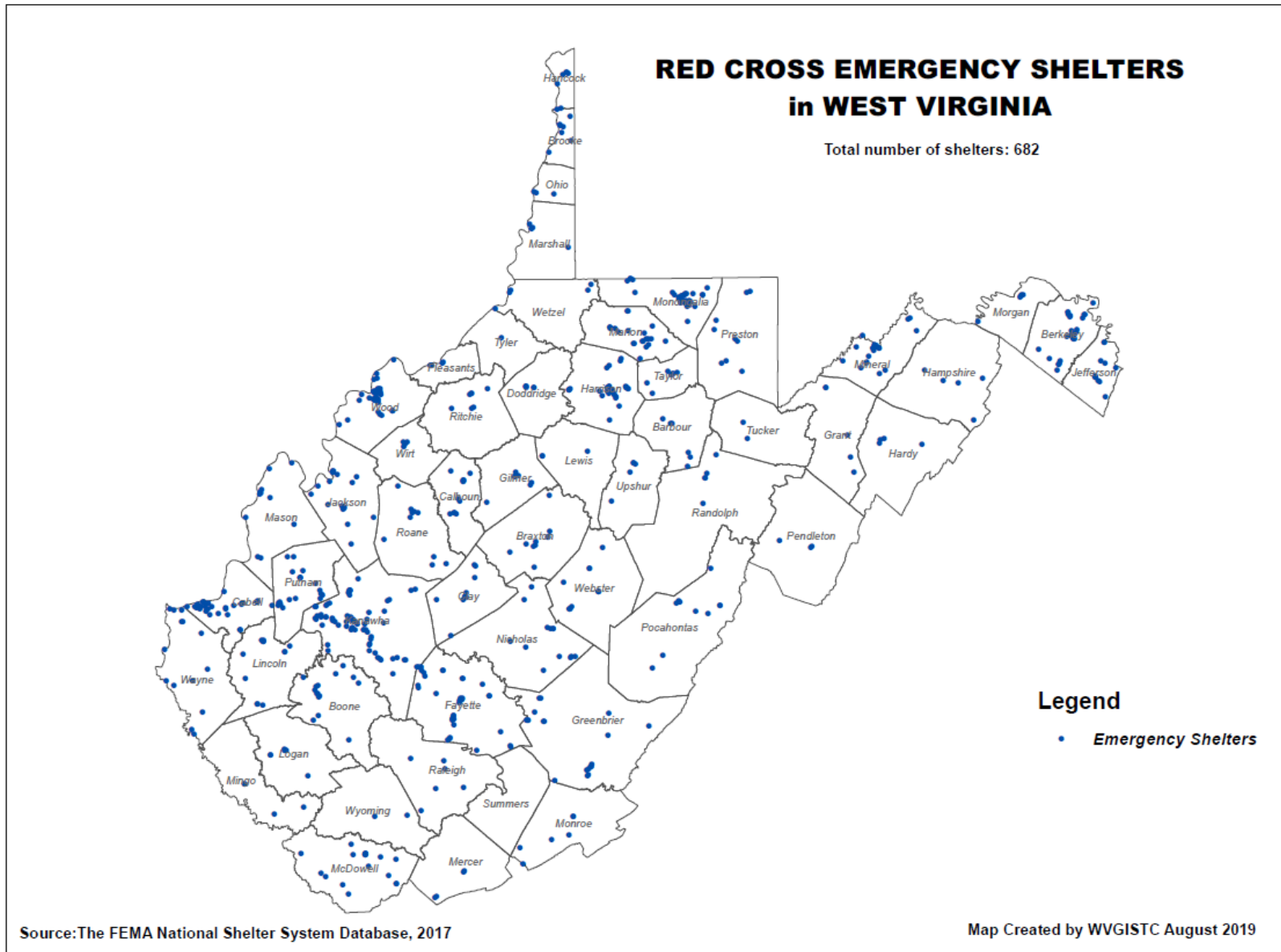


Statewide Flood Risk Assessment

Shelter Modeling for WV

Red Cross Shelters



Statewide Flood Risk Assessment

Shelter Modeling for WV

2016 June Flood: Shelter Database Information Requested

- 1) Shelter Names and Locations for WV 2016 Flood
- 2) Number of people housed at each shelter
- 3) Period of time people stayed at shelter
- 4) Any other useful sheltering statistics for population displacement and short-term shelter models
- 5) The communities where people came from (towns, unincorporated areas, address, county etc.)
- 6) Household breakdown statistics of Displaced Population (see next slide)

