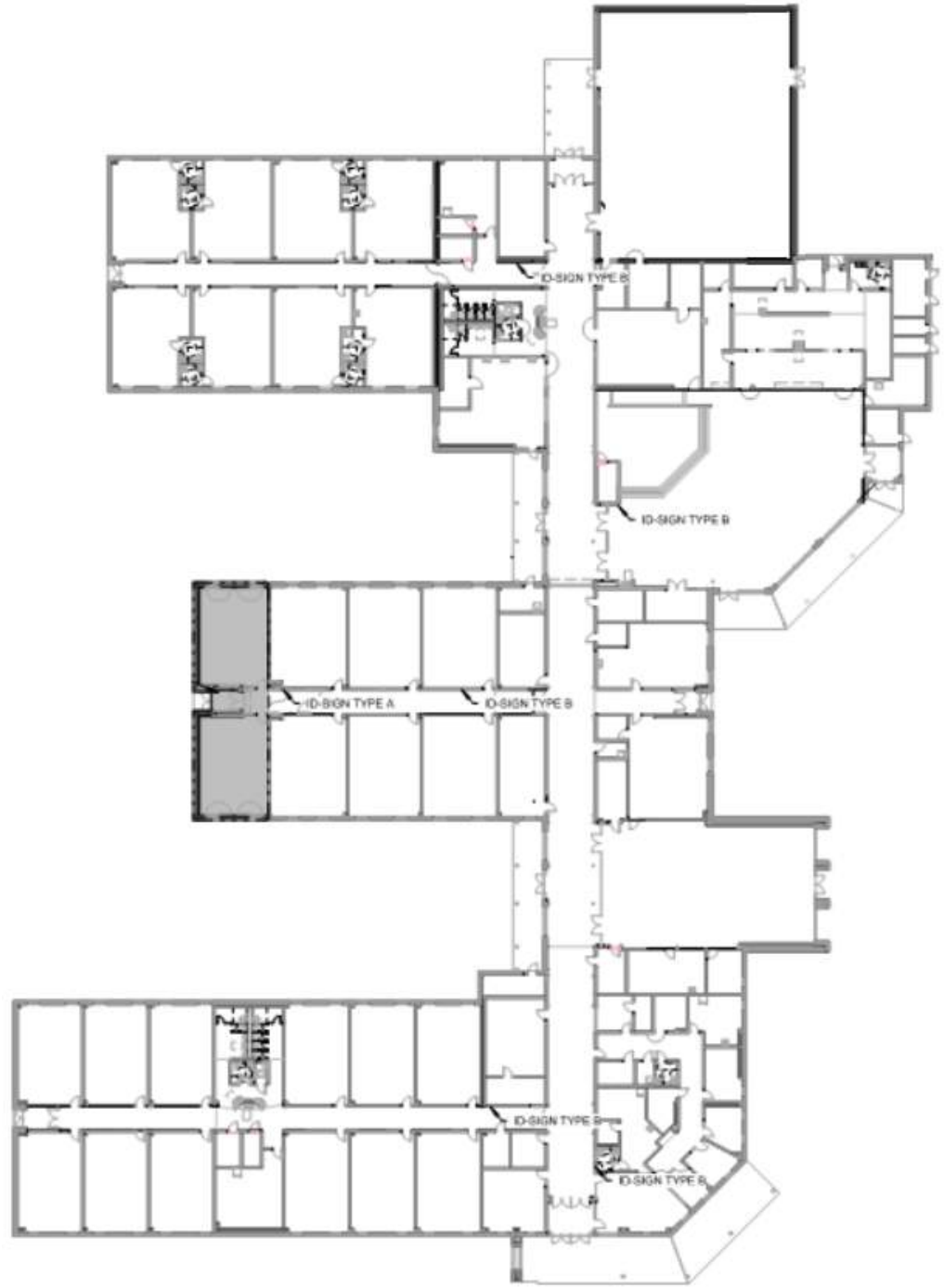
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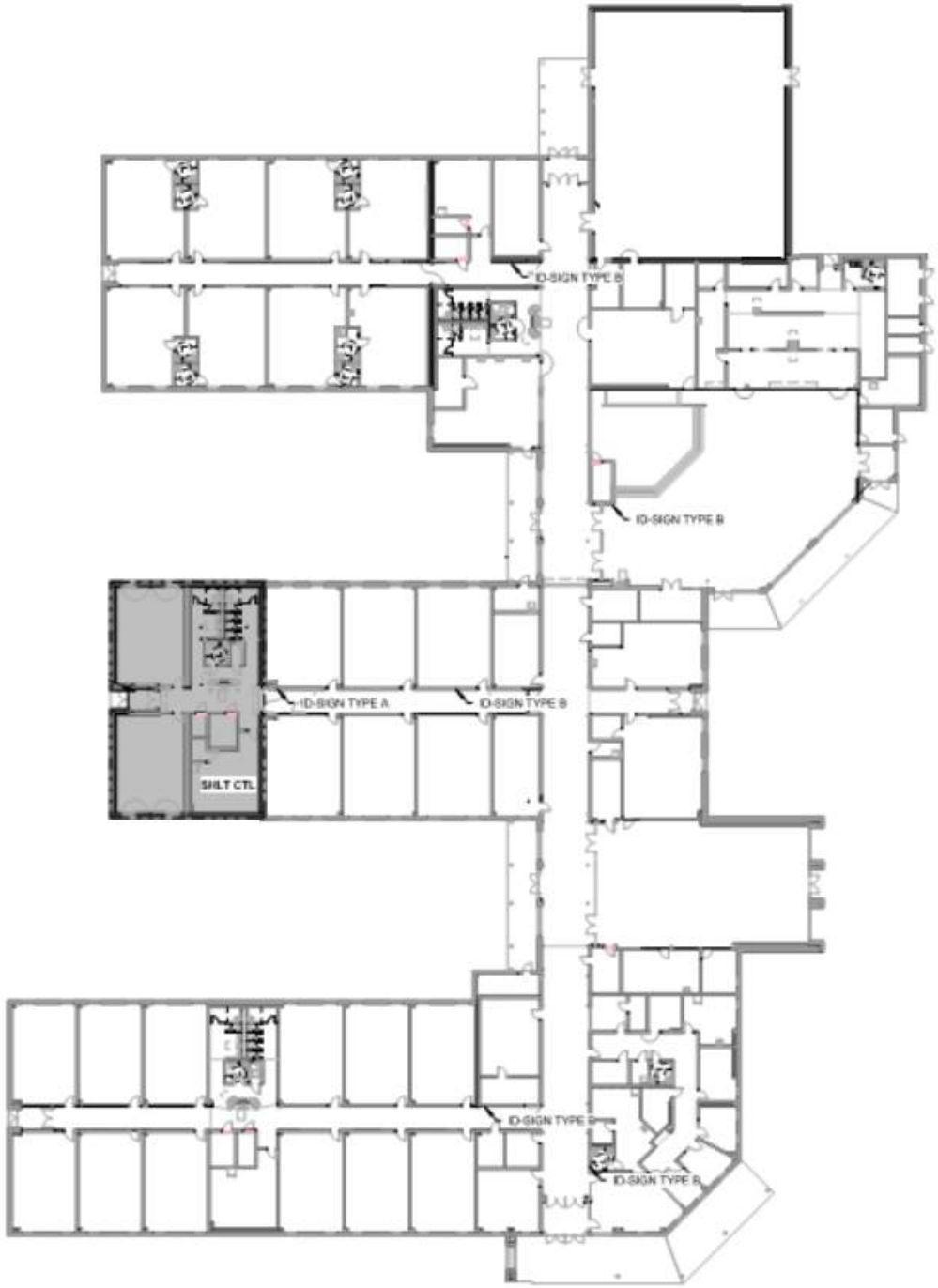
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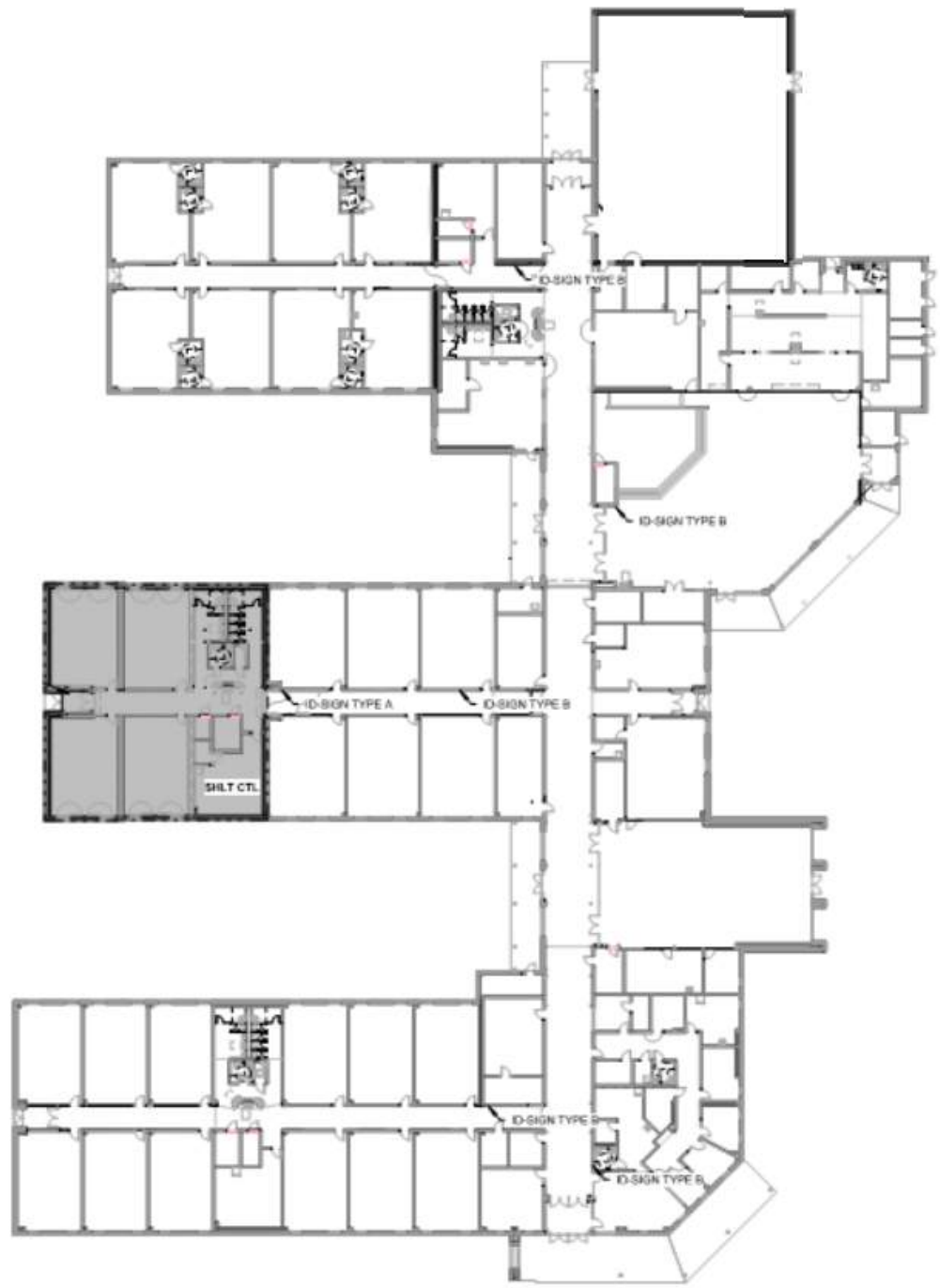
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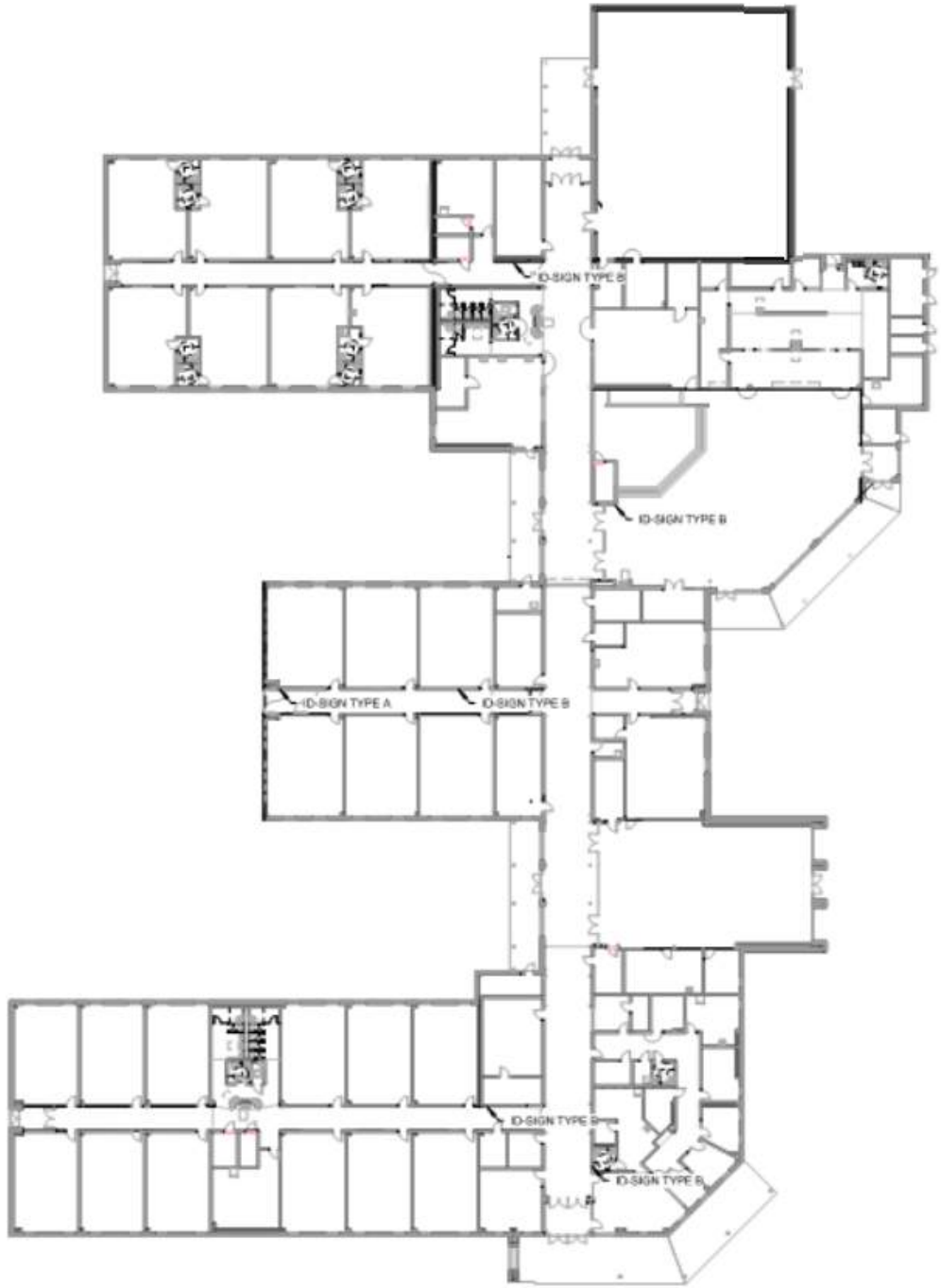
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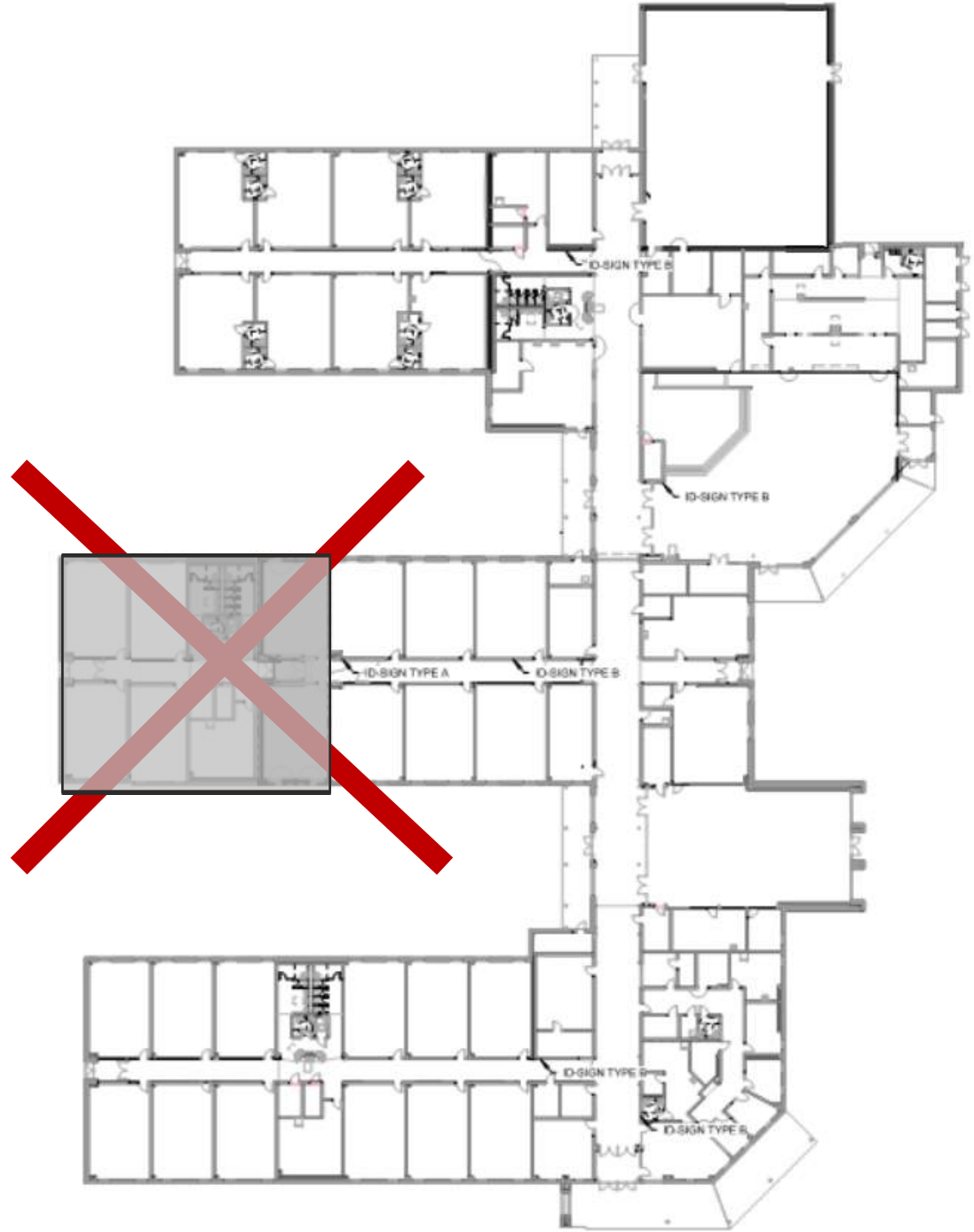
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Additions

