AMPHIBIOUS ARCHITECTURE:

Where
FLOOD RISK REDUCTION
meets
CLIMATE CHANGE ADAPTATION

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WHAT IS AMPHIBIOUS ARCHITECTURE?

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- **A buoyancy system beneath the house displaces water to provide flotation as needed, and a vertical guidance system allows the rising and falling house to return to exactly the same place upon descent.**

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- **Amphibious construction is an adaptive flood risk reduction strategy that works in synchrony with a flood-prone region's natural cycles of flooding, rather than attempting to obstruct them.**

Maasbommel, Netherlands

Maasbommel, Netherlands

LOUISIANA

For about 40 years, amphibious houses at Old River Landing in rural Louisiana have been rising and falling reliably with the level of flooding of the Mississippi River.

AMPHIBIOUS FOUNDATIONS ARE NOT NEW!

Dry in September . . . The same house . . . Floating in February

LOUISIANA

Cost of buoyancy system is typically $5,000 or less.

Dry in September . . . The same house . . . Floating in February

Old River Landing, Pointe Coupee Parish, LA

Old River Landing,
Pointe Coupee Parish, LA


69
6757

Old River Landing, Pointe Coupee Parish, LA

Old River Landing, Pointe Coupee Parish, LA


MAY 11 2011

After the spring 2011 flood. Amphibious house on left is undamaged. Note waterline on elevated house on right.

Extensive damage to home on left. Undamaged amphibious home on right.

WHAT IS THE BUOYANT FOUNDATION PROJECT?

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BFP
buoyant foundation project
FLOAT WHEN IT FLOODS

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The system consists of three basic elements: buoyancy blocks underneath the house that provide flotation, vertical guidance posts that prevent the house from going anywhere except straight up and down, and a structural sub-frame that ties everything together.

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IT'S NOT A ONE-SIZE-FITS-ALL SOLUTION!

BUOYANT FOUNDATIONS CREATE HOMES THAT FLOAT IN A FLOOD

Advantages

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- **Half the cost (or less) of permanent static elevation**

COMPARISON OF 3 CONDITIONS

House on traditional masonry piers

House elevated to 8 feet

House with a Buoyant Foundation

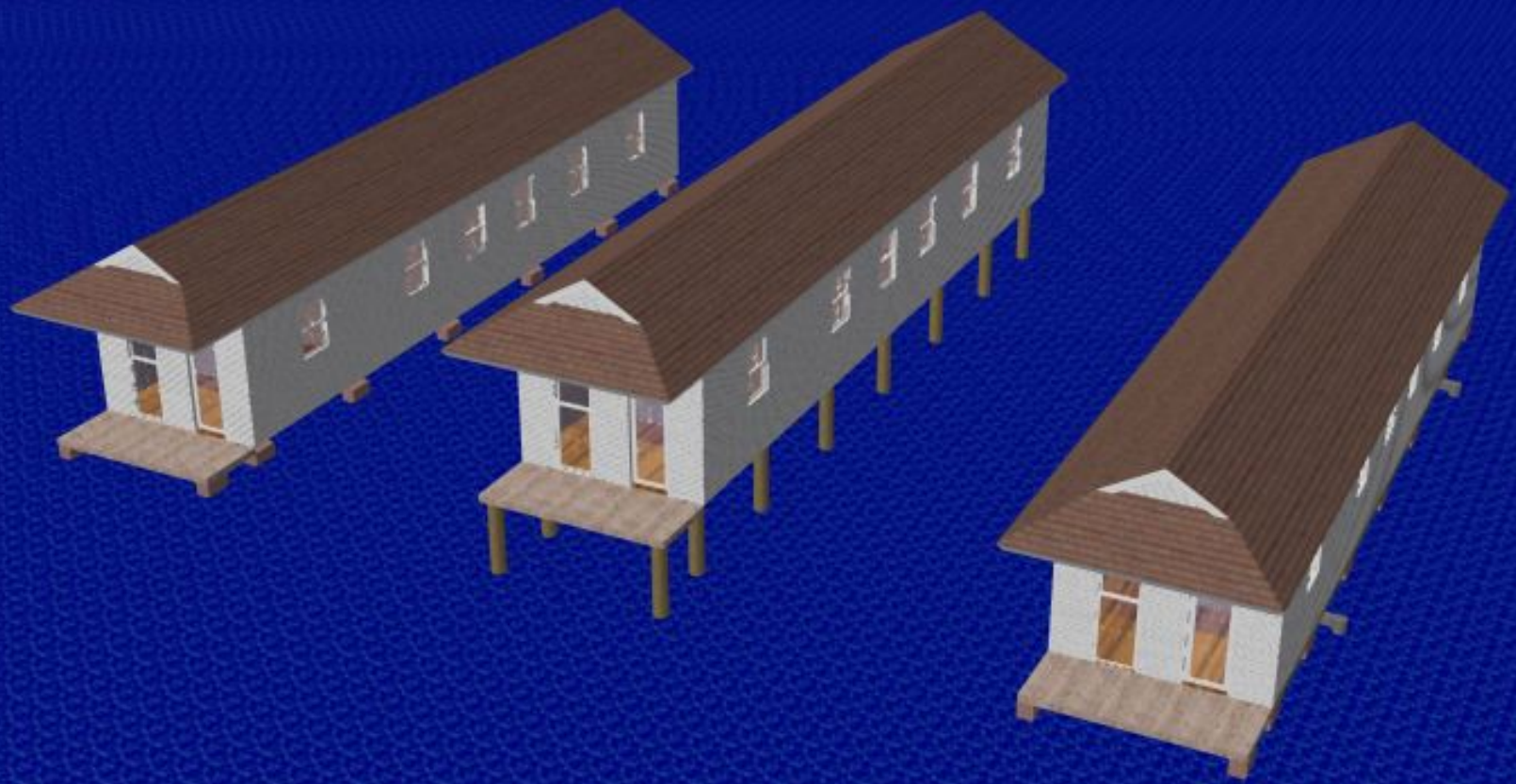
NOW ADD WATER . . .