Statewide Flood Risk Assessment

Shelter Modeling for WV

2016 June Flood: Household Information Requested of Displaced Population for 2016 Flood – Can be aggregated into classes

- **Income** (HH Income < \$20K; \$20K-\$30K; \$30K-\$50K; \$50K-\$60K; HH Income > \$60K)
- **Ethnicity** (White, African American, Hispanic, Asian/Other)
- **Age** (Age < 15; 15 < Age < 65; Age > 65)
- **Housing Information:**
 - **House Ownership Type** (Owned or Rental)
 - **Occupancy Class Type** (Single family, Multi-family, Mobile Home, etc.)
 - **House Geography** (Urban versus Rural Location)
- *Also companion pet data (dogs, cats) or other animal information if available*

Goal: Add Shelter Model to Hazus FAST

ORIGINAL MODEL:

- The expert-based short-term shelter model developed by Harrald et al. (1989) at George Washington University for the earthquakes in Northern California in a contract with the American Red Cross

Reference:

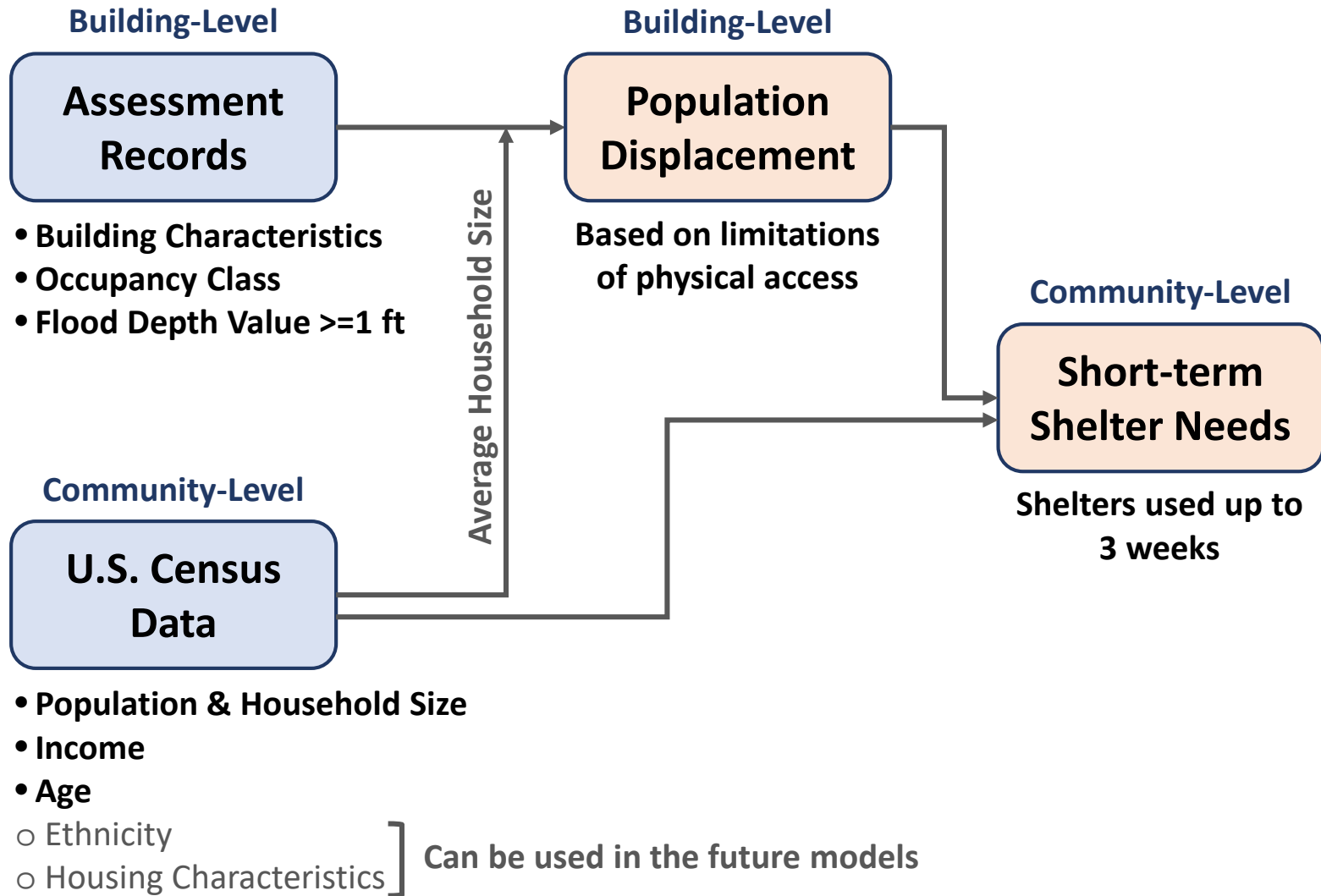
- Harrald, J. R., Al-Hajj, S., Fouladi, B., & Jeong, D. (1994). Estimating the demand for sheltering in future earthquakes. Unpublished paper, Department of Engineering Management, the George Washington University, Washington, DC.

