B**ackground:** On February 23, 2016, the City Commission approved on first reading multiple ordinances adopting the 2015 editions of the International Code Council (ICC) model construction codes and 2014 edition of the National Electrical Code, which became effective July 1, 2016. Based on public comment and discussion during the February 23, 2016 meeting, the City Commission directed Staff to amend (for second reading) City Code Section 5-206 by deleting the new 2015 International Building Code (IBC) requirement *mandating* storm shelters for new or expanded K-12 educational facilities and critical emergency operations facilities (designed and constructed to the *ICC 500* - *ICC/NSSA Standard for the Design and Construction of Storm Shelters*). Although the previous two editions of the IBC (2009, 2012) required that *voluntarily* constructed storm shelters meet *ICC 500* standards, they did not *mandate* storm shelters for any use or occupancy type. On March 1, 2016, the amended IBC adopting ordinance was approved by the Commission on second reading.

The Commission directed Staff to further review the new 2015 IBC storm shelter requirements (and/or potential modified, alternative requirements) with/among USD 497 representatives, private school representatives, project designers, emergency operations facility owners/operators and the Building Code Board of Appeals. Recommendations for storm shelter requirement code amendments were tentatively scheduled to be reconsidered by the City Commission by the end of 2016.

Below are the 2015 IBC requirements for storm shelters. The new 2015 IBC sections mandating storm shelters in critical emergency operations facilities and educational facilities (Group E occupancies), which were not adopted and were deferred for future Commission consideration, are stricken through. The referenced *ICC 500* is a separate International Code Council standards document for the design and construction of storm shelters.

423.1 General. In addition to other applicable requirements in this code, storm shelters shall be constructed in accordance with *ICC 500*.

423.1.1 Scope. This section applies to the construction of storm shelters constructed as separate detached buildings or constructed as safe rooms within buildings for the purpose of providing safe refuge from storms that produce high winds, such as tornados and hurricanes. Such structures shall be designated to be hurricane shelters, tornado shelters, or combined hurricane and tornado shelters.

423.2 Definitions. The following terms are defined in Chapter 2: **STORM SHELTER. Community storm shelter. Residential storm shelter.**

~~423.3 Critical emergency operations. In areas where shelter design wind speed for tornados in accordance with Figure 304.2(1) of *ICC 500* is 250 MPH, 911 call stations, emergency operation centers and fire, rescue, ambulance and police stations shall have a storm shelter constructed in accordance with *ICC 500*.~~

~~**Exception:** Buildings meeting the requirements for shelter design in *ICC 500*.~~

Added staff commentary: The types of critical emergency operations facilities that are required to have shelters are those that house emergency responders or systems that a local community decides it would want to be operational after a tornado event. Most storm shelters are safe rooms within a bigger facility, and shelters can be used for other purposes during normal building operation. Examples include bathrooms or locker rooms in fire stations or police stations.

~~423.4 Group E occupancies. In areas where the shelter design wind speed for tornados 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*.~~

Added staff commentary: Lawrence (and much of the central U.S.) is located in an area with the highest minimum shelter design wind speed, 250 MPH. This is based on over 60 years of historical data showing this area (often referred to as "tornado alley" and "Dixie alley) has sustained the highest frequency of very damaging storms with very high wind speeds. Additional information and maps are included at the end of this report in the Appendix.

History of FEMA, IBC and *ICC 500* Storm Shelter Standards: Federal Emergency Management Agency (FEMA) publications giving design and construction guidance for both residential and community safe rooms have been available since 1998. Since that time (per FEMA), thousands of safe rooms have been built, and a growing number of these safe rooms have already saved lives in actual events. Information provided in the March 2015 Edition of *FEMA P-361, Safe Rooms for Tornadoes and Hurricanes*, indicates there has not been a reported failure of a safe room constructed to FEMA criteria.

The first edition of *FEMA P-361*, published in the year 2000, served as the legacy document for development of the *ICC 500*. The *ICC 500, ICC/NSSA Standard for the Design and Construction of Storm Shelters*, was produced by ICC in cooperation with the National Storm Shelter Association (NSSA). The first edition of the *ICC 500* was published in 2008 and was recently updated and republished in 2014. The original *FEMA P-361* document has been updated twice (in consultation with ICC and NSSA), in 2008 and March 2015. The March 2015 edition of *FEMA P-361* references much of the design criteria of the 2014 edition of the *ICC 500* with some exceptions, most of which are recommended criteria and best practices that exceed *ICC 500* standards.

