



A Look at School Buildings with Resilience in Mind

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"A Look at School Buildings with Resilience in Mind"



- Educational Facilities are asked to serve our communities in many ways.
 - Operational 24/7/365
 - Provide Next Generation learning opportunities
 - Provide physical and mental health and well-being
 - Community experiences within the arts, sciences and competition sports
 - Critical Facilities that provide shelter and rescue from natural and man-made disasters



"A Look at School Buildings with Resilience in Mind"



Learning Objectives:

- 1.Steps towards a threats and hazards assessment
- 2.Resilient design strategies for building systems
- 3.Resilient design strategies for site and building design
- 4.Resilient design strategies for human health and well-being protection

Resources



[C3 Living Design Project - RELi](#)
[U.S. Green Building Council \(USGBC\)](#)
[ASCE – PRISM Infrastructure Resilience](#)
[Envision - Institute for Sustainable Infrastructure](#)
[Zofnass Program for Sustainable Infrastructure \(Harvard\)](#)
[Financial System Resilience Index \(NEF\)](#)
[2030 Challenge / SB2030](#)
[International Living Future Institute](#)
[Living Future](#)
[Living Building Challenge](#)
[Autodesk](#)
[2030 Palette: Design and Planning Strategies](#)
[Disaster Safety](#)
[TornadoHistoryProject](#)
[Illinois State Geological | ISGS](#)
[Red Cross](#)

[FEMA P-320](#), Taking Shelter from the Storm: Building a Safe Room
[FEMA P-361](#), Safe Rooms for Tornadoes and Hurricanes
[FEMA-428](#), Design Safe School Projects in Case of Terrorist Attacks and School Shootings
[IBC 2015](#) – International Building Code
[ICC 500-2014](#): ICC/NSSA Standard for the Design and Construction of Storm Shelters
[NFPA 909](#): Code for the Protection of Cultural Resource
[NFPA 13](#): Standard for the Installation of Sprinkler Systems
[NIST Special Publication 1190](#)
Community Resilience Planning Guide

[ASCE 7-10](#) American Society of Civil Engineers (ASCE) 2010. Minimum Design Loads For Buildings and Other Structures.
[ASCE 24-14](#). Flood Resistant Design and Construction.
[FEMA P-750](#) NEHRP Recommended Seismic Provisions for New Buildings and Other Structures
[FEMA P-55](#). Coastal Construction Manual.
[FEMA P-908](#). Mitigation Assessment Team Report
[ICC 500](#) ICC/NSSA Standard for the Design and Construction of Storm Shelters.
[IRC](#) International Residential Code.
[NOAA](#) National Weather Service, National Hurricane Center.

Resilient Design & shared attributes



Resilience = a **unified preparedness** to withstand, adapt and recover from **Shocks** and **Stresses**

Shocks = Short-term Threats & Hazards (natural and man-made)

Stresses = Long-term Adversities (generational)

Project viewed as a **diverse system of systems**

Ability to **bounce back** from adversities

Ability to **thrive forward** through

- Learning
- Adapting
- Changing

Shocks: short-term threats & hazards



Natural	Technological	Human-Caused
Avalanche	Airplane crash	Biological attack
Animal disease outbreak	Dam Failure	Chemical attack
Drought	Levee Failure	Cyber incident
Earthquake	Mine accident	Explosives attack
Epidemic	Hazardous materials release	Radiological attack
Flood/Flash Flooding	Power failure	Sabotage
Hurricane	Radiological release	Active shooter
Landslide	Train derailment	
Pandemic	Urban conflagration	
Tornado		
Tsunami		
Volcanic eruption		
Wildfire		
Winter storm		

Stresses: Long Term Adversity & Hardship

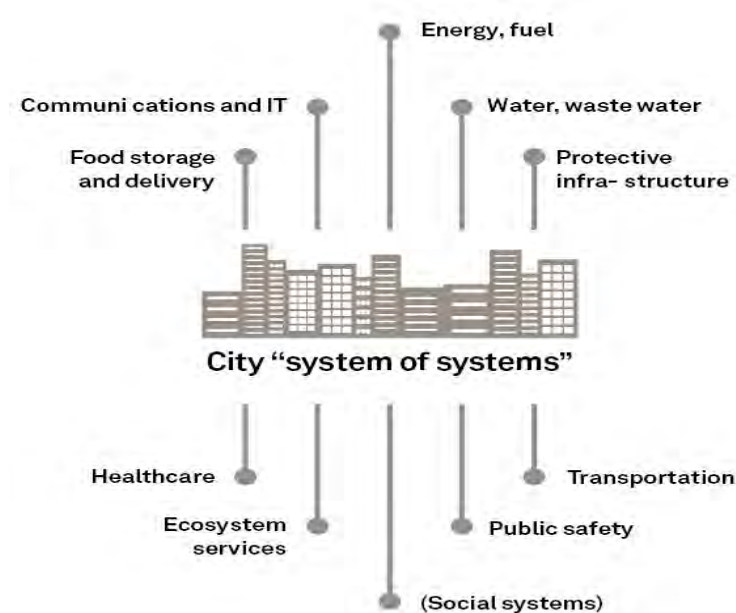


Natural	Technological	Human-Caused
Climate Change	Hazardous materials release Historical power failure Radiological release Aging Infrastructure	Decreasing population/Unemployment Increasing population/Affordable housing Socioeconomic divisions

Systems Thinking



- **Multiple Systems** make up the Structure for the whole project.
- The **interactive relationships** between multiple system **elements** and the **holistic system** enable a project to achieve resilience.



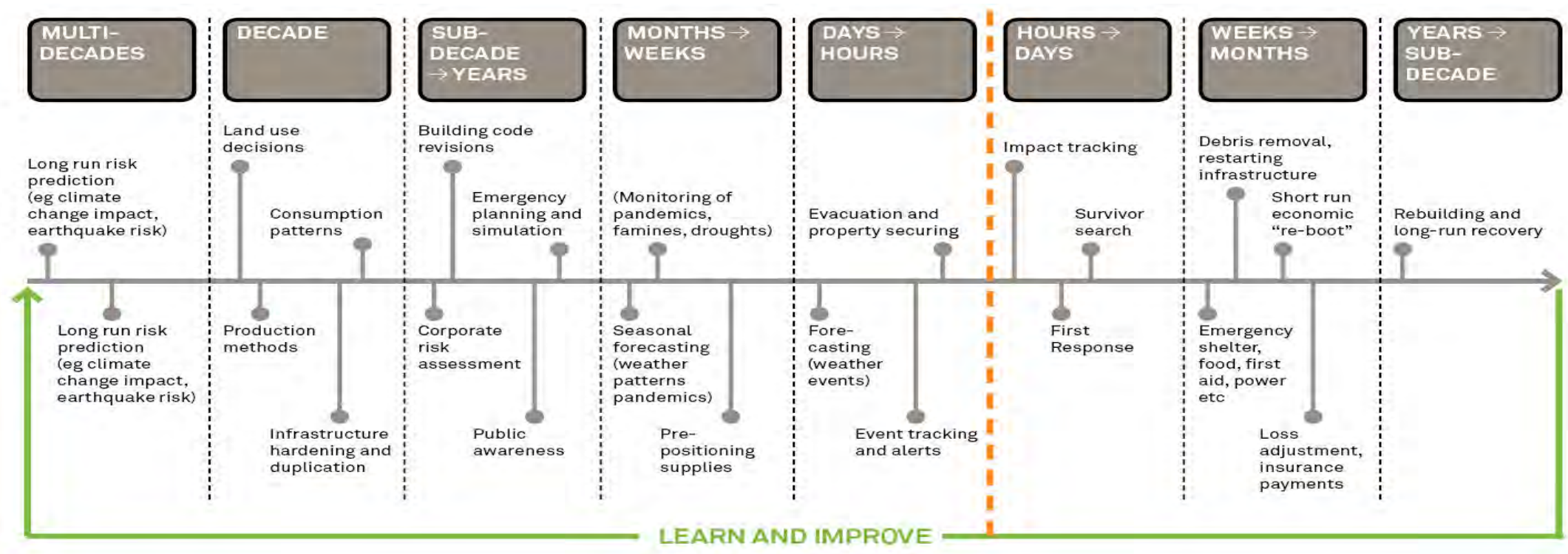
Integrative Design Approach



- View project as a living-system
- Redundancy and diversity
- Assemble the best team (co-learners)
- Engage the Owner (Goal Setting Session)
- Align around common goals
- Pick a Performance Metric
- Looking at Cost and Schedule
- Research
- Look for synergies
- Maximizing efficiencies and decision making



Resilience is a process



Resilient Design

& shared attributes



- **How can educational facilities become resilient contributors within their community?**
- **What are the core concepts for designing a resilient building?**



Task #1 – IDENTIFICATION & ASSESSMENT

- **Identify relevant Shocks** – Threats & Hazards (deliberate and natural)
- **Identify relevant Stresses** – Long-term adversities
- **Assemble a Threats & Hazards Assessment**



Task #1 – IDENTIFICATION & ASSESSMENT

How do we do this? Use your resources:

<https://www.fema.gov/national-preparedness-system> (national preparedness- CPG 101)

<https://www.fema.gov/national-preparedness-system> (national preparedness- CPG 201)

www.disastersafety.org (natural shocks)

www.fema.gov (flood risk maps)

<http://www.noaa.gov/> (floods, tornados, hurricanes, earthquakes)

<https://gacc.nifc.gov/> (USDA – wildfires)

www.airnow.gov (EPA)

<http://www.tornadohistoryproject.com/tornado/Texas/2016/map>



Discover the risks you face.

Click your state on the map
or enter your Zip Code below.

