National Structure Inventory:
Use in Planning

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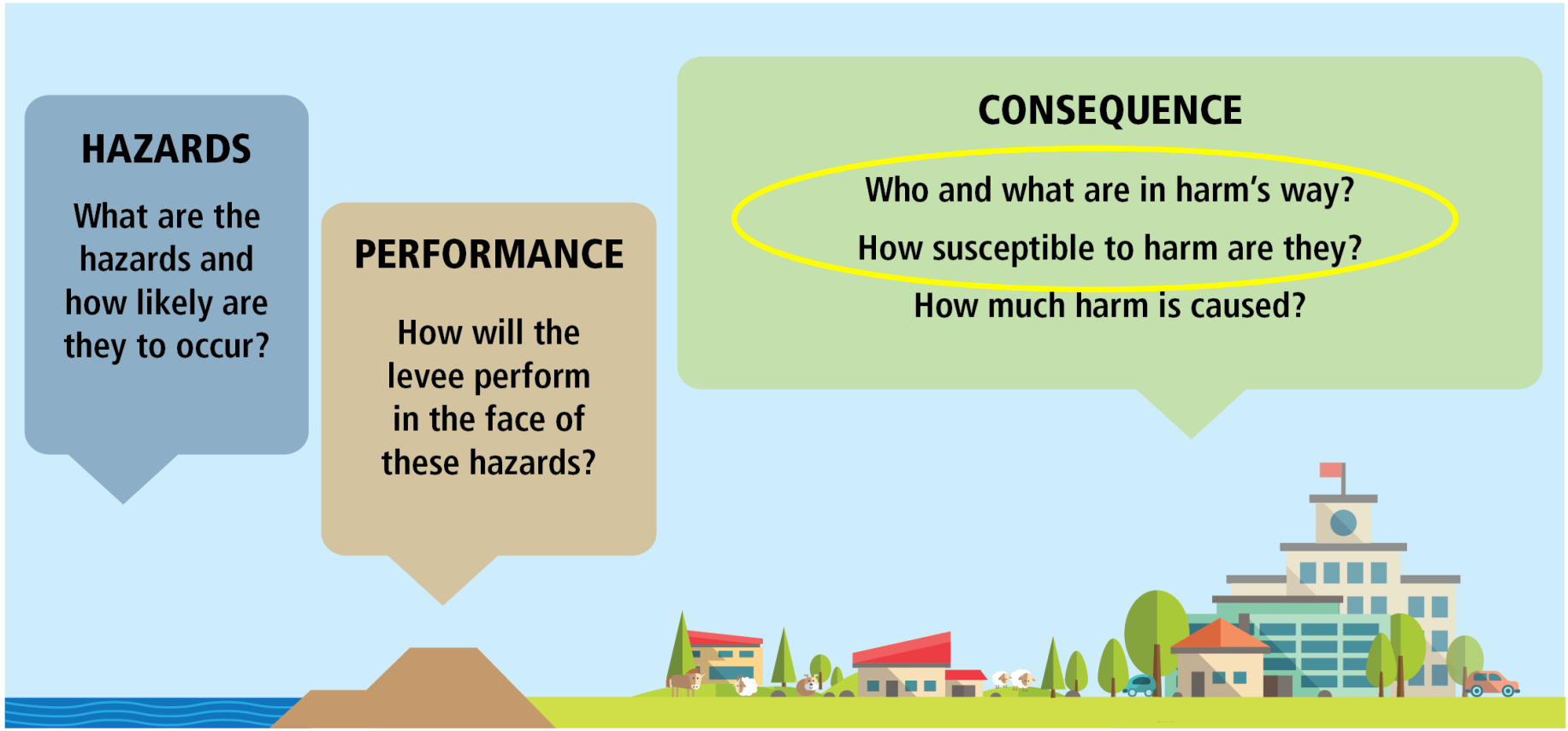
January 26, 2022

COMPONENTS OF RISK

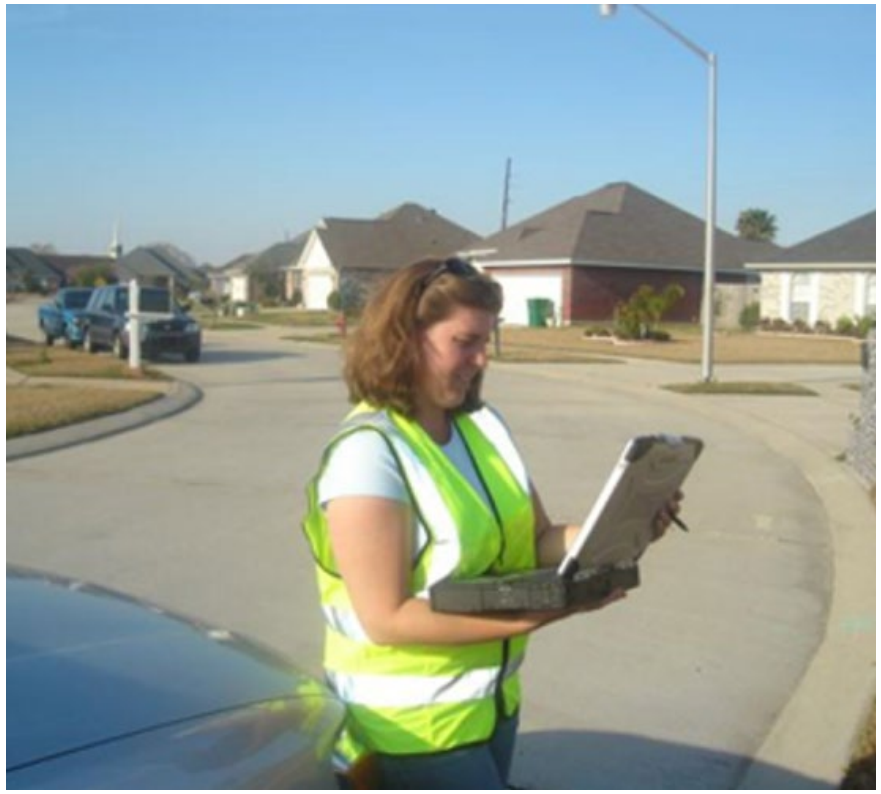


RISK = f (HAZARD, PERFORMANCE, CONSEQUENCE)

What is a Structure Inventory?

Multi-Family
Two Stories
Slab
Brick
10,000 SqFt
$5,000,000
30 People

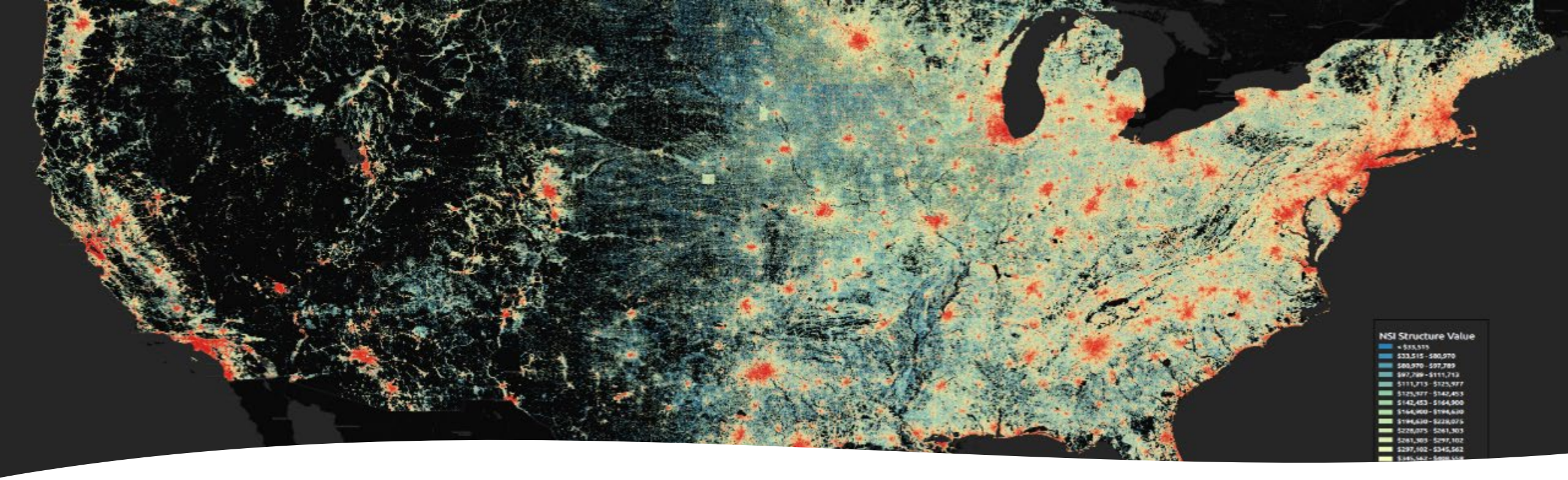
Single-Family
Two Stories
Basement
Wood
2,500 SqFt
$250,000
3 People



STEP 1	Identify structure inventory study area limit
STEP 2	Acquire county tax parcel overlay
STEP 3	Clip tax parcels to study area & convert polygons to points (centroids)
STEP 4	Acquire county tax database
STEP 5	Match parcels with tax database
STEP 6	Troubleshoot unmatched parcels (limited manual editing)
STEP 7	Add ground elevation (LiDAR-derived Digital Elevation Model)
STEP 8	Building footprint analysis
STEP 9	Marshall & Swift value adjustment (Tax Value -> DRV)
STEP 10	Foundation height stratified random sample

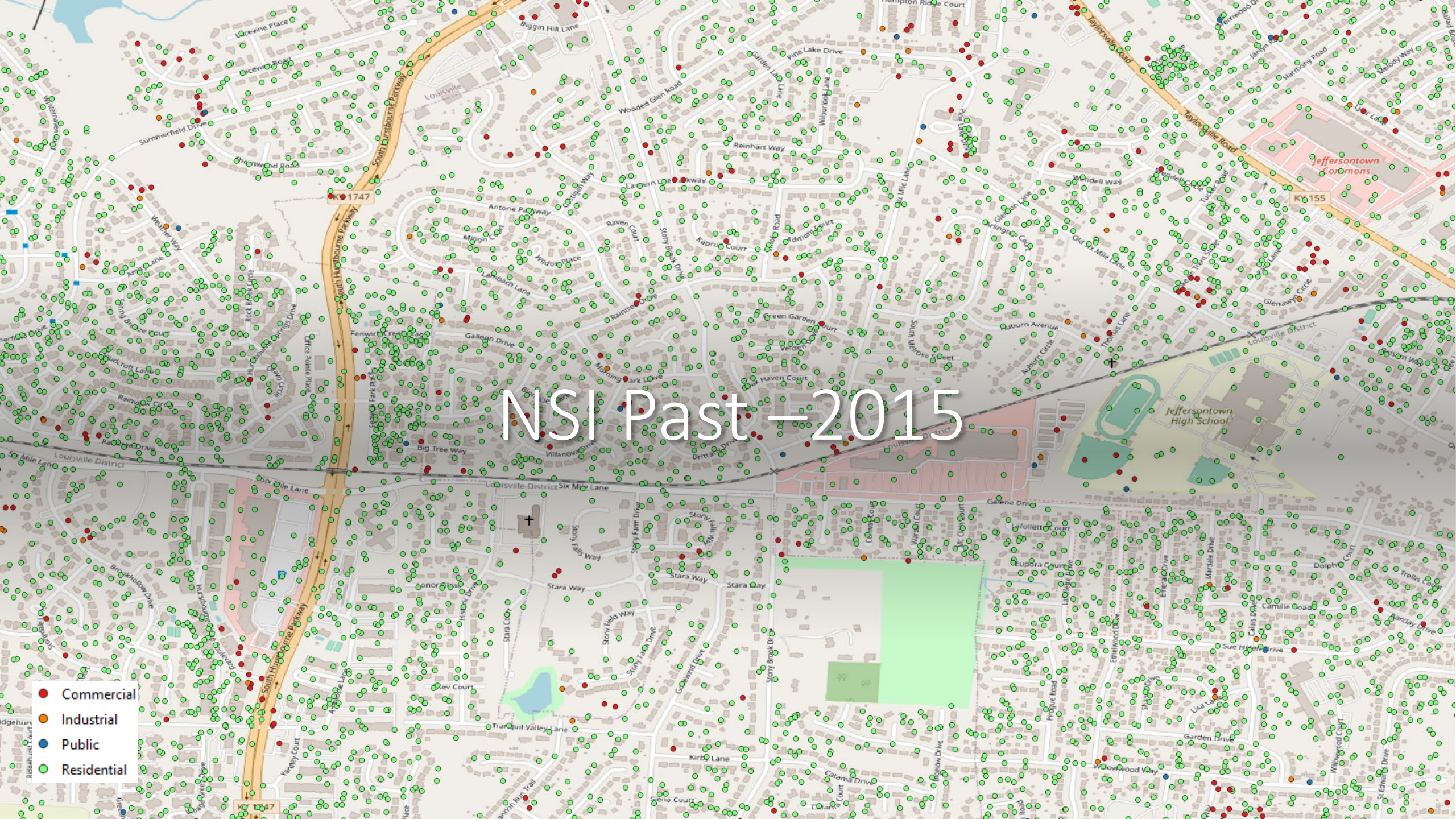
Elegant Methods From a Pre-SMART Planning Age