Building Safety Division Staff Reviews with Stakeholders/Designers: In late April 2016, Staff scheduled an initial meeting with USD 497 representatives. Follow-up discussions with USD 497 were conducted in mid-May, early June and early July. During June, staff contacted the Archdiocese of Kansas in Kansas City (there are two Catholic schools in Lawrence) and the Headmaster of Bishop Seabury Academy (for which a FEMA-approved storm shelter was constructed 4-5 year ago) in regard to the 2015 IBC storm shelter requirements; both referred Staff to the local architectural firm that had designed, or was working on design, for construction projects for their schools. From late April into August, City and USD 497 Staff also contacted other Kansas school districts in which FEMA and/or *ICC 500* shelters had been constructed, and conducted additional research with ICC and FEMA.

On August 26, 2016, USD 497 Facilities Staff, the USD 497 Superintendent, representatives from Sabatini Architects and Gould-Evans (firms involved in design and construction of recent USD 497 construction projects and the FEMA-approved storm shelter in Bishop Seabury Academy) and Building Safety Division Staff met to review the new IBC storm shelter requirements for schools, discuss several key *ICC 500* design criteria and cost-drivers, and share design/research information. Key 2015 IBC and *ICC-500* (2014) requirements/design criteria discussion items identified during the August 26th meeting (and prior stakeholder meetings) are outlined in the table below, which was used for reference in subsequent review meetings. Subsequent meetings with the above-identified designers and stakeholders, and the Director of Real Estate & Construction for the Archdiocese of Kansas in Kansas City, Mr. Leon Roberts, were conducted on September 21 and October 28, 2016. Information from the August 26 and September 21, 2016 meetings was forwarded to the Director of Veritas Christian School in mid-October, 2016, who was also invited to the scheduled October 28, 2016 meeting.

2015 IBC Trigger for Design Compliance with ICC 500 (2014)	School/School Designer Concerns	Staff Comments
New construction or addition with design occupant load $\geq$ 50; shelter must be capable of housing total occupant load of the entire school.	Most classrooms have a design occ. load of 30-35, so any addition of more than 1 classroom would trigger shelter requirement for entire occ. load of school; suggested a modified trigger (e.g., area of addition is greater than 50% of existing area of school).	Staff is conducting research to determine if ICC is considering possible updates or clarifications for the 2018 IBC and/or IEBC (Existing Building Code). Staff found one proposal to ICC that suggested a 25% expansion of existing floor area as a trigger to require construction of a shelter to house entire school occ. load.
ICC 500 Design Wind Speed (2008 & 2014 Editions)[1]	USD 497 Bond Design Wind Speed for Bond Project Hardened Rooms (HR)	Staff Comment
250 MPH[1]	160 – 180 MPH (USD 497 will forward design criteria for review)	Require 250 MPH Design Wind Speed[1]

ICC 500 Occupant Design Density (2008 & 2014 Editions)		USD 497 HR Occupant Design Density		Staff Comment
Standing or seated	5 sq. ft. per occ.	Standing or seated	2 sq. ft. per occ.[2]	2-3 sq. ft. may work for elementary age, but may not work for older children. USD 497 has offered demonstration of occupancy in smaller HRs during drill/s.
Wheelchair	10 sq. ft. per occ.	Wheelchair	N/A	Require larger area (probably 10 sq. ft.) to accommodate some wheelchairs.

ICC 500 Minimum Sanitation Facilities (2008 & 2014 Editions)		USD 497 Bond Project HRs	Staff Comment
Toilets	$\leq$ 50 occupants = 1; 51 – 500 occupants = 2; 1 additional per 500 occupants or portions thereof > 500 occupants.	No requirement	Should be some sanitation facilities, since certain storms could require sheltering for well over an hour; further review and consider options.
Hand-washing facilities (sinks)	$\leq$ 50 occupants = None; >50 occupants = 1 per 1,000 occupants.	No requirement	See comment above.
ICC 500 - Independent Peer Review by a Registered Design Professional (independent from the registered design professional in responsible charge of the storm shelter design).		School/school designers concerned about cost.	2014 Ed. of ICC 500 requires for shelters for K-12 schools with occ. load > 16; 2008 Ed. of ICC 500 required for shelters with occ. load > 300.