Size your shelter accordingly

Renovations

There are no requirements for a storm shelter in the case of renovations to a facility.

However, if you renovate in the future, based on the level (extent) of renovation you will have to bring the shelter into compliance with current code.

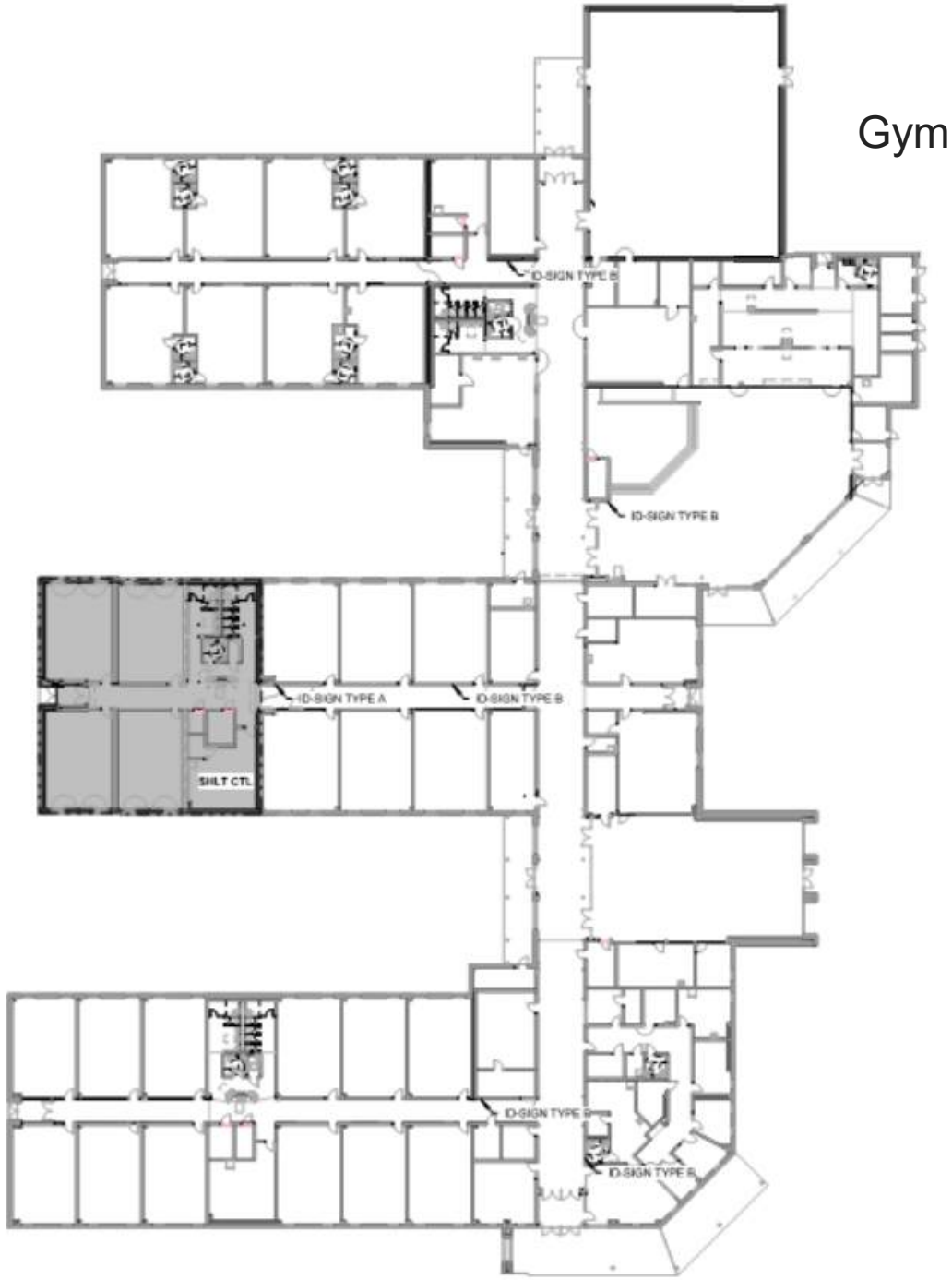
Required Occupant Capacity

423.4.1 Required Occupant Capacity. The required occupant capacity of the storm shelter shall include all the buildings on the site, and shall be the greater of the following:

1. The **design capacity** of the classrooms, vocational rooms, and offices in the Group E occupancy.
2. The **occupant load** of any indoor assembly space that is associated with the Group E occupancy.

Design Capacity:
(Students + Staff)

30 classrooms x 22 (TEA)
+
<u>Staff</u>
700



Gym: 630

Required Occupant Capacity

423.4.1 Required Occupant Capacity. The required occupant capacity of the storm shelter shall include all the buildings on the site, and shall be the greater of the following:

1. The **total occupant load** of the classrooms, vocational rooms, and offices in the Group E occupancy.
2. The **occupant load** of any indoor assembly space that is associated with the Group E occupancy.