VARIABLES:

- Socio-economic variables for shelter model weighted by experts:
 - **Income** (In five classes from \$10,000 to \$35,000)
 - **Ethnicity** (White, African American, Hispanic, Asian/Other)
 - **Age** (Under or above 65)
 - **Residence Type** (Owned, Rental, Vacation)
- Modified and applied to floods in "Flood Model Hazus-MH Technical Manual", Chapter 13 **removing ethnicity and residence type**

*Objective: Incorporate **Population Displacement and Short-Term Shelter Needs** in FEMA's Open Hazus script*

Proposed Shelter Model



Shelter Model – Displacement

BASE MODEL: Flood Model Hazus-MH Technical Manual

MODIFICATIONS: Scale of calculations changed to buildings

DATA:

- **Hazard Occupancy Code** and **Flood Depth Value** for Jefferson County at the scale of buildings (Building Inventory)
- **Average Household Size** of the communities from census data (2017 American Community Survey (ACS) 5-Year Estimates downloaded from "American Fact Finder")

METHOD:

- Extraction of the **buildings** located in flood zones with the depth value of 1 ft or more
- Estimating the number of the **residential units** in each building using the occupancy code
- Calculation of the estimated **residing population** in each building using the average household size of the community
- Adding the population of the buildings in each community

Shelter Model – Displacement

DEFINED EQUATION:

$$\#DI_{IN} = \sum_{j=1}^n (\text{ResUNIT}_{IN} \times \text{AveHHSIZE}_{COMM})$$

Where:

$\#DI_{IN}$ = the number of displaced individuals as a result of inundation with the depth equal or more than 1 foot

ResUNIT_{IN} = the number of residential units in each building located within the area of inundation with the depth equal or more than 1 foot

AveHHSIZE_{COMM} = the average household size of the community where the building is located

j = the number of residential buildings within the flooded area with the depth equal or more than 1 foot

OBJECTID	Lat	Long	Flood Depth Value	Hazard Occupancy Code	Residential Units FLD Zones	Ave HH Size	Residing Population	Displaced Population 1ft or More	TRACTCE10	Block Group ID	BLOCKCE10	GEOID10	NAME10
535	39.2876158	-77.86459387	1	RES1	1	2.49	2.49	2.49	972505	540379725051	1047	540379725051047	Block 1047
536	39.2875983	-77.86462745	1	RES1	1	2.49	2.49	2.49	972505	540379725051	1047	540379725051047	Block 1047
537	39.2876014	-77.8647403	1.1	RES1	1	2.49	2.49	2.49	972505	540379725051	1047	540379725051047	Block 1047
538	39.2875286	-77.8648382	1.1	RES3A	2	2.49	4.98	4.98	972505	540379725051	1047	540379725051047	Block 1047
539	39.2868605	-77.86563603	N/A	RES1	1	2.49	2.49	0.00	972501	540379725011	1089	540379725011089	Block 1089
540	39.2867933	-77.86543516	1.4	RES1	1	2.49	2.49	2.49	972501	540379725011	1089	540379725011089	Block 1089
541	39.2864864	-77.86500677	0.1	RES1	1	2.49	2.49	0.00	972501	540379725011	1089	540379725011089	Block 1089
542	39.2870223	-77.86477163	0.4	RES1	1	2.49	2.49	0.00	972501	540379725011	1089	540379725011089	Block 1089
543	39.2871321	-77.86495628	0.2	RES1	1	2.49	2.49	0.00	972501	540379725011	1089	540379725011089	Block 1089

A part of the population displacement table at building level

Shelter Needs

BASE MODEL: Flood Model Hazus-MH Technical Manual

MODIFICATIONS: Income classes updated based on the inflation rate

DATA:

- **Displaced Population** estimated in the previous part
- **Household Income** and **Age** from census data (2017 American Community Survey (ACS) 5-Year Estimates downloaded from "American Fact Finder")

METHOD: Based on "Flood Model Hazus-MH Technical Manual", Chapter 13, at the scale of communities:

- Calculation of the percentage of households in the **income classes**:
 - IM1: HH Income per year < **\$20,000**
 - IM2: **\$20,000** <= HH Income per year < **\$30,000**
 - IM3: **\$30,000** <= HH Income per year < **\$50,000**
 - IM4: **\$50,000** <= HH Income per year < **\$60,000**
 - IM5: **\$60,000** <= HH Income per year
- Calculation of the percentage of individuals in the **age classes**:
 - AM1: Less than **15** years
 - AM2: **15** to **64** years
 - AM3: **65** years or more

Shelter Needs

MODIFICATIONS TO INCOME CLASSES:

- The inflation rate of 1990 to 2017 (1.87) was slightly changed while applying to make the intervals match the census data

Income Class	Original and Hazus Models	Modified Model
IM1	HH Income < \$10,000	HH Income < \$20,000
IM2	\$10,000 <= HH Income < \$15,000	\$20,000 <= HH Income < \$30,000
IM3	\$15,000 <= HH Income < \$25,000	\$30,000 <= HH Income < \$50,000
IM4	\$25,000 <= HH Income < \$35,000	\$50,000 <= HH Income < \$60,000
IM5	\$35,000 <= HH Income	\$60,000 <= HH Income

Shelter Needs

USED EQUATIONS:

$$\#STP = \sum_{k=1}^5 \sum_{m=1}^3 [\alpha_{km} \times DP \times HI_k \times HA_m]$$

Where:

#STP = Number of people using established shelters

α_{km} = a constant calculated as below

DP = Displaced population by inundation with equal or more than 1 foot depth (from the previous stage)

HI_k = Percentage of population in the kth income class

HA_m = Percentage of population in mth age class

Where:
$$\alpha_{km} = (IW \times IM_k) + (AW \times AM_m)$$

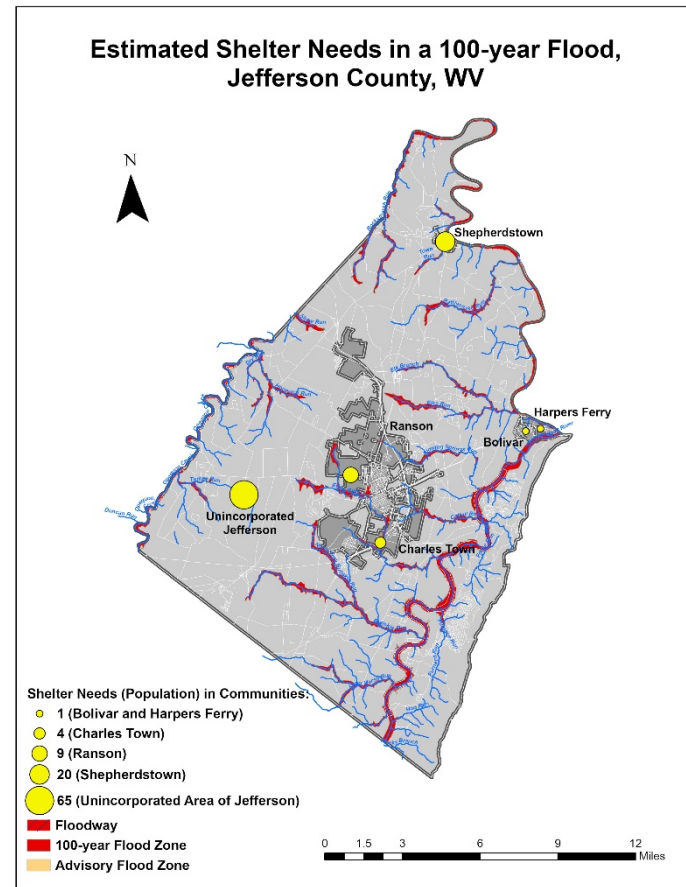
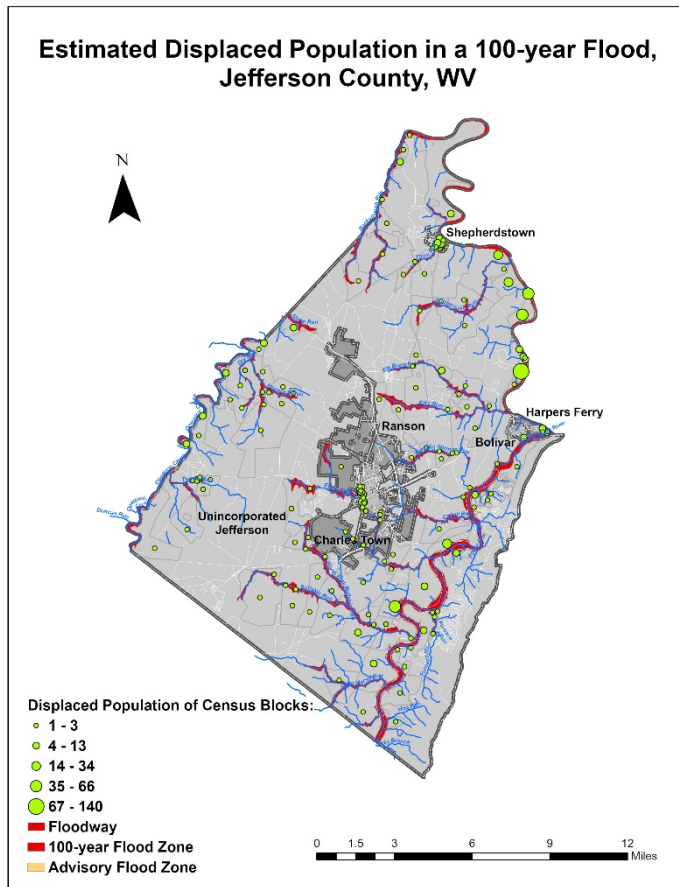
IW = Shelter category weight for income (0.8)