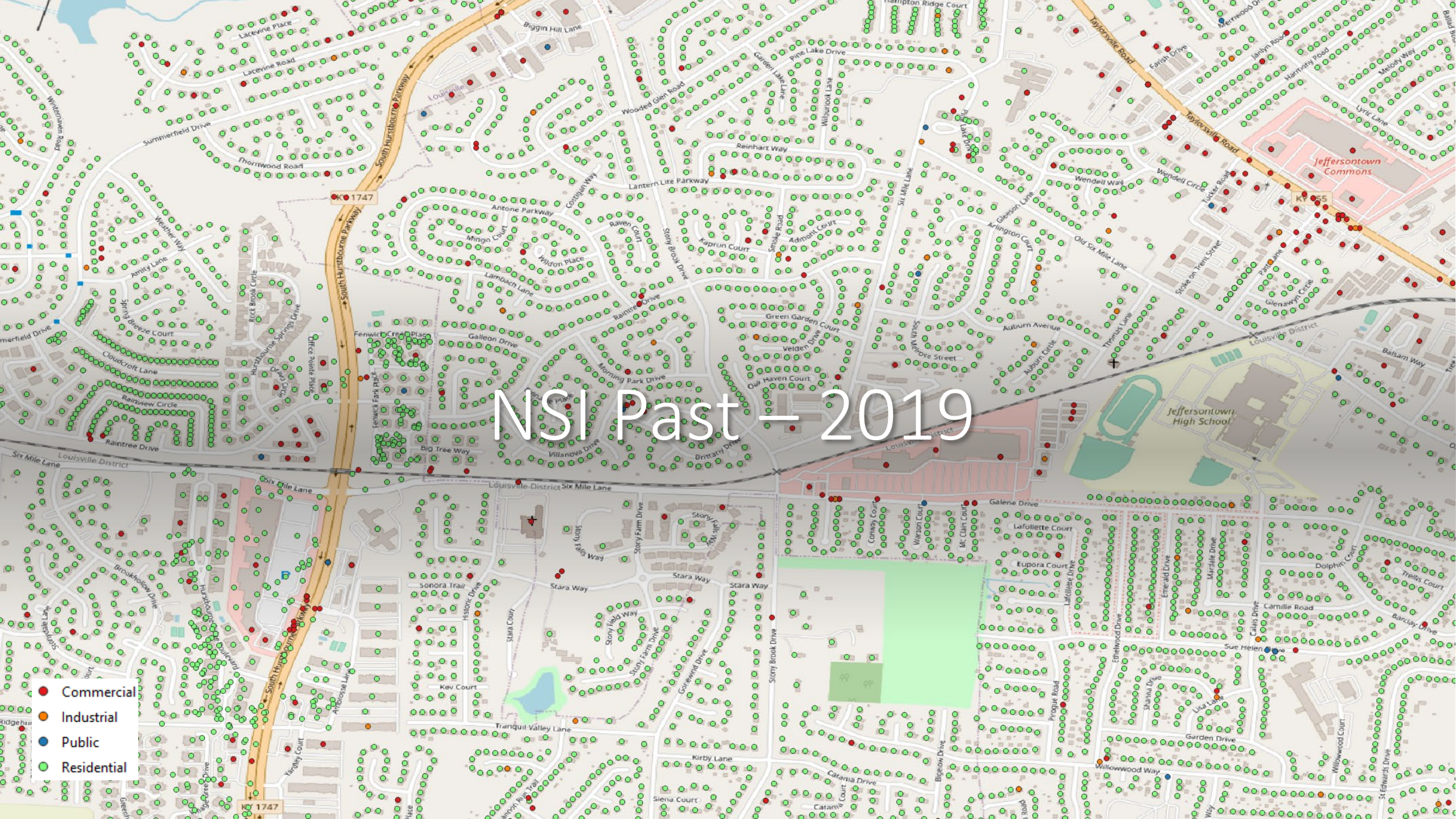
- Direct Observation
  - Windshield Surveys
  - Interviewing Owners
- Custom Parcel Analysis



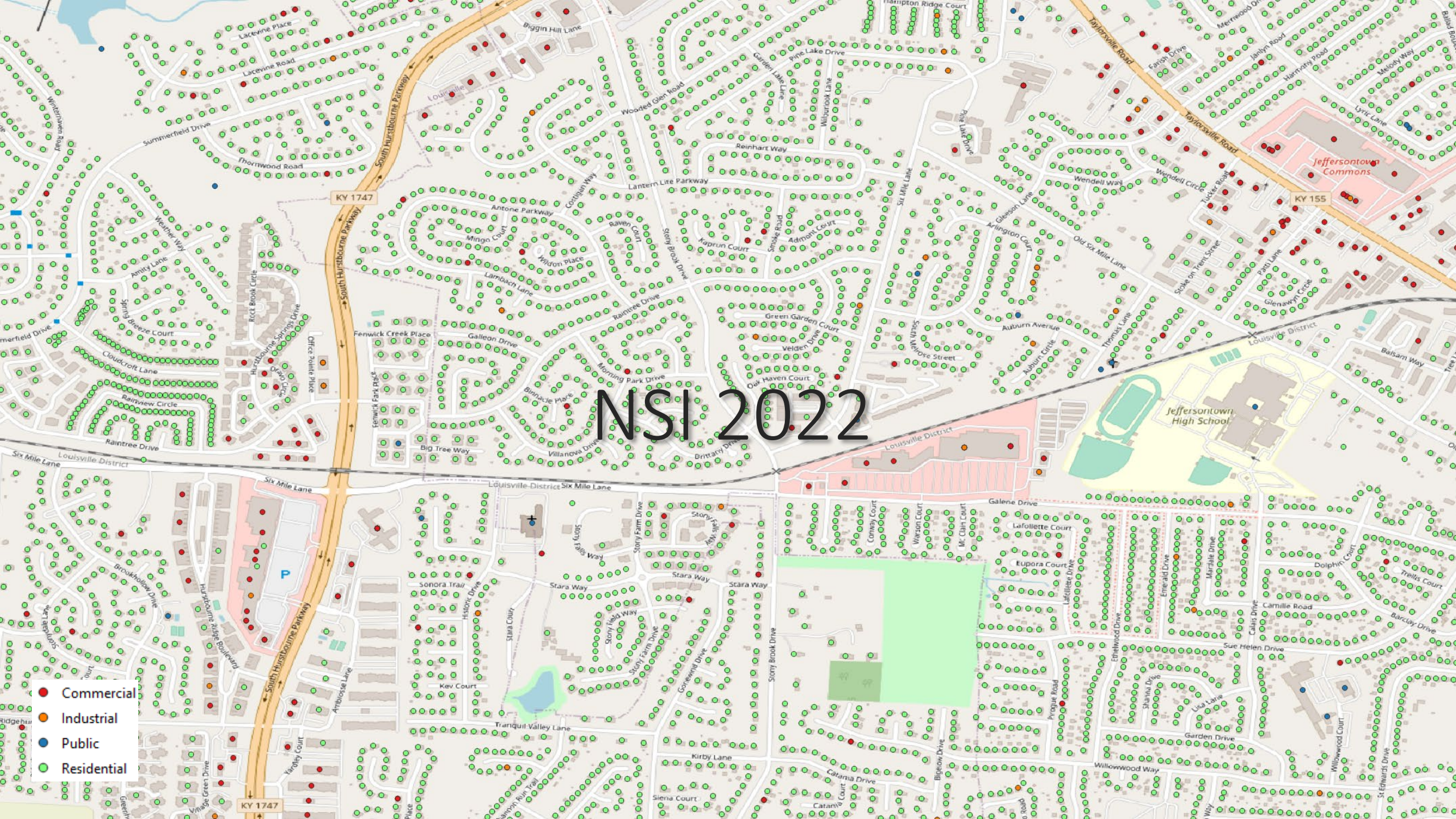
The National Structure Inventory

The NSI was initially developed to support the evaluation of consequences in risk assessments for Dams


NSI Past – 2015
Commercial
Industrial
Public
Residential



NSI Past – 2019


NSI 2022
Commercial
Industrial
Public
Residential
KY 1747
KY 155
South Hurstbourne Parkway
Taylorsville Road
Six Mile Lane
Louisville District
Jeffersontown Commons
Jeffersontown High School
Lantern Lite Parkway
Raintree Drive
Wooded Glen Road
Pine Lake Drive
Reinhart Way
Antone Parkway
Story Brook Drive
Green Garden Court
Auburn Avenue
Old Six Mile Lane
Galene Drive
Story Farm Drive
Stara Way
Sonora Trail
Tranquil Valley Lane
Kirby Lane
Siena Court
Catania Drive
Willowwood Way
Garden Drive
Sue Helen Drive
Carnelle Road
Eupora Court
Lafollette Court
Big Tree Way
Morning Park Drive
Fenwick Creek Place
Galleon Drive
Cloudcroft Lane
Rainview Circle
Spring Breeze Court
Amity Lane
Summerfield Drive
Thorntwood Road
Lacewine Place
Lacewine Road
Biggin Hill Lane
Hampton Ridge Court
Taylorsville Road
Wendell Way
Wendell Circle
Tucker Road
Gleason Lane
Arlington Court
Thomas Lane
Balsam Way
Brookhollow Drive
Hurstbourne Ridge Boulevard
Ambrose Lane
Yardley Court
Village Green Drive
Historic Drive
Kev Court
Gonewind Drive
Prague Road
Ethelwood Drive
Lisa Lane
Willowwood Court
St Edwards Drive
Dolphin Court
Trellis Court
Barclay Drive
Marjale Drive
Emerald Drive
Lafollette Drive
Conway Court
Warson Court
Mc Clain Court
Shania Drive
Bigelow Drive
Catania Court
Kaprun Court
Admont Court
Smoke Road
Wildon Place
Lambach Lane
Mingo Court
Raven Court
Contigan Way
Garden Lake Lane
Wilburlook Lane
Velden Drive
Oak Haven Court
Binnacle Place
Villanova Drive
Brittany Drive
Fenwick Park Place
Office Pointe Place
Hurstbourne Springs Drive
Ricci Brook Circle
Weather Way
Lyric Lane
Melody Way
Harmony Road
Janlyn Road
Merriwood Drive
Parish Drive
Stoke on Trent Street
Parti Lane
Glenawyn Circle
Auburn Circle
Melrose Street
Story Silo Way
Story Lights Way
Stara Court
Story Field Way
Ridgehurst Court
Southgate Lane
Winterwarm Road