Results highlighted below ↓



FLOOD EDUCATION MAPPING TOOL

FLOOD EDUCATION MAPPING TOOL | ABOUT THE TOOL | FAQs | HCFCFD.org



ADDRESS SEARCH [HELP](#)

e.g. 9900 Northwest Fwy., Houston, TX 77092

MAP VIEW OPTIONS - Select One

☒ **Mapped Floodplains**

Floodway

1% (100-year) Floodplain

0.2% (500-year) Floodplain

1% (100-year) Coastal Floodplain

☐ **Watersheds (color-coded)**

Ponding

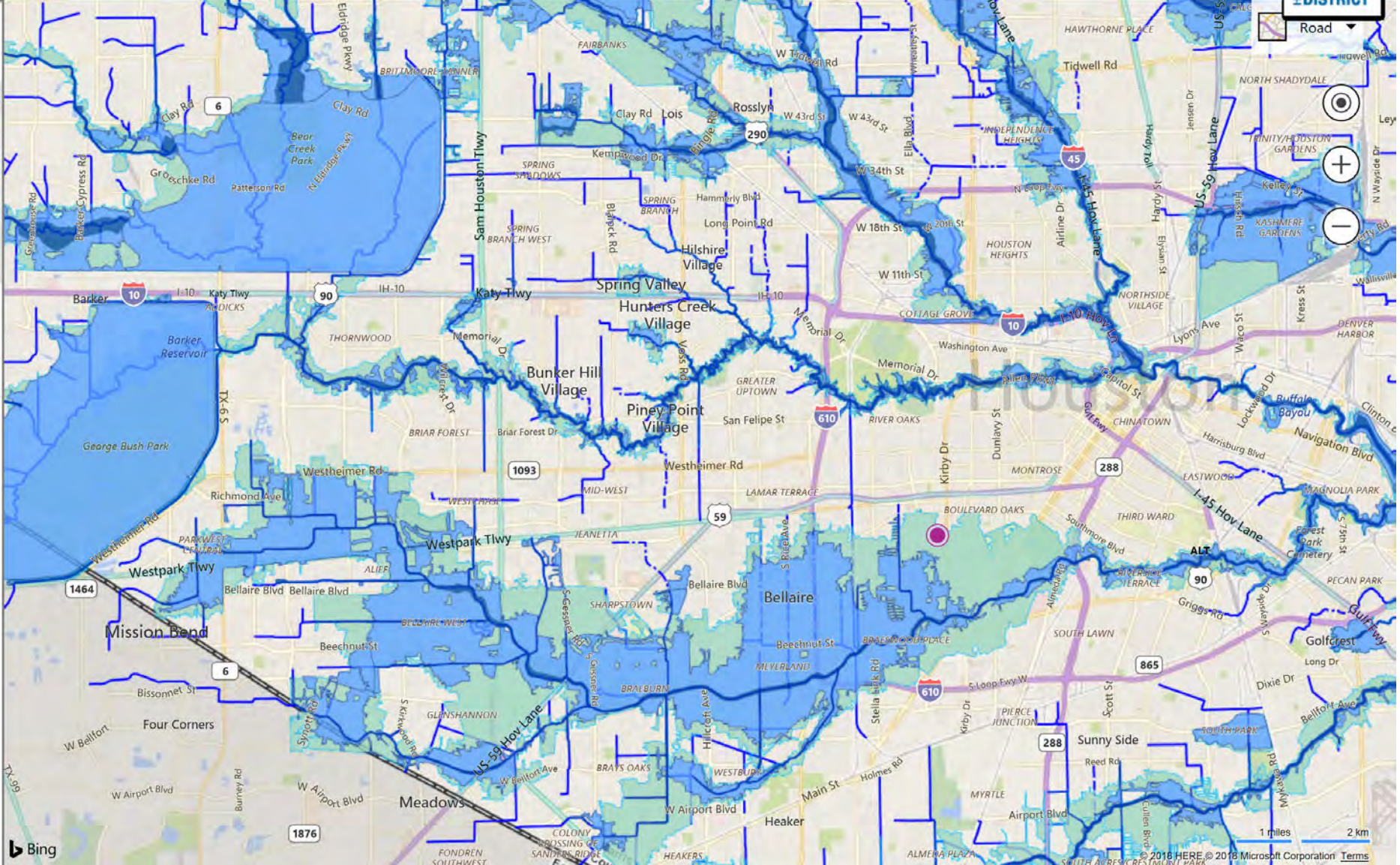
☒ **Channels (Bayous and Creeks)**

Open Channels

Enclosed Channels

☒ **Harris County Boundary**

[Reset to County-Level View](#) [Disclaimer](#)



An interactive mapping tool of the Harris County Flood District

Tornadoes in Texas in 2016

Year

2016

Month

all

Day

all

State

Texas

Fujita

all

County

all

Submit

Map

Table

Export

Source

100 tornadoes found

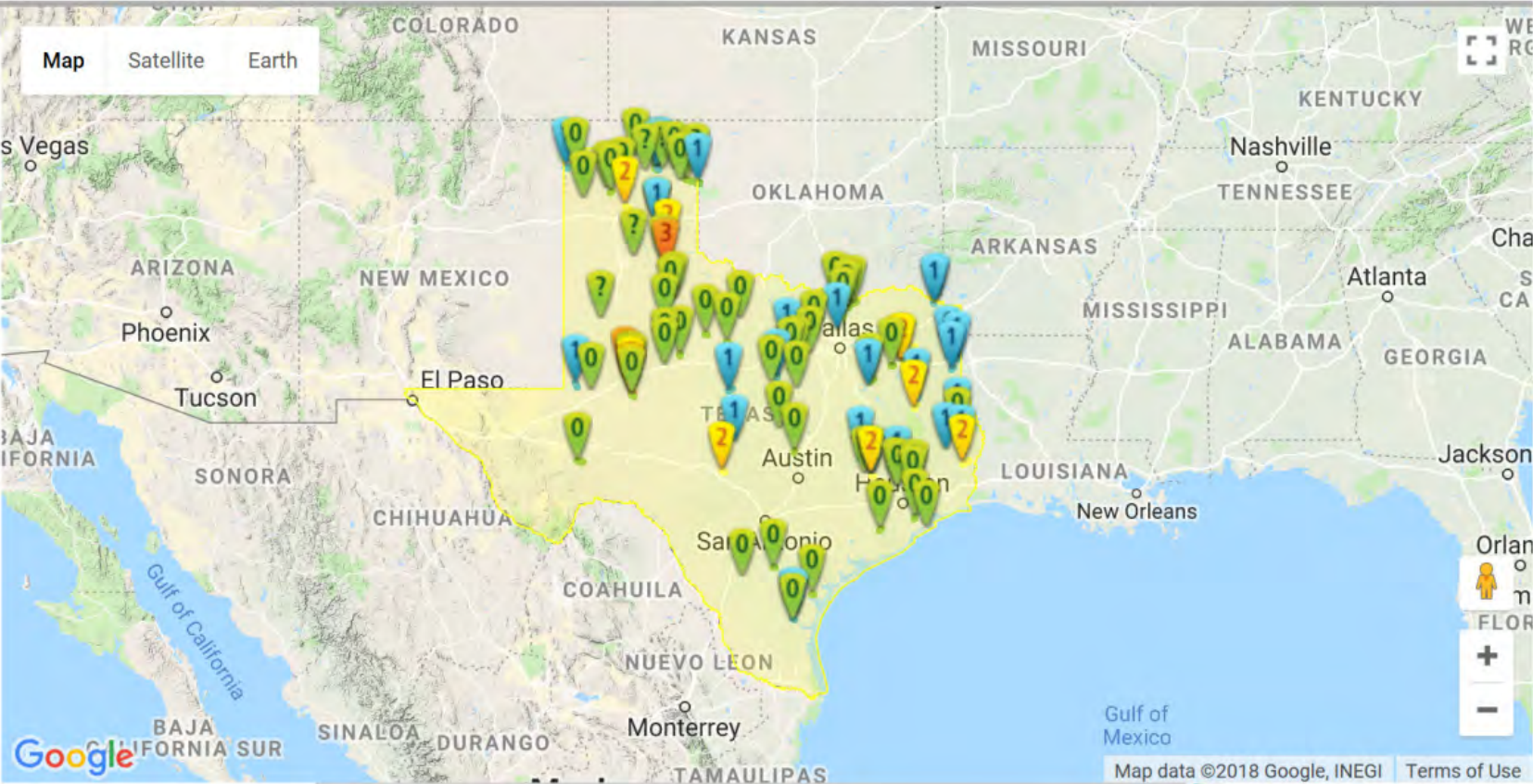
Custom Controls

- Show Tornadoes☒
- Show Tornado Paths☒
- Show Polygons [?]☒

Disclaimer [?]

Related Searches

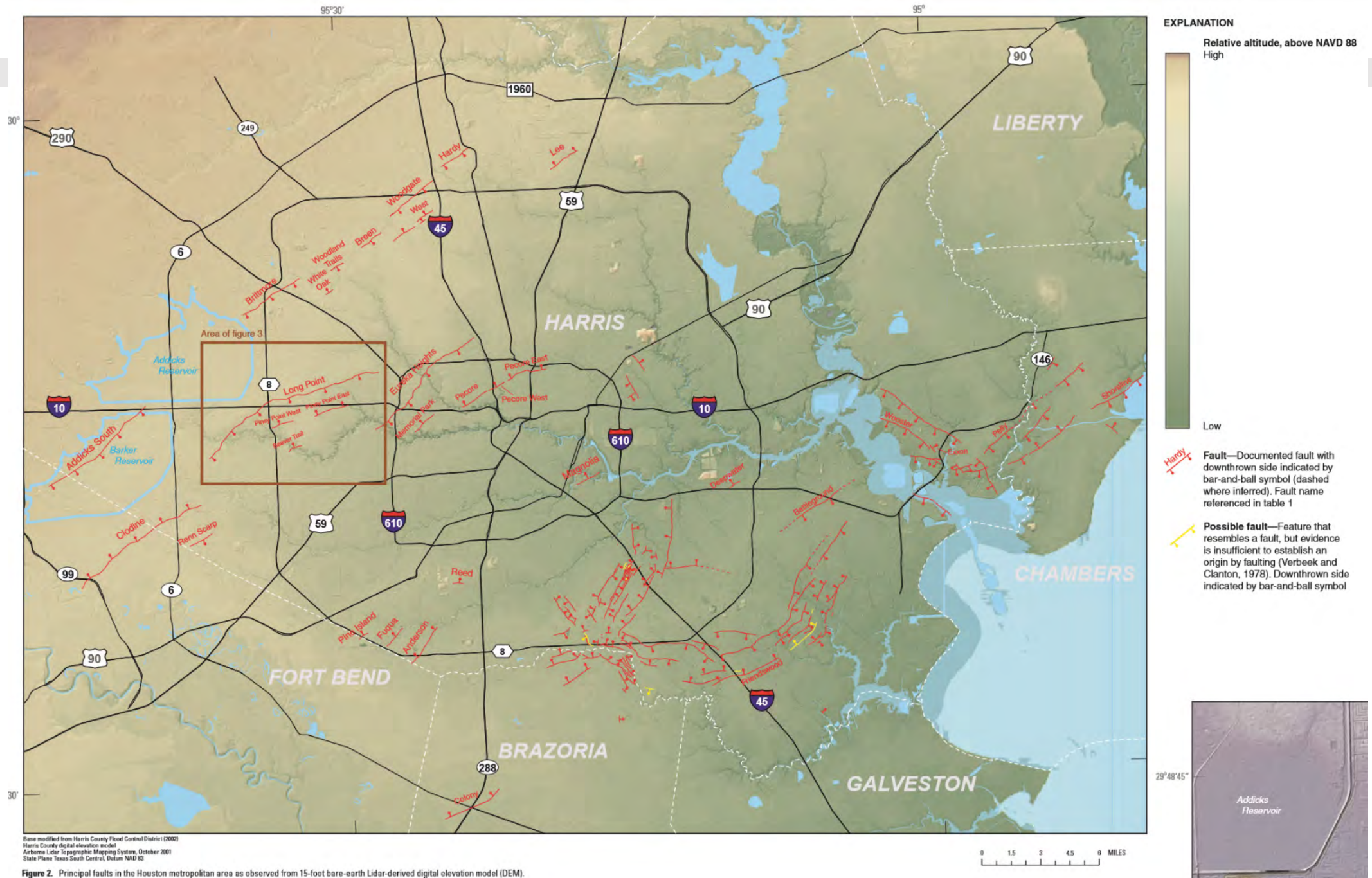
- Texas
- Texas, 2016
 - Texas, 2015
 - Texas, 2014
 - Texas, 2013
 - Texas, 2012



Summary Definitions [?]