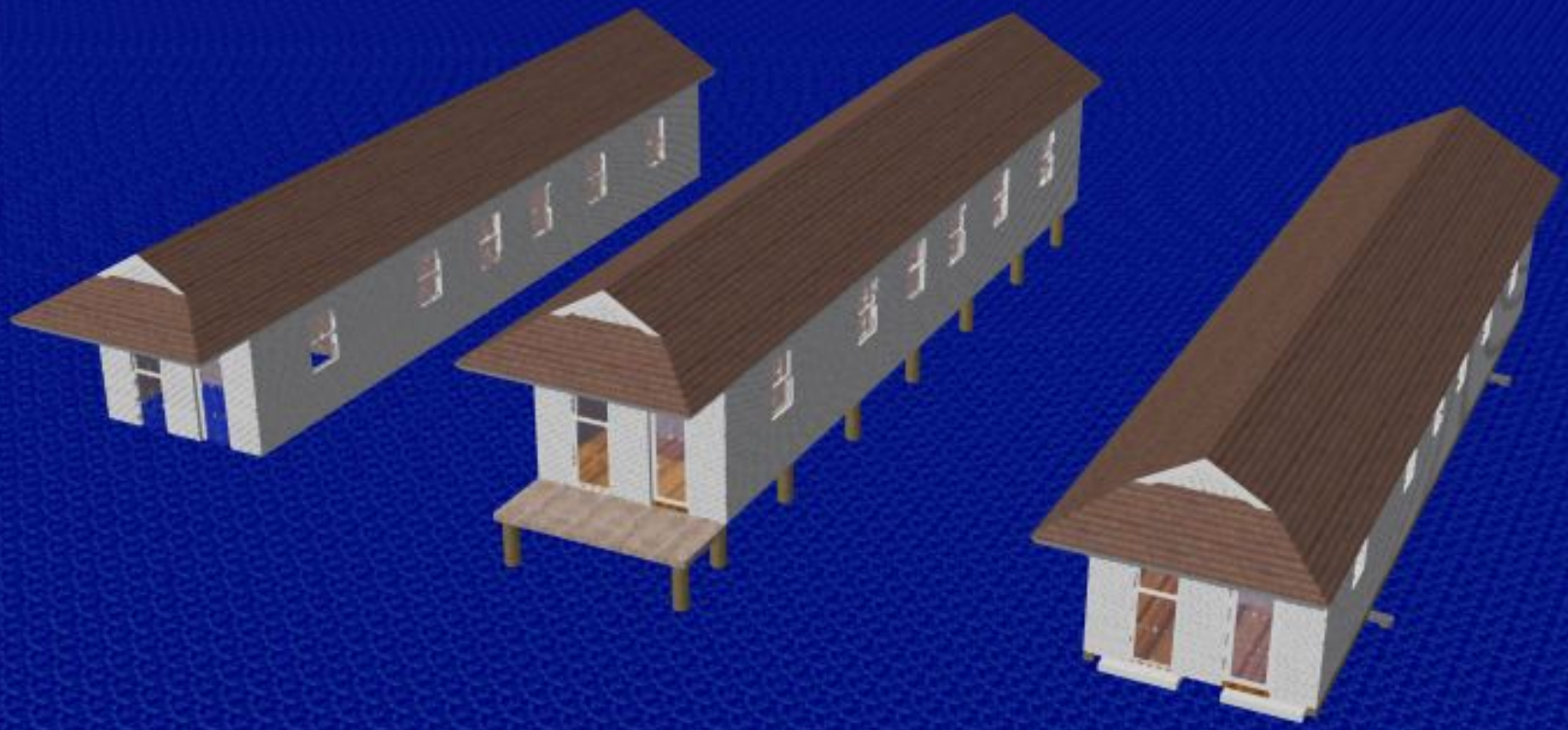
Existing
Shotgun
House

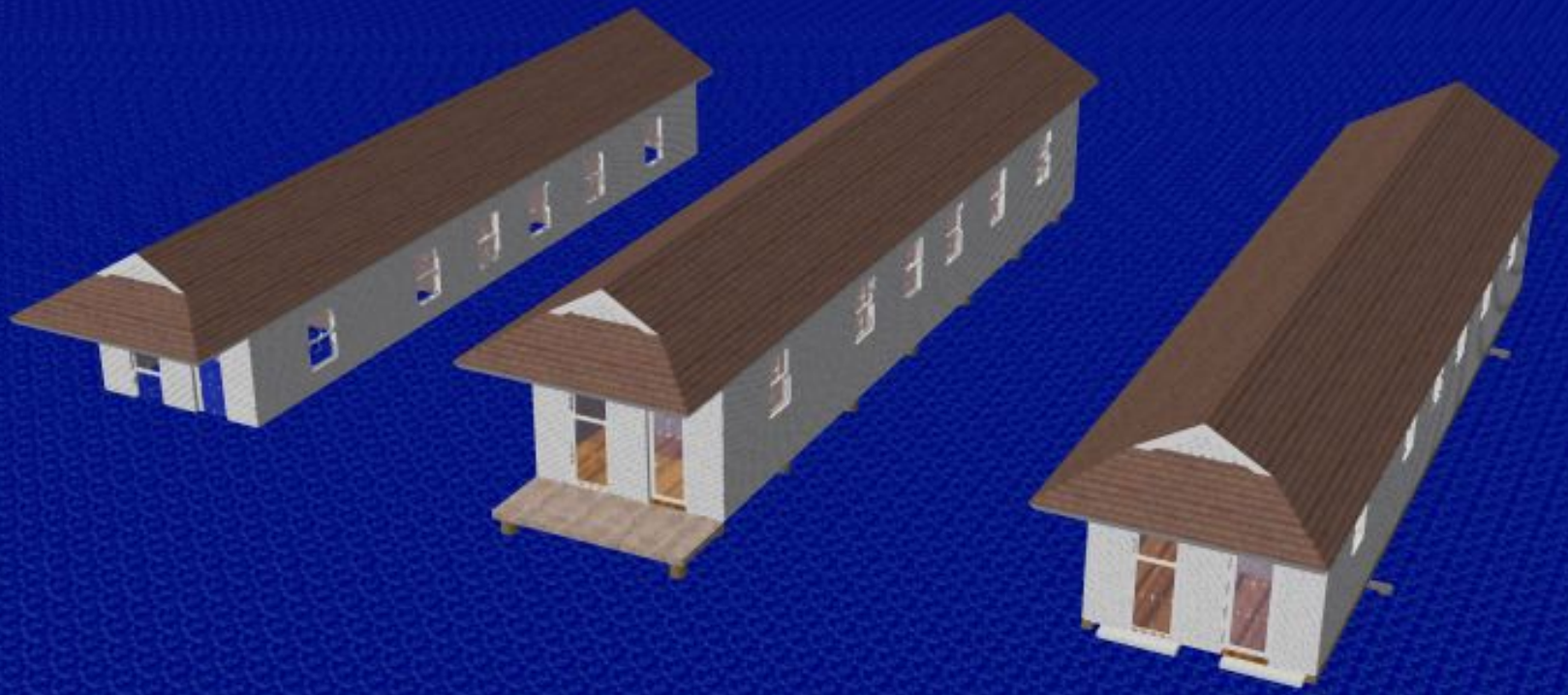
Shotgun House
Elevated to 6 ft

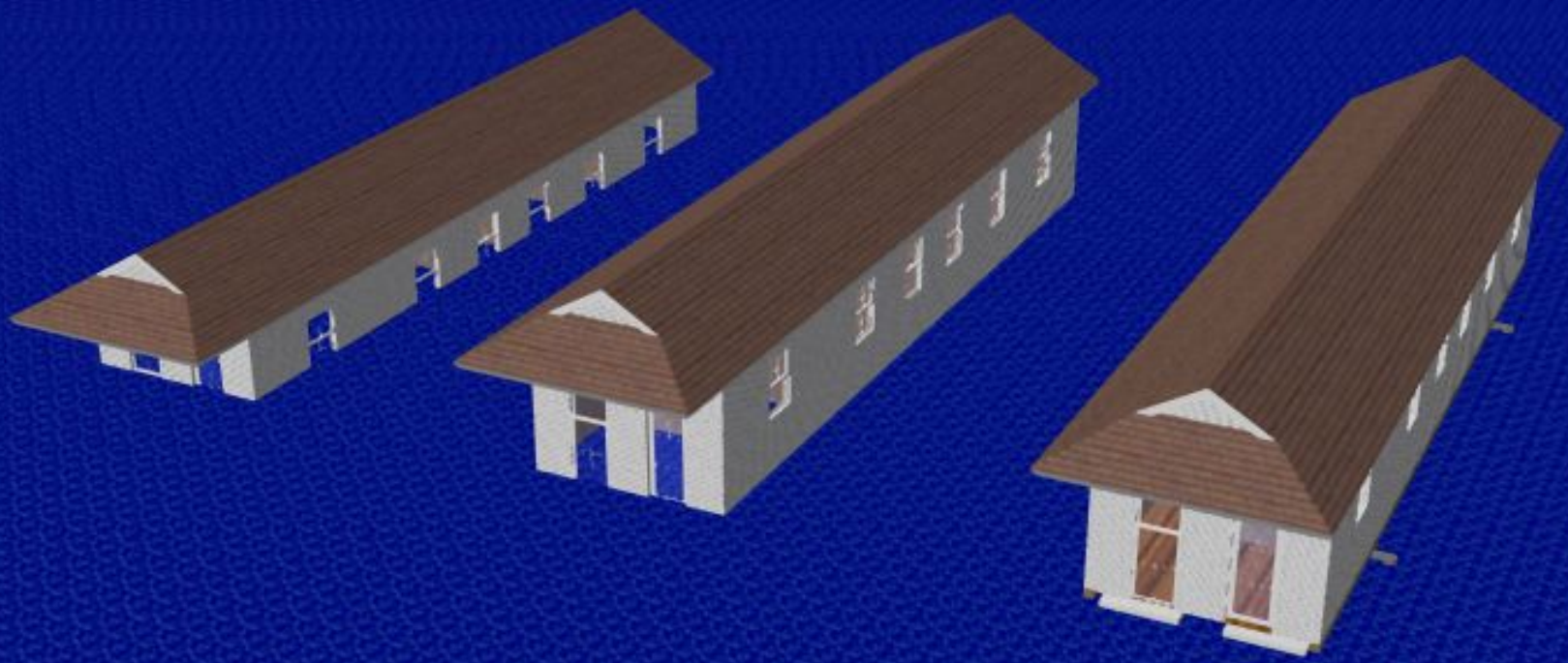
Shotgun House on a
Buoyant Foundation

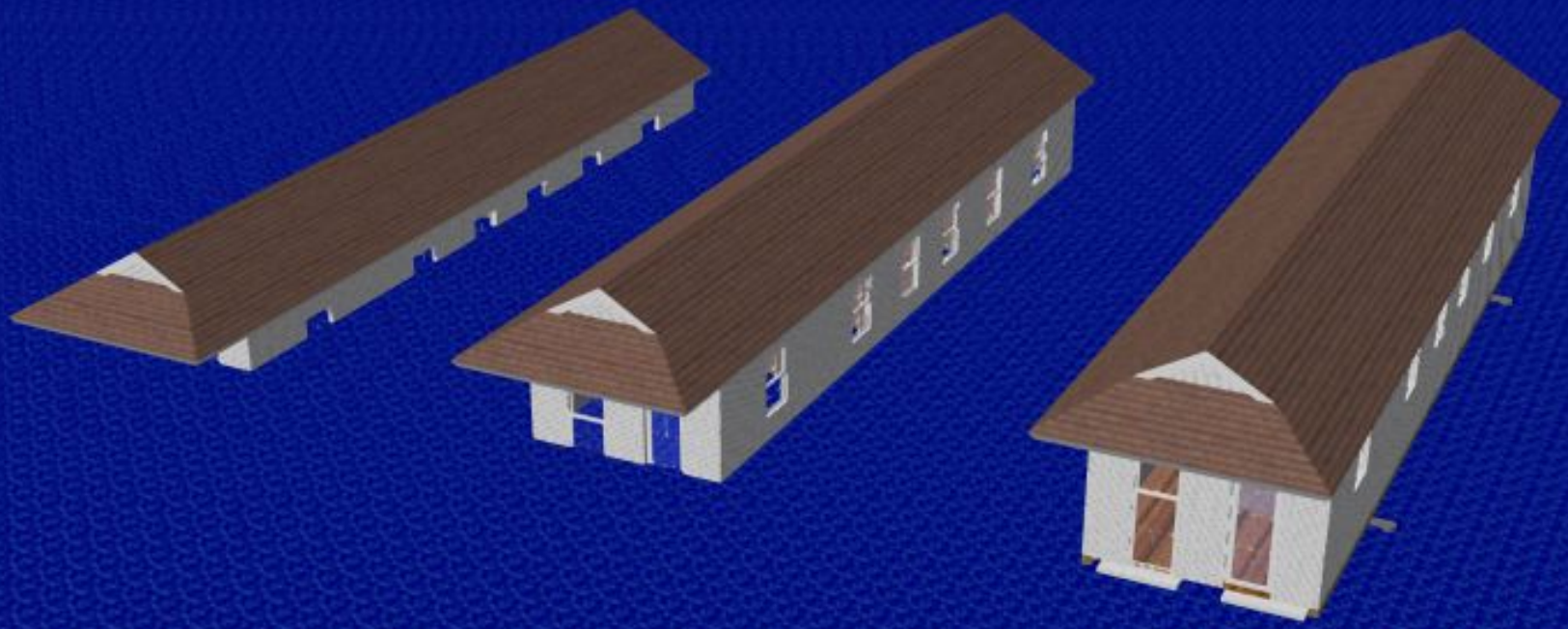
NOW ADD WATER . . .