NSI Key Attributes: Occupancy Type

- Uses HAZUS codes
  - RES1 = Single-Family
  - Com1 = Retail
  - Etc.
- Often associated with
  - Depth-Damage Functions
  - Population Assignment
  - Value uncertainty

NSI Key Attributes: Building Type

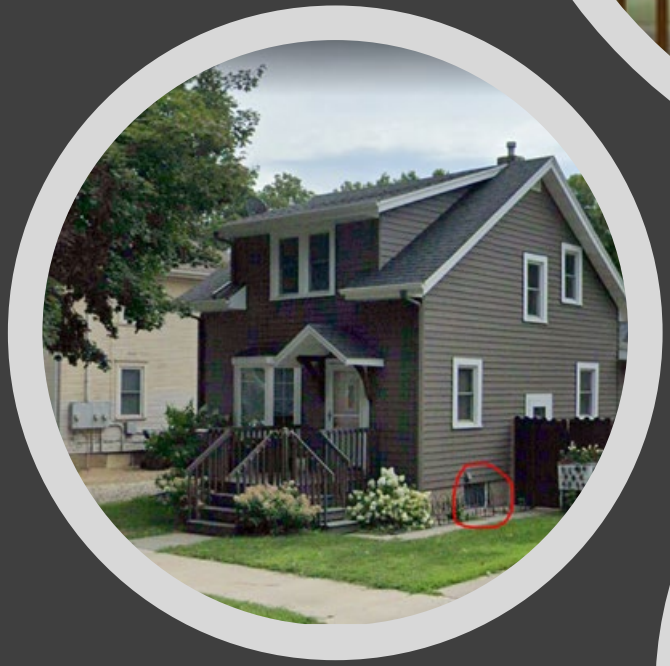
- Uses HAZUS categories
  - Wood, Steel, Masonry, etc.
- Often associated with
  - Stability Functions in LifeSim
  - Structure Value

NSI Key Attributes: Structure Value

- Depreciated Replacement Value
- $/SqFt
  - Varies with use type
  - Year Built
  - Income of area
    - RES1 only
- SqFt Estimate
- Content to structure value ratios based on HAZUS

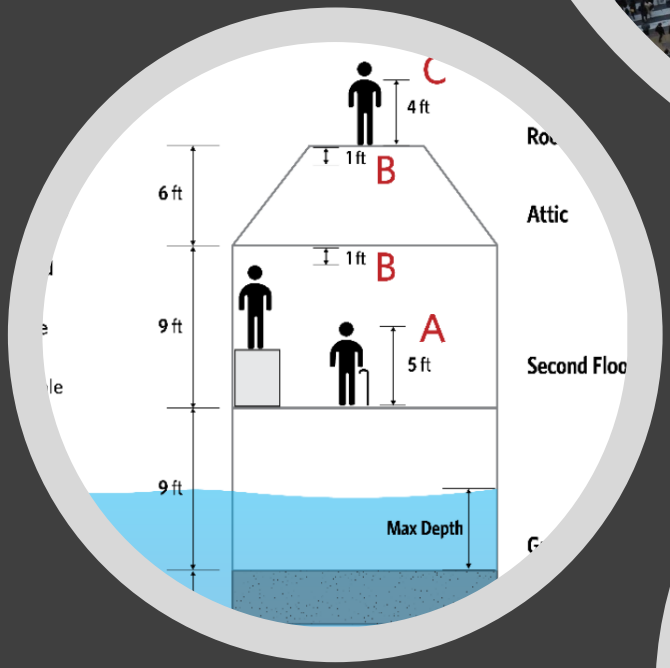
NSI Key Attributes: Foundation Type

- Uses HAZUS categories
  - Slab, Pier, Basement, etc.
- Often associated with
  - Depth-Damage Functions (Basement)
  - Foundation Height / FFE



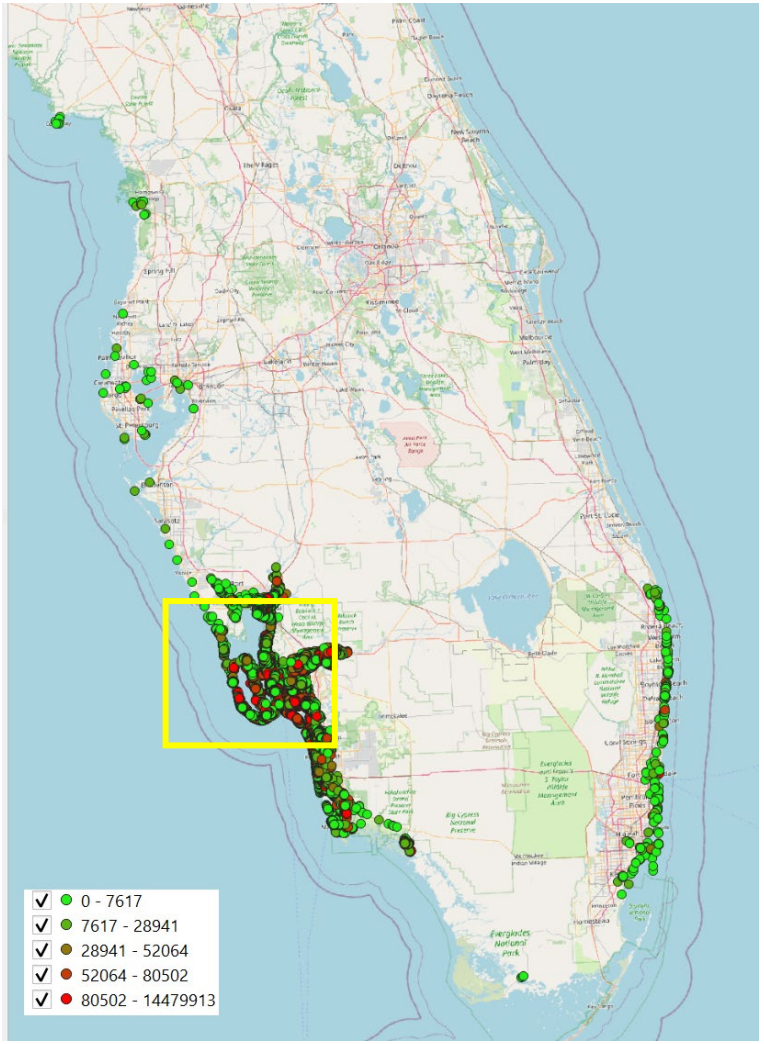
NSI Key Attributes: Population

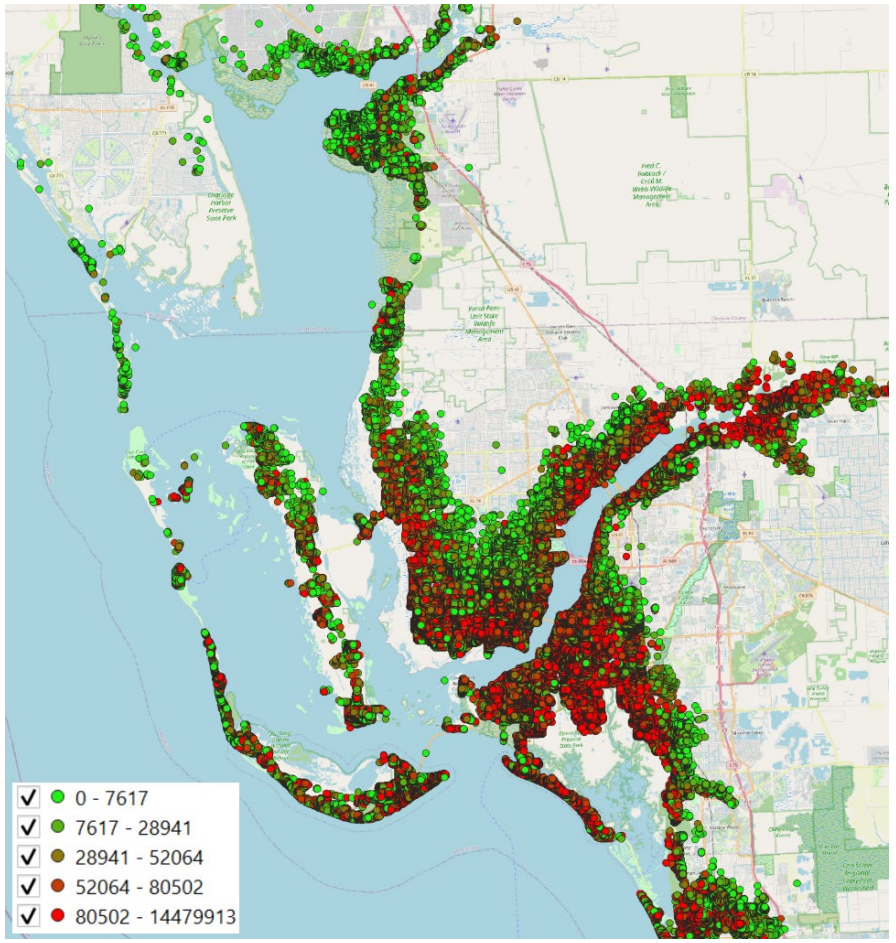
- Day and Night
  - Residential higher at night
  - Non-Residential higher during day
- Over and Under 65
  - Linked with disability rates in LifeSim



Application of NSI

- Provides data for models and studies
- Allows for instant estimates of large study areas
- Nationwide coverage