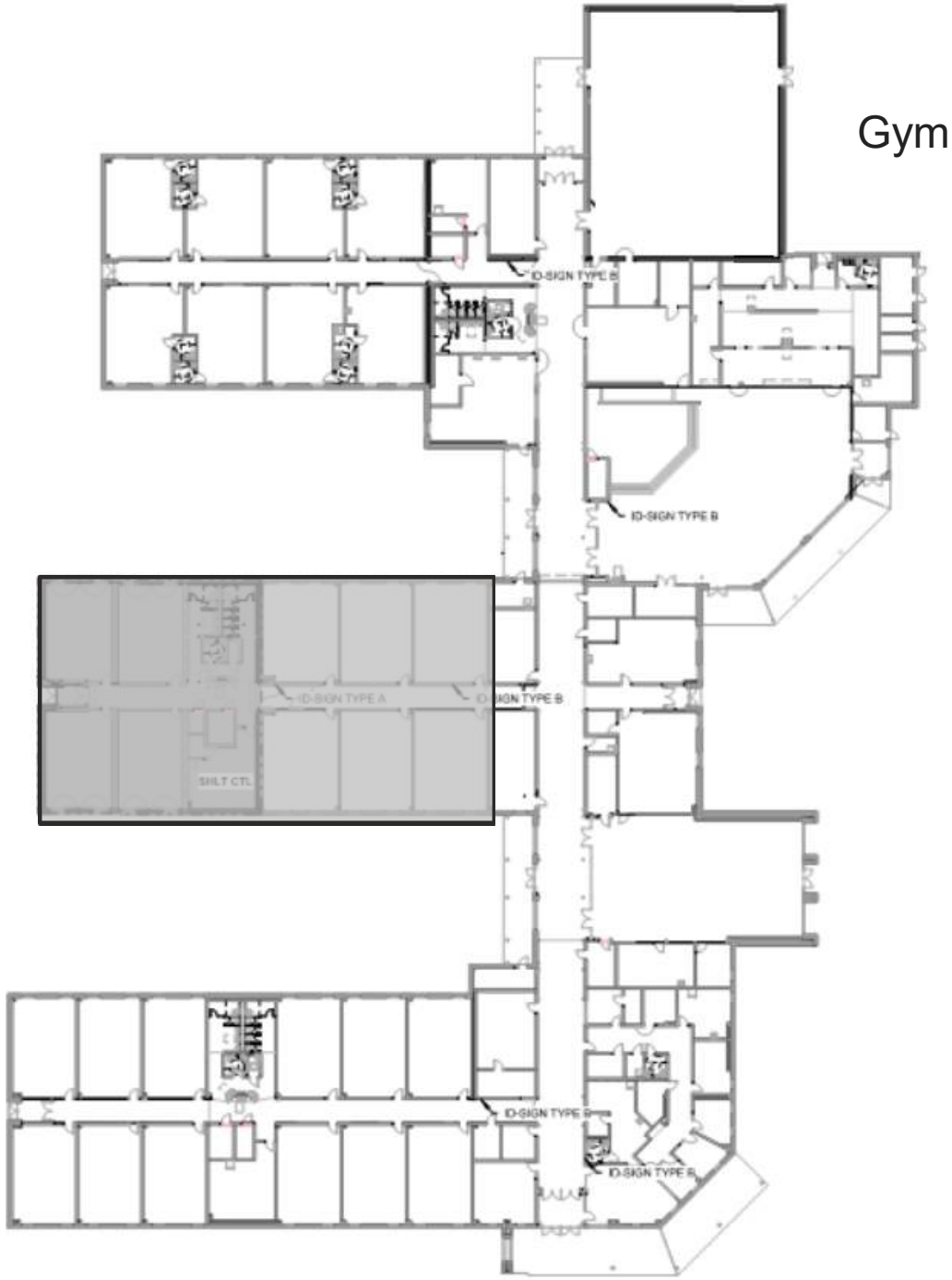
TABLE 1004.5
MAXIMUM FLOOR AREA ALLOWANCES PER OCCUPANT

FUNCTION OF SPACE	OCCUPANT LOAD FACTOR[a]
Assembly without fixed seats	
Concentrated	7 net
(chairs only—not fixed)	
Standing space	5 net
Unconcentrated (tables and chairs)	15 net
Business areas	150 gross
Educational	
Classroom area	20 net
Shops and other vocational room areas	50 net

Source: 2018 IBC

Occupant Load:
(IBC Chapter 10 Egress)

20sf/person
+
Staff
+
<u>Admin (150sf/person)</u>
1,500



Gym: 630

Required Occupant Capacity

- The 2015 IBC Commentary states:

“Once the number of occupants to be accommodated is decided, ICC 500 provides details for the design and construction of the shelter.”

“It is not the intent to require the shelter to be designed for the total occupant load of the building that is used for means of egress.”

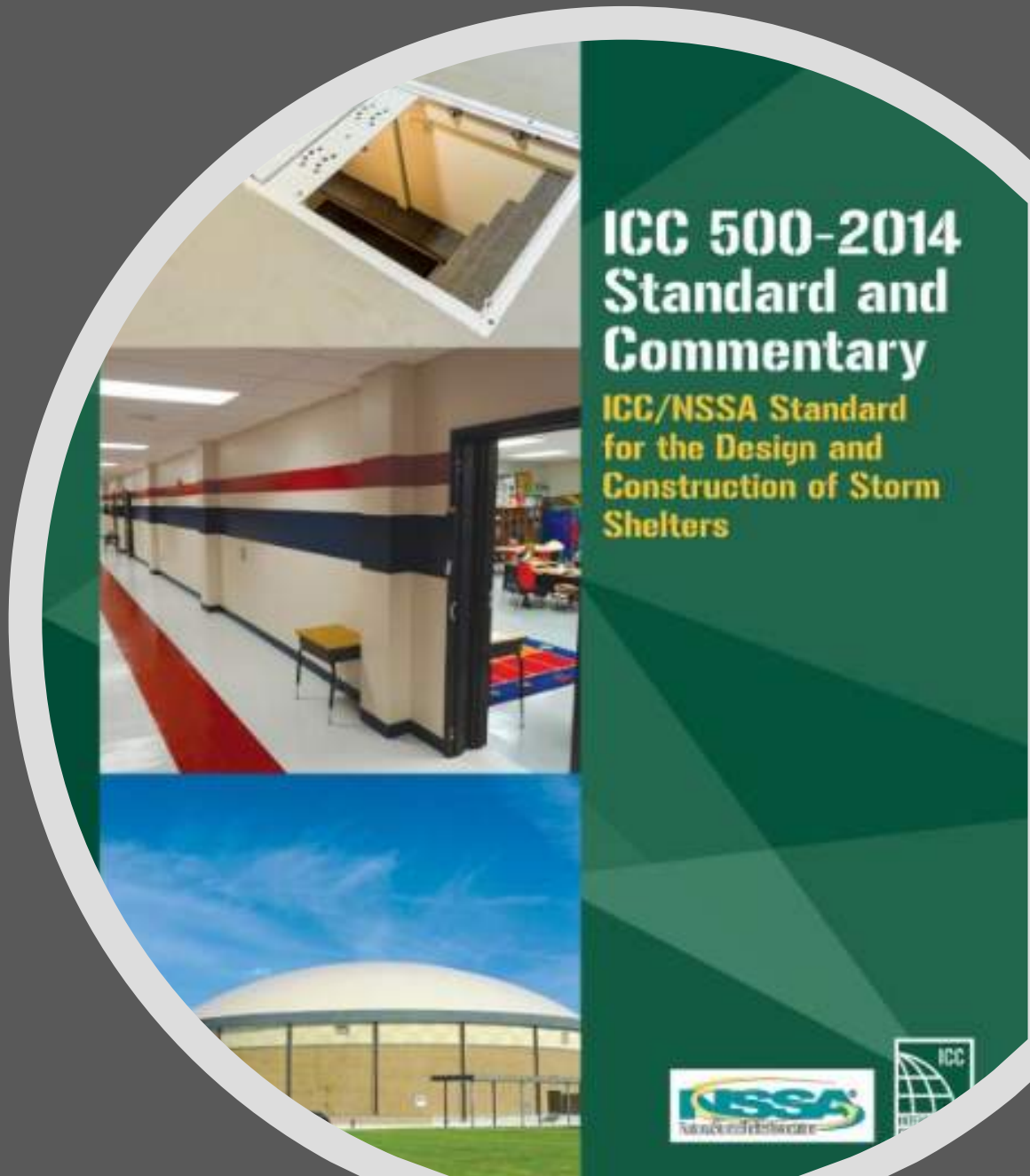
- The required capacity of the storm shelter is intended to be the expected number of students and staff on a typical school day or the capacity of the largest indoor assembly space, whichever is greater.

Recommendations

1. Clarify the language
2. Communication
3. Agree on the interpretation
4. Right-size the shelter

ICC 500 - 2014

ICC/NSSA Standard for the Design and Construction of Storm Shelters



ICC 500 - 2014
ICC/NSSA Standard for the Design and Construction of Storm Shelters

- Chapter 1 Application And Administration
- Chapter 2 Definitions
- Chapter 3 Structural Design Criteria
- Chapter 4 Siting
- Chapter 5 Occupancy, Means Of Egress, Access And Accessibility
- Chapter 6 Fire Safety
- Chapter 7 Shelter Essential Features And Accessories
- Chapter 8 Test Methods For Impact And Pressure Testing
- Chapter 9 Referenced Standards

ICC 500 - 2014
Chapter 5 – Occupancy, Means of Egress, Access and Accessibility
501 – Community Shelters

501.1.1 Occupant density. The minimum required shelter floor area per occupant shall be determined in accordance with Table 501.1.1, and this section. The number of standing, seated, wheelchair or bedridden spaces shall be determined based upon the needs of the shelter determined by the applicable authority having jurisdiction and the designer.

TABLE 501.1.1
OCCUPANT DENSITY – COMMUNITY SHELTERS

TYPE OF SHELTER	MINIMUM REQUIRED USABLE SHELTER FLOOR AREA[a] IN SQUARE FEET PER OCCUPANT
Tornado	
Standing or seated	5
Wheelchair	10
Bedridden	30

Usable Storm Shelter Floor Area

The ICC 500 states:

501.1.2.1 Calculation of usable floor area. The usable shelter floor area shall be determined by using the following percentages:

1. Reducing the gross floor area of shelter areas with areas of concentrated furnishings or fixed seating by a minimum of **50 percent**.

Auditorium

2. Reducing the gross floor area of shelter areas with areas of unconcentrated furnishings and without fixed seating by a minimum of **35 percent**.