Date(s) (yyyy-mm-dd)	Tornadoes	Fatalities	Highest Fatalities	Injuries	Highest Injuries	Longest Path	Widest Path
2016-02-23 - 2016-09-17	100	1 person	1 person	10 people	5 people	25.94 miles	3221 yards

User Comments (0)





Zip Code: Zip Code

Go

State

Texas

Go

My Current Location

Texas Commission on Environmental Quality (TCEQ)

More Maps

! Action Day

Inter-Tribal Environmental Council

Good



NFPA Threats Assessment

POTENTIAL THREATS ASSESSMENT

	N/A	Likelihood of Occurrence			Potential Severity		
		Low	Moderate	High	Low	Moderate	High
Unintentional Act							
Fire/explosion	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Health emergency	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Hazardous material spill or release	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Transportation accident	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Intentional Act							
Terrorism	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cyber attack	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Arson	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Theft	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Vandalism	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Sabotage	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Civil disturbance, public unrest, mass hysteria, riot	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Strike	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
System Failure							
Loss of electricity	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Water leak	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Building collapse/structural failure	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Fuel shortage	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Communications system interruption	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Air/water pollution contamination	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Water control structure, dam, or levee failure	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
HVAC system failure	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Loss of protection systems	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Geological							
Earthquake	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Tsunami	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Volcano	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Landslide/mudslide	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Biological							
Pandemic disease	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Animal or insect infestation	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Meteorological							
Flood, flash flood, seiche, tidal surge	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Drought	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Wild fire (forest, range, urban)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Snow, ice, hail, sleet, avalanche	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Windstorm, tropical cyclone, hurricane, tornado, water spout, dust/sand storm	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Extreme heat/cold	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Lightning	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

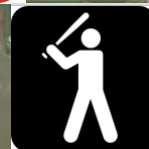
- What is the likelihood of occurrence?
 - Historical Data
 - Prevalence
- What is the potential severity?
 - Overall impact
 - Disruption to critical infrastructure
 - Recovery

NFPA 909, Code for the Protection of Cultural Resource Properties
- Museums, Libraries, and Places of Worship



Task #2 – CONTEXT & EFFECTS

- Describe Threats & Hazards of concern, showing how they may affect the community
 - What are the different impacts depending on the time, place, and conditions?
 - What have been past experiences with threats and hazards?
 - How might future experiences with threats & hazards differ due to changes in demographics, climate, and the built environment?
-
- | | |
|---|---|
| <ul style="list-style-type: none">• What is the estimated recovery time?<ul style="list-style-type: none">• Past experiences• Recovery sequence | <ul style="list-style-type: none">• What is the estimated cost?<ul style="list-style-type: none">• Materials to restore & adapt• Manpower |
|---|---|



Google

Assessment Matrix



SHOCK	STRESS	LIKELIHOOD (1-3)	IMPACT (1-3)	RECOVER TIME (hrs-days)	COST (1-3)	IMPORTANCE FACTOR (1-3)
Flooding		3	3	14 days	3	3
Earthquake		1	1	~	1	1
Tornado		1	2	30 days	2	2
	Air Pollution	2	2	~	2	2
Electricity Loss		1	1	4 hrs	1	1
Cyber Terrorism		1	2	24 hrs	2	2
Intruder		1	3	8 hrs	3	3
	Social Division	3	3	~	3	3



Task #3 – TAKE ACTION

- Strategies for Existing Buildings
- Strategies for New Construction

Prevention, Protection, and Mitigation / Response and Recovery

Emergency Preparedness Planning

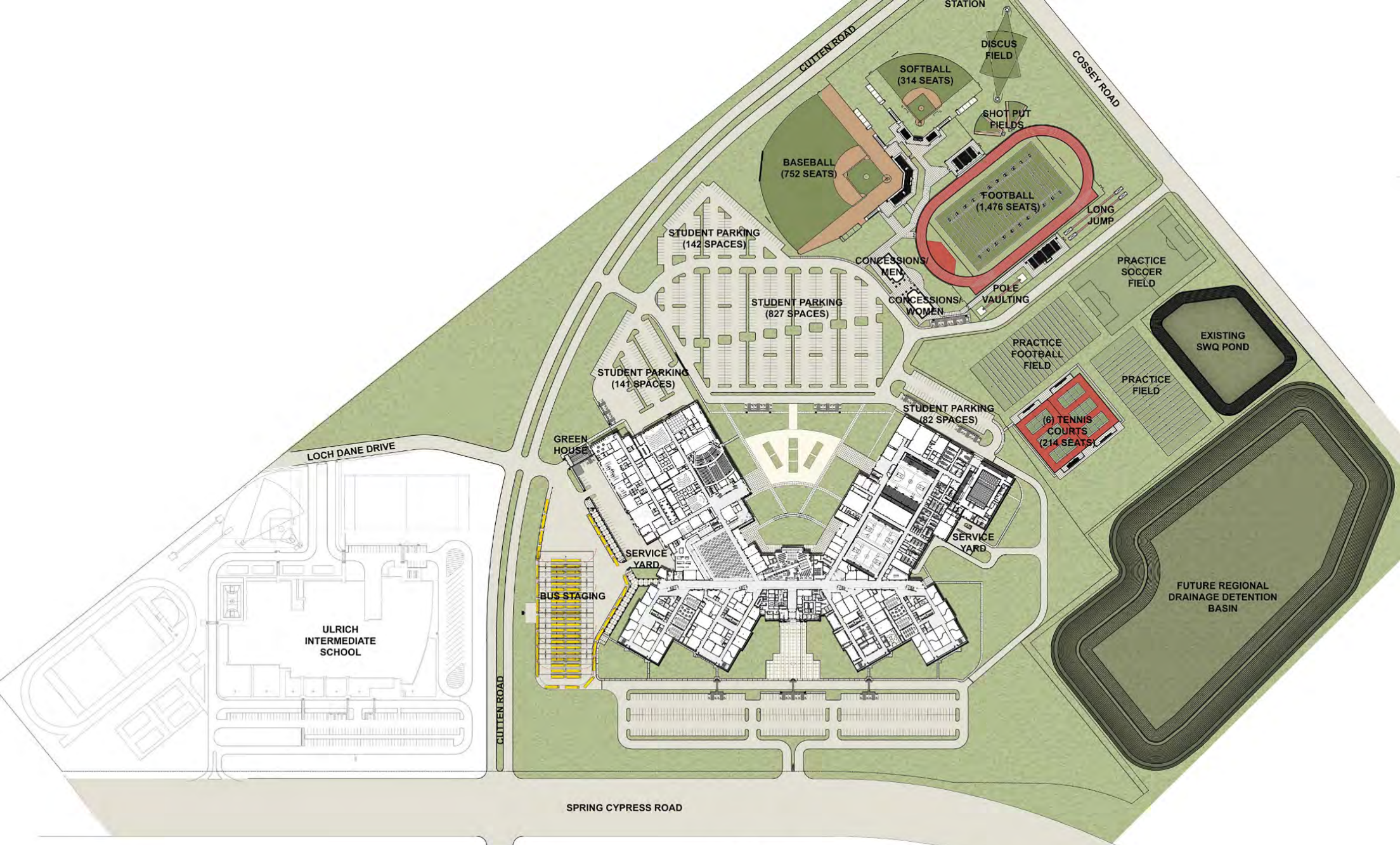


For Common Hazards and Extreme Events

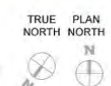
- Develop **Emergency Operations Plan (EOP)** that outlines actions to be taken in the event of a crisis
 - Fire/Evacuation
 - Lockdown during acts of violence
 - Tornado/Severe Weather
 - Shelter in Place
 - Reverse Evacuation
- Communications
 - Emergency alert systems & Tornado sirens
 - Wi-Fi & Cellular networks
 - Radio
 - P.O.T.S. Phone
 - Satellite Phone