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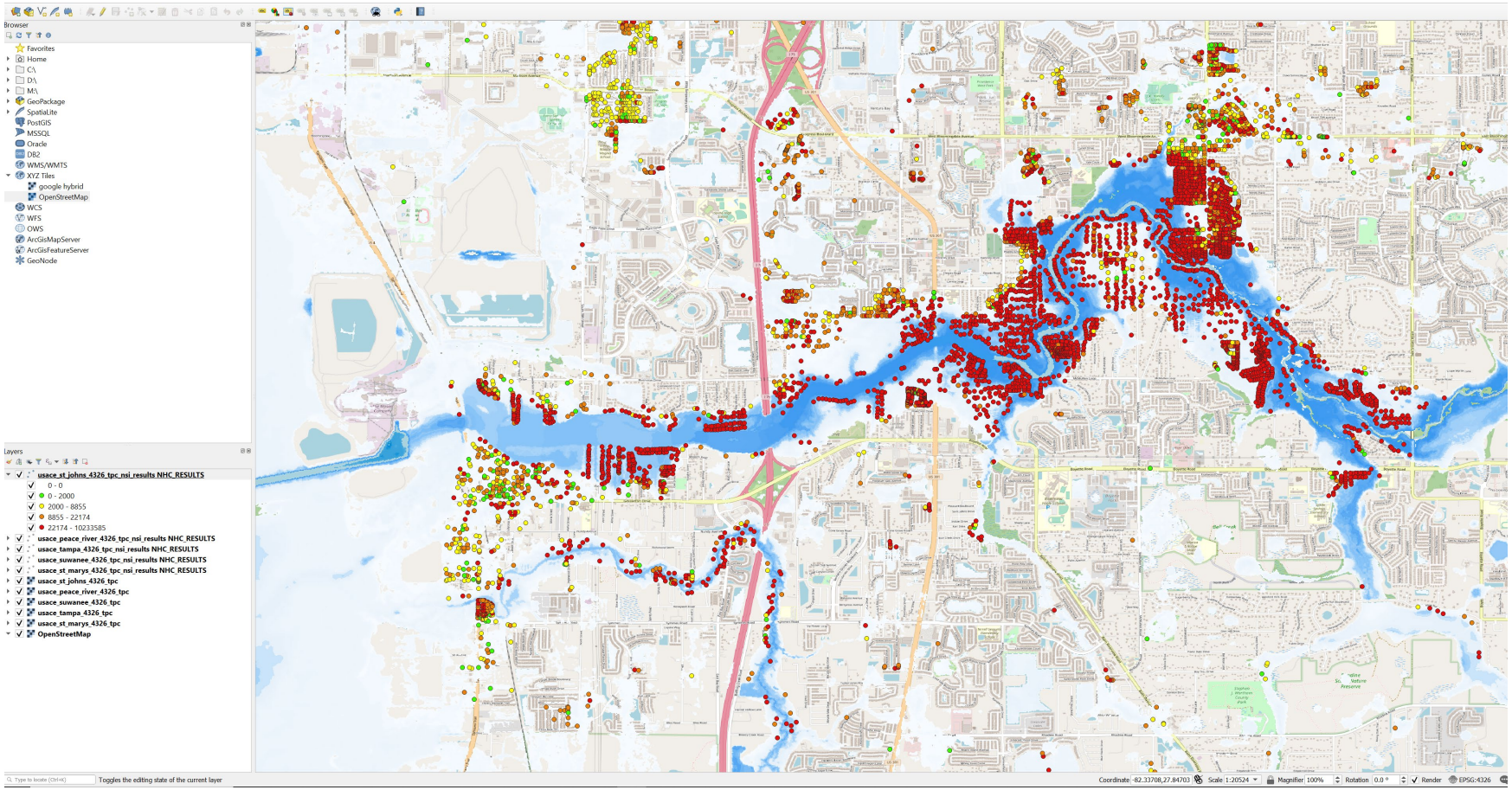
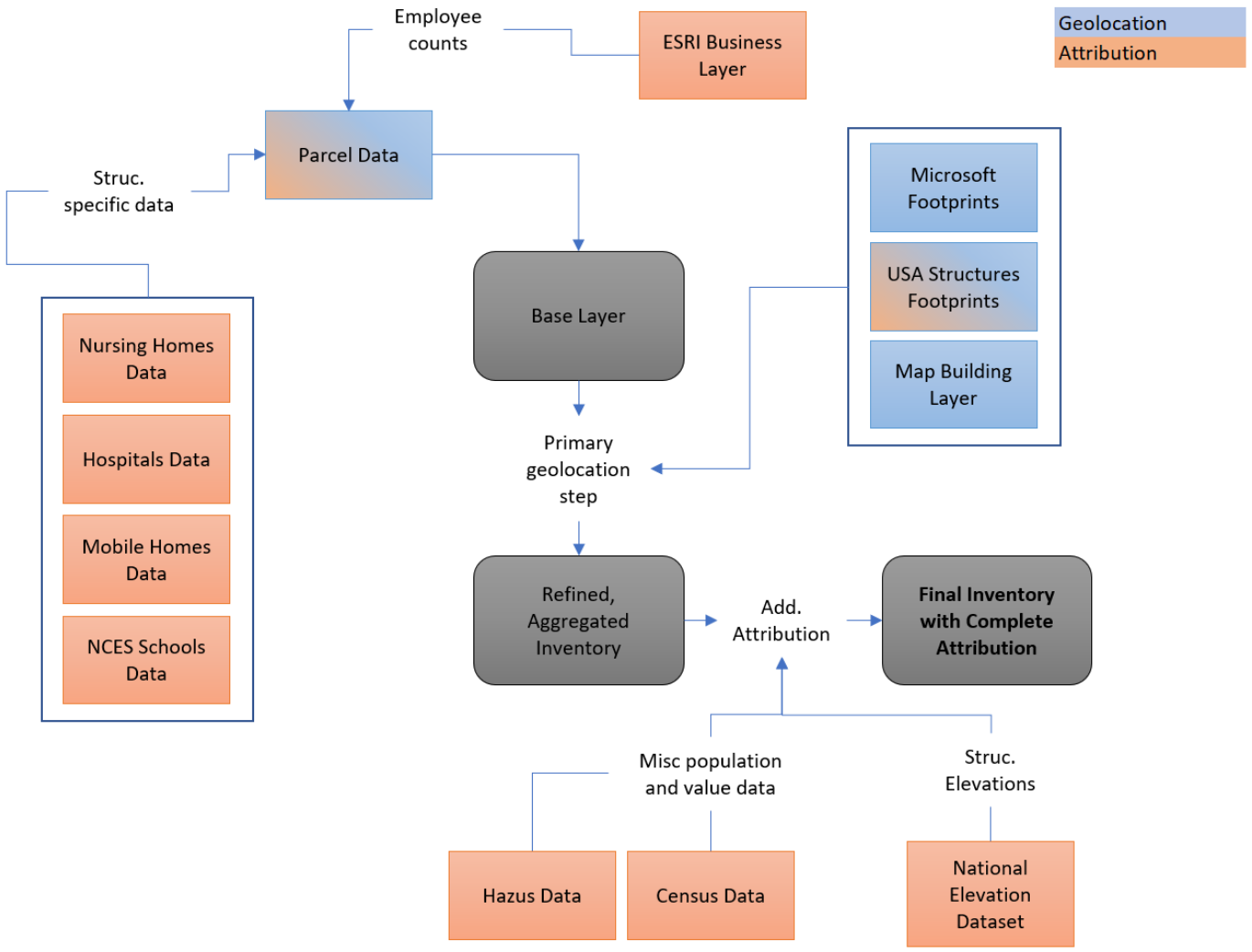
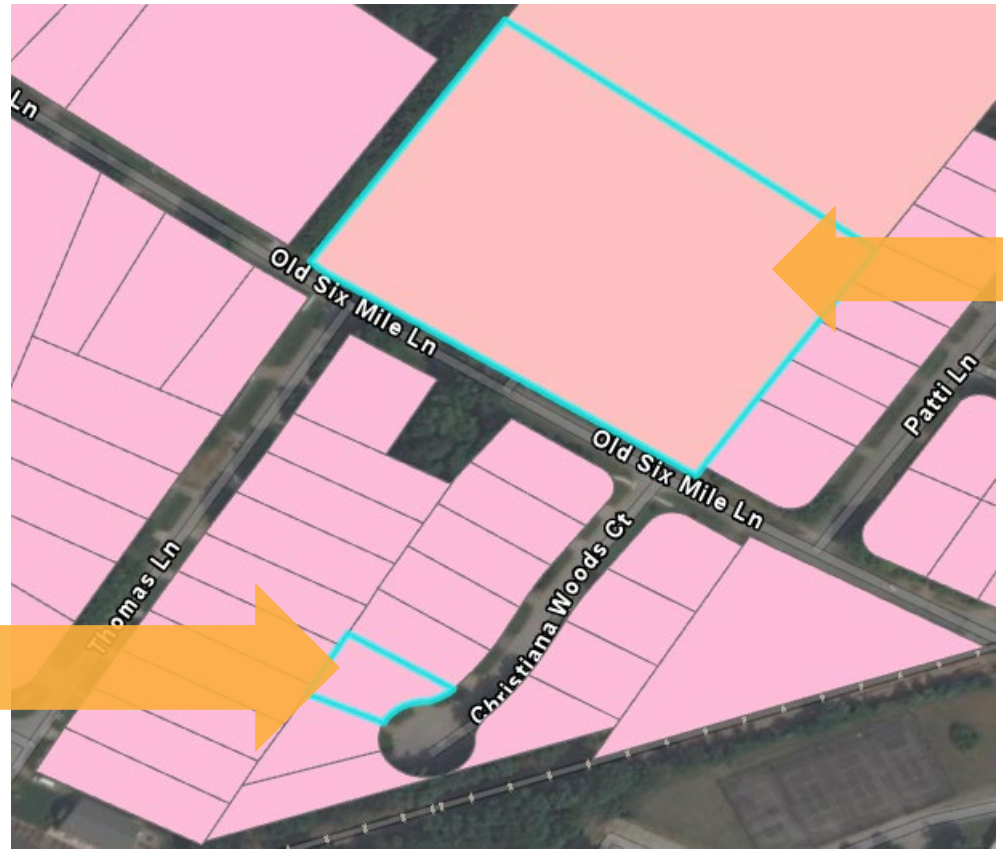


Generating the NSI



Generating the NSI

Year Built	1994
Number of Buildings	<Null>
Building Square Foot	2354
Number of Stories	2+B
Number of Stories Decription	2 story with basement
Total Rooms	<Null>
Number of Units	<Null>
BEDROOMS	2
Total Baths	3
Total Baths Calculated	3
Partial Baths	1
Garage Carport Type	A
Garage Code Description	ATTACHED GARAGE
Parking Spaces	2
Pool Indicator	<Null>
Pool Indicator Description	<Null>
Market Value of Land	35000
Market Value of improvements	200590
Market Value	235590
Market Value Year Established	2018
Building Classification	<Null>
Building Classification Code Description	<Null>
Building Style Type	N
Building Style Description	CONVENTIONAL
Construction Code	W
Construction Code Description	WOOD
Exterior Wall Type	S
Exterior Wall Description	SIDING (ALUM/VINYL)
Foundation Type	B
Foundation Type Description	Crawl/Raised