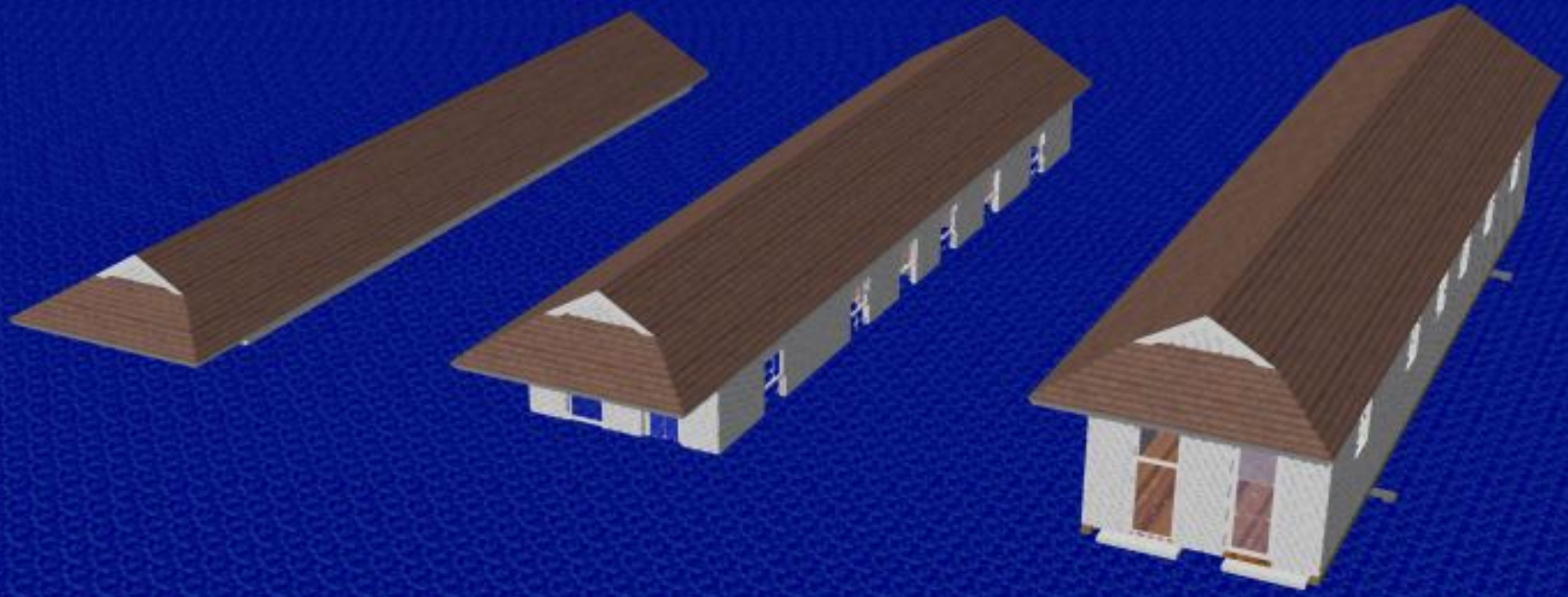


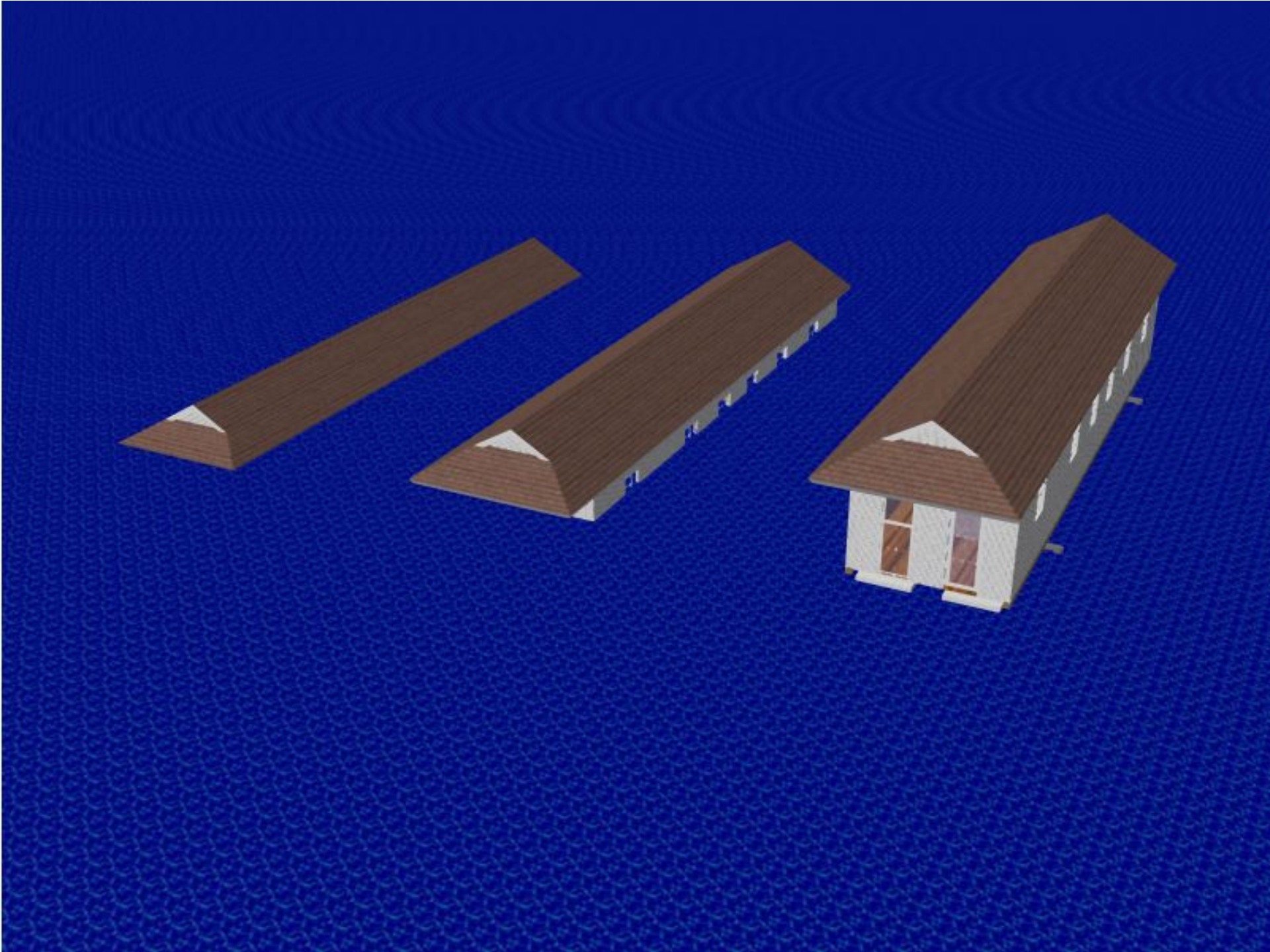


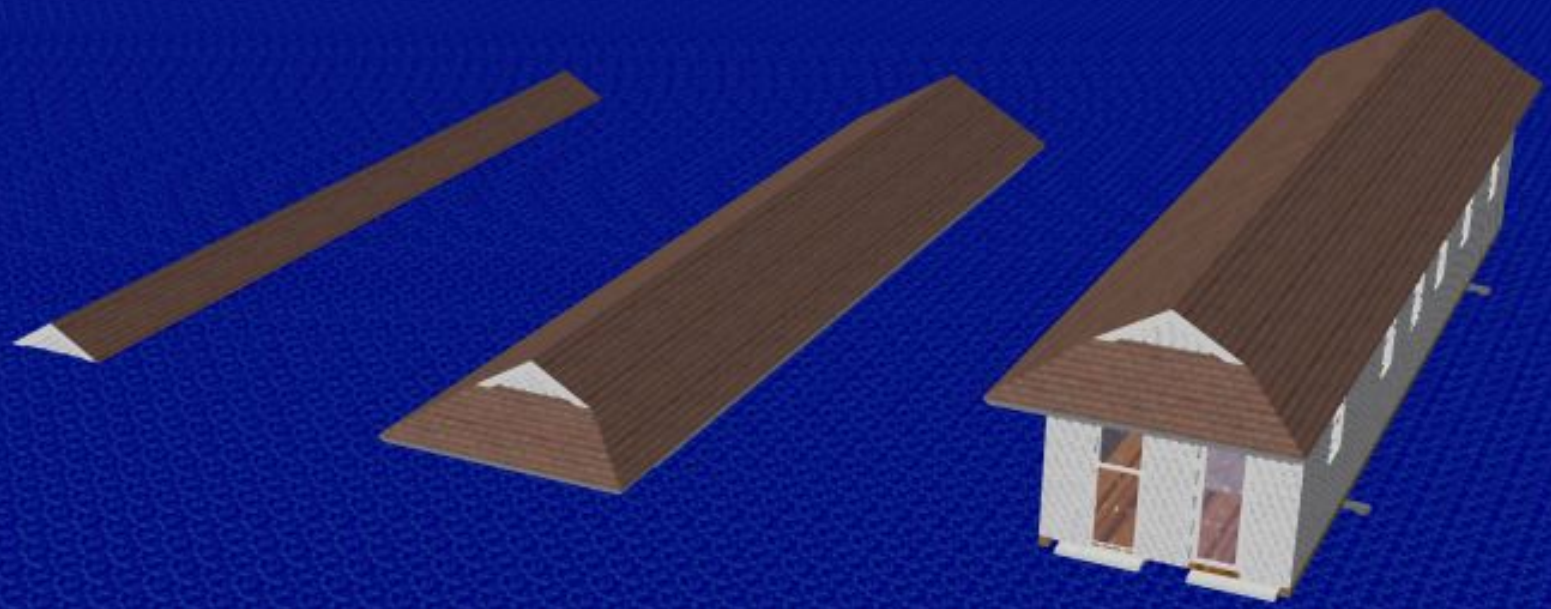


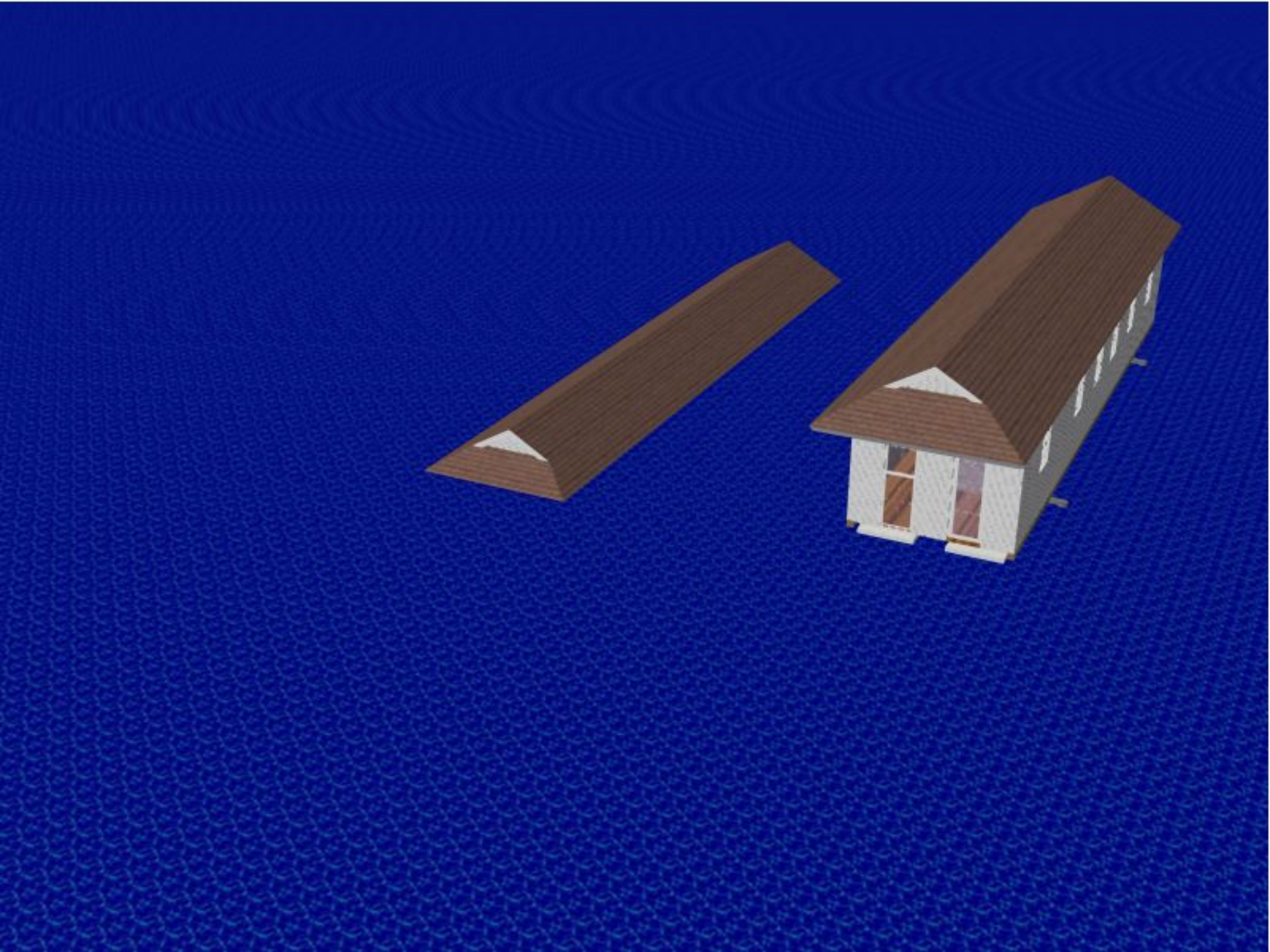


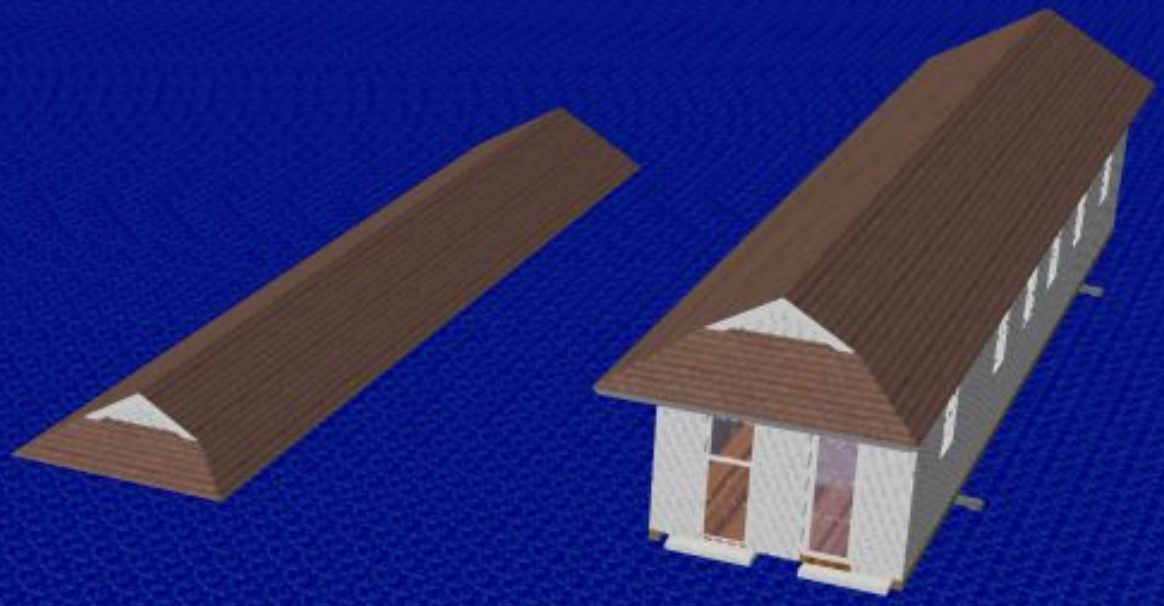