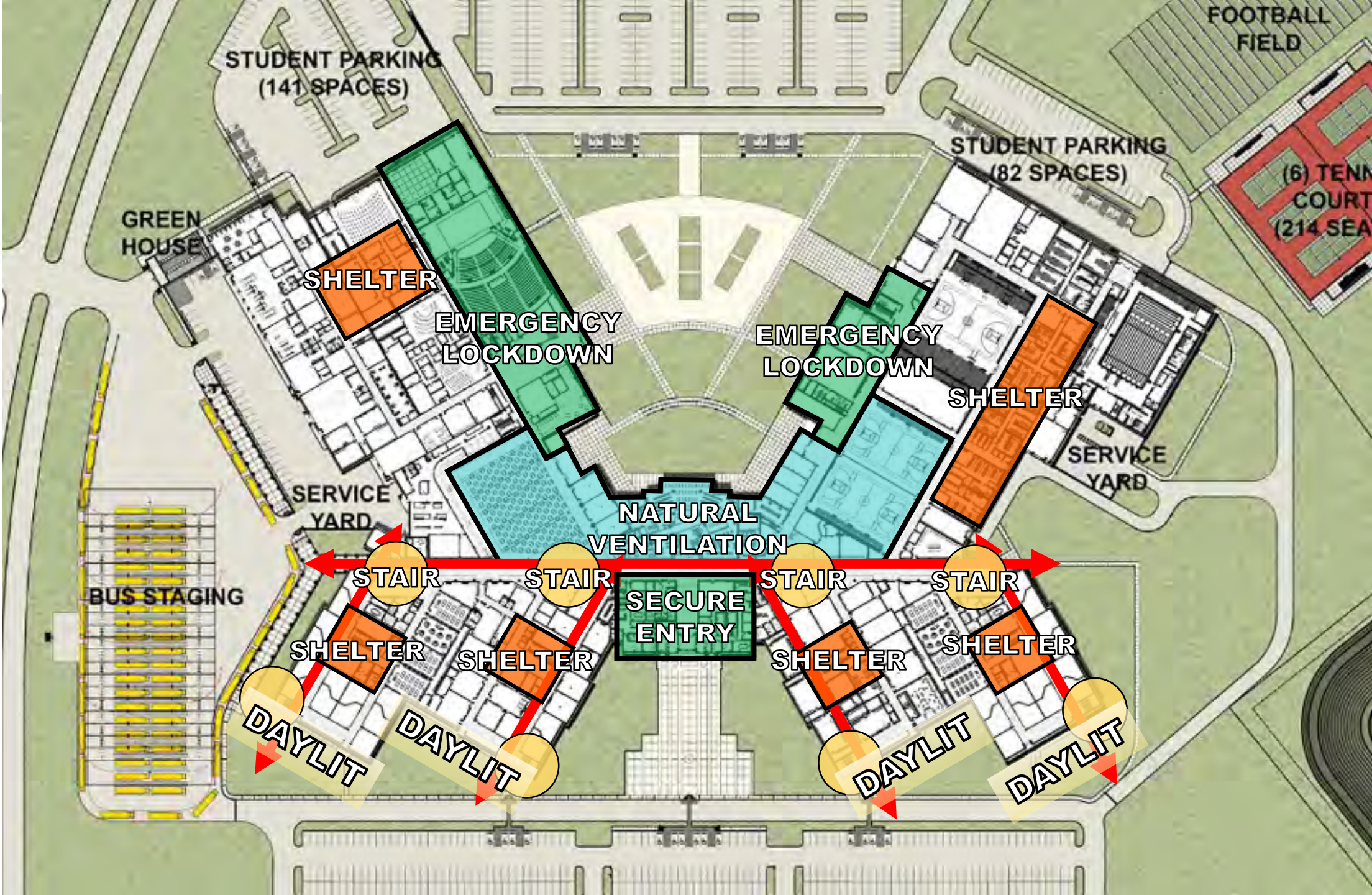


(The ability of a community to accelerate the recovery process begins with its efforts in pre-disaster preparedness)



Site Plan









Preferred Sites

Flood plain

- Avoid sites located in the 100-year flood plain
- Protect critical structures from the 500-year flood elevation
- Provide flood protection for existing buildings below 500-year flood elevation
- Avoid Coastal Zones inundated by 2'-6" of sea level rise or greater
- Locate electrical and mechanical equipment above the 500-year flood plain

Site Geology, Ecology, Biodiversity

- Avoid developing on green field sites
- Avoid sites located in environmentally sensitive areas
- Avoid sites with fault zones
- Prevent surface/ground water contamination (reduce pesticide/fertilizer reliance)
- Protect or Restore native habitats
- Protect or Restore/Create species biodiversity

Quality access to essential community operations and amenities

- First response
- Multiple points of access
- Multi-modal transportation

Site Selection

SITE DATA

SITES	Size	LAND COST		SHARED		Neighbors	Distance	Access	UTILITIES					Project Fit	Topography	Flood Plain	Features	1275%	Ranking
		Cost	Cost / Acre	Facilities	Curriculum				Electric	Gas	Data	Sewer	Water					Score	
1. E. Bishop Rd.	62	\$1,566,700	\$25,269	None	None	None	3	Tertiary	-	-	-	-	-	-	Flat	None	Stream	1.10	9
2. Veterans Dr.	70	\$3,500,000	\$50,000	None	None	None	2	Primary	3-ph	4H	Cable	8	10	2	Flat	None	None	1.88	5
3. N Cactus Lane	58	\$2,030,000	\$35,000	Ball & Park	Hospital	Highway / Hospital	3	Second	3-ph	0	0	0	0	3	Slight	None	None	1.61	6
4. 11255 N Sparrow Lane	119	\$2,000,000	\$16,807	None	None	None	4	Tertiary	-	-	-	-	-	-	Slight	Adjacent	River	0.90	15
5. O Tolle Lane	56	\$340,000	\$6,071	None	None	Rail/Airport	2	Primary	3-ph	4H	cable	8	6	2	Flat	Adjacent	Stream	2.06	3
6. 11251 E Ambassador	48.5	\$1,700,000	\$35,052	None	None	Rail/ Highway	3	Primary	-	-	-	-	-	-	Flat	None	Lake	0.86	16
7. 22 Fairway Drive	78	\$950,000	\$12,179	None	None	None	2	Tertiary	-	-	-	-	-	-	Rolling	Flood Way	Lake	0.98	11
8. 42n & Richview Rd	71	\$700,000	\$9,859	None	None	Rail/ Highway	2	Primary	3-ph	10L	cable	8	6	2	Slight	Adjacent	None	2.25	2
9. Wells By Pass	38	\$1,364,760	\$35,915	None	None	Rail/ Highway	3	Primary	-	-	-	-	-	-	Slight	None	None	0.98	11
10. E Violet Rd.	37	\$138,525	\$3,744	None	None	None	6	Tertiary	-	-	-	-	-	-	Slight	Adjacent	None	1.12	8
11. County Farm Rd	77	\$246,400	\$3,200	None	None	None	4	Tertiary	-	-	-	-	-	-	Rolling	Adjacent	None	1.14	7
12. Robin & Stratford	35	\$132,050	\$3,773	None	None	None	7	Tertiary	-	-	-	-	-	-	Flat	None	None	1.06	10
13. 13235 E Oakton	40	\$120,000	\$3,000	None	None	None	4	Tertiary	-	-	-	-	-	-	Hilly	Adjacent	None	0.94	13
14. N McCauley Lane	25	\$110,000	\$4,400	None	None	None	3	Tertiary	-	-	-	-	-	-	Hilly	None	None	0.92	14
15. Veterans Dr.	40	\$1,200,000	\$30,000 *	Ball & Park	Hospital	None	3	Primary	3-ph	4H	fiber	12	8	2	Flat	Adjacent	None	1.96	4
16. Wells By Pass	60	\$1,500,000	\$25,000	None	None	Rail/ Highway	3	Primary	3-ph	4H	fiber	12	8	2	Slight	None	None	2.41	1
17. Veterans Dr.	50	\$1,750,000	\$35,000 *	None	Hospital	None	3	Primary	3-ph	4H	fiber	12	8	2	Flat	Adjacent	None	1.98	4

* estimated

WEIGHTING OF CRITERIA

Ranking	Size
3	55
2	70
1	50
0	45

Cost/Acre	Facilities	Curriculum
\$10,000	Ball & Park	Hospital
\$20,000	Ball Fields	
\$30,000	Parking	
\$35,000	None	

Dist.	Access	Elec.	Gas	Data	Sewer	Water
1	Primary		4H 8M	Fiber Cable	12	12
2	Second	3-ph	10L	T1	8	8
3	Tertiary			DSL	6	6
4	None				4	4

Topo	Flood Plain
Slight	None
Rolling	Adjacent
Flat	Flood Way
Hilly	

Plan the Site



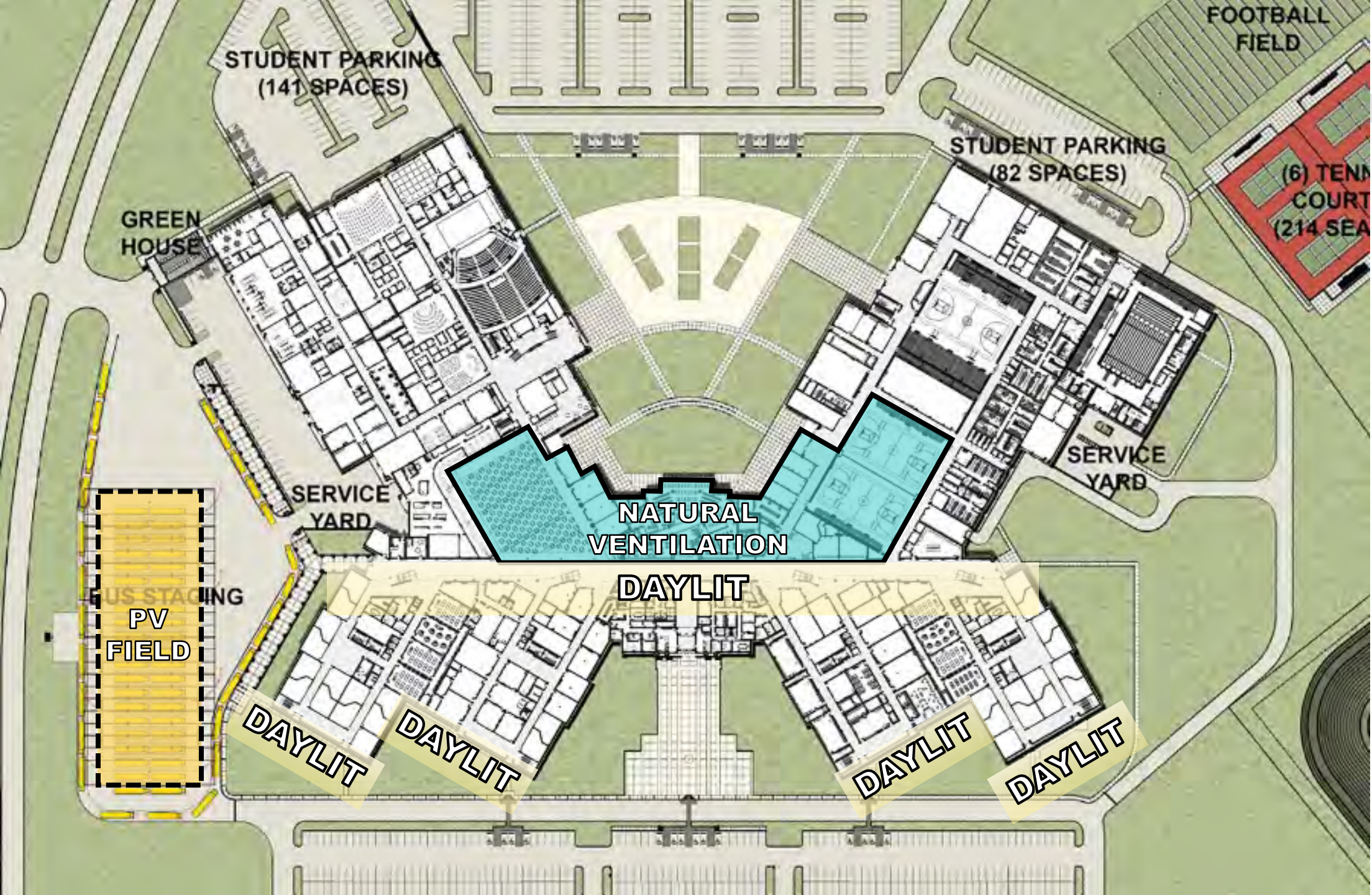
Building Orientation
Passive/Active
Solar Strategies