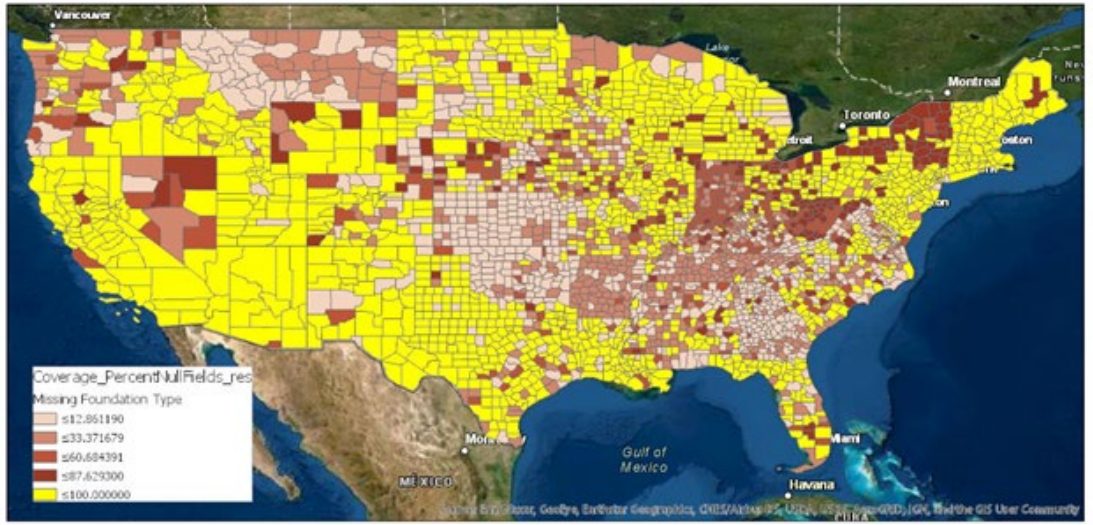
Year Built	1972
Number of Buildings	11
Building Square Foot	22827
Number of Stories	3
Number of Stories Decription	<Null>
Total Rooms	<Null>
Number of Units	<Null>
BEDROOMS	<Null>
Total Baths	0
Total Baths Calculated	0
Partial Baths	0
Garage Carport Type	<Null>
Garage Code Description	<Null>
Parking Spaces	0
Pool Indicator	<Null>
Pool Indicator Description	<Null>
Market Value of Land	810020
Market Value of improvements	1052420
Market Value	1862440
Market Value Year Established	2018
Building Classification	<Null>
Building Classification Code Description	<Null>
Building Style Type	<Null>
Building Style Description	<Null>
Construction Code	<Null>
Construction Code Description	<Null>
Exterior Wall Type	<Null>
Exterior Wall Description	<Null>
Foundation Type	<Null>
Foundation Type Description	<Null>

Structure Location and Type

- Identification
  - Parcel Data
  - ESRI Business Layer
  - NCES
  - HIFLD
    - Nursing Home
    - Hospitals
    - Mobile Homes
- Footprints
  - USA Structures
  - Microsoft
  - Map Building Layer

Data Availability

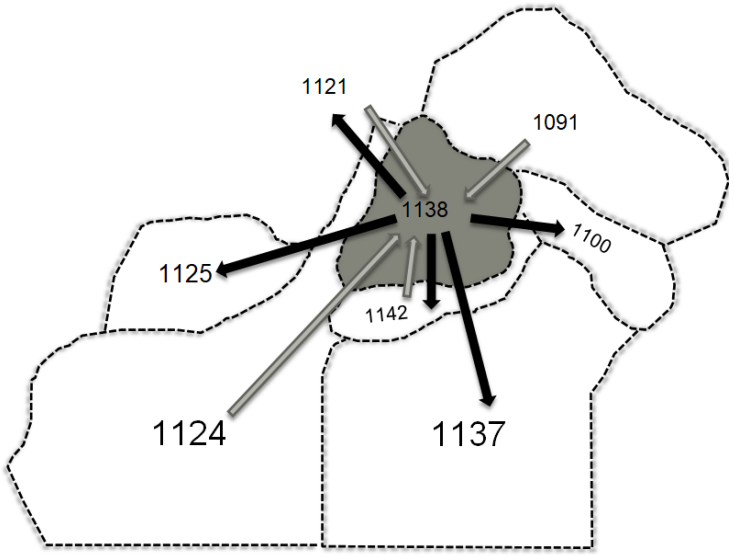
Feature	Value
KY_Structures	
IMAGE_NAME	Li204-lexington
(Derived)	
(Actions)	
OBJECTID	2406584
BUILD_ID	14273351
OCC_CLS	NULL
PRIM_OCC	NULL
SEC_OCC	NULL
PROP_ADDR	NULL
PROP_CITY	NULL
PROP_ST	NULL
PROP_ZIP	NULL
OUTBLDG	NULL
HEIGHT	6.400000095367432
SQMETERS	21399.462890625
SQFEET	230341.671875
H_ADJ_ELEV	NULL
L_ADJ_ELEV	NULL
FIPS	21111
CENSUSCODE	21111004900
PROD_DATE	2011-07-06 00:00:00
SOURCE	NGA
USNG	16S FH 09793 34980
LONGITUDE	-85.7445988698696
LATITUDE	38.25629477893921
IMAGE_NAME	Li204-lexington
IMAGE_DATE	2011-07-06 00:00:00
VAL_METHOD	Unverified
REMARKS	NULL
UUID	{e300c8dc-dc88-4388-a0d7-a6c9bb901..
Shape_Length	0.013912786478807804
Shape_Area	2.2026127351336762e-06



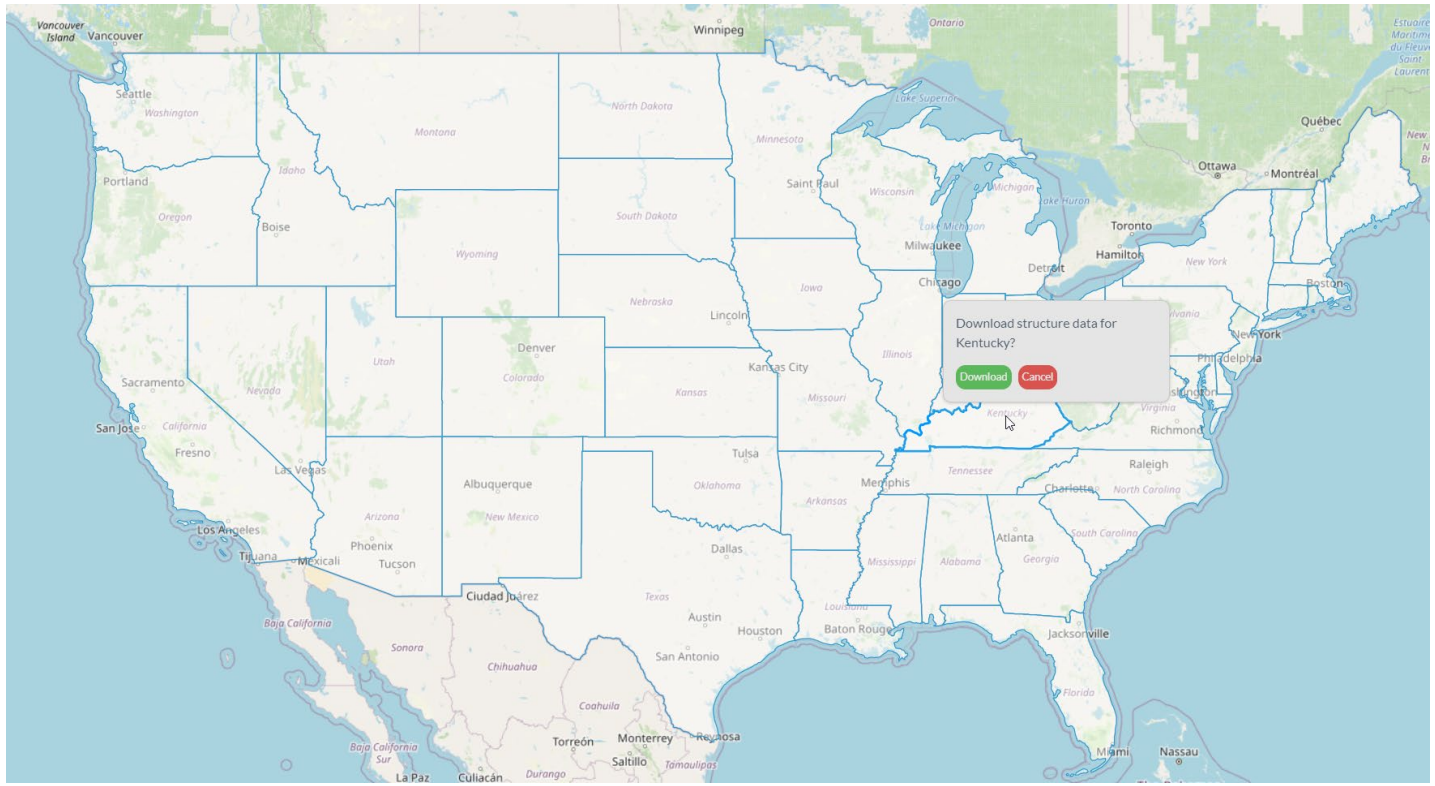
Population Assignment

POP2AMU65	2
POP2AMO65	0
POP2PMU65	1
POP2PMO65	0

- Census Block Level
  - LEHD workers shift Day and Night counts
  - Special: Hospital Bed Counts
  - New Developments absorb growth indicated by ACS
- Structure Level Assignment
  - Weight by housing units, number of employees, bed counts
- Age: Tract level demographics; block level LEHD; nursing homes