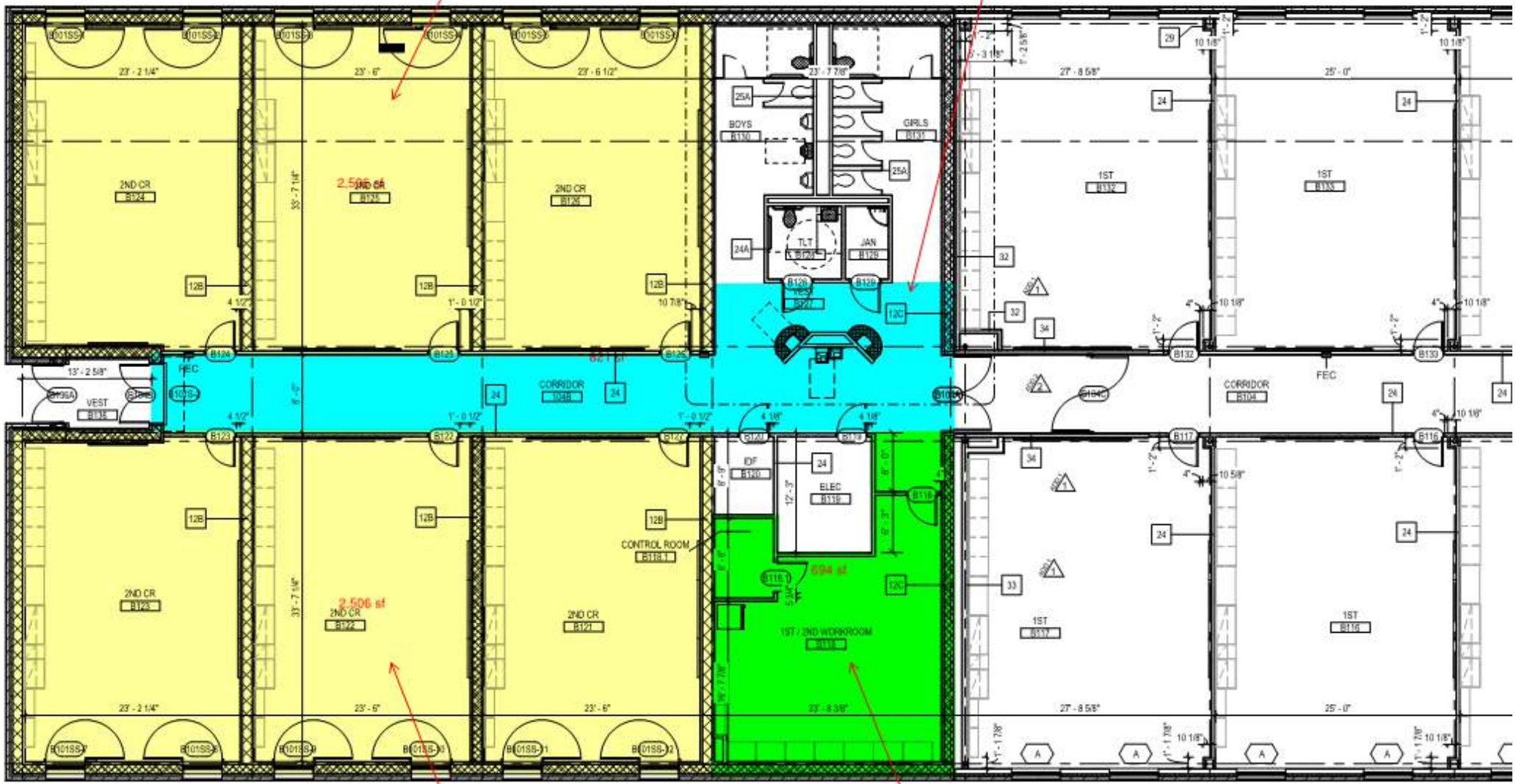
Classroom

3. Reducing the gross floor area of shelter areas with areas of open plan furnishings and without fixed seating by a minimum of **15 percent**.

Gymnasium, Corridor

GROSS
UNCONCENTRATED
AREA 2,506SF (35%) =
1,629SF

GROSS OPEN PLAN
AREA 821SF (15%) =
698SF



GROSS
UNCONCENTRATED
AREA 2,506SF (35%) =
1,629SF

GROSS
CONCENTRATED AREA
694SF (50%) = **347SF**

Density and Usable Storm Shelter Floor Area

TABLE 501.1.1 - OCCUPANT DENSITY - COMMUNITY SHELTERS

MINIMUM REQUIRED USABLE SHELTER FLOOR AREA PER OCCUPANT (SQ. FT.) - TORNADO			
	AREA / OCC	OCCUPANTS	USABLE AREA REQUIRED
SEATING OR STANDING	5	698	3,490
WHEELCHAIR (1 PER 200 OCCUPANTS, 501.1.3)	10	2	20
BEDRIDDEN	30	0	0
TOTAL USABLE AREA REQUIRED		700	**3,510** SQUARE FEET

501.1.2 USABLE STORM SHELTER FLOOR AREA

USABLE SHELTER FLOOR AREA PER OCCUPANT (SQ. FT.) - TORNADO			
	AREA	REDUCTION	USABLE AREA SQFT
CONCENTRATED	694	50%	347
UNCONCENTRATED	5012	35%	3,258
OPEN PLAN	821	15%	698
TOTAL USABLE AREA PROVIDED			**4,303** SQUARE FEET

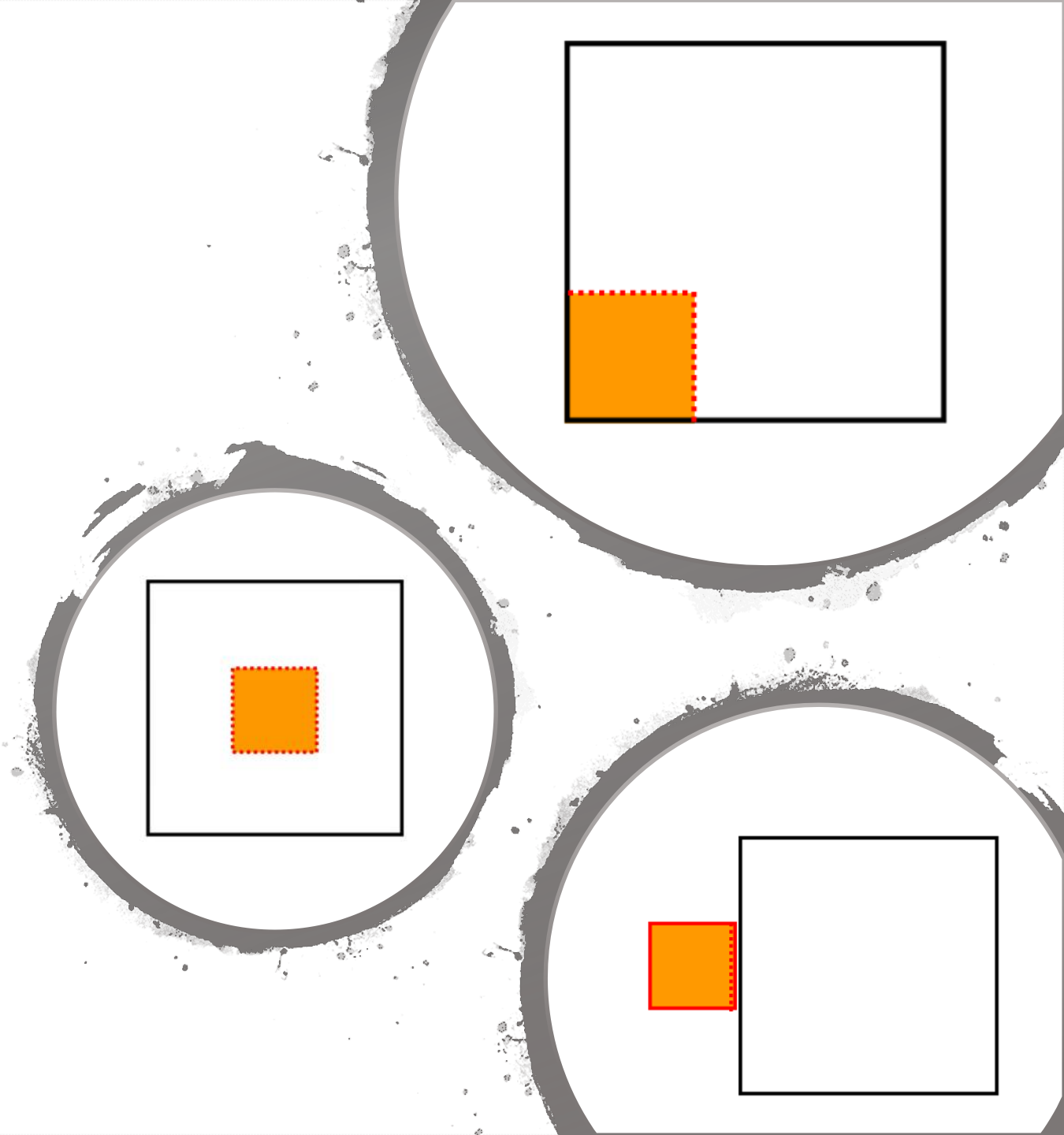
Alternative Calculation of Usable Floor Area

- The ICC 500 states:

501.1.2.2 Alternative calculation of usable floor area. The usable shelter floor area shall be determined by subtracting from the gross floor area, the floor area partitions and walls, columns, fixed or movable objects, furniture, equipment or other features that under probable conditions cannot be removed.

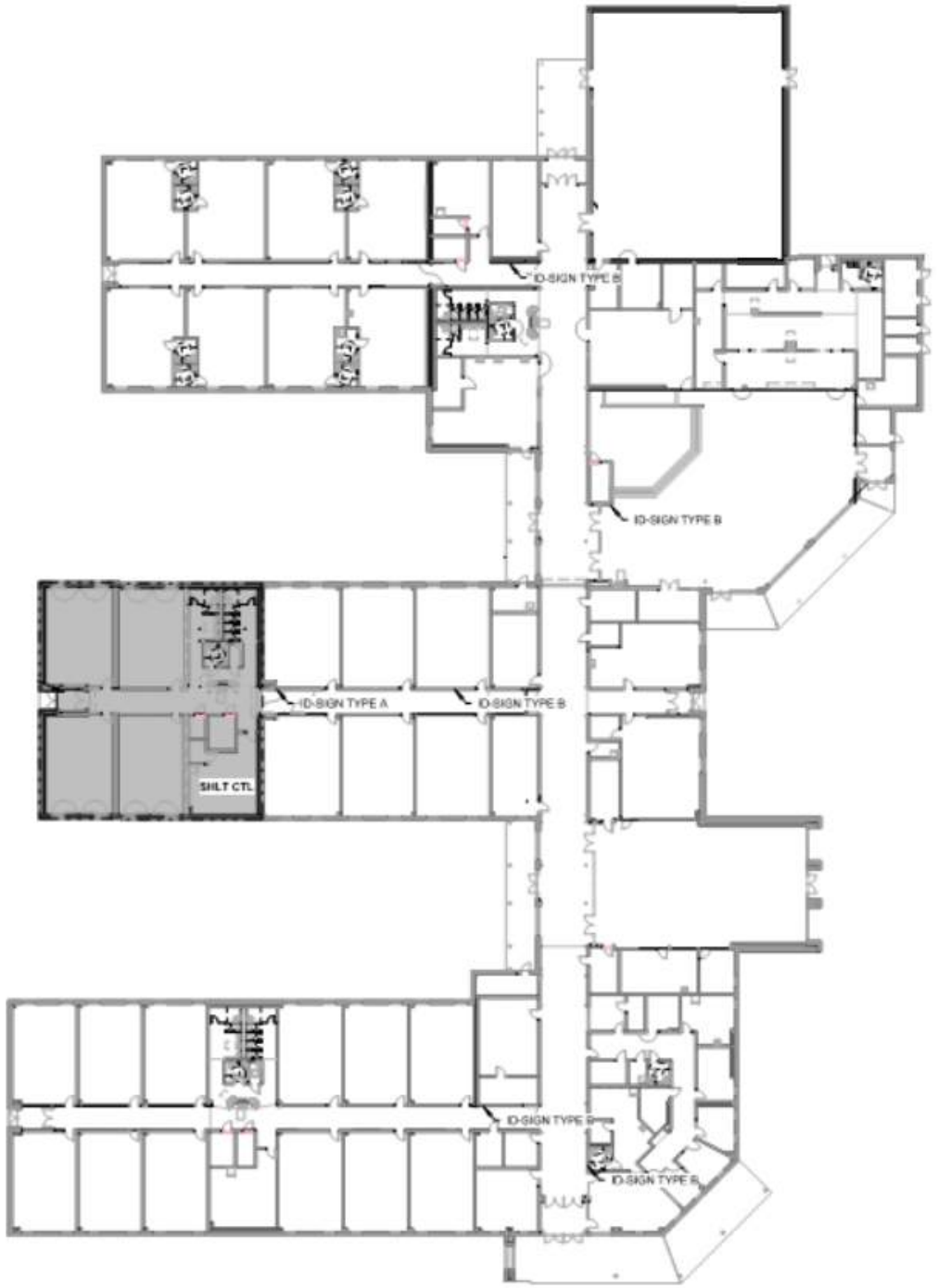
Storm Shelter Location

- Classrooms, Gymnasium and/or locker rooms, toilet rooms and other
- 1 shelter vs multiple
- Adjacent to vs within a building
- Multiple levels
- Sublevel