Renewable Energy
Solar



Carbon Neutrality



STUDENT PARKING
(141 SPACES)

GREEN
HOUSE

STUDENT PARKING
(82 SPACES)

FOOTBALL
FIELD

(6) TENN
COURT
(214 SEA

SERVICE
YARD

SERVICE
YARD

NATURAL
VENTILATION

DAYLIT

BUS STAGING
PV
FIELD

DAYLIT

DAYLIT

DAYLIT

DAYLIT

Low Impact Development

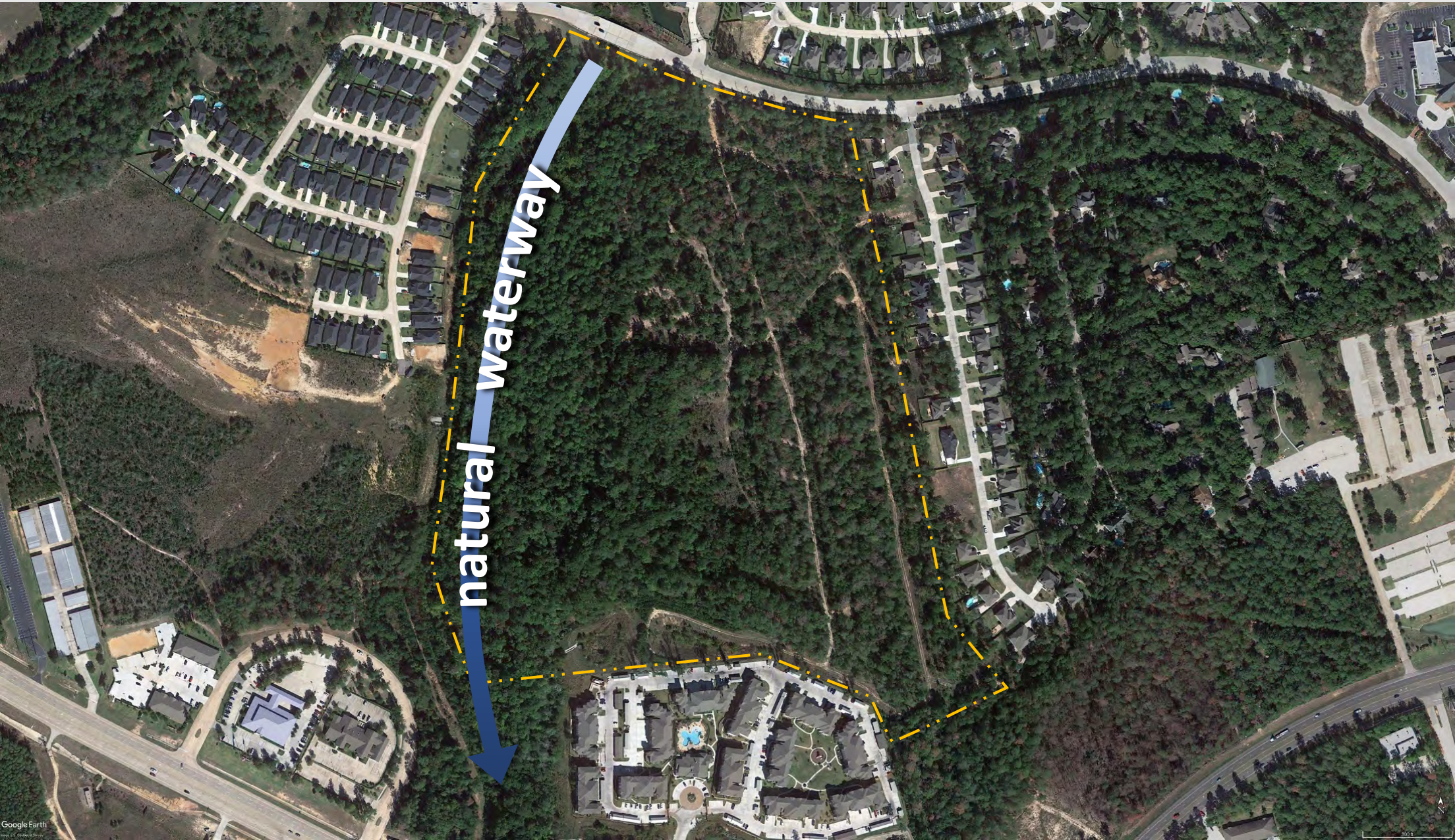


- Protect/Restore **natural features** & **native habitats**
- Protect/Restore natural drainage patterns
- Protect **prime farmland** and floodplains
- Provide **native plantings** to minimize pesticides and surface/groundwater contamination
- Storm Water Pollution Prevention Plan (SWPPP)

- Minimize site disturbances
- Minimize total impervious area
- Disconnect impervious surfaces
- Bioretention and engineered soils
- Bioswales
- Rainwater harvesting