Using the NSI: Data Download

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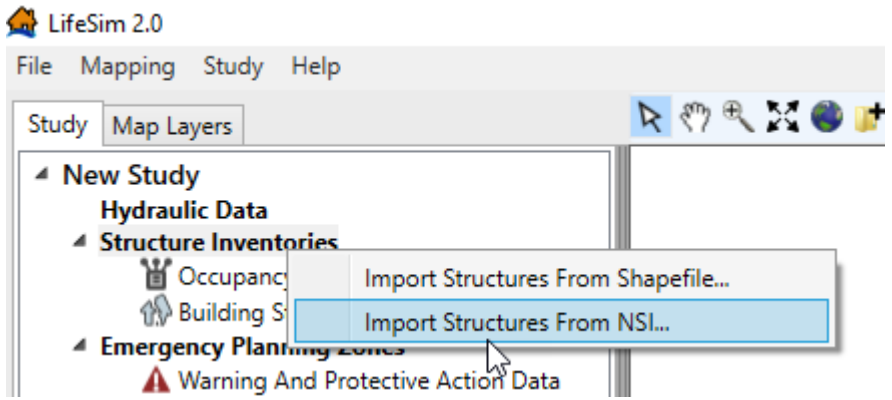
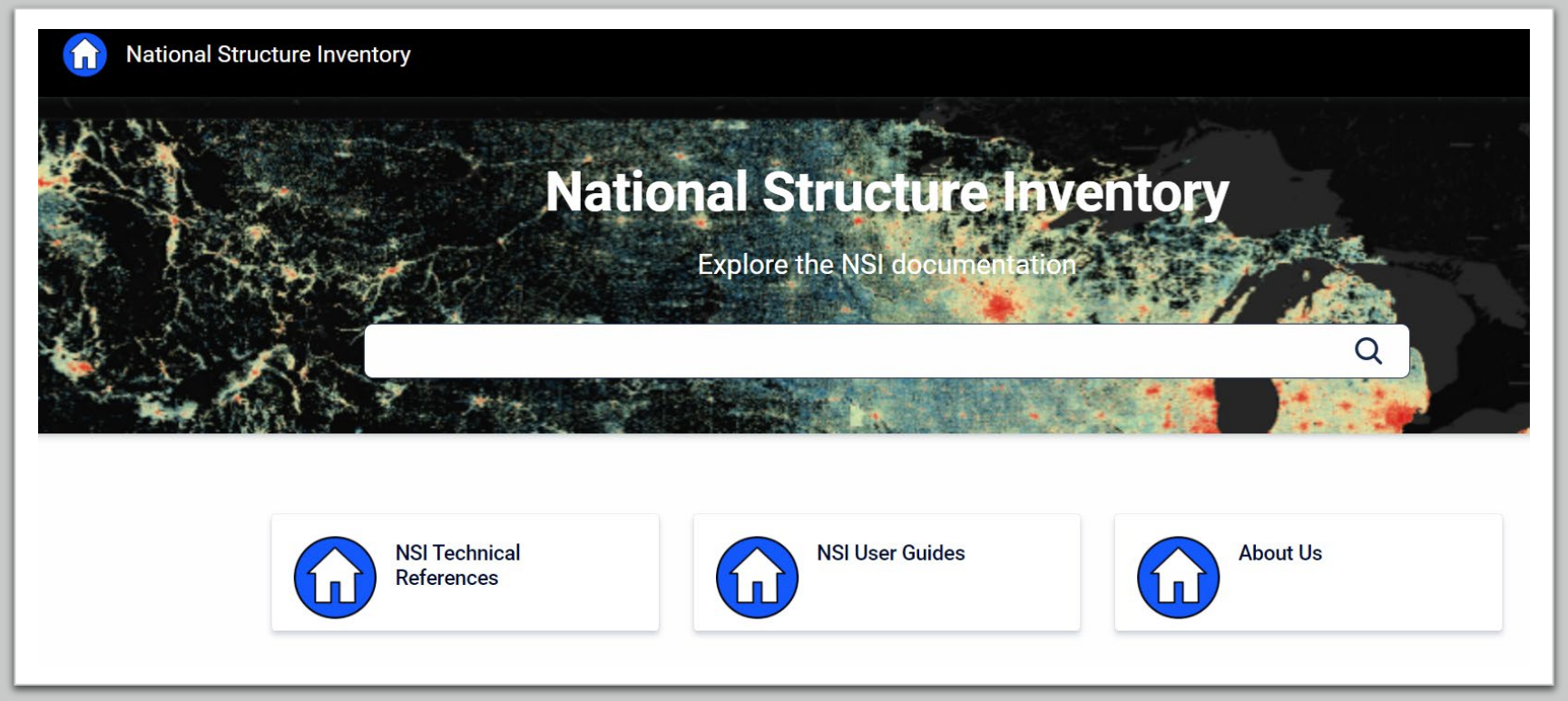
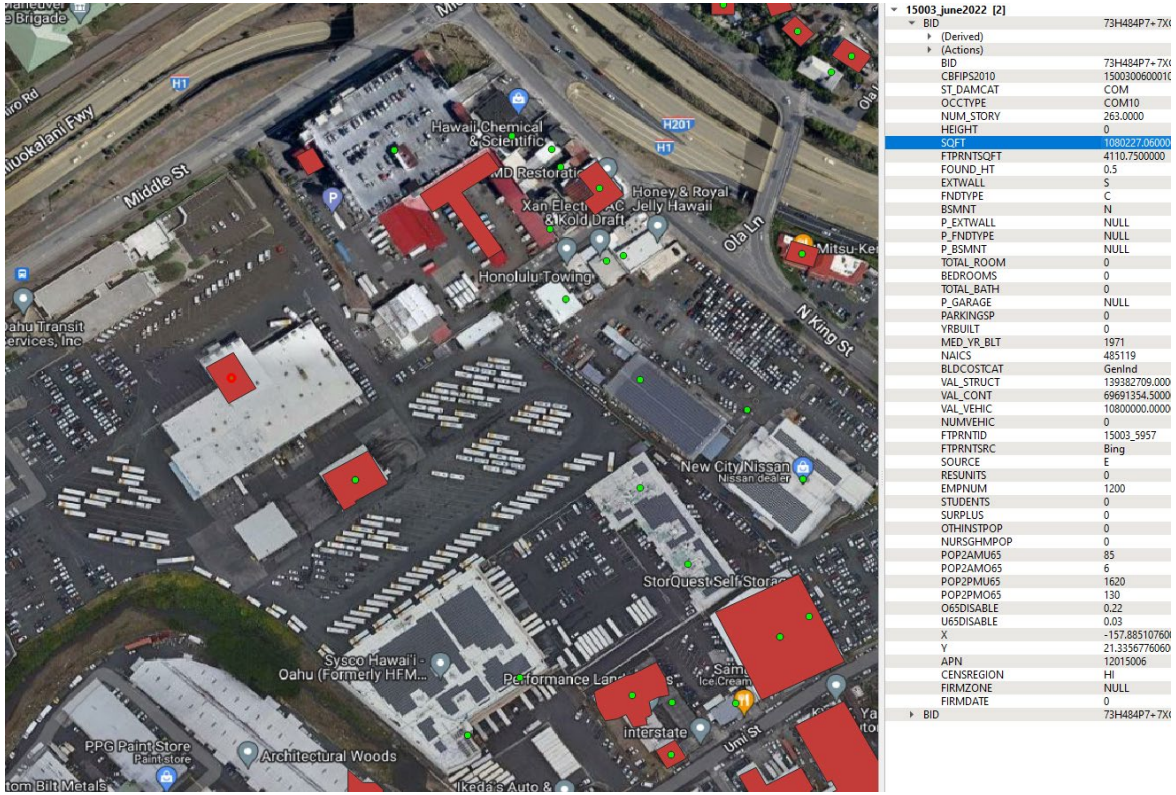
https://nsi.sec.usace.army.mil/nsiapi/structures?fips=15005
```





Using the NSI: Documentation

- Attribute list
- FAQ
- Survey Guide
- Contact Info



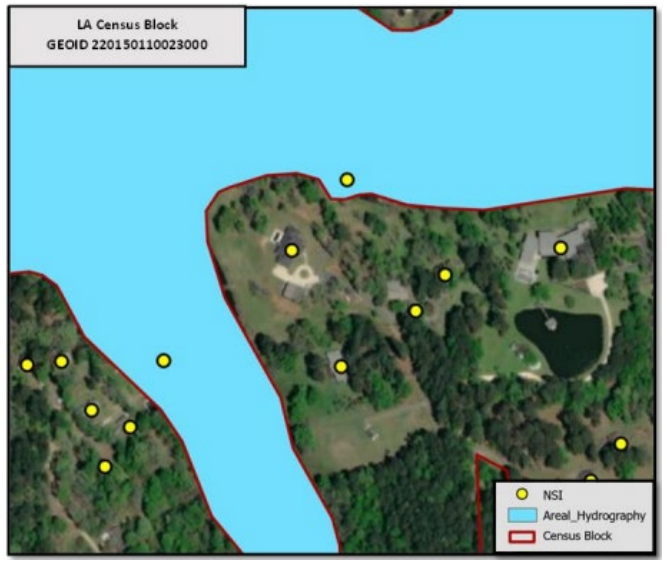
15003_june2022 [2]	
BID	73H484P7+7X(
(Derived)	
(Actions)	
BID	73H484P7+7X(
CBFIPS2010	1500300600001(
ST_DAMCAT	COM
OCCTYPE	COM10
NUM_STORY	263.0000
HEIGHT	0
SQFT	1080227.06000
FTPRNTSQFT	4110.7500000
FOUND_HT	0.5
EXTWALL	S
FNDTYPE	C
BSMNT	N
P_EXTWALL	NULL
P_FNDTYPE	NULL
P_BSMNT	NULL
TOTAL_ROOM	0
BEDROOMS	0
TOTAL_BATH	0
P_GARAGE	NULL
PARKINGSP	0
YRBUILT	0
MED_YR_BLT	1971
NAICS	485119
BLDCOSTCAT	GenInd
VAL_STRUCT	139382709.000
VAL_CONT	69691354.5000
VAL_VEHIC	10800000.0000
NUMVEHIC	0
FTPRNTID	15003_5957
FTPRNTSRC	Bing
SOURCE	E
RESUNITS	0
EMPNUM	1200
STUDENTS	0
SURPLUS	0
OTHINSTPOP	0
NURSGHMPOP	0
POP2AMU65	85
POP2AMO65	6
POP2PMU65	1620
POP2PMO65	130
O65DISABLE	0.22
U65DISABLE	0.03
X	-157.885107606
Y	21.3356776060
APN	12015006
CENSREGION	HI
FIRMZONE	NULL
FIRMDATE	0
BID	73H484P7+7X(

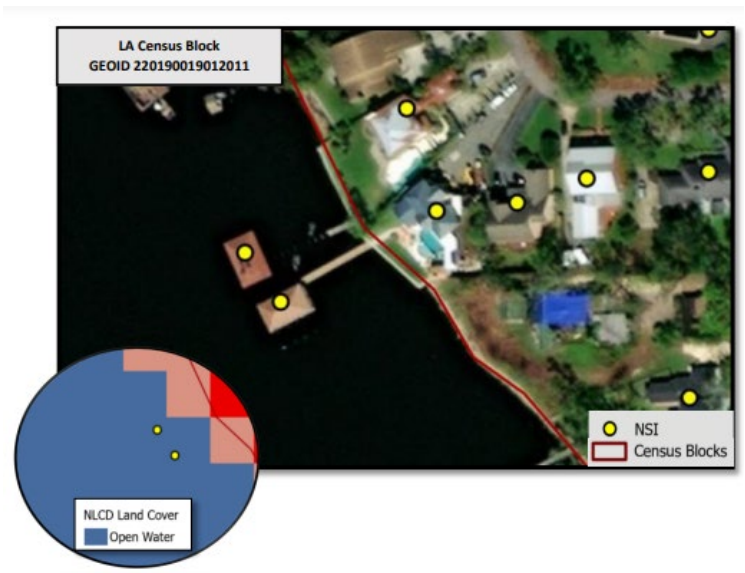
Limitations

- Poor data inputs can result in odd data outputs
- Especially when multiple sources are wrong in the same location

Quality Checks: Locations

- Low-lying areas





- Poor coverage

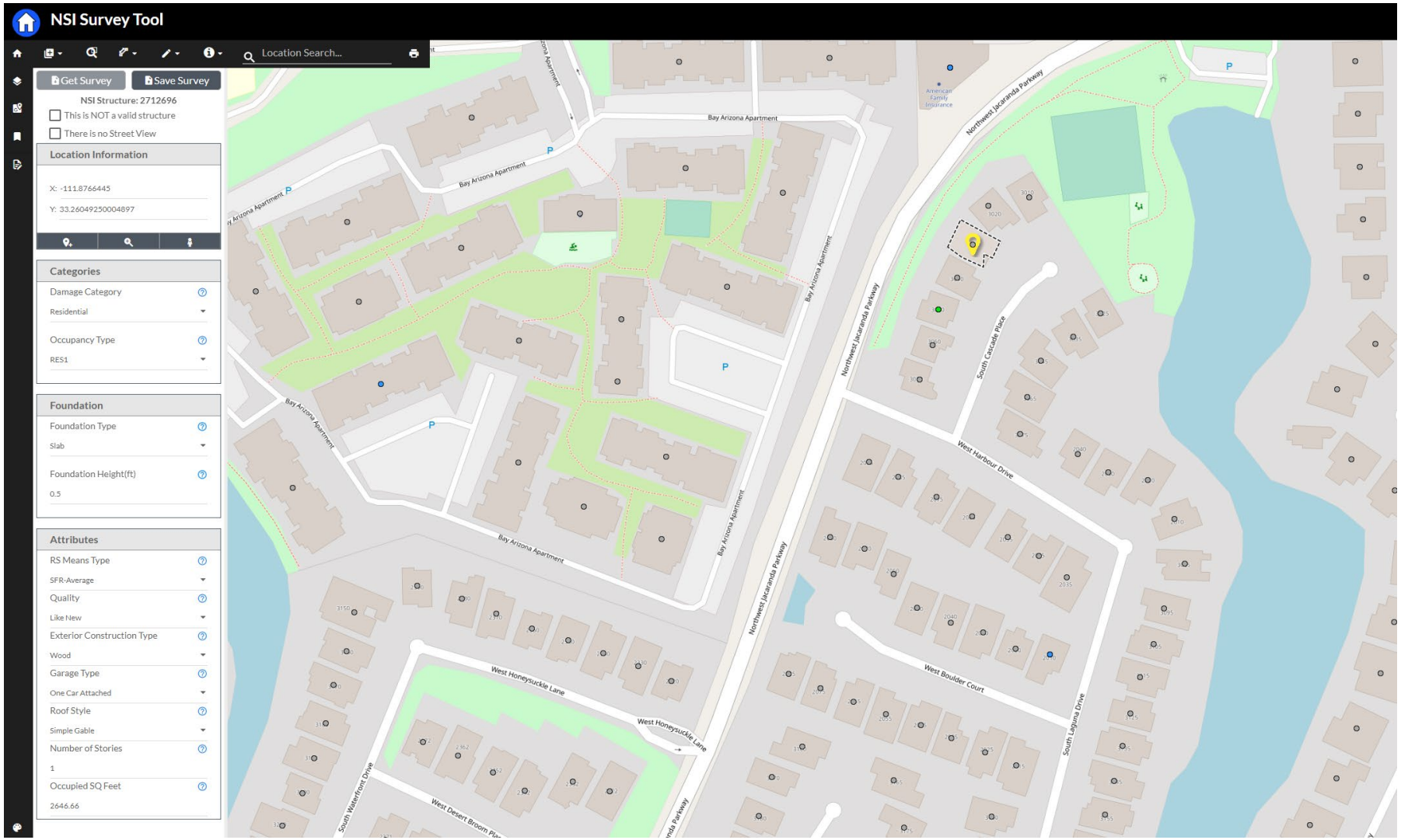
Quality Checks: Values

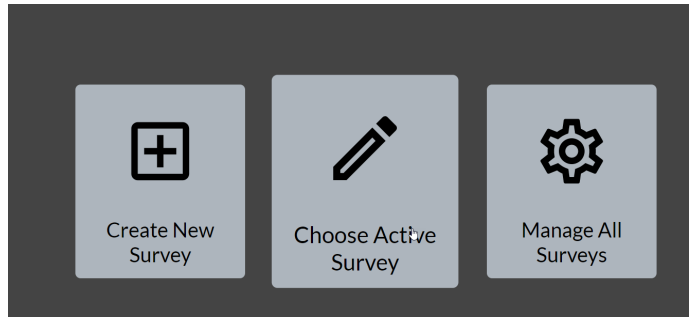
- Examine outliers for accuracy
  - Structure inputs
  - Model outputs
- Consider whether depreciation and other factors are reasonable for your study area

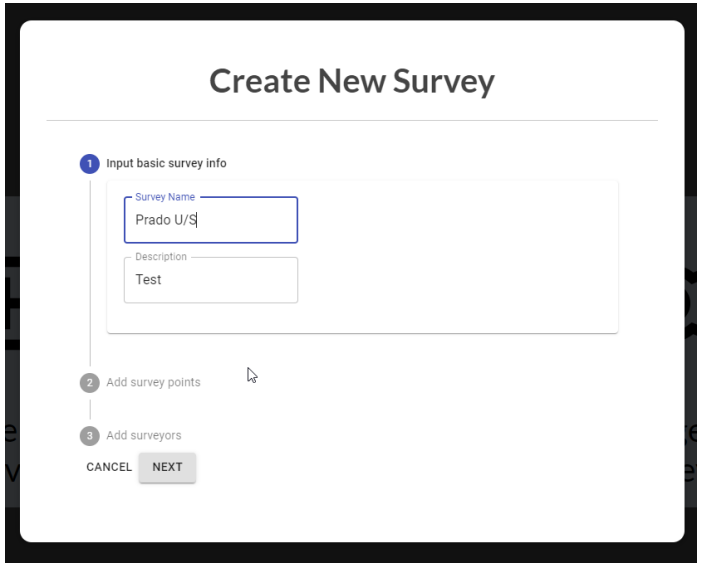
Quality Checks: Heights

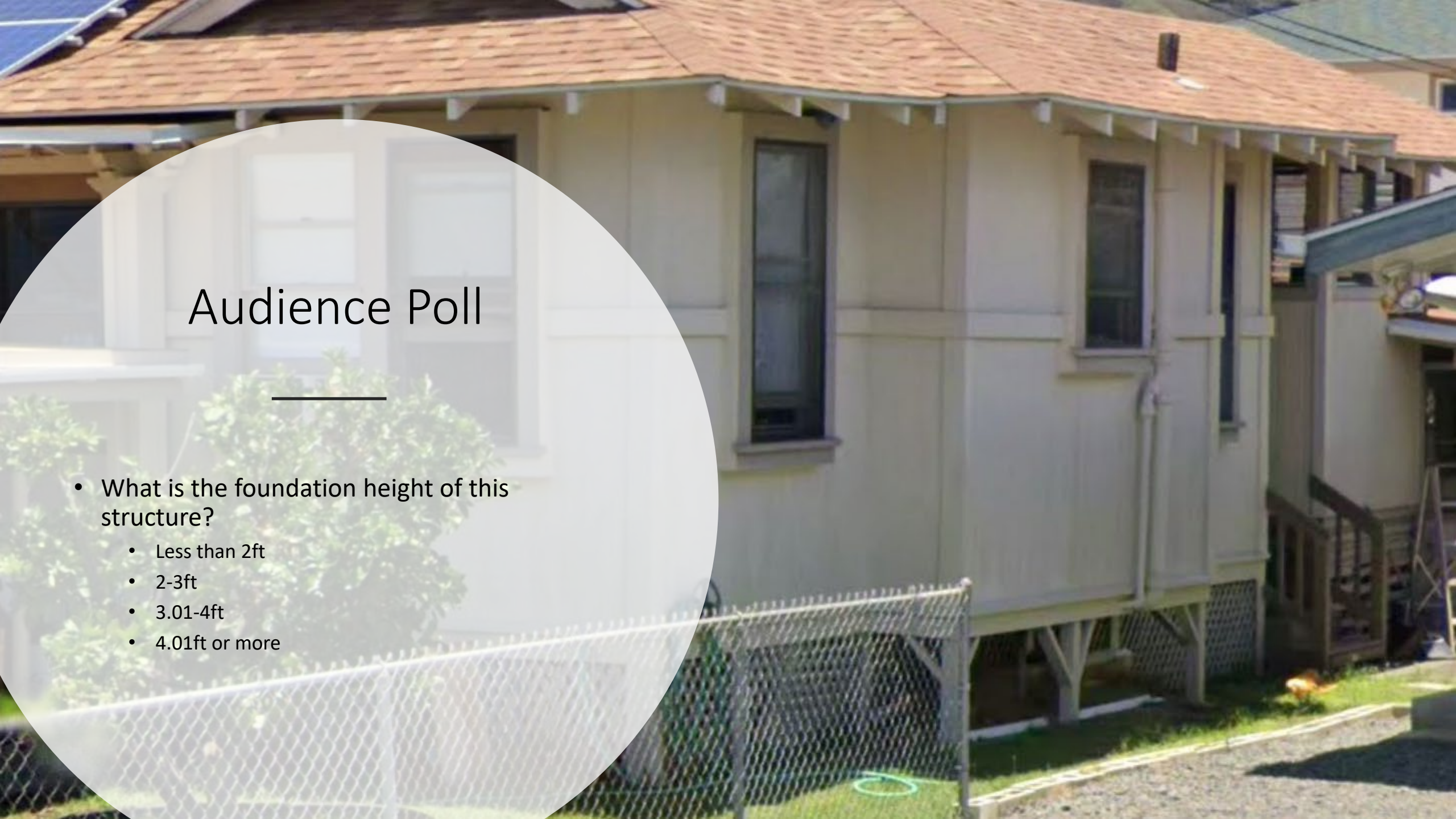
- Foundation heights can have significant impact on dollar damage and life loss
- The NSI currently relies on national values for heights of a given foundation type
- Structure specific foundation type data is not available for all counties
- Consider validating and modifying the default assignments
  - Spot checks may be appropriate for low-level analyses
  - We recommend surveys for investment decisions

Survey Tool


NSI Survey Tool
Location Search...
Get Survey
Save Survey
NSI Structure: 2712696
This is NOT a valid structure
There is no Street View
Location Information
X: -111.8766445
Y: 33.26049250004897
Categories
Damage Category
Residential
Occupancy Type
RES1
Foundation
Foundation Type
Slab
Foundation Height(ft)
0.5
Attributes
RS Means Type
SFR-Average
Quality
Like New
Exterior Construction Type
Wood
Garage Type
One Car Attached
Roof Style
Simple Gable
Number of Stories
1
Occupied SQ Feet
2646.66
Bay Arizona Apartment
Northwest Jacaranda Parkway
South Cascade Place
West Harbour Drive
West Honeysuckle Lane
West Boulder Court
South Laguna Drive
South Waterfront Drive
West Desert Broom Place


Create New Survey
Choose Active Survey
Manage All Surveys


Create New Survey
1 Input basic survey info
Survey Name
Prado U/S
Description
Test
2 Add survey points
3 Add surveyors
CANCEL
NEXT



Audience Poll

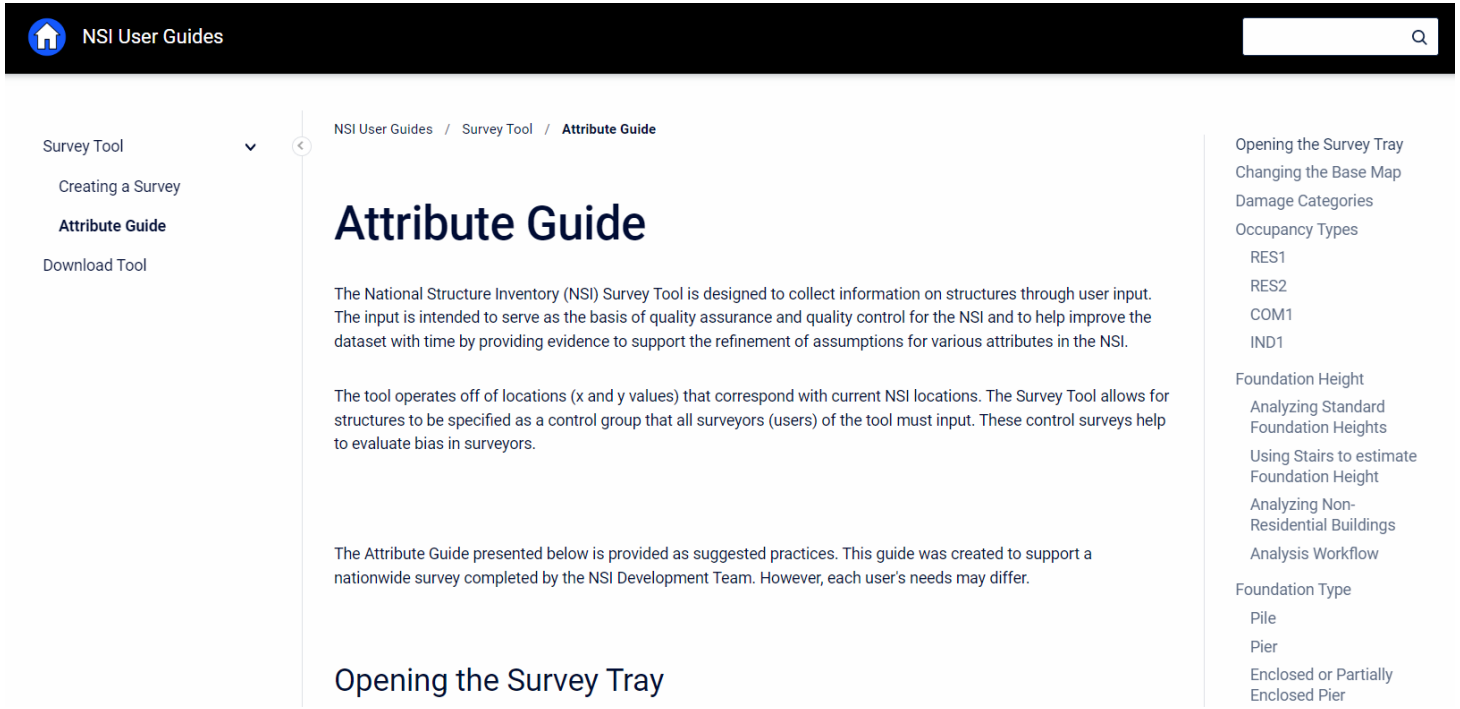
- What is the foundation height of this structure?
  - Less than 2ft
  - 2-3ft
  - 3.01-4ft