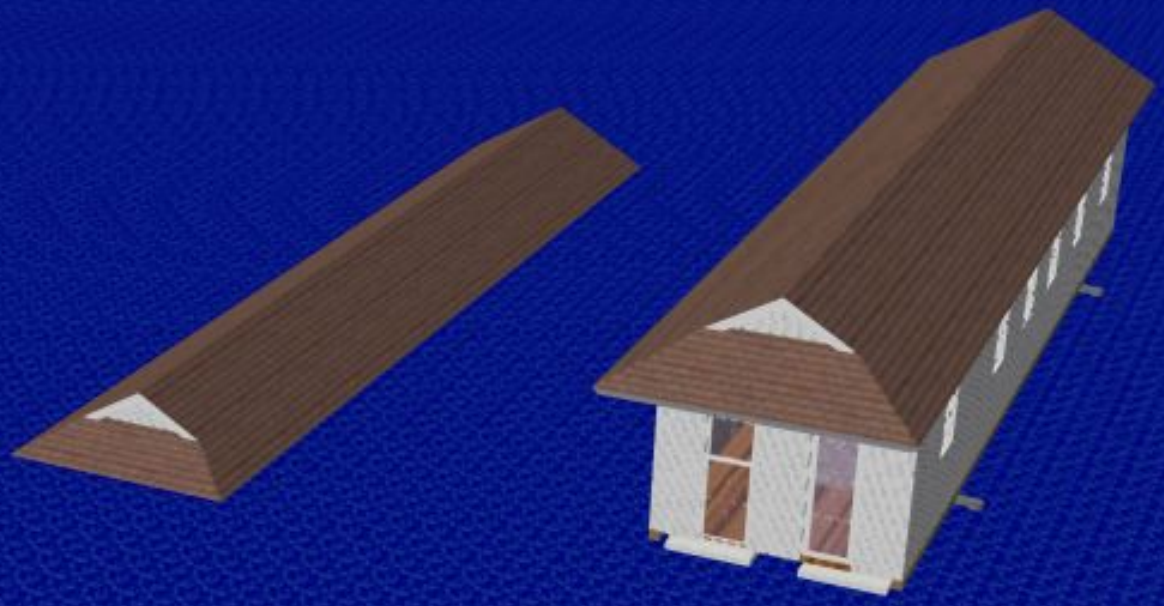






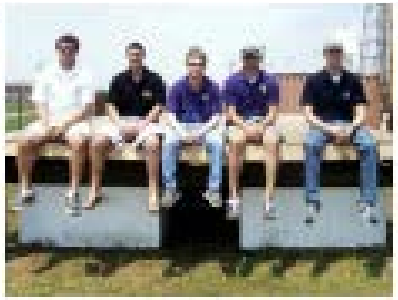


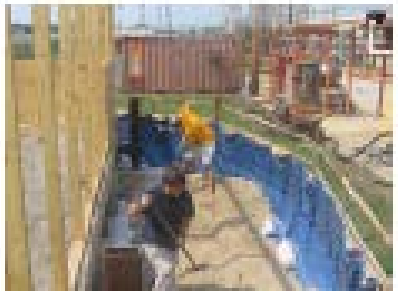
WHICH WOULD YOU CHOOSE?



WHICH WOULD YOU CHOOSE?