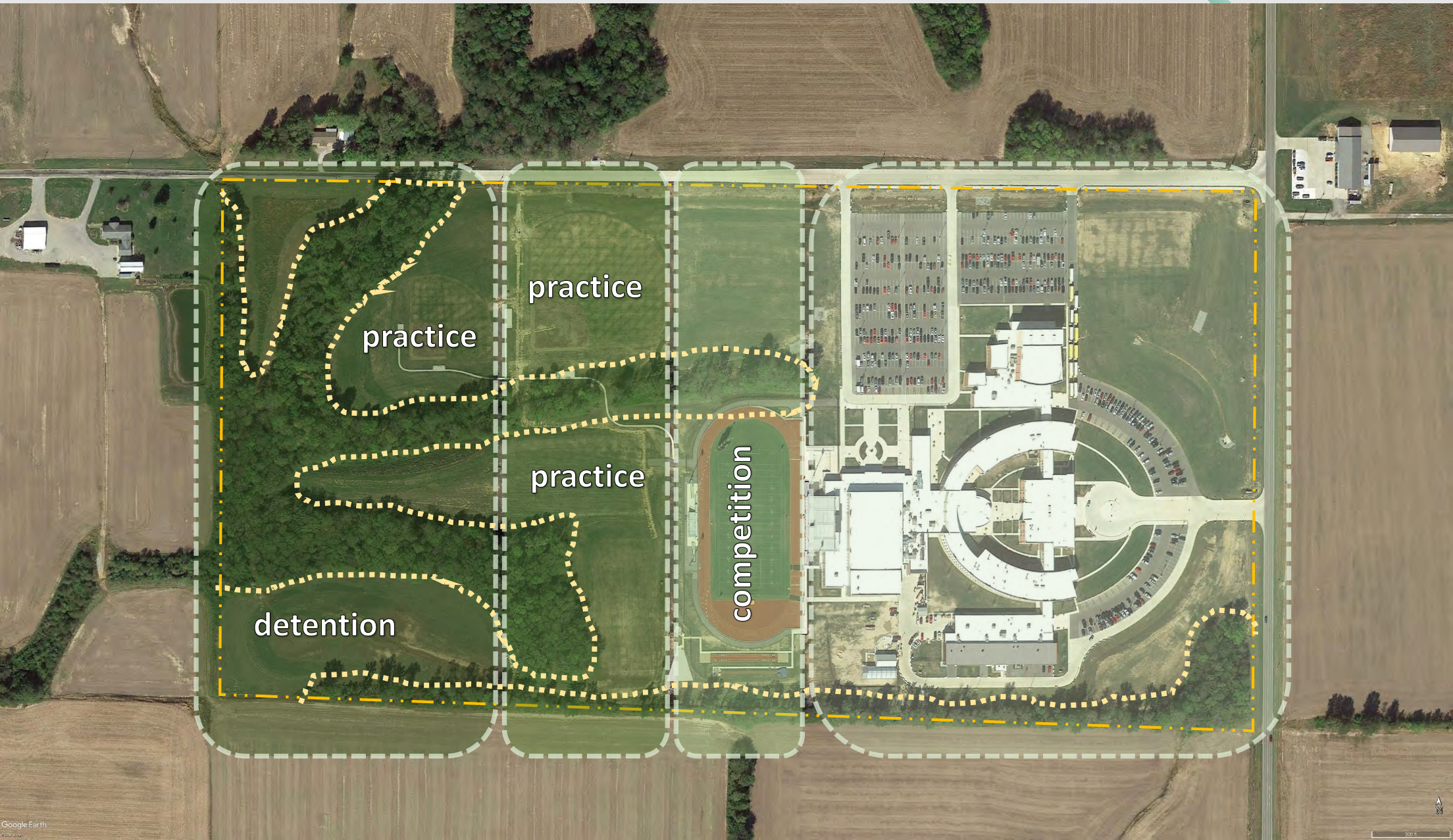












Resilient Strategies

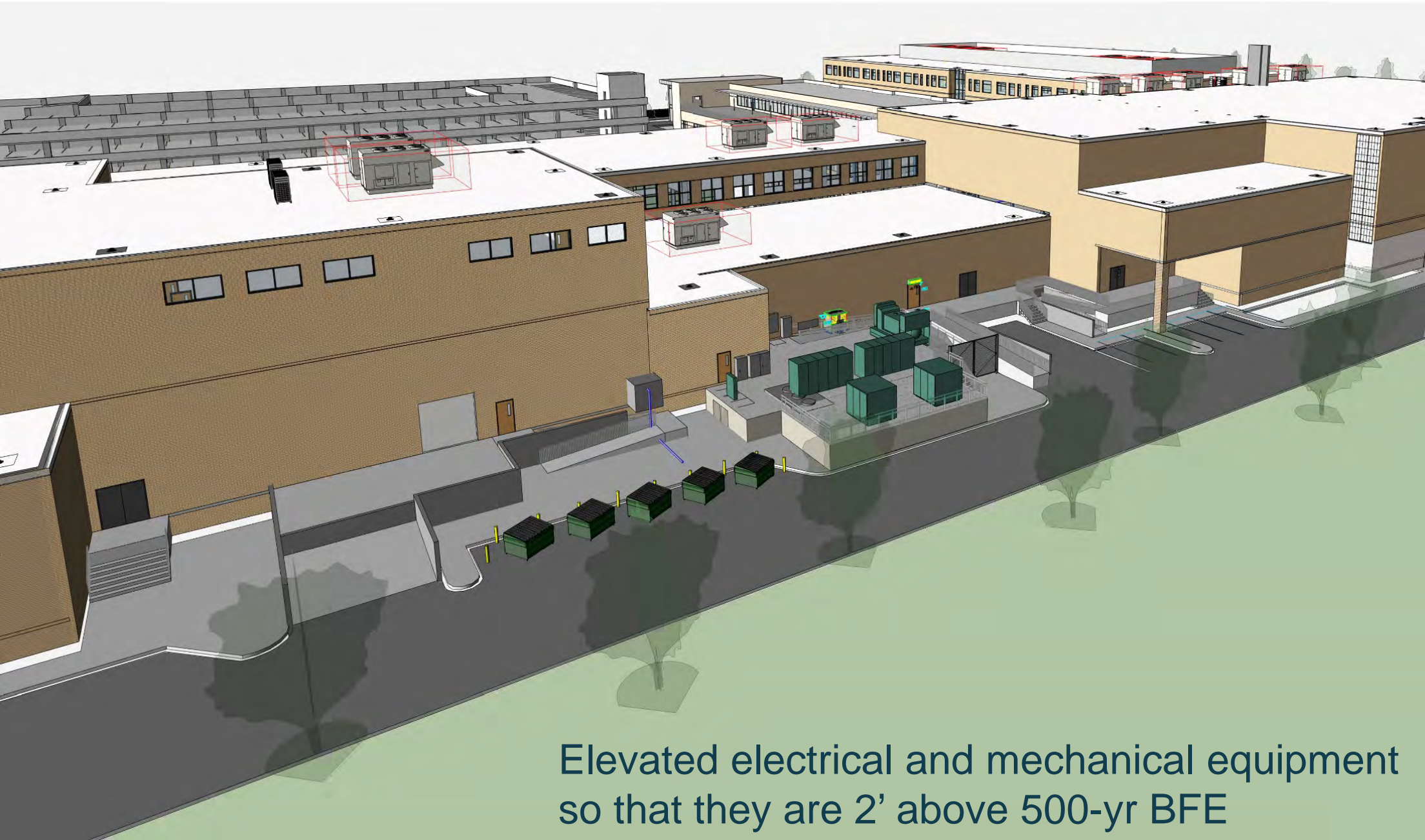


Elevated new building so that finish floor is 2' above 500-yr BFE (100-yr flood plain)

Proposed flood wall to protect the existing science wing

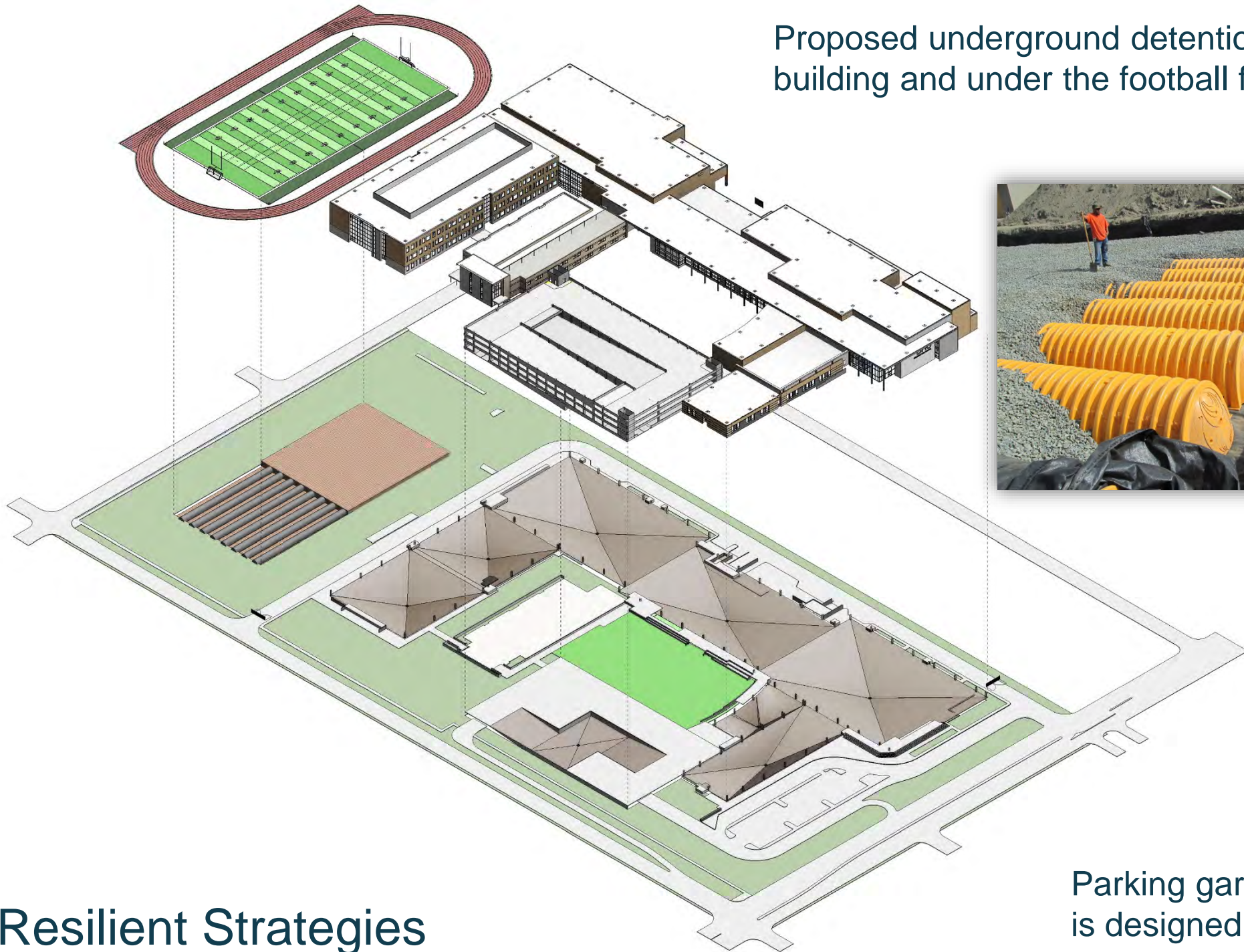
Provide artificial turf in the central courtyard

Resilient Strategies



Elevated electrical and mechanical equipment
so that they are 2' above 500-yr BFE

Proposed underground detention under the building and under the football field



Resilient Strategies

Parking garage
is designed to flood

The Keys to a Resilient Building



- Mark Madorsky, P.E., CxA, LEED AP BD+C
- President
- LEAF Engineers

The Day Before...



Aerial Photo of a Flooded High School Site



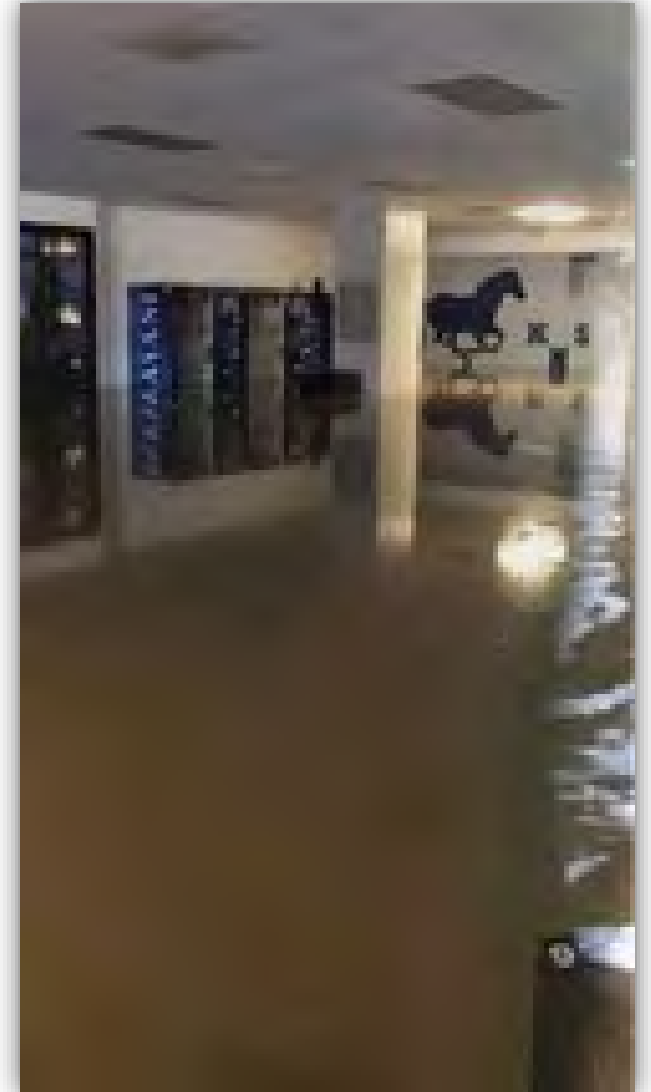
Video Footage



Impact



- 623,967 square feet affected
- Sports Fields Inundated
- +\$50,000,000 repair contract
- Closed 8 months, portions 1 year
- Priceless Legacy Loss (trophies, banners, etc.)
- Disruption of Community Spirit



Resilient Strategies



HARDENING

within

RESILIENCY

- Strengthening Structure
- High Wind Loading
- Redundant Power Services
- Withstand the Storm
- Maintain Operations Without Interruption
- \$\$\$\$-\$\$\$\$

- Potable water storage
- Elevate Critical Infrastructure
- Civil Defense Response Site
- Recover Operational Status Quickly
- Preventative Maintenance
- \$-\$\$