[1]See Appendix and excerpts from FEMA P-361: Tornado Severity and Design Wind Speeds.

[2]USD 497 Staff has indicated that if an occupant design density of 5 sq. ft. per occupant had been used for certain Bond Project classroom addition projects (for which just a couple of classrooms rooms were added), and the additions were designed to serve as the storm shelter or "hardened room" for the entire school occupant load, most of those additions would have been required to be nearly doubled in size.

Critical Emergency Operations Facilities Review: In early November 2016, Staff followed up with various stakeholders to arrange a November 18, 2016 meeting to review and discuss the 2015 IBC storm shelter requirements for critical emergency operations facilities. There was general consensus that the 2015 IBC storm shelter requirements for new critical emergency operations facilities should be adopted as written.

Appendix – Excerpts from FEMA P-361: Tornado Severity and Design Wind Speeds

Tornado Severity: The severity of a tornado is categorized by the Enhanced Fujita Scale (EF Scale). Despite their rarer occurrence in comparison with weaker tornadoes, strong tornadoes are responsible for most tornado fatalities. During the period of 1950-2011, 86 percent of all tornado fatalities were caused by tornadoes rated EF3 and greater (NIST 2013). To capture tornado threat as a function of tornado severity, National Oceanic and Atmospheric Administration (NOAA) has developed maps to show areas historically subjected to the highest number of strong tornadoes. Figure A2-2 shows the areas of the U.S. with the highest frequency of recorded strong and violent tornadoes, those designated as EF3, EF4 or EF5.