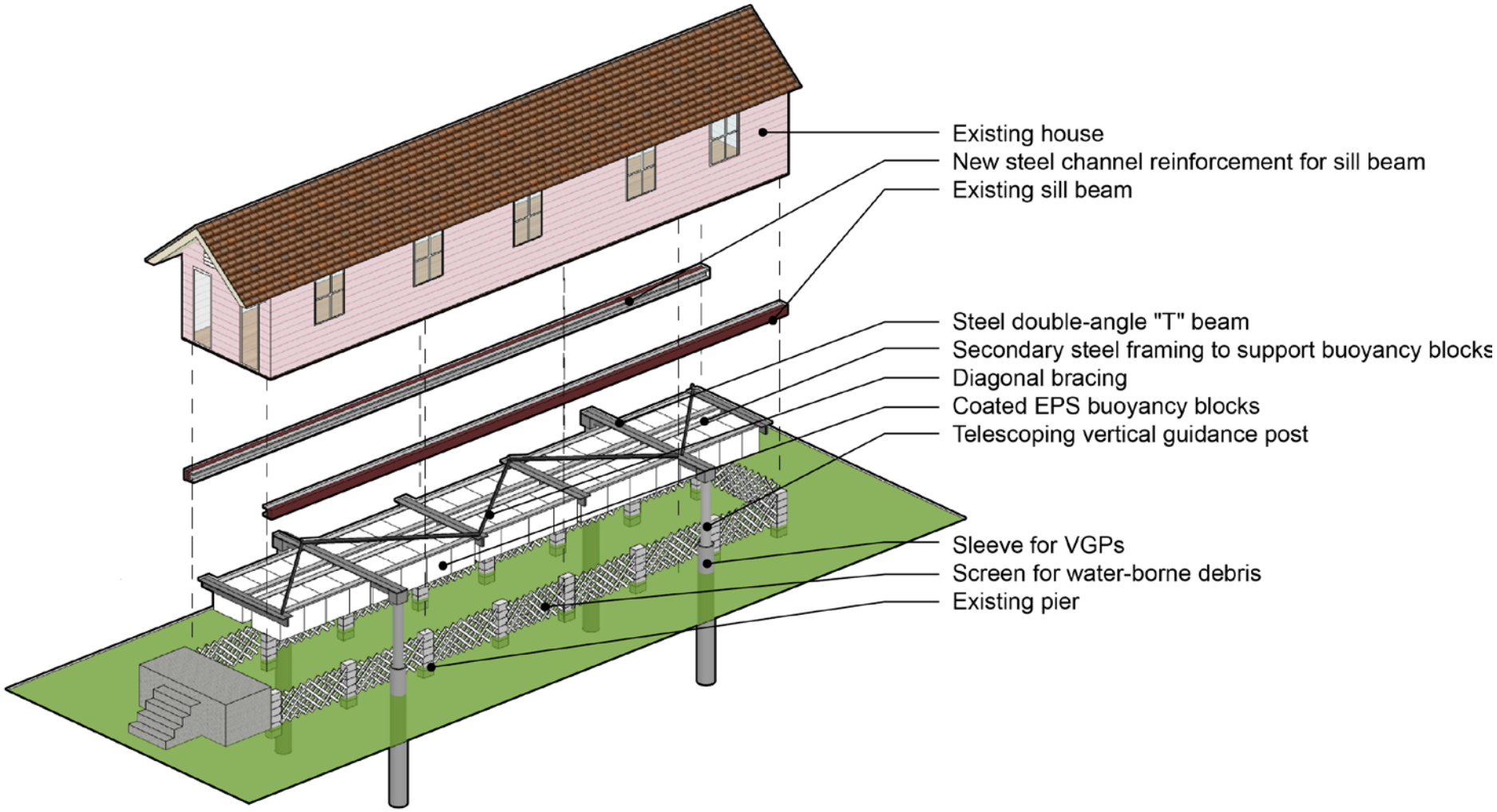
TESTING THE PROTOTYPE AT LSU



BFP applied to a New Orleans shotgun house


Existing house
New steel channel reinforcement for sill beam
Existing sill beam
Steel double-angle "T" beam
Secondary steel framing to support buoyancy blocks
Diagonal bracing
Coated EPS buoyancy blocks
Telescoping vertical guidance post
Sleeve for VGPs
Screen for water-borne debris
Existing pier

SO WHY FIGHT FLOODWATER
WHEN YOU CAN FLOAT ON IT?