Site Selection is Everything



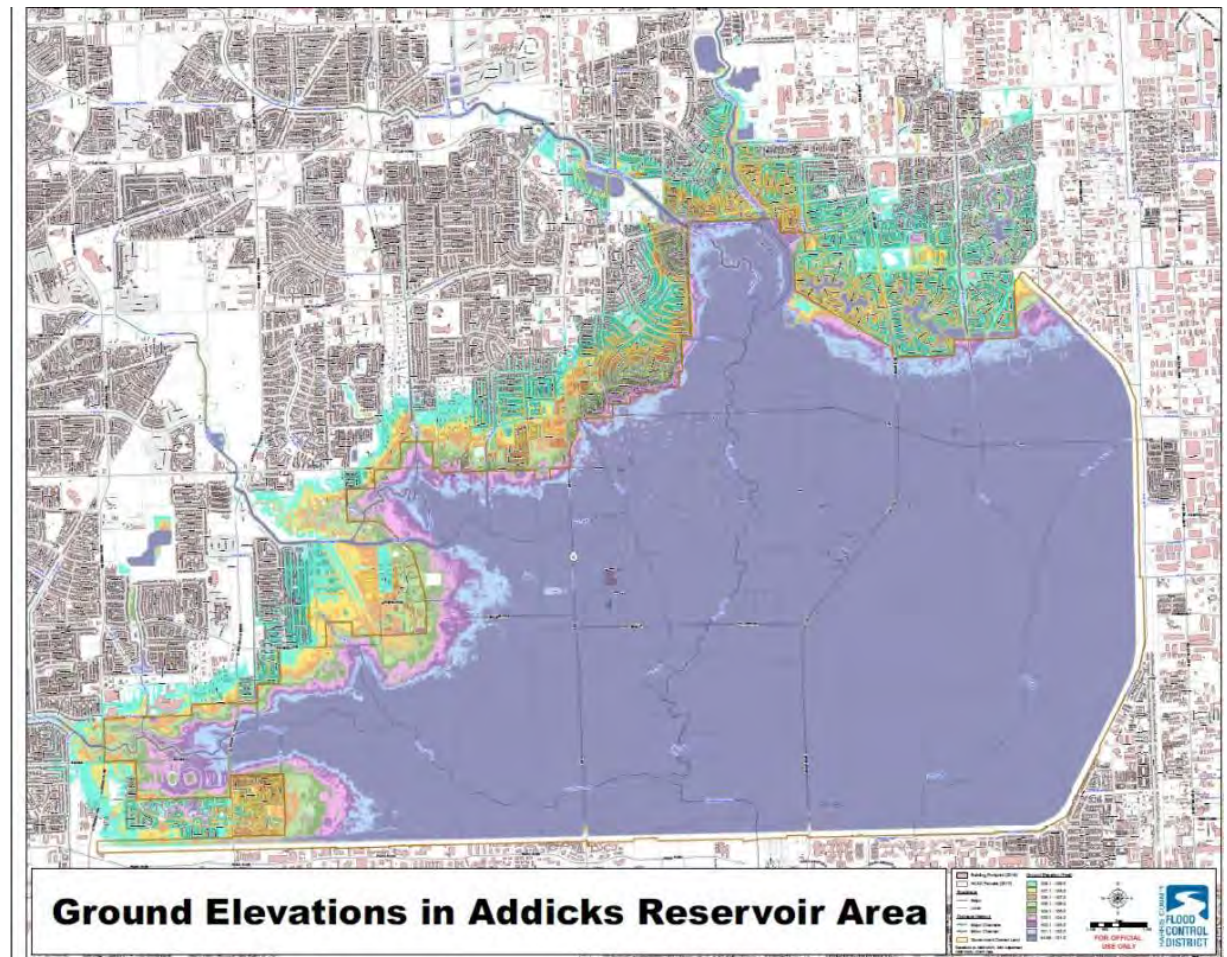
- Review Aerials and FEMA Maps
- Review Wind Maps (DFW in 250 MPH Zone Per IBC)
- Assume the Worst Case Asset Protection
 - Life Expectancy
 - Operational Criticality
 - Risk of Flood/Wind Damage



Extended Site Parameters



- Storm Event Performance
- Major Roadway Impacts
- Residential Risks
- Staff Transportation
- Utility Interruptions



Best Practices Water Protection



- 1' / 500 year flood elevation (2' in Harris County, Texas)
- Padmount Equipment 1' AFF
- Electrical/MDF/NOC on 2nd Floor
- Drains at Doors, drains in Vestibules
- Durable Flooring Selections



Best Practices Water Protection



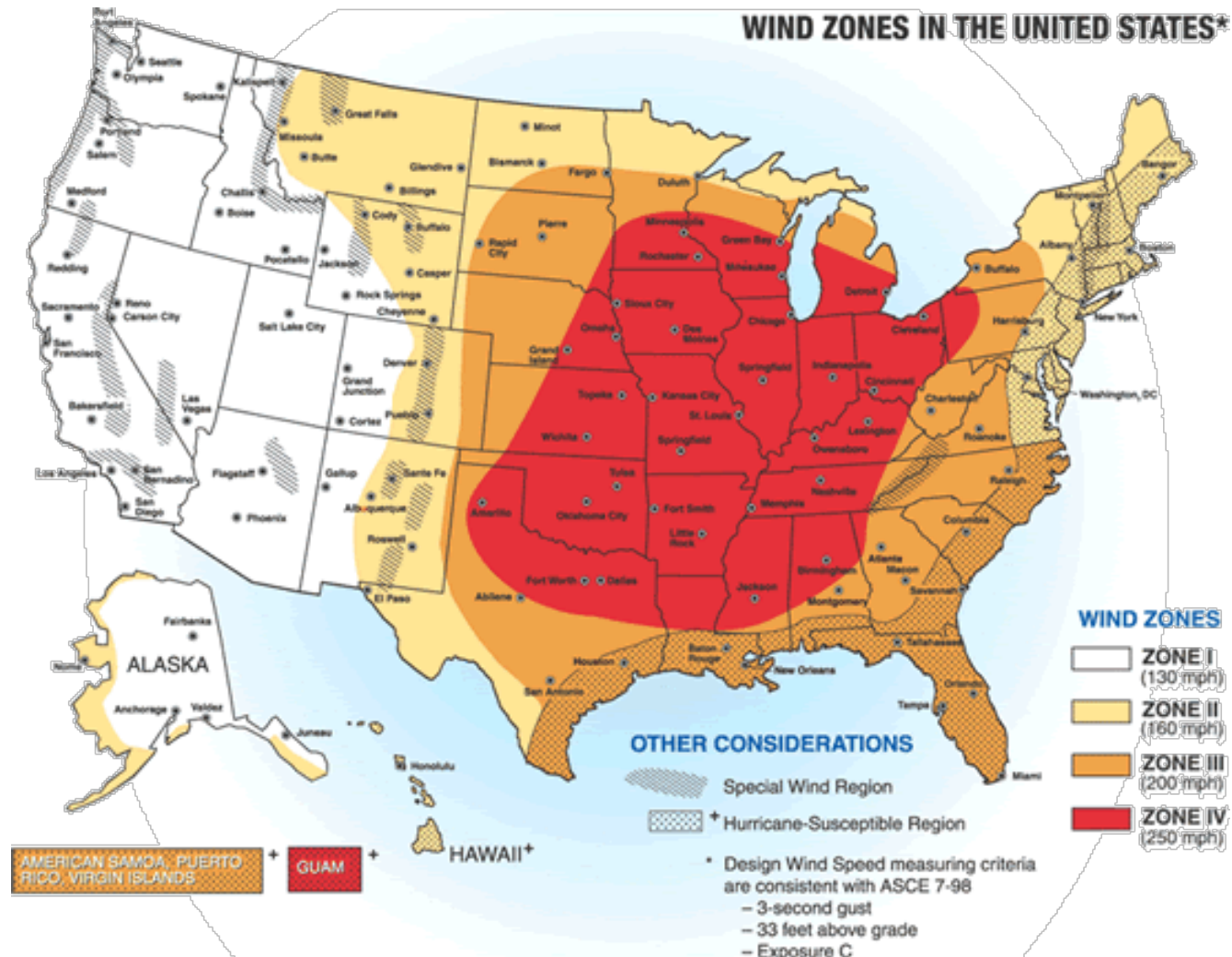
- CMU walls on 1st Floor
- Cementitious wall board on 1st Floor
- Sanitary Check Valves
- Curbs for Ground Floor Glazing
- Flood Barriers, Site Berms, Levees



Best Practices Wind



- Shelter Design Wind Speeds For Tornadoes
- Resist 100 mph stud
- Resist 67 mph roof impact



Best Practices Wind

- HVAC Restraints Roof/Site
- Landscaping Away From Building
- Interior Shelter Room
- Wind Loading of Canopies/Roofs
- Impact Resistant Glass/Frames
- Indoor Generator Room
- Indoor Water Cooled Chillers



Best Practices Operations



- Detailed Weather Reports
- Operations Center (EOC)
- Coordinate Response with Regional EOC's
- Business Continuity Plans
- Colocation for Technology Infrastructure



After the Storm



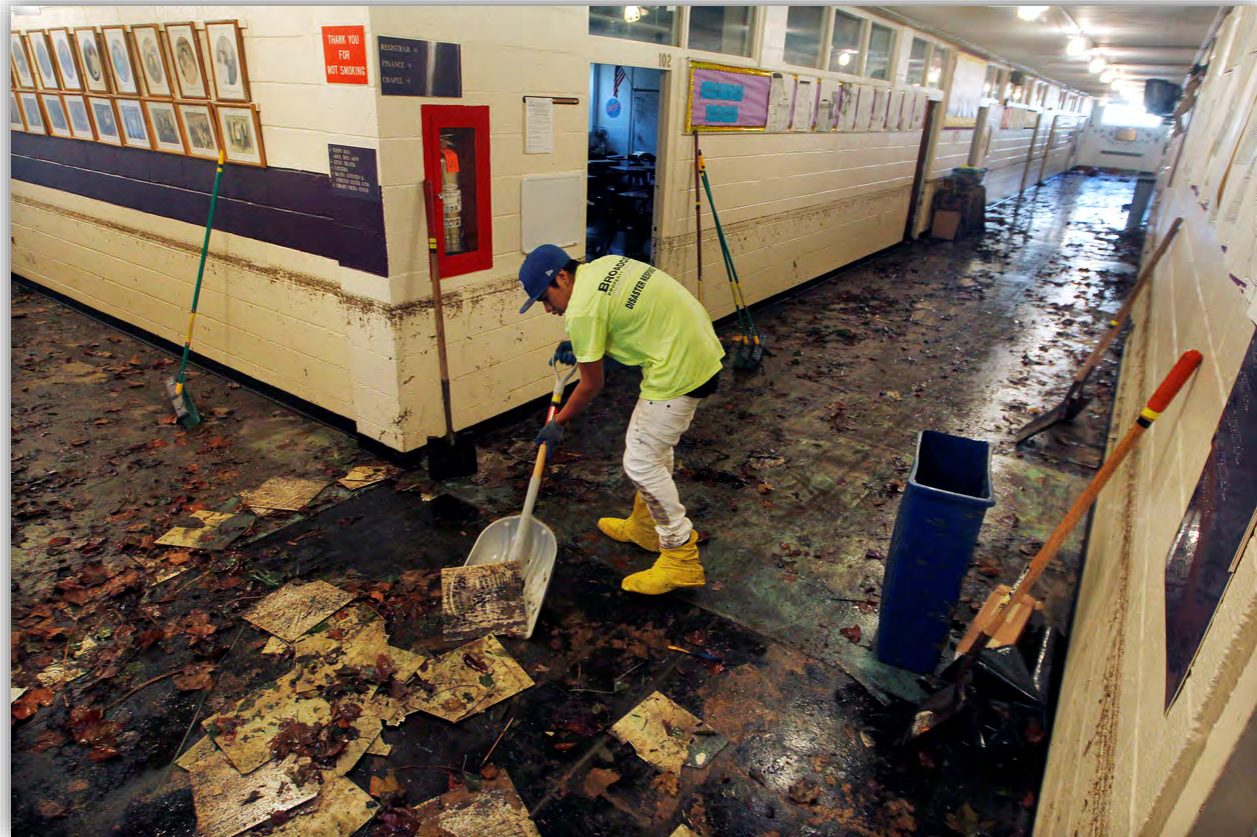
- Assessment, Photographs and Video
- Contact Insurance Agent, FEMA, State
- Hygienist, Architects, Engineers
- Mitigate/Restore/Replace Infrastructure
- Disaster recovery consultant (Federal Funding Process Expert)



Some Hidden Risks



- Mold
- Desks, Chairs, Books, Supplies
- Contaminated Duct Systems
- Exposure of Building Materials and Systems to High Humidity Levels
- Toxic Hydrocarbons and Fecal Matter in Flood Waters



Trending Now...