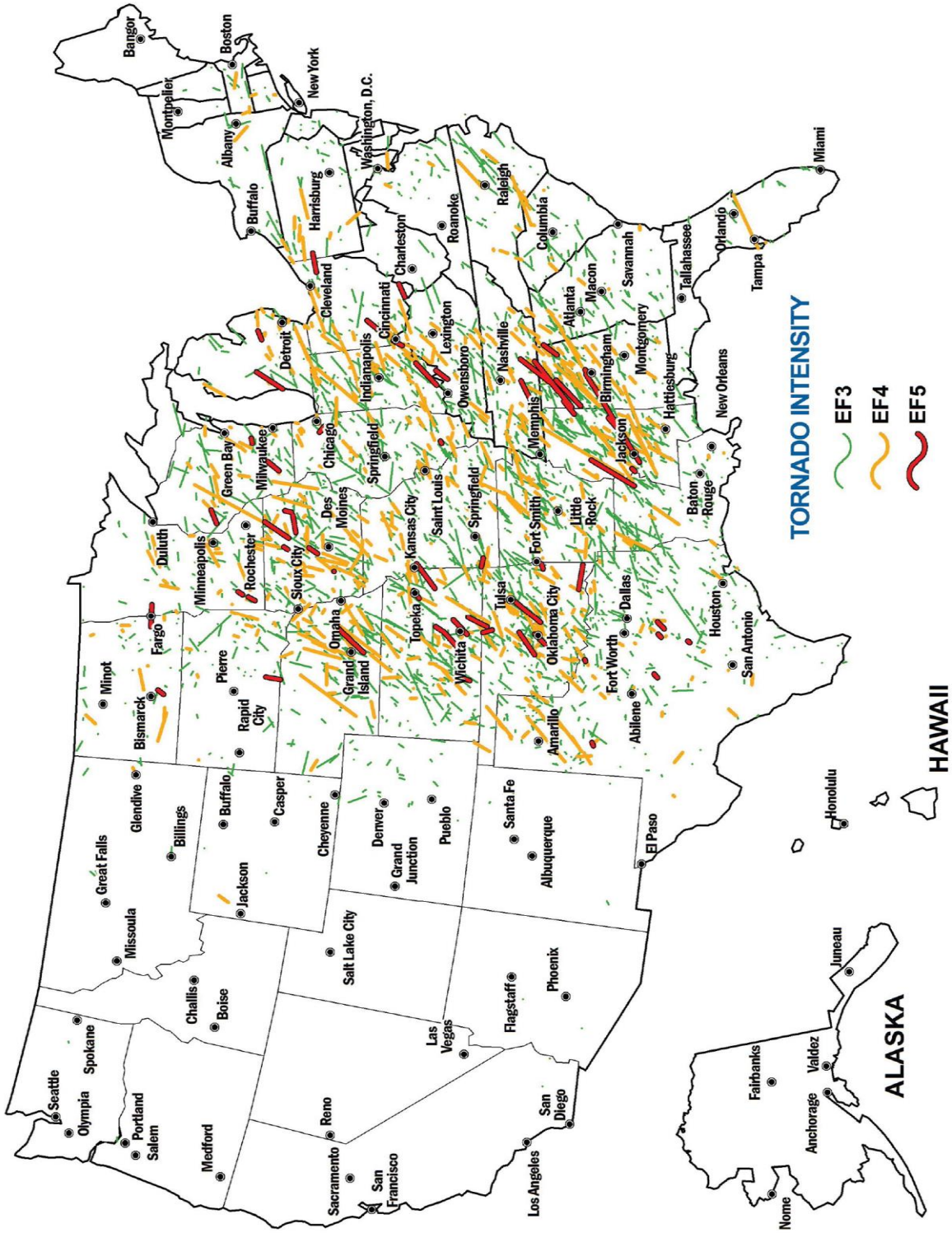
The ICC 500 tornado wind speed map (see Figure B3-1) was developed using a deterministic analysis of NOAA tornado data to correlate the mapped frequency of strong tornadoes with four tornado wind speed zones: 250 mph, 200 mph, 160 mph, and 130 mph. The higher the tornado wind speed zone associated with any given location, the greater the threat from strong tornadoes. However, the ICC 500 tornado wind speed map does not show a high level of detail and therefore the design wind speed may not be clear when a safe room is to be sited and constructed near a tornado wind zone contour line. Designers and code officials should recognize that the mapped design wind speed contour lines were not drawn or intended to be interpreted as precise geographic coordinates. When planning or designing safe rooms, designers should remember that the intended purpose of a safe room is to protect people from death or injury. Accordingly, a prudent approach would be to assume the site lies within the higher tornado wind speed zone.

Development of the Safe Room Design Wind Speeds for Tornadoes: The NOAA Storm Prediction Center data used to develop the Figure B3-1 wind speed zones covered the years 1950 through 2006. The current map is nearly identical to the first edition FEMA P-361 safe room wind speed map which was developed in conjunction with TTU using data collected from 1950 through 1998. Tornado occurrence statistics prior to 1950 are available, but they are lower quality. From 1950 through 2006, a total of 50,096 tornadoes were recorded in the contiguous United States. Each of these tornadoes was assigned an F Scale level.

To develop wind speed zones, NOAA tallied the occurrences of tornadoes between 1950 and 2006 and plotted them on a grid map of the United States composed of 80 km x 80 km squares (2,470 square miles). Tornadoes rated using the F Scale were reclassified as EF Scale events (same corresponding scale number) and the number of combined EF3, EF4, and EF5 tornado occurrences within each 2,470-square mile square was tabulated for the whole country. These frequencies of occurrence data were used to develop the location of the contours shown in Figure B3-1.

250 mph wind speed zone: The 250 mph wind speed zone (Figure B3-1) includes all 2,470-square mile grid squares with two or more EF5 tornadoes recorded between 1950 and 2006. The 250 mph zone also includes areas with 10 or more EF4 and EF5 tornado occurrences combined during this same period.

FEMA P-361, Figure A2.2. Recorded EF3, EF4 and EF5 tornadoes in the United States from 1950 to 2013. (SOURCE; NOAA NATIONAL WEATHER SERVICE, STROM PREDICTION CENTER).



FEMA P-361, Figure B3-1. Safe room design wind speed for tornadoes (SOURCE; ICC 500 FIGURE 304.2(1); USED WITH PERMISION). The darkest shaded zone covers the middle part of the United States, where the most intense tornado damage has occurred.