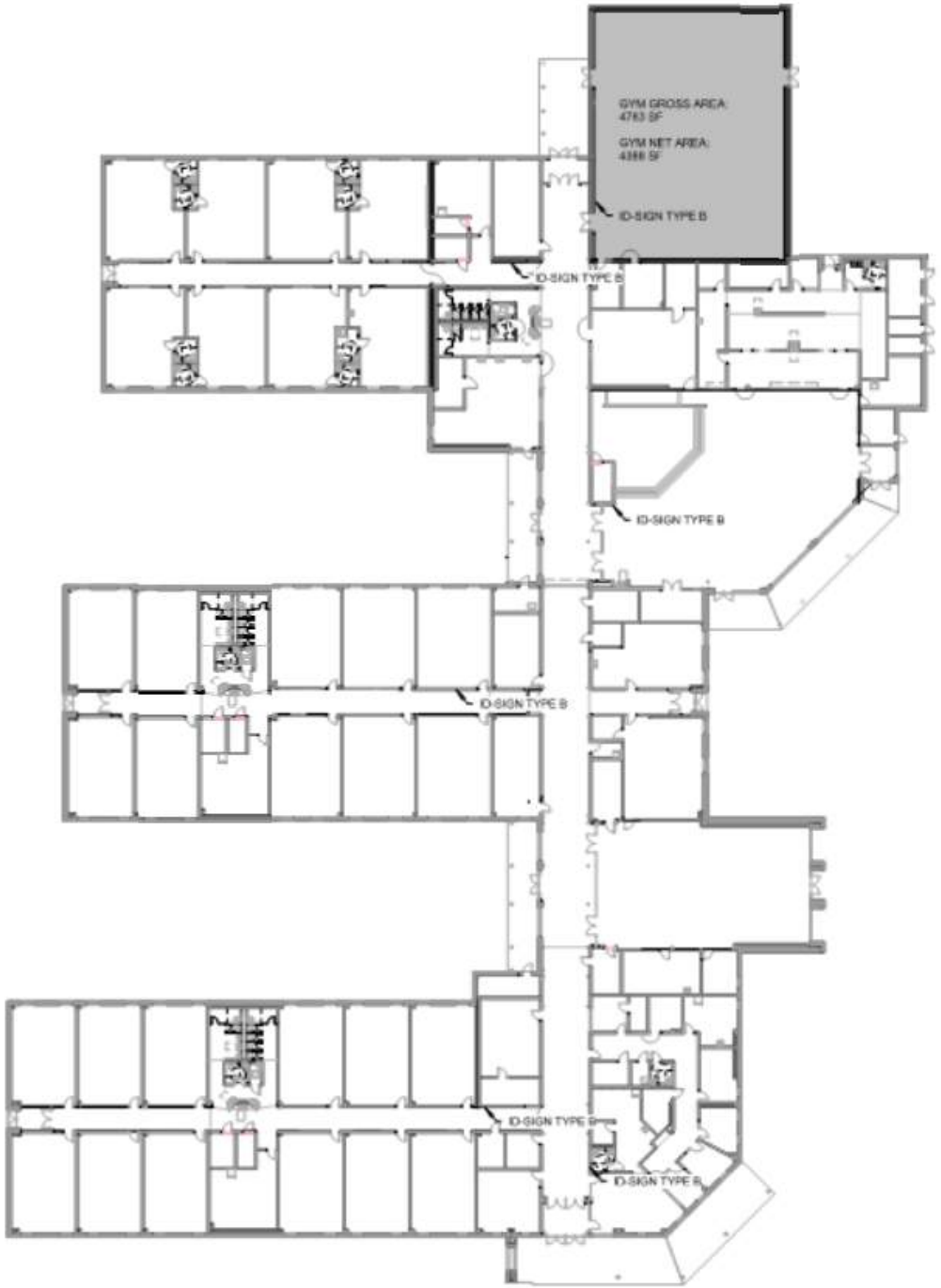
Location

Classrooms



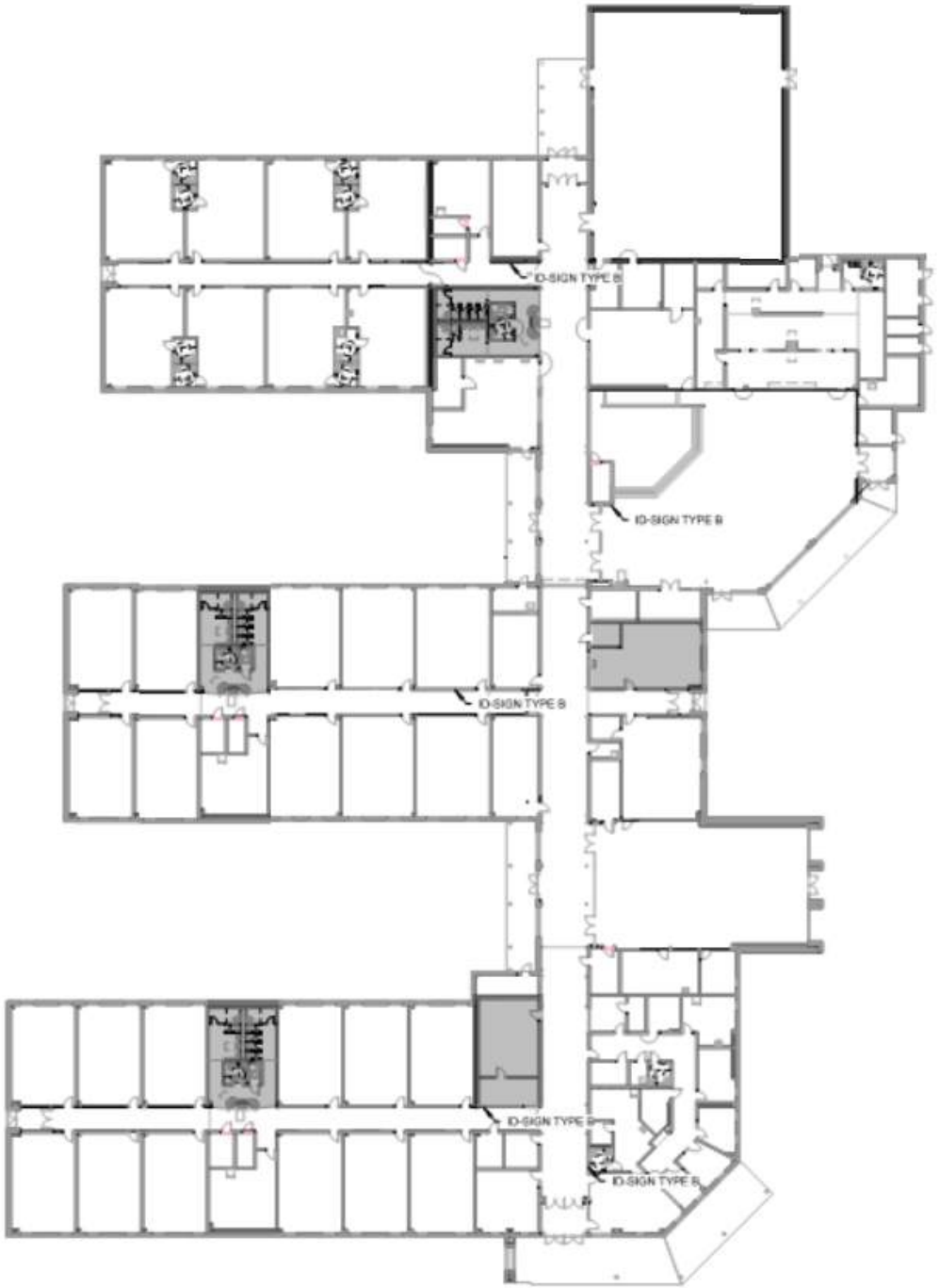
Location

Gymnasium



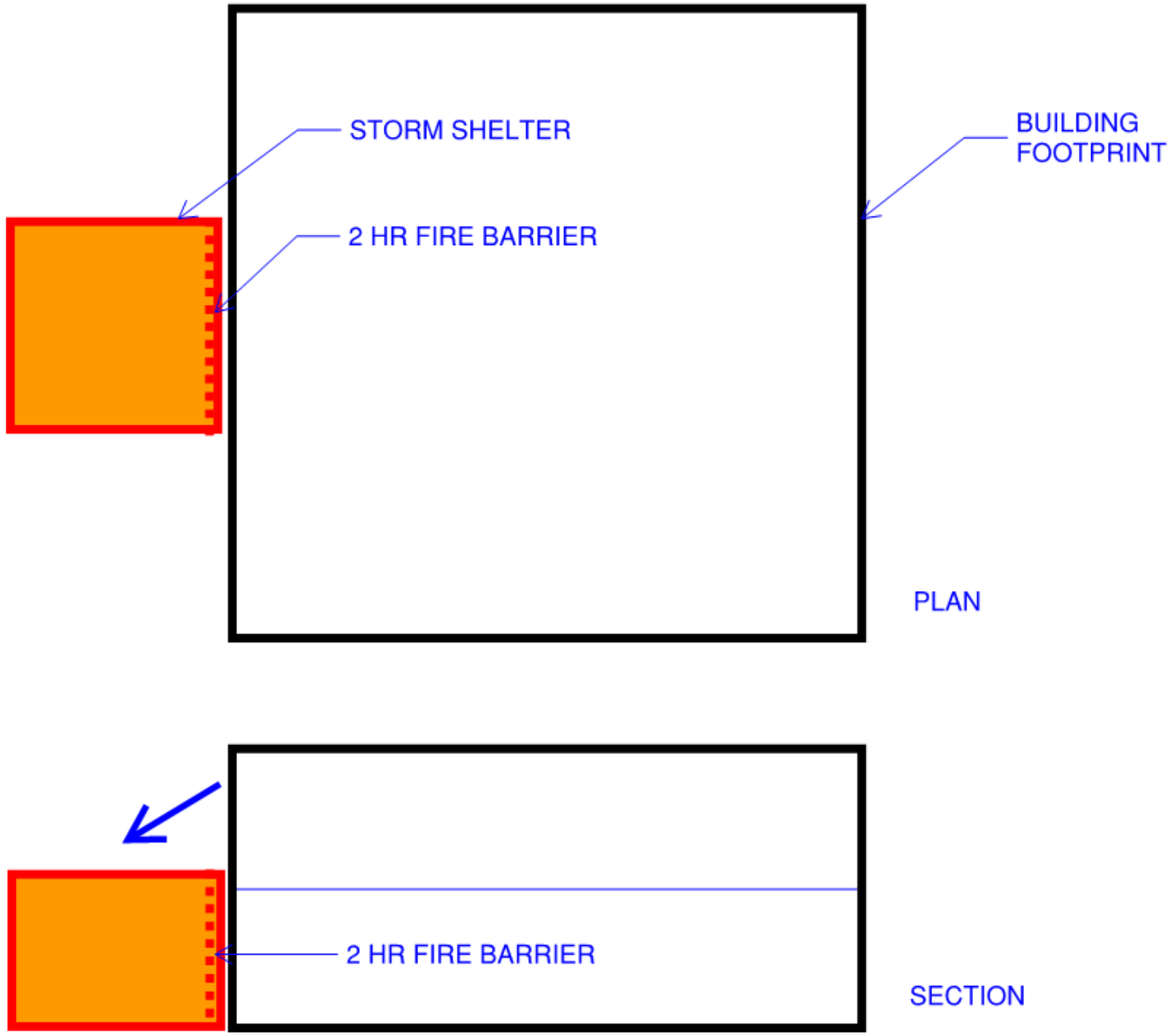
Location

Toilet rooms
+ additional
spaces



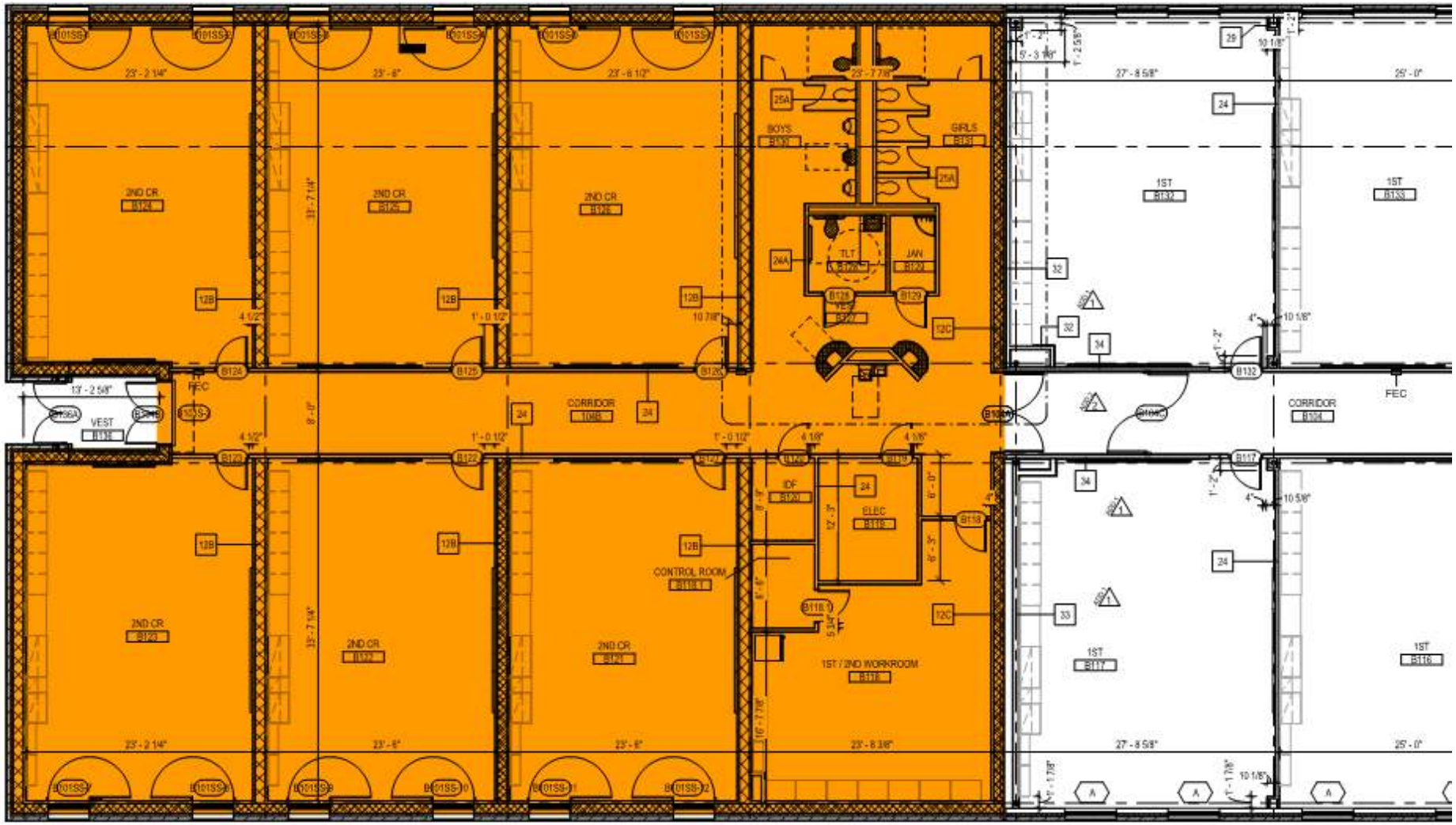
Location