AW = Shelter category weight for age (0.2)

IM_k = Relative modification factor for income (calculated using table 13.2 in the manual)

AM_m = Relative modification factor for age (calculated using table 13.2 in the manual)

Jefferson County Pilot – Results



#	CID	Census ID	Community Name	County	Incorporated / Unincorporated	Total Population	Residential Units in Flood Zones	Average Household Size	Population Residing in Flood Zones	Percentage of Population Residing in Flood Zones	Estimated Displaced Population (Inundation >= 1 ft)	Percentage of Population in Flood Zones Displaced	Estimated Population in Need of Shelter (Inundation >= 1 ft)	Percentage of Population in Flood Zones in Need of Shelter
1	540065		JEFFERSON COUNTY *	JEFFERSON COUNTY	Unincorporated	41,907	501	2.6	1322	3.2%	549	41.5%	65	4.9%
2	540030	5408932	BOLIVAR, TOWN OF	JEFFERSON COUNTY	Incorporated	1,246	3	2.4	7	0.6%	7	100.0%	1	15.7%
3	540066	5414610	CHARLES TOWN, CITY OF	JEFFERSON COUNTY	Incorporated	5,766	24	2.5	60	1.0%	22	37.5%	4	6.1%
4	540067	5435284	HARPERS FERRY, TOWN OF	JEFFERSON COUNTY	Incorporated	236	6	2.1	13	5.3%	10	83.3%	1	10.1%
5	540068	5466988	RANSON, CITY OF	JEFFERSON COUNTY	Incorporated	4,945	81	2.7	215	4.4%	51	23.5%	9	4.3%
6	540069	5473468	SHEPHERDSTOWN, TOWN OF	JEFFERSON COUNTY	Incorporated	1,573	61	1.7	104	6.6%	100	96.7%	20	19.4%
7	Total in county			Jefferson County	-	55,673	676	-	1721	3.1%	740	43.0%	100	5.8%

Future Directions

- Include more variables relevant to housing characteristics in the shelter model such as:
 - Housing Ownership Type (Owned or Rental)
 - Occupancy Type (Single family, Multi-family, & Mobile Home)
 - Geography: Urban versus Rural
- Research and review the actual shelter data of floods provided by the American Red Cross to test the model
- Data preparation for unincorporated areas missing in the census data by subtracting the demographic data of the communities from those of the county
- Automate data processing of the required variables for displacement and shelter estimations
- Customize Open Hazus “FAST” Flood Assessment Structure Tool including population displacement and shelter needs

“... the task of estimating and preparing for shelter demand is still very challenging.”
(Dr. John Harrald, 2019)

“The results of all modeling efforts should be interpreted with a degree of skepticism.”
(Harrald et al., 1994, p.13)

“Any model is a selective representation of reality.” (Harrald et al., 1994, p.14)