Dhaka, Bangladesh

LIFT House under construction

LIFT House, Prithula Prosun, Bangladesh

CO_2Bambu

BFP

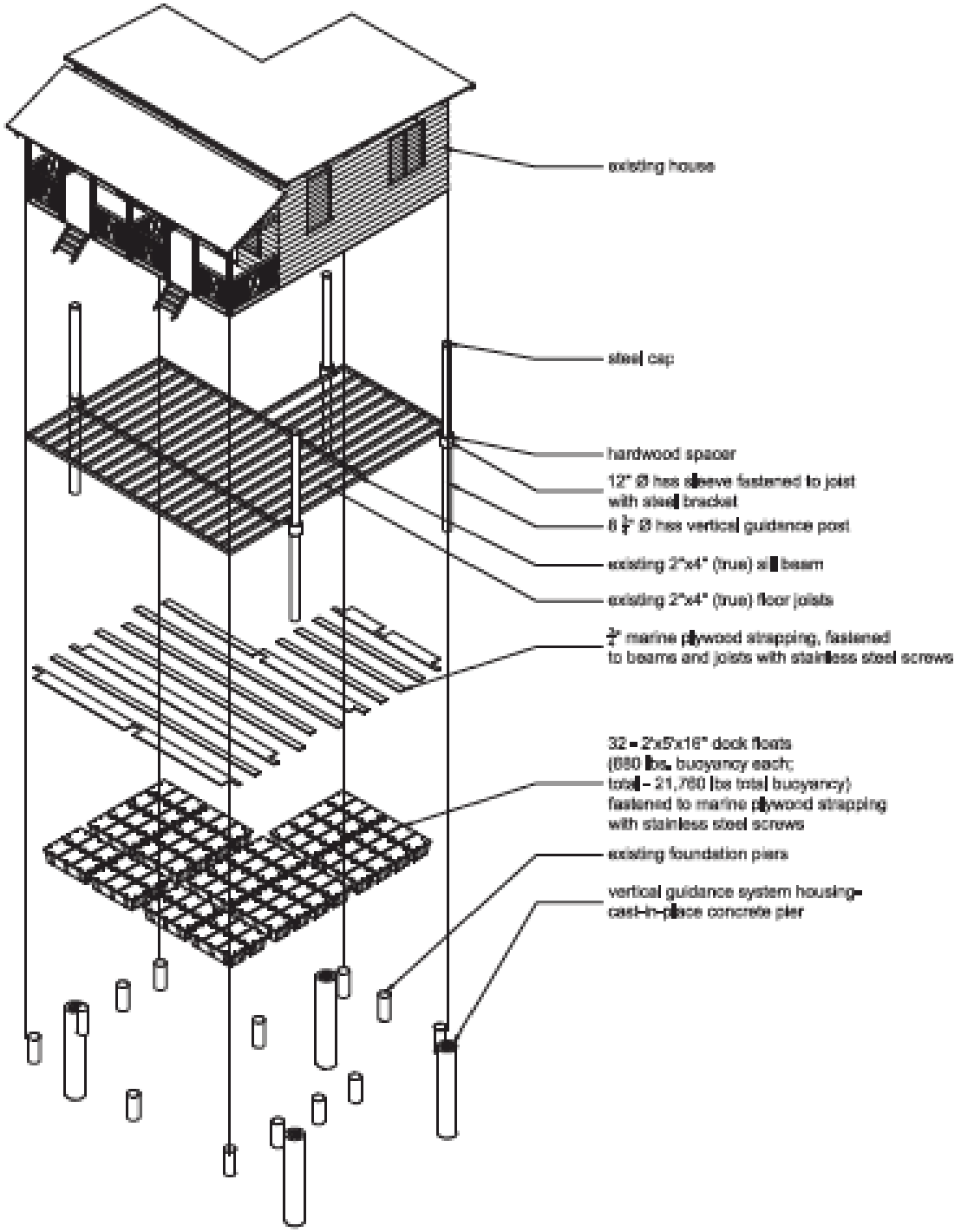
buoyant foundation project

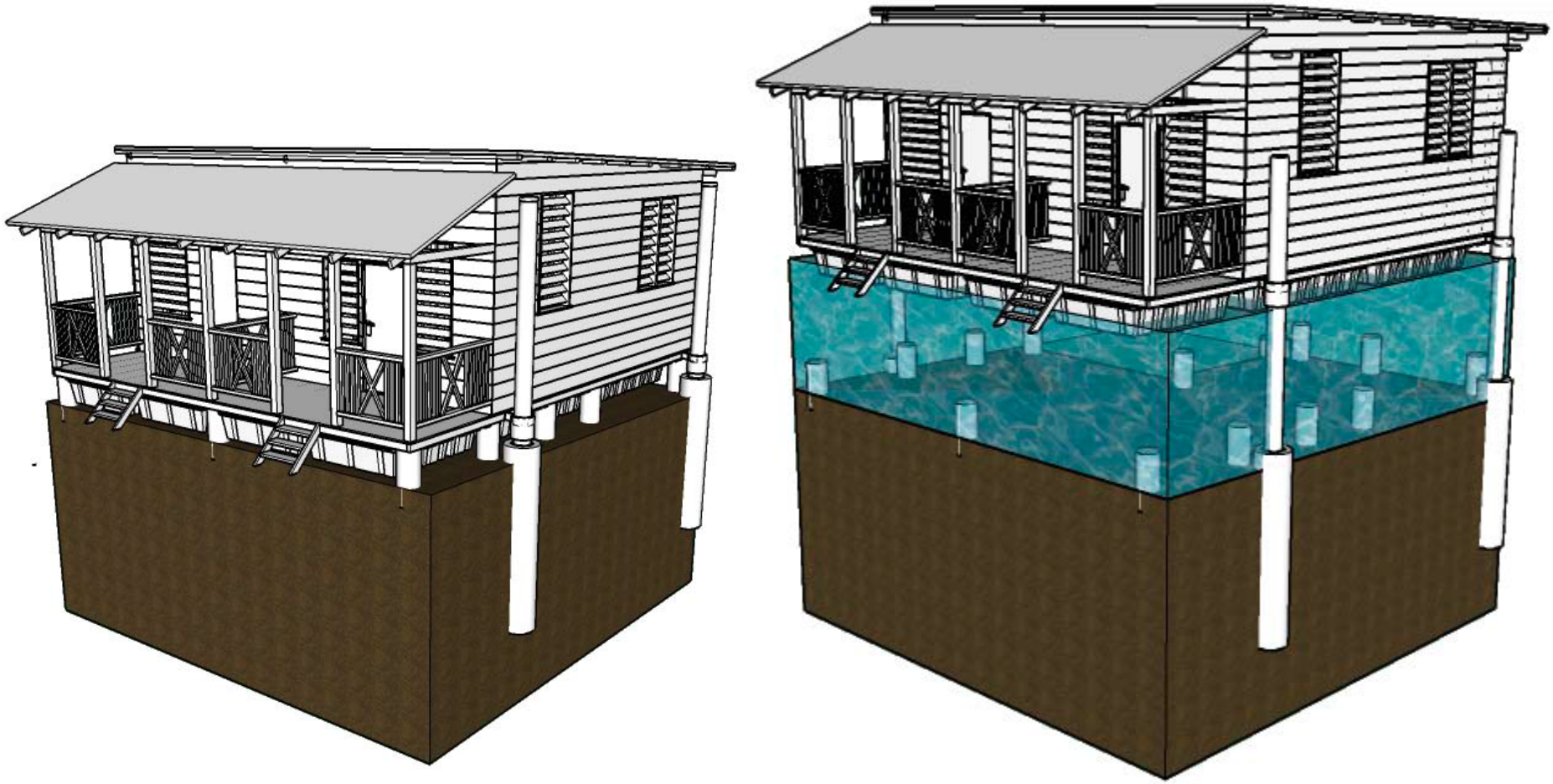
FLOAT WHEN IT FLOODS

Amphibious design for Malacatoya, Nicaragua

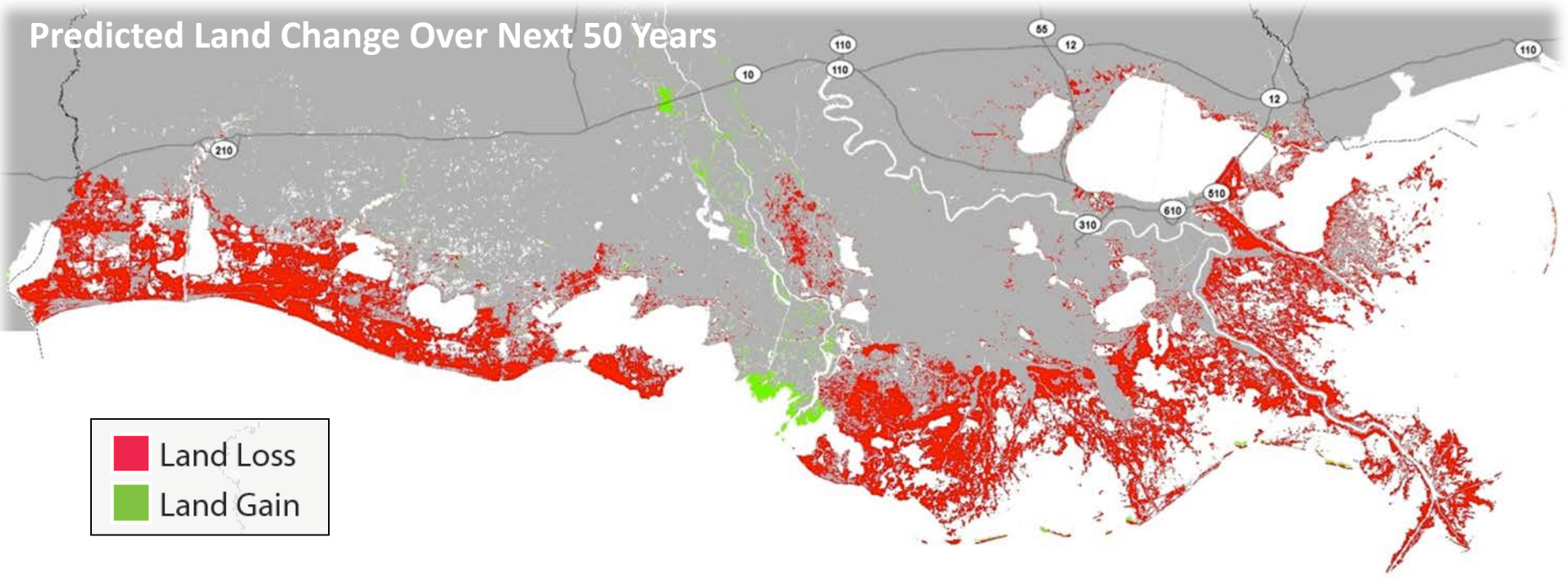

Bliss Pastures
Port Maria


Port Maria house


existing house
steel cap
hardwood spacer
12" Ø hex sleeve fastened to joist with steel bracket
6 ½" Ø hex vertical guidance post
existing 2"x4" (true) sill beam
existing 2"x4" (true) floor joists
¾" marine plywood strapping, fastened to beams and joists with stainless steel screws
32 - 2'x5'x16" dock floats (680 lbs. buoyancy each; total - 21,760 lbs total buoyancy) fastened to marine plywood strapping with stainless steel screws