■ Elevated Substation



Trending Now...



- **Emergency generator**
 - Lighting
 - auditorium house lights
 - exist signs
 - Communications
 - Command center
 - fire alarm equipment
 - Coolers and freezers
- **Manual transfer switch**
 - Portable generator
 - Lights and heating at gyms, locker rooms kitchen, cafeteria maintenance
 - Kitchen equipment



Trending Now...



■ Demountable Flood Barriers



Trending Now...



■ Aqua dams



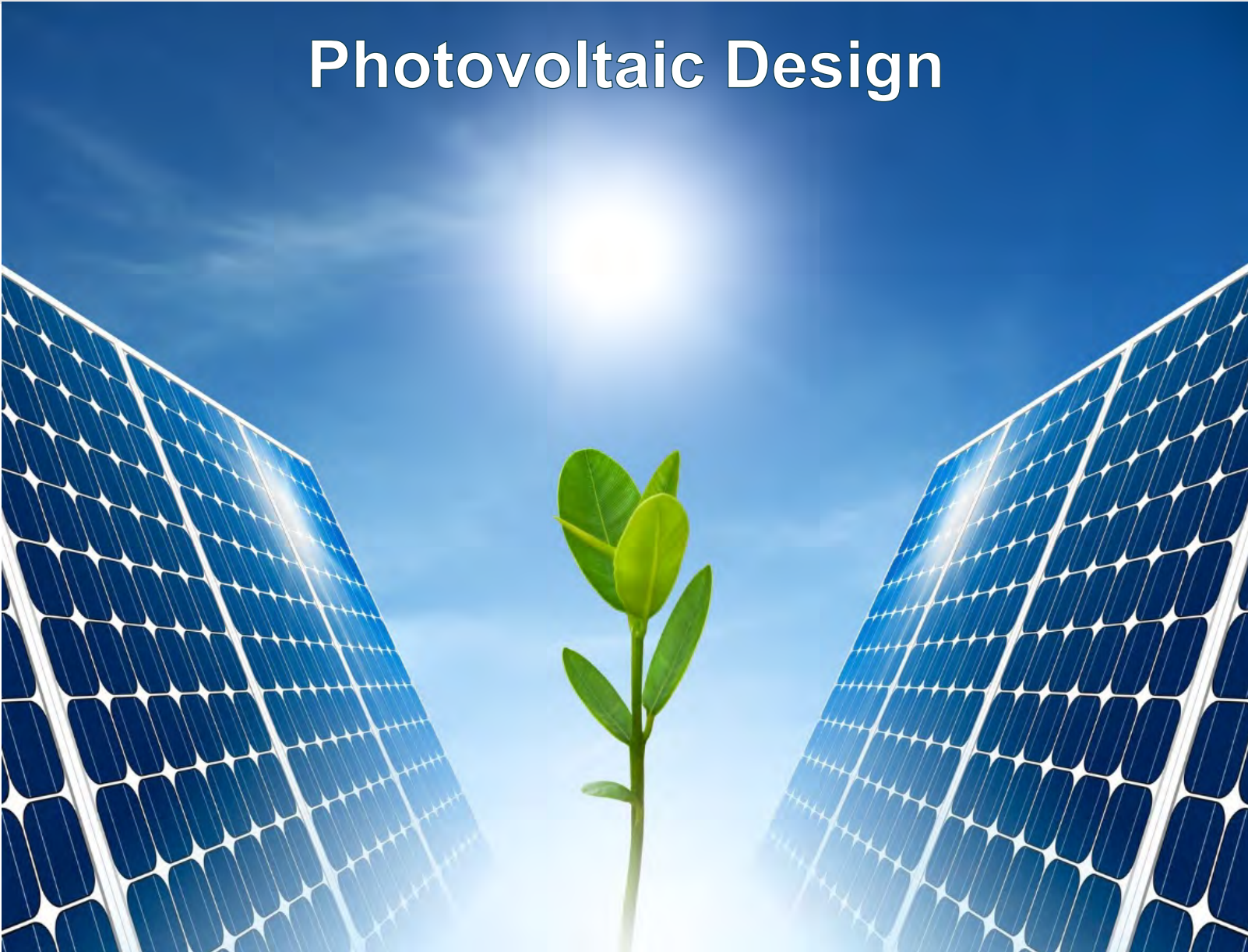
Trending Now...



- High Strength Glazing



Photovoltaic Design



Solar Panel Layout – Roof, Ground, Canopy



Net Metered Photovoltaic (PV) System Proforma



Facility Size – 240,000 sq. ft.

- Projected Annual Electric Consumption: 2,104,000 kWh
- Projected Annual Electric Bill Summary: \$195,876
- Utility Rate Structure:
LGS with Net Metering Agreement for Interconnection and Parallel Operation of Grid-Connected On-Site Solar Generation

1 MW Solar Array Performance

- Area: 198,924 sq. ft. (4.6 acres)
- Annual Production: 1,702,000 kWh
- Initial Capital Cost: \$2,000,000
- Annual Electric Savings: \$165,500
- Simple Payback: 11.6 Years
- 20 Year Life Cycle M&O Savings: \$3,310,000
- Total Energy to Grid: 34,040 MWh

Safe and Secure Schools - Layering



Physical Security

- 6' Iron Fencing Around Entire Perimeter
- Bollards, Speed Bumps, Vehicular Barriers
- Dedicated First Responders Access Drive
- Secure Entry Vestibule with Ballistic Hardening
- Window Sill Heights Elevated (5')
- Access Controlled Doors



Safe and Secure Schools - Layering



Surveillance, Messaging, Intelligence

- PTZ Surveillance Cameras with Facial Recognition Software
- Gunshot Detection & Weapons Radar
- Incident Response Room
 - Master Keys/Proximity Cards
 - Floor Plans
 - Access to Cameras
 - Access to Public Address





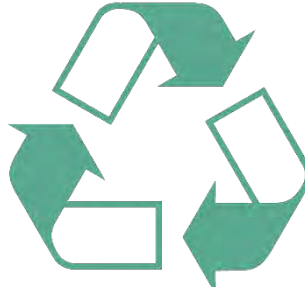
Community Resilience – Health & Wellbeing

- Reducing Environmental Impact
- Human Performance and Productivity
- Community Engagement & Connectivity

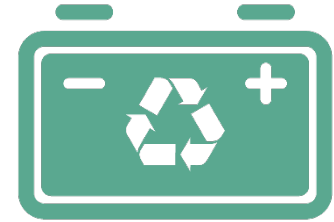
Reducing Environmental impact



Reduce
air pollutant
emissions



Facility recycling program
& waste management
planning



Material selection/
Material effectiveness

Facility recycling program & waste management planning



- **Trash Compactor**

- Reduced disposal costs
- Landfill Reduction



Water efficiency



- Reduce potable water consumption
- Provide landscaping that does not require permanent irrigation systems
- Reduce runoff
- Improve water quality
- Provide on-site food production for a % of the building footprint
- Rainwater harvesting for facility use and crisis use



Human Performance and Productivity



- Indoor Air Quality Performance:
Mechanically, Naturally, Mixed-mode
- Environmental Tobacco Smoke Control
- Low-Emitting Materials
- Reinforced natural daylighting
- Quality Views to Exterior for 25%
of Occupied Space
- High-Quality Interior Lighting
- Provide effective acoustic design

Daylight and Views

Fresh Air

Human Productivity



Community Engagement & Connectivity



Community Access



Improve quality of life

Has identified, assessed, and incorporated community needs, goals, and objectives into the project



Knowledge and society

Meeting space
Shared library
Civic space
Shared Athletics



Incorporate Community Views & Local Character



Community production

Plant nursery
Organic food
Auto repair
News and radio

Local Investments



Deep rooted community attachment to school, willing to come together after crisis

- Expand Citizen Participation:
 - Councils, Organizations, Communication
- Resilient Organizations:
 - Develop a resilient organization
 - Social equity: community, supply chain, project team
- Develop or Expand Local Skills
 - Project delivery
 - Hire locally
 - Skills outreach
 - Local development and competitiveness

Community Engagement & Connectivity



Surrounding density and diverse uses



Crisis and Health
Services



Walkability



Non-motorized
Transit



Public Transit

Measures for the Social/Wellness Environment



Elements	Measures
Organizations	<ul style="list-style-type: none">•Distribution of community groups across the region•Number of active interfaith organizations•Diversity and number of community organizations
Communications and social media	<ul style="list-style-type: none">•Speed with which messages travel through official and unofficial channels•Number of people who have or do not have access to social media
Connectedness	<ul style="list-style-type: none">•Number and type of organizations in which people are engaged•Number of people registered to vote•Knowledge of what resources are available during and after a disaster•Network analysis to map social connectedness
Trust	<ul style="list-style-type: none">•Amount of connection and communication between local officials•Public confidence in leadership•Public trust in leadership
Volunteerism	<ul style="list-style-type: none">•Number of people who participate on neighborhood teams (e.g., Community Emergency Response Teams)•Number of volunteer hours per capita•Number of active disaster response teams in a neighborhood/community•Number of people who attend neighborhood meetings•Number of people who attend community resilience training
Other	<ul style="list-style-type: none">•Number of people with access to transportation•Types of transportation available•Connection of residents who do not use social media with other community providers



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