  - 4.01ft or more

Audience Poll

- What is the foundation height of this structure?
  - Less than 8ft
  - 8-9ft
  - 9.01-10ft
  - 10.01ft or more

Sampling Execution Best Practices

- Make use of the NSI Survey Tool's Attribute Guide
  - Developed by the NSI Surveyors
- Calibrate with known structures
- Use "control" structures when working with a team
  - You can compare results, look for biases, etc.



Sampling Design Best Practices

- Not unique to NSI
  - Except NSI provides a potential sampling frame
- Sample size mostly varies with how confident you want to be
  - Population size doesn't matter as much as people typically think
  - Formulas vary depending on whether you're interested in mean or proportion
- Stratifications can help improve accuracy, but multiplies sample size

$$n' = \frac{NZ^2P(1-P)}{d^2(N-1)+Z^2P(1-P)}$$

where n' = Sample size with finite population correction,
N = Population size,
Z = Z statistic for a level of confidence,
P = Expected proportion (If the prevalence is 20%, $P = 0.2$), and
d = Precision (If the precision is 5%, then $d = 0.05$)

$$n = \left(\frac{Z*S}{E}\right)^2, \text{ where}$$

n = Sample size
Z = Z-Value (1.96)

$$S = \frac{Foundation\ Height_{High} - Foundation\ Height_{Low}}{6}$$

E = Allowable error (0.20 feet)

Using sample data

- You can overwrite NSI values with new best estimates and use distributions in consequence models
  - Heights, structure values
- Consider updating unobserved structure values
- The NSI may know some things (foundation type) from parcel data but guesses at others (foundation height)
  - Creating new occupancy types may be necessary to take advantage of this information

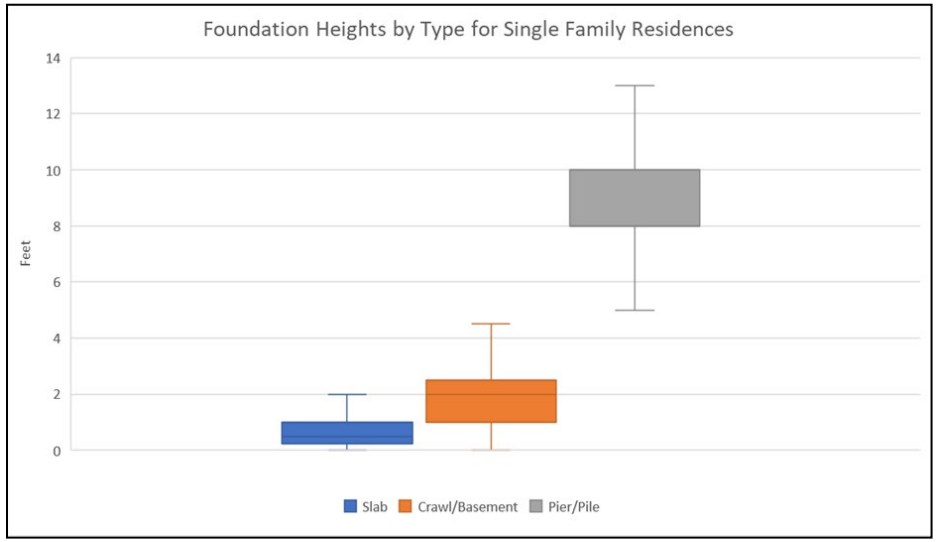
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
1	srId	userNa	comple	isContr	saId	fdId	x	y	invalidS	noStree	cbfips	occtype	stDamc	foundH	numSto	sqft	foundTy	rsmean	quality	constTy	garage	roofSty
2	103	F	TRUE	TRUE	177	28796127	-86.9175	40.41017	FALSE	FALSE	1.82E+14	COM4	COM	0	2	55704.84	Mat	Other	Like New	Masonry o	Three Car	Flat
3	105	D	TRUE	TRUE	179	28796127	-86.9175	40.41019	FALSE	FALSE	1.82E+14	IND5	IND	0	2	50254.64	Cont	Factory	Average	Masonry o	None	Flat
4	106	L	TRUE	TRUE	181	28796127	-86.9175	40.41019	FALSE	FALSE	1.82E+14	EDU2	PUB	-901	-901	48647.21	Unkn	School - V	Average	Masonry o	None	Flat
5	108	L	TRUE	TRUE	185	69589420	-82.88152	41.52502	FALSE	TRUE	3.91E+14	RES1	RES	-901	-901	-901	Unkn	Unknown	Unknown	Unknown	Unknown	Unknown
6	109	L	TRUE	TRUE	186	87654268	-94.93824	29.21636	FALSE	FALSE	4.82E+14	RES1	RES	12	1	1648.37	Slab	SFR-Avera	Average	Stucco	Two Car B	Simple Gal
7	110	D	TRUE	TRUE	183	69589420	-82.88152	41.52502	FALSE	TRUE	3.91E+14	RES1	RES	-901	-901	-901	Unkn	Unknown	Unknown	Unknown	Unknown	Unknown
8	111	L	TRUE	TRUE	187	11311897	-81.83614	27.27965	FALSE	FALSE	1.2E+14	RES2	RES	-901	-901	-901	Unkn	Manufactu	Unknown	Manufactu	Unknown	Unknown
9	113	D	TRUE	TRUE	188	87654268	-94.93824	29.21636	FALSE	FALSE	4.82E+14	RES1	RES	8	1	2092.79	Epir	SFR-Custo	Average	Wood	Two Car B	Gable and
10	114	L	TRUE	TRUE	189	55540100	-74.06475	39.98153	FALSE	FALSE	3.4E+14	RES1	RES	0	0	0						
11	115	D	TRUE	TRUE	190	11311897	-81.83614	27.27965	FALSE	TRUE	1.2E+14	RES2	RES	-901	1	796.07	Unkn	Manufactu	Unknown	Unknown	None	Unknown