existing foundation piers
vertical guidance system housing- cast-in-place concrete pier

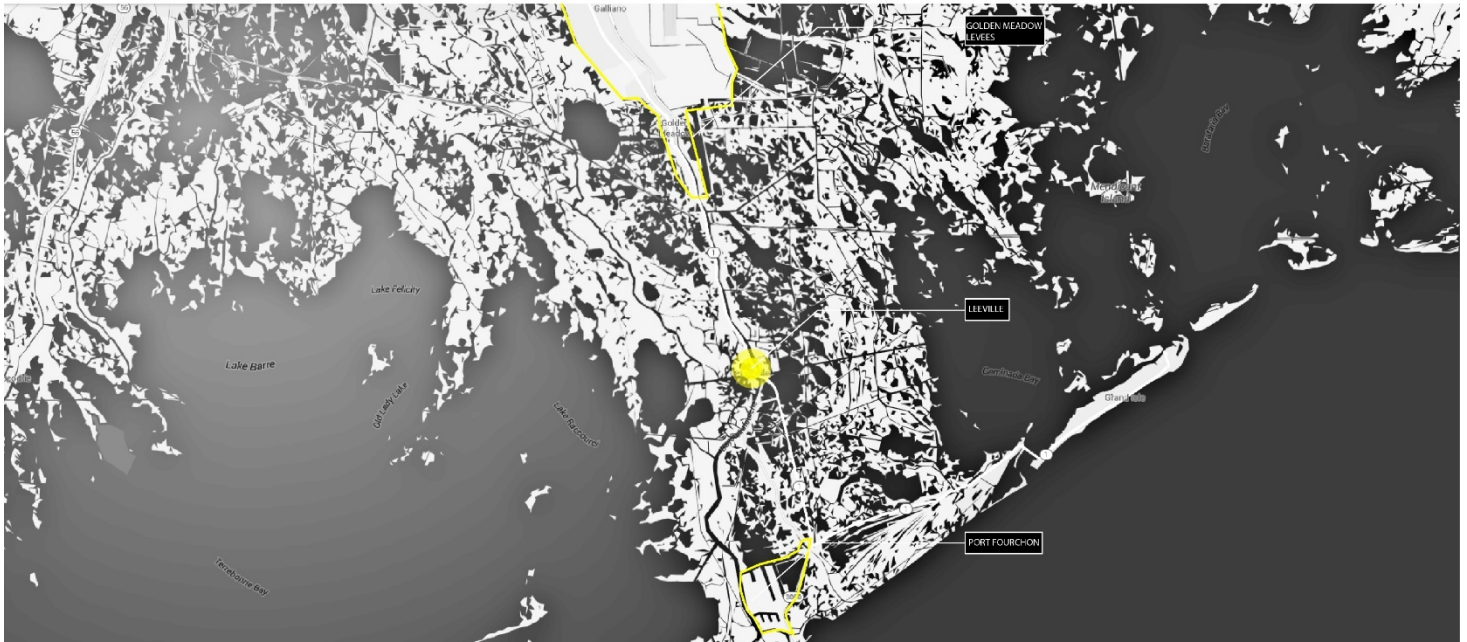


LOUISIANA IS EXPERIENCING A COASTAL CRISIS



Potential to lose an additional 800 – 1,750 square miles of land over the next 50 years


LEEVILLE


GOLDEN MEADOW LEVEES
LEEVILLE
PORT FOURCHON

Mant Exploration Operating
Old Hwy 1
Old Hwy 1
Tropical Seafood
Bayou Lafourche
Bayou Lafourche


CAMP MADELYN


CAMP FOR RENT


CAMP MADELYN
CAMP FOR RENT
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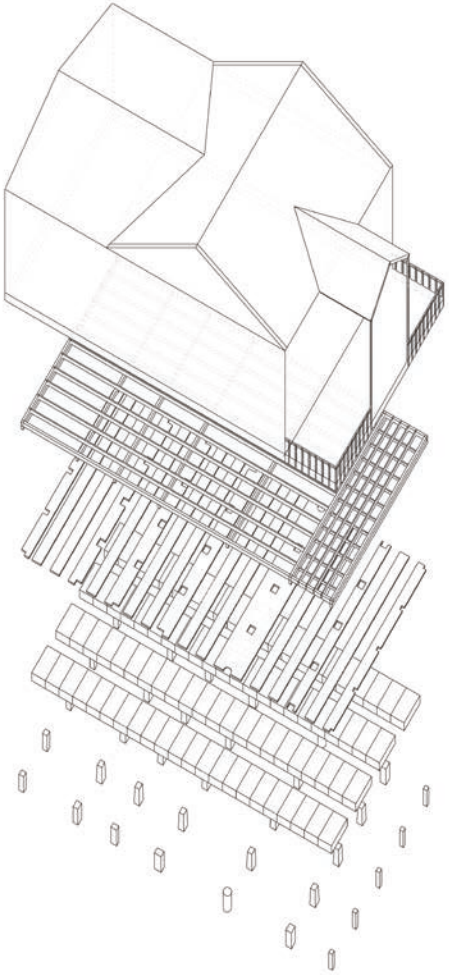


LOSSES AVOIDED RATIO

The Losses Avoided Ratio is the ratio of the calculated Losses Avoided to the calculated Mitigation Cost.