Adjacent



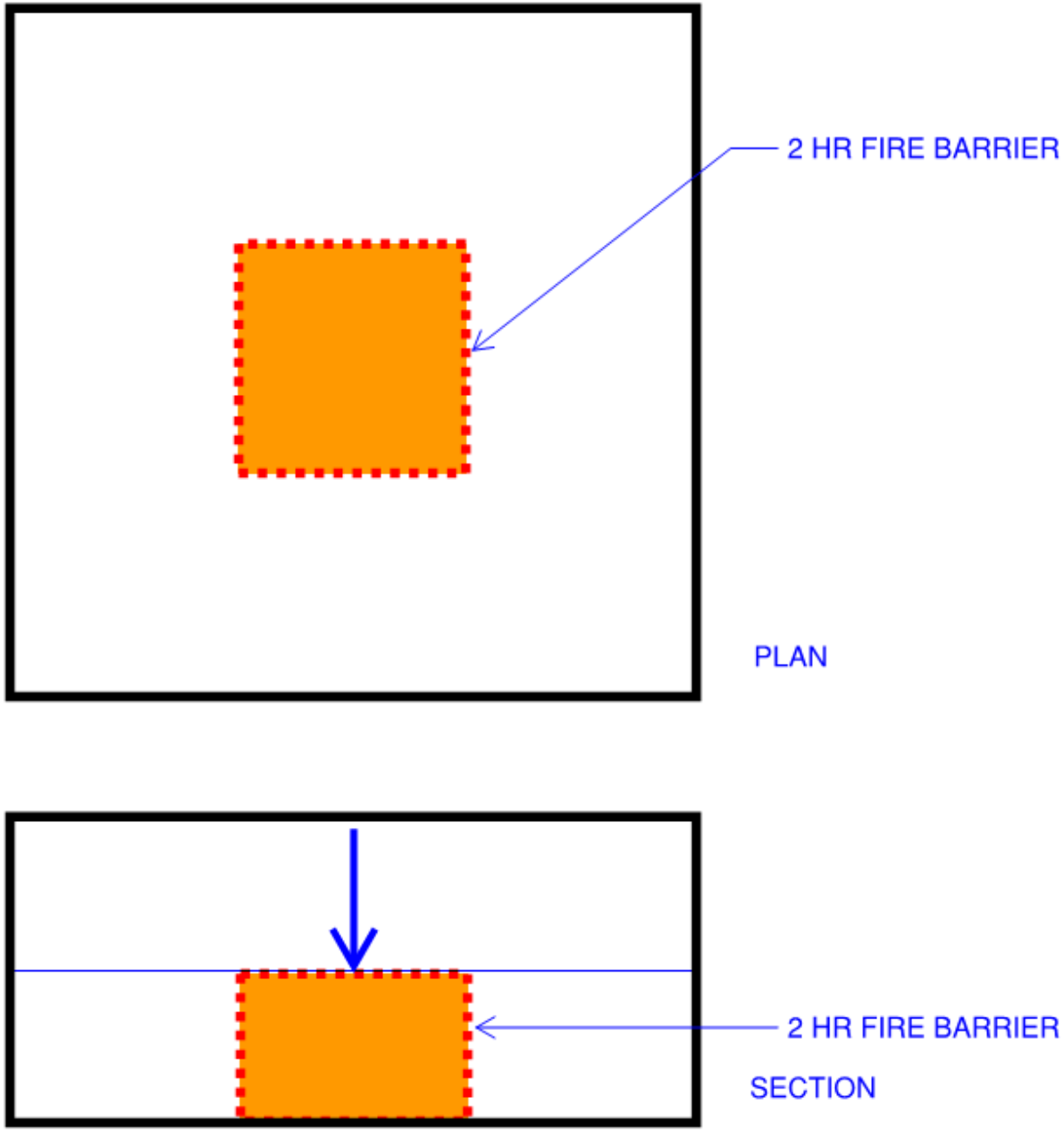
Location

Adjacent



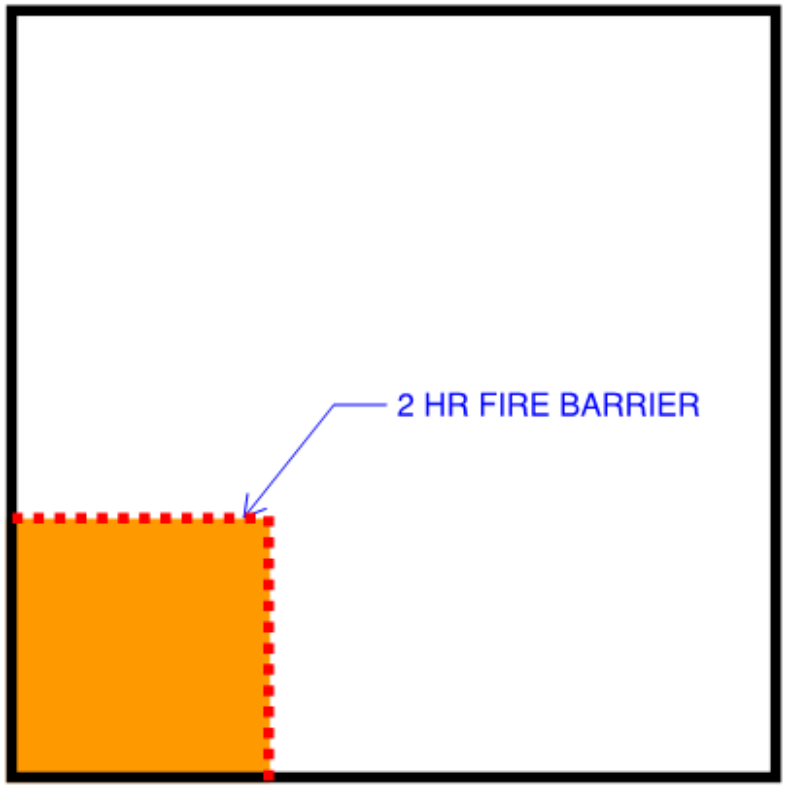
Location

Within

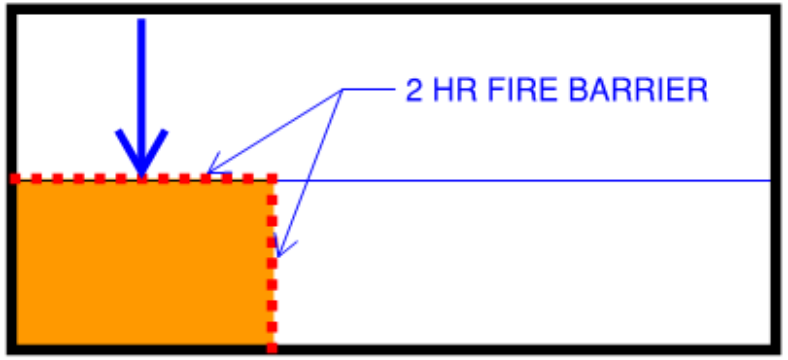


Location

Within



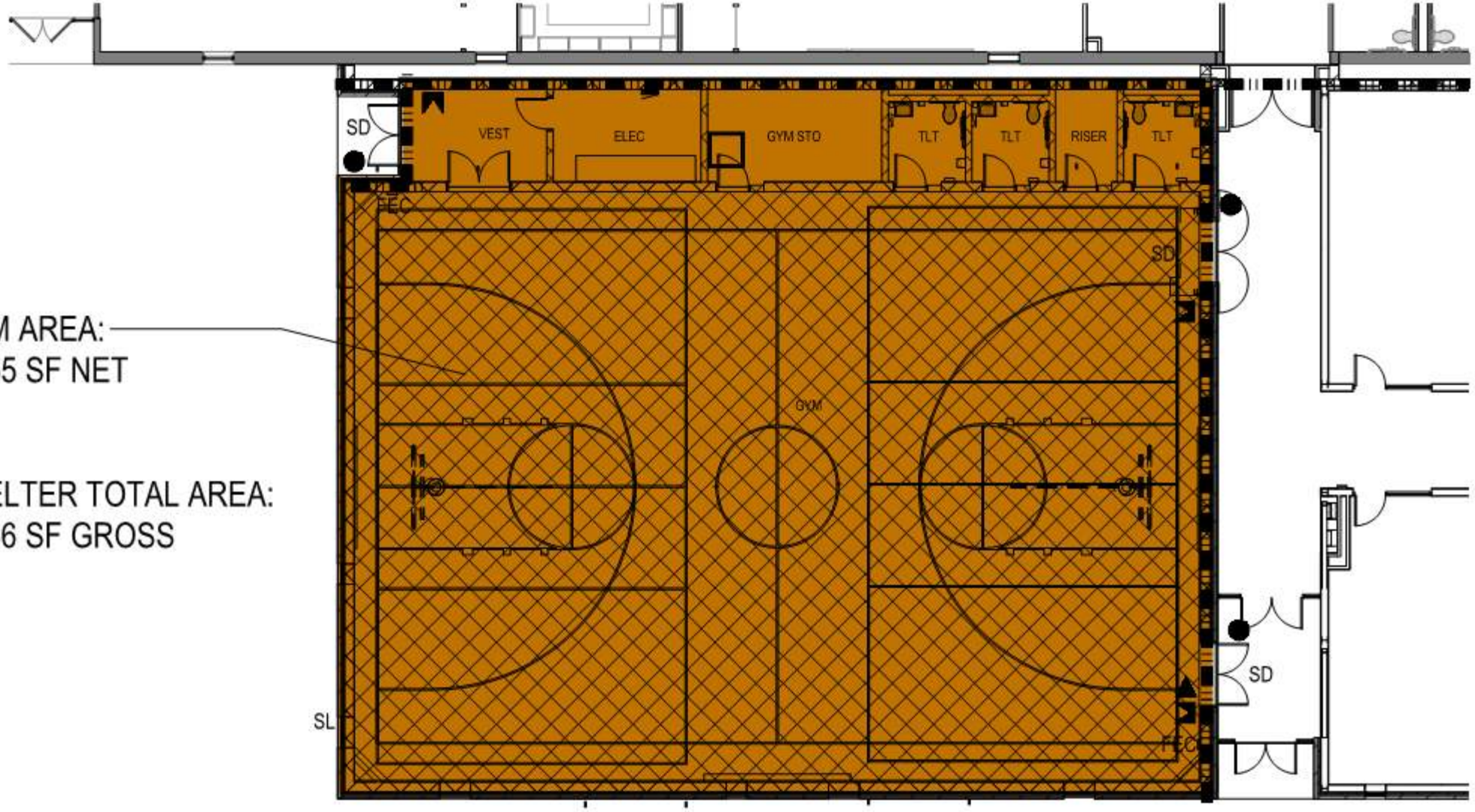
PLAN



SECTION