12	116	D	TRUE	TRUE	191	55540100	-74.06474	39.98153	TRUE	FALSE	3.4E+14	RES1	RES	0	0	0						
13	117	F	TRUE	TRUE	182	69589420	-82.88152	41.52502	FALSE	TRUE	3.91E+14	RES1	RES	0	1	994	Unkn	Unknown	Unknown	Unknown	None	Unknown
14	118	L	TRUE	TRUE	193	1.03E+08	-88.17788	43.02536	FALSE	FALSE	5.51E+14	RES3E	RES	1	1	1503.95	Base	SFR-Avera	Like New	Wood	Three Car	Gable and
15	120	L	TRUE	TRUE	195	53839612	-74.944	39.78118	FALSE	FALSE	3.4E+14	COM4	COM	0.5	1	2852.21	Slab	Office	Average	Masonry o	None	Flat
16	121	F	TRUE	TRUE	194	87654268	-94.93825	29.21637	FALSE	FALSE	4.82E+14	RES1	RES	10	2	0	Epir	SFR-Avera	Like New	Wood	One Car B	Simple Hip
17	124	L	TRUE	TRUE	197	1.04E+08	-121.9443	37.47366	FALSE	FALSE	6E+13	IND3	IND	0	1	35084.74	Slab	Other	Average	Masonry o	None	Flat
18	125	F	TRUE	TRUE	196	11311897	-81.83614	27.27965	FALSE	TRUE	1.2E+14	RES2	RES	2	1	662.27	Craw	SFR-Avera	Average	Manufactu	None	Simple Gal
19	129	D	TRUE	TRUE	192	1.03E+08	-88.17387	43.02546	FALSE	FALSE	5.51E+14	RES3-EF	RES	0	2	23944.02	Slab	Apartmen	Average	Brick	None	Gable and
20	130	F	TRUE	TRUE	198	55540100	-74.06474	39.98154	TRUE	FALSE	3.4E+14	RES1	RES	0	0	0	Slab					
21	133	F	TRUE	TRUE	201	1.03E+08	-88.17419	43.02493	TRUE	FALSE	5.51E+14	RES3E	RES	0	0	0						
22	134	L	TRUE	TRUE	199	22283785	-116.9497	46.37359	TRUE	FALSE	1.61E+14	GOV2	PUB	0	0	0						
23	135	D	TRUE	TRUE	200	53839612	-74.94401	39.78118	FALSE	FALSE	3.4E+14	GOV1	PUB	0.25	1	3206.96	Slab	Office	Average	Masonry o	None	Flat
24	136	L	TRUE	TRUE	203	77492099	-76.54956	40.78258	FALSE	TRUE	4.21E+14	COM1	COM	-901	-901	-901	Unkn	Store - Ret	Unknown	Unknown	Unknown	Unknown
25	137	L	TRUE	TRUE	205	4332111	-110.9139	32.14685	FALSE	FALSE	4.02E+13	RES1	RES	1	1	819.67	Slab	Manufactu	Average	Manufactu	None	Offset Mo
26	138	D	TRUE	TRUE	204	1.04E+08	-121.9441	37.47341	FALSE	FALSE	6E+13	IND5	IND	0.1	1	72620.67	Slab	Office	Like New	Masonry o	None	Flat
27	139	F	TRUE	TRUE	202	53839612	-74.94401	39.78119	FALSE	FALSE	3.4E+14	GOV1	COM	0	1	3095.27	Slab	Office	Average	Masonry o	None	Flat
28	141	L	TRUE	TRUE	206	89203040	-95.29197	29.60859	FALSE	TRUE	4.82E+14	RES2	RES	-901	-901	-901	Unkn	Manufactu	Unknown	Unknown	Unknown	Unknown

Use of NSI in Alternative Analysis

- Not terribly unique from other structure inventories
- General
  - Consider future development
    - Changes to population for life loss applications
  - Update price levels when necessary
- Nonstructural
  - Create new Occupancy types when changing damage functions
  - Modify foundation type and height for raises

Future Research

- Treatment of uncertainty
  - Structure level
  - Spatial Correlation
- Occupancy
  - Time Use Updates
  - Customers, etc.
- Input Data Refinement
  - Quality Control
  - Machine Learning
- Social Vulnerability
- Web Development



NSI Team

Leads

PI: Nicholas Lutz, HEC

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Web Devs: Randy Goss and Triet Nguyen, CRREL

Advisor: Will Lehman, HEC

Technology	Link	Who can submit an Issue?	Who can read responses?
Email	nsi@usace.army.mil	Public	The sender
Discourse	https://discourse.hecdev.net/c/nsi/10	USACE staff	The public
Github	https://github.com/HydrologicEngineeringCenter/NSI/discussions	Public	The public

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Questions?