Losses Avoided = Costs of building repair + contents damage + displacement
Losses Avoided Ratio = Losses Avoided / Mitigation Cost

The losses avoided ratio for a pre-mitigation flood depth of **0.5m**
= $38,930 / $30,280
= **1.28**

The losses avoided ratio for a pre-mitigation flood depth of **1m**
= $62,430 / $30,280
= **2.06**

The losses avoided ratio for a pre-mitigation flood depth of **1.5m**
= $78,021 / $30,280
= **2.58**

A ratio greater than one indicates that applying the mitigation strategy to the house in question is expected to be beneficial or that it has performed successfully.


A


Lake Winnipeg
Gypsumville
Pineimuta Lake
Pinaymootang
Lake Manitoba
Winnipeg

Flooding on the Peguis Reservation, 2011

Assiniboine River Flooding, 2011

SUMMARY

		Losses Avoided Ratio for Flood Depth			
Building Replacement Value	*Flood Mitigation Cost*	*0m*	*0.5m*	*1.0m*	*1.5m*
$70,000	$10,000 ($10 / sq.ft)	1.10	3.46	7.91	10.02
	$25,000 ($25 / sq.ft)	0.44	1.38	3.16	4.01
	$40,000 ($40 / sq.ft)	0.28	0.86	1.98	2.51
$120,000	$10,000 ($10 / sq.ft)	1.90	4.82	10.24	12.76
	$25,000 ($25 / sq.ft)	0.76	1.93	4.10	5.11
	$40,000 ($40 / sq.ft)	0.47	1.21	2.56	3.19
$250,000	$10,000 ($10 / sq.ft)	3.96	8.37	16.32	19.90
	$25,000 ($25 / sq.ft)	1.58	3.35	6.53	7.96
	$40,000 ($40 / sq.ft)	0.99	2.09	4.08	4.97

PERMANENT STATIC ELEVATION AND INCREASED WIND VULNERABILITY

Permanent Static Elevation for Houses

Especially after Hurricanes Katrina and Sandy, the US Federal Emergency Management Agency (FEMA) has required many homeowners in flood-prone areas to elevate their houses in order to retain their eligibility for subsidized flood insurance policies from the National Flood Insurance Program (NFIP).

NFIP is critically important in the US housing market because banks require flood insurance as a precondition for providing mortgages to homes in flood zones.

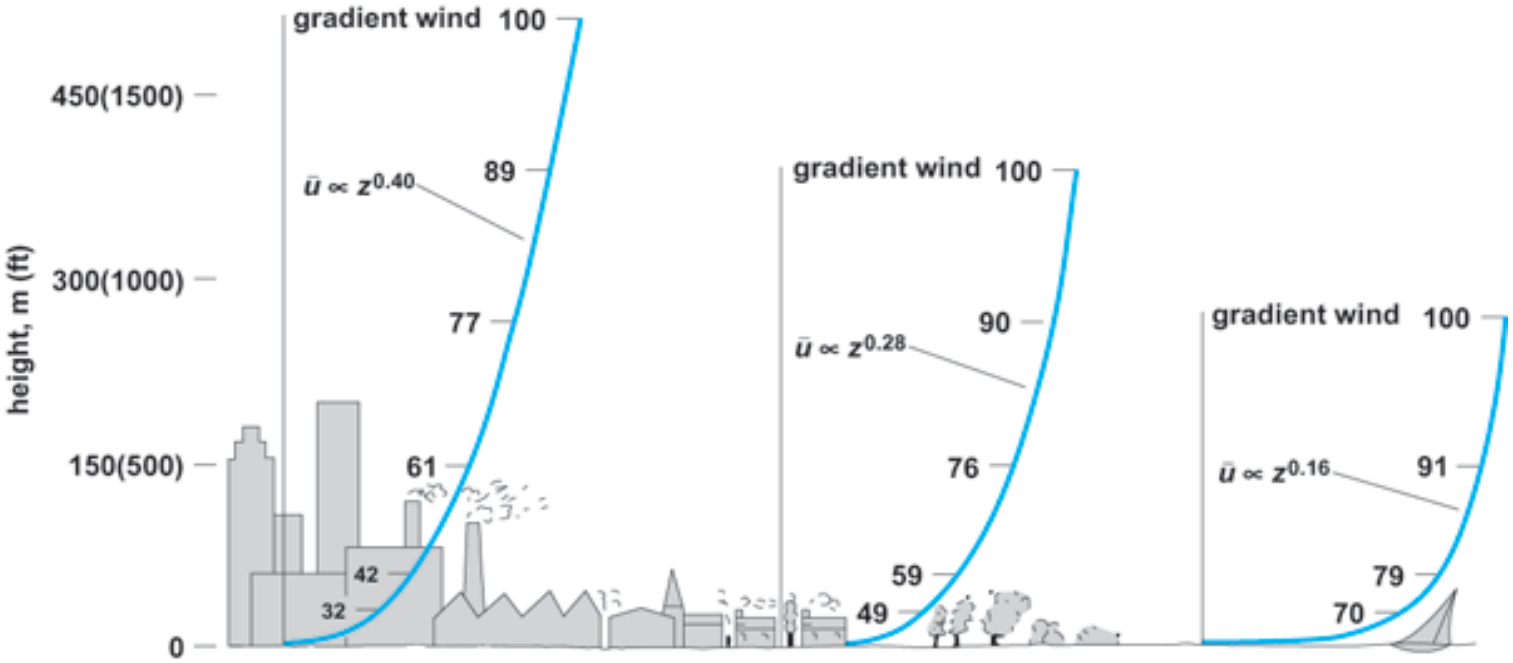
Disadvantages of Permanent Static Elevation

- **Difficult access – especially for the elderly & disabled**
- **Very expensive**
- **Creates gap-toothed effect in a neighborhood**
- **Homes lose close relationship to the street**

  (with loss of neighborhood character in an urban setting)
- **Provides insufficient protection from extreme flooding**
- **Increases the home's vulnerability to wind damage**

PERMANENT STATIC ELEVATION AND INCREASED WIND VULNERABILITY

Homes may be exposed to significantly higher wind speeds when elevated.



PERMANENT STATIC ELEVATION AND INCREASED WIND VULNERABILITY

Case Study – preliminary analysis

House with a 4 meter mean roof height elevated to a 10 meter mean roof height:

Case Study	Roof Mean Height	EAL (%)
Current scenario	4 m	2.8%
Elevated scenario	10 m	4.9%

Increase in roof height wind speed: **11%**

Increase in wind pressure: **19%**

Increase in expected annual loss (EAL): **75%**

This effect becomes more pronounced the higher the structure is raised above the ground.

IMPLICATIONS FOR MICROINSURANCE:

1. Amphibious retrofits are an inexpensive and effective way to reduce risk profiles

2. Reduced risk translates into reduced premiums

3. Lower premiums make microinsurance more accessible

4. Could become part of Catastrophe Risk Protection plans combining coverage for agriculture and housing

5. Amphibious retrofit is a one-time expense that prevents future damage, appropriate for subsidies from governments or NGOs

5. Potential for dramatic improvement in community resilience

ICAADE2017

THE SECOND INTERNATIONAL CONFERENCE ON AMPHIBIOUS ARCHITECTURE, DESIGN AND ENGINEERING

June 25 - 28 2017

University of Waterloo, Waterloo, ON

WWW.ICAADE.ORG

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Social Sciences and Humanities
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