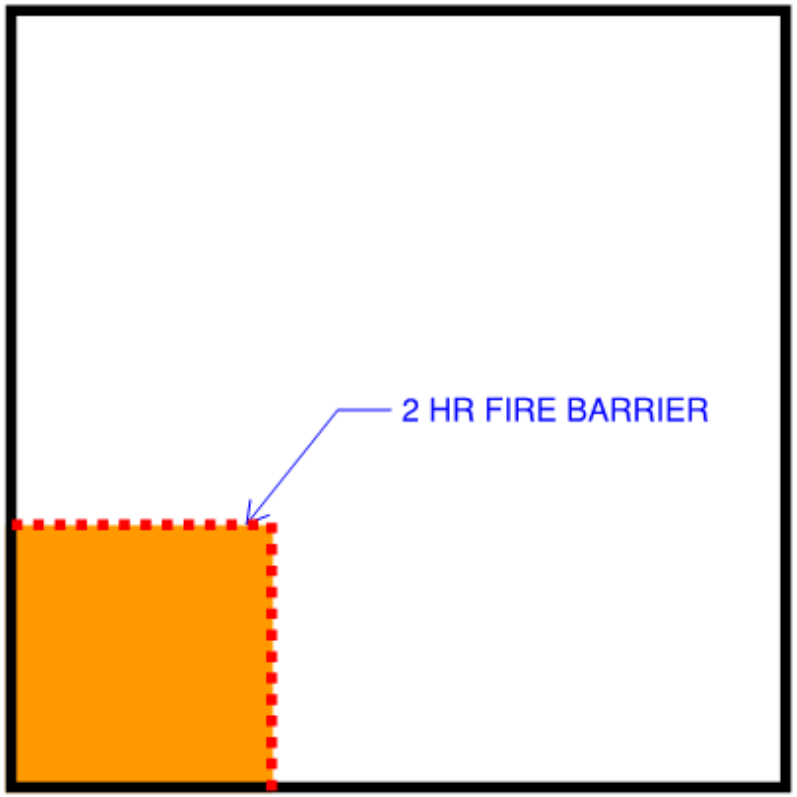
Location

Within

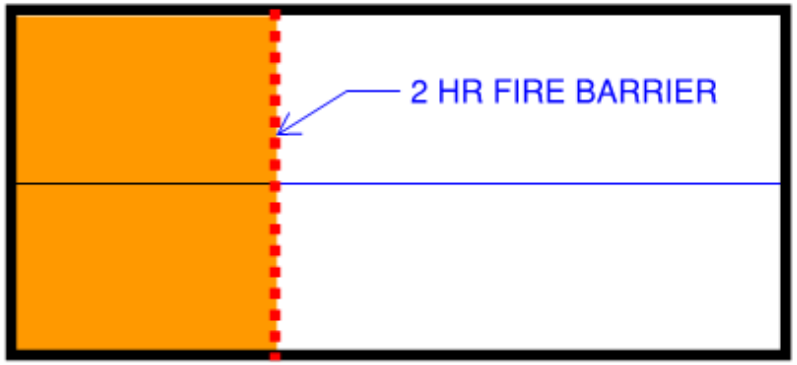


Location

Multiple levels

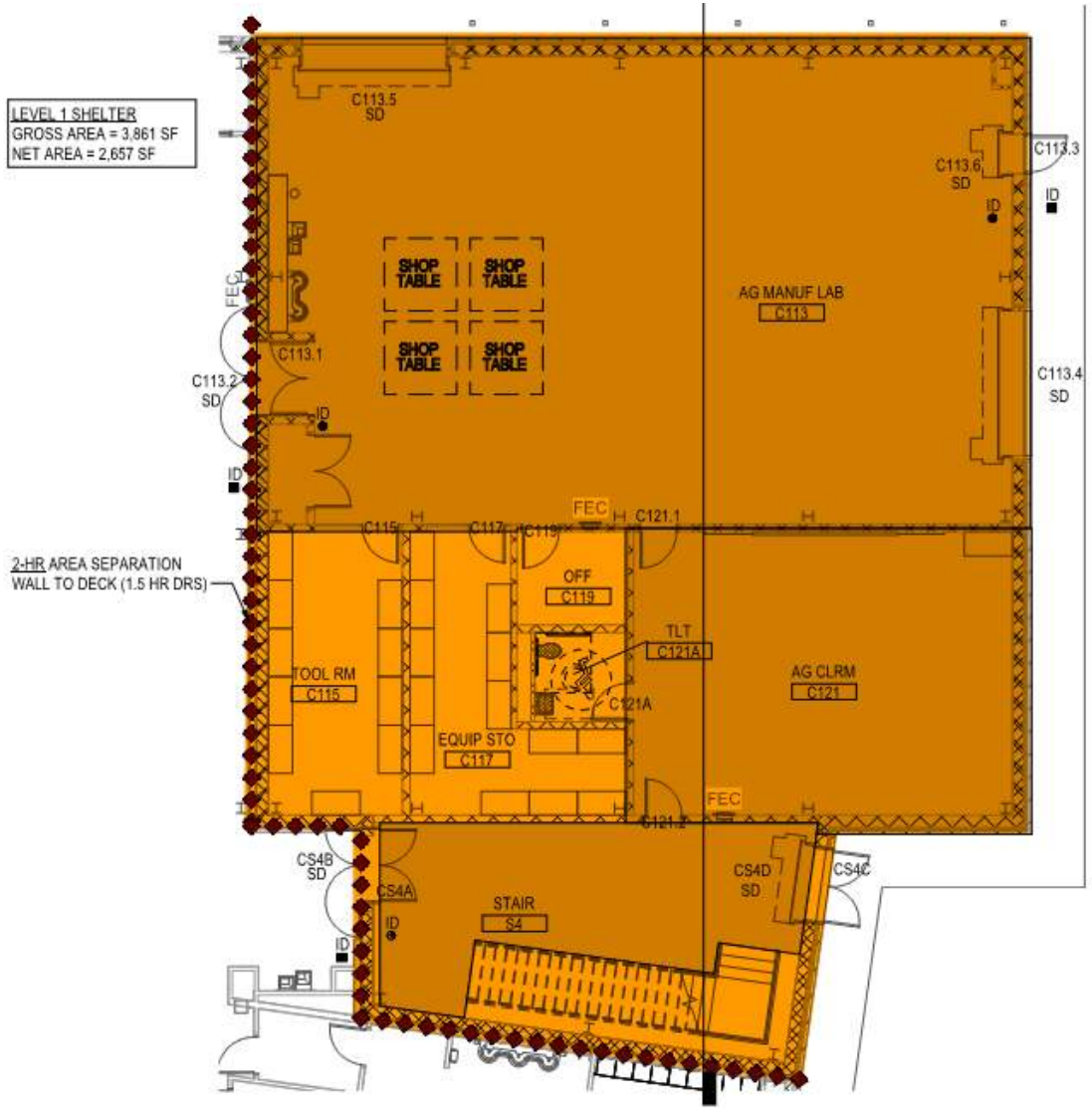


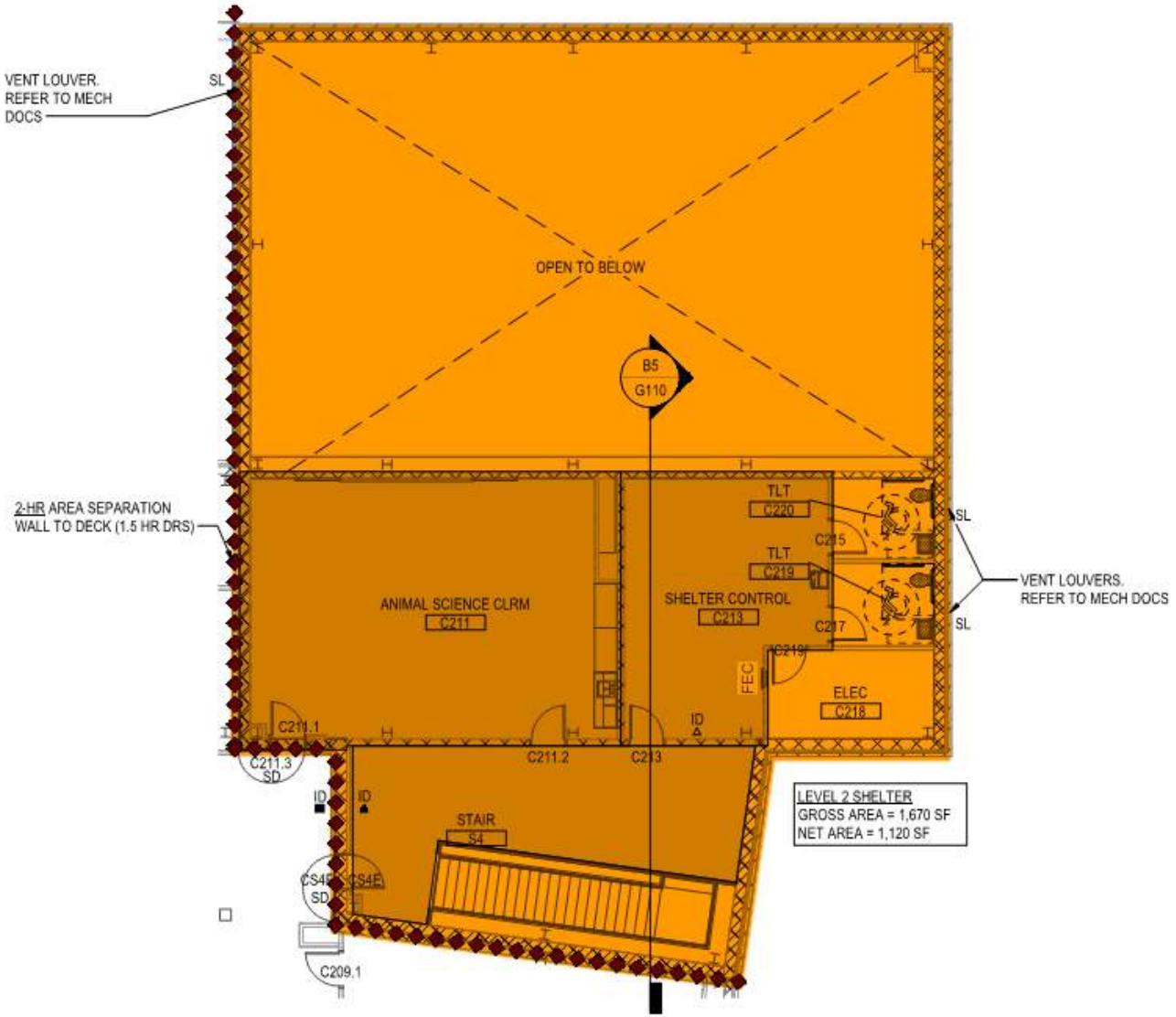
PLAN



SECTION

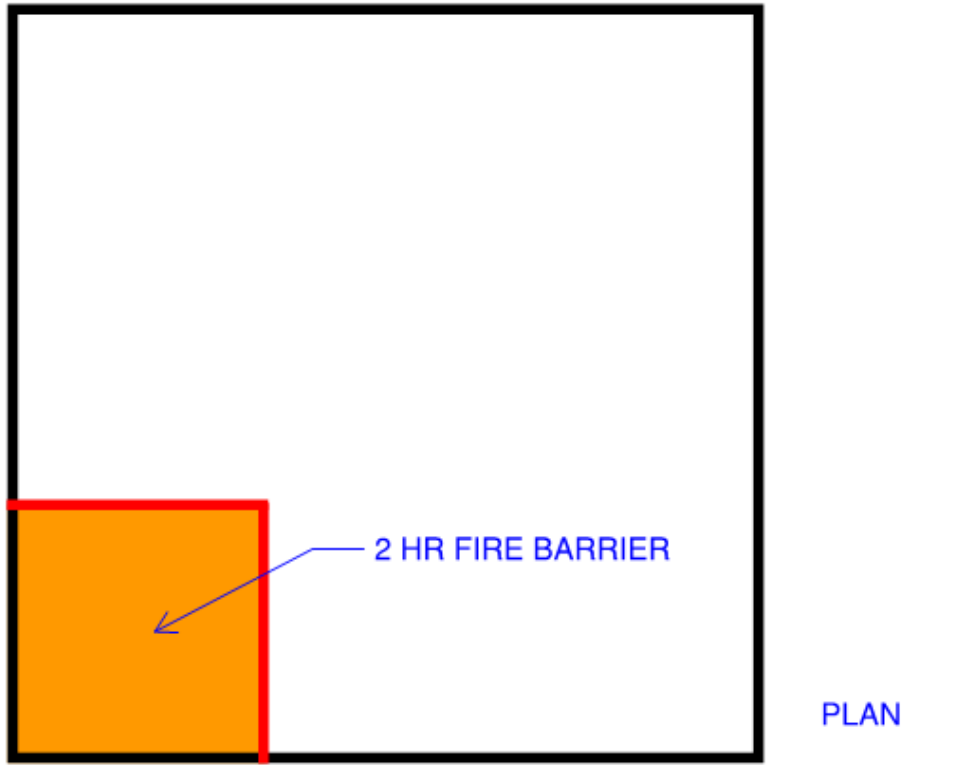
Location Multiple levels



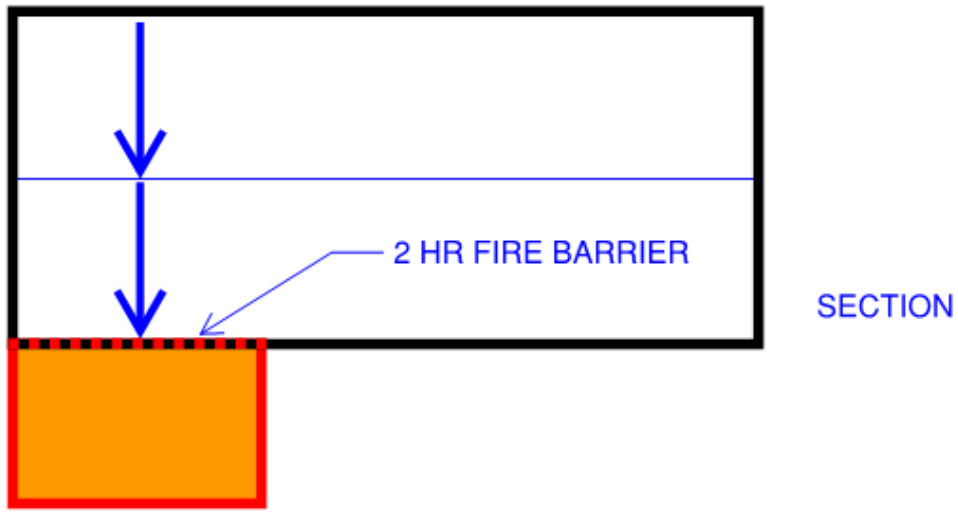


Location

Sublevel



PLAN

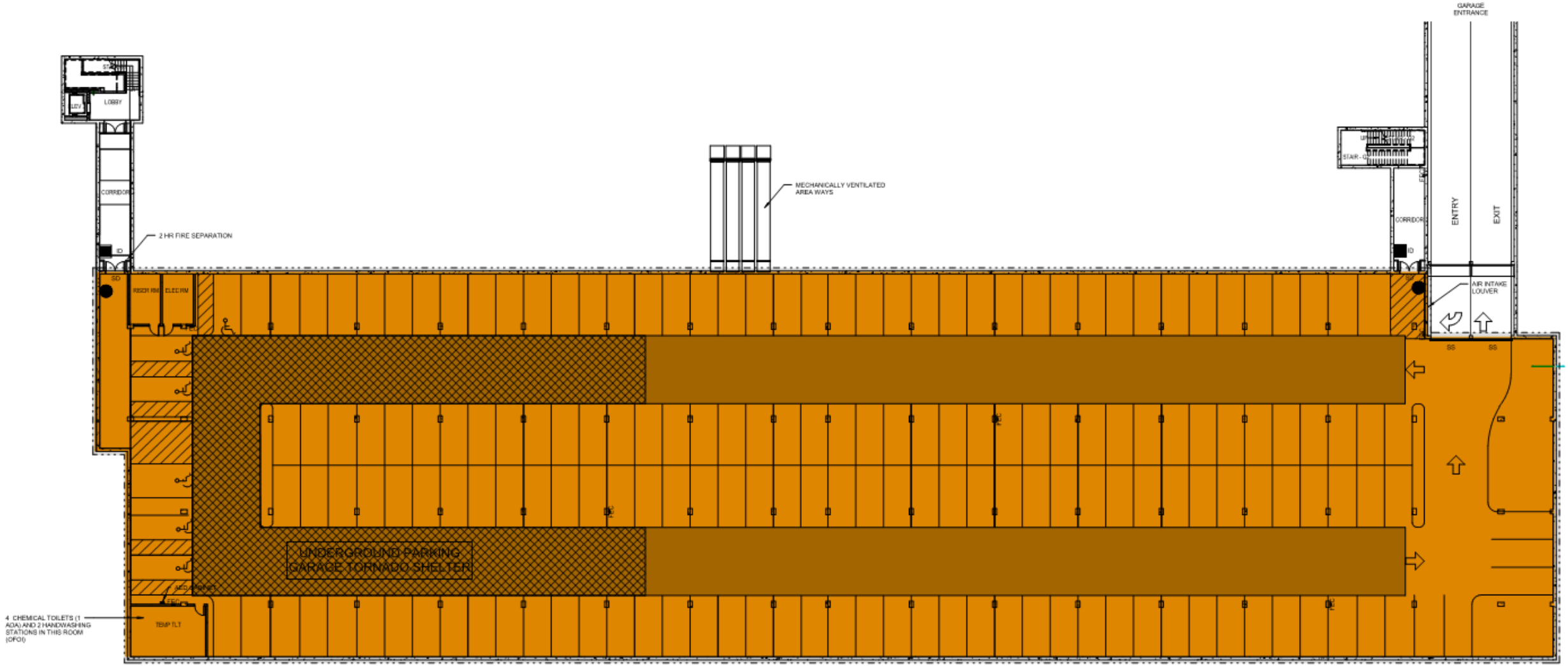


SECTION

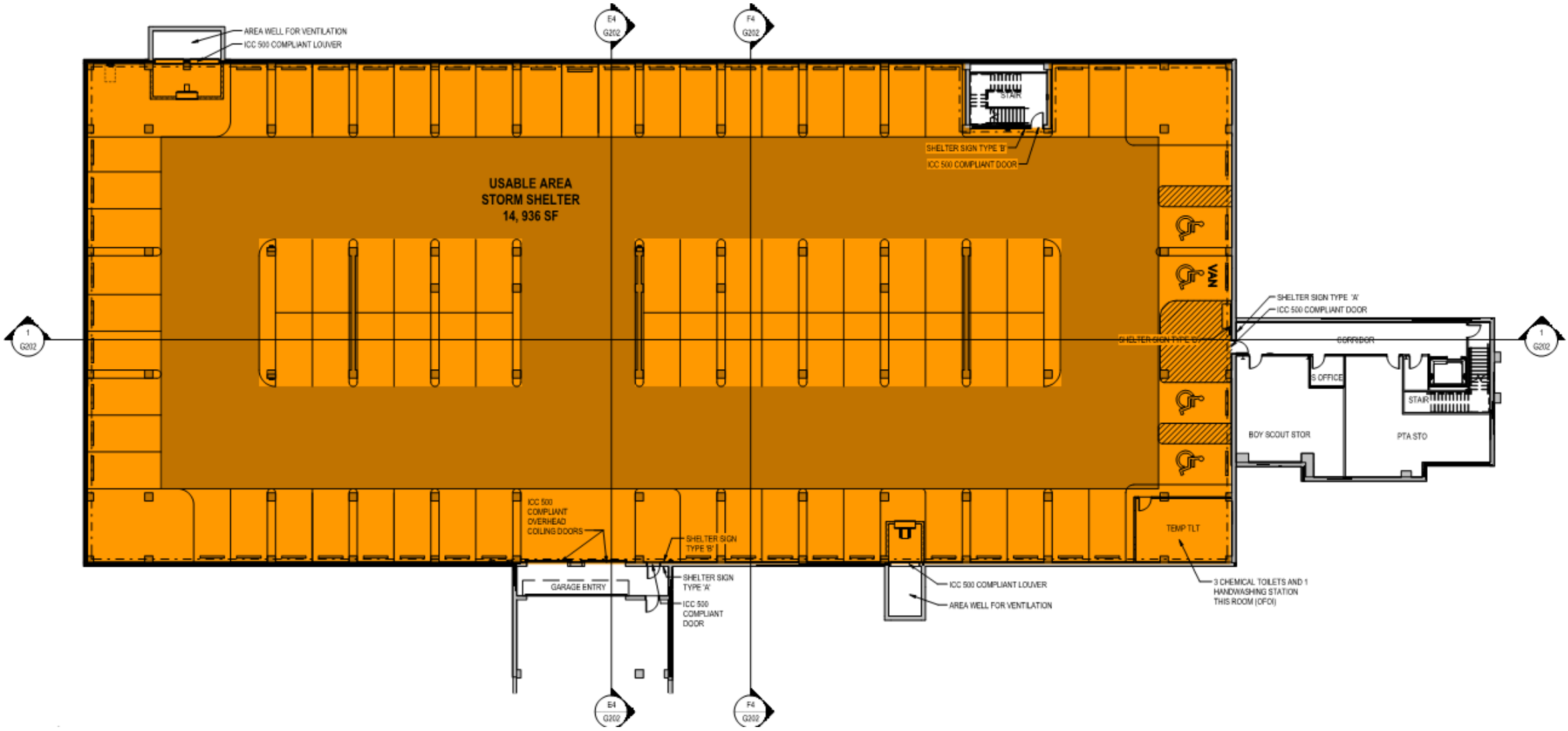
Location

Sublevel

Location Sublevel



Location Sublevel




Thank You
Stantec