

Linking Flood Risk to Resilience

MERIT: A Decision Support Tool for Risk-based Resilience
Investment

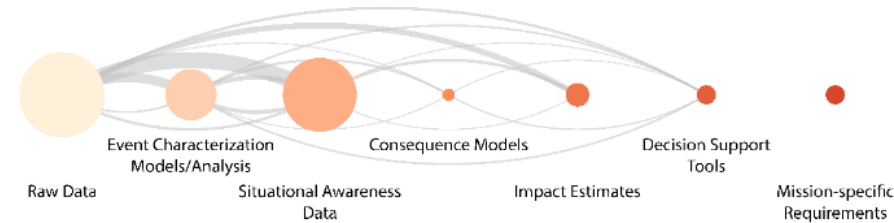
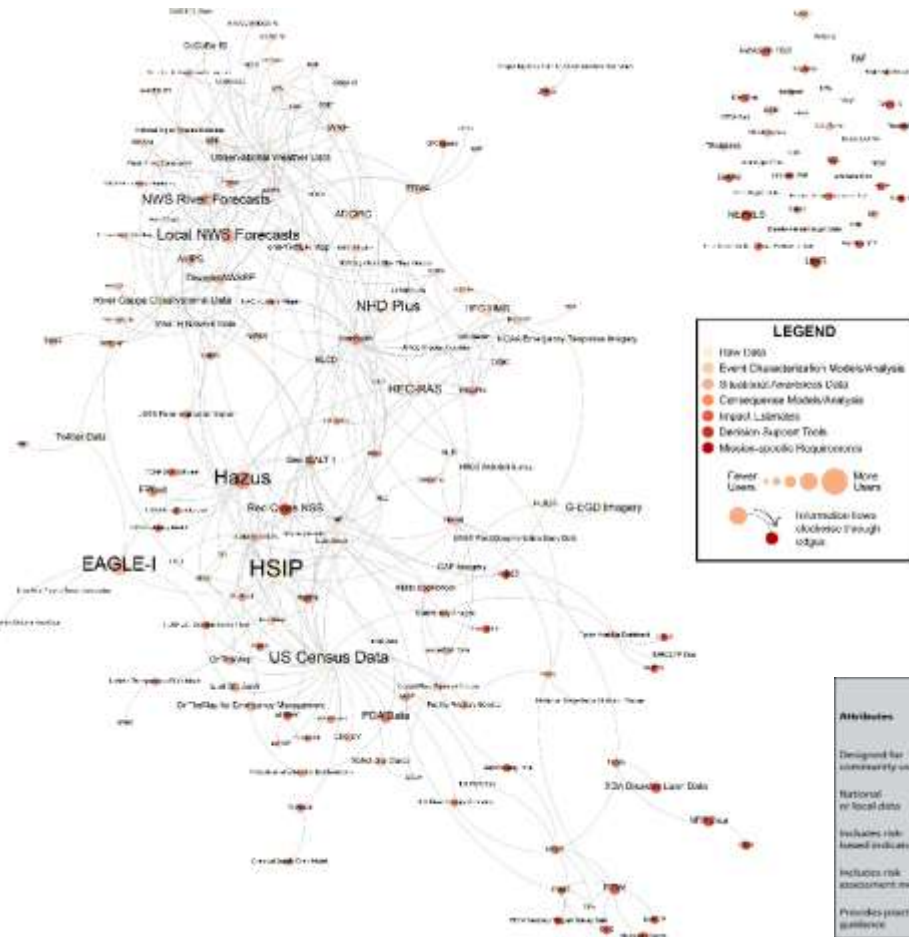
*Funded by: US Department of Homeland Security
Science & Technology Directorate*



Linking risk to resilience for practical decision making

- Communities need to understand their risk, but risk models are designed for experts
- Communities are unique and resilience means something different to each community
- How does a community prioritize investments while taking into account risk, resilience, and their own priorities?
- *How do we give a community the information they need to start the conversation?*

The gap: Linking flood risk to practical recovery and mitigation decisions



Attributes	Resilience Indices and Assessment Methods												Requirements to Evaluate Resilience Investments
	SoR	BRIC	Resilience Capacity Index	MST Guide	Zurich Framework	Resilience CR	CARE CR	MRPLS Framework	UN Sustainable Resilience	Coastal Resilience Index	Community Rating System	SPUR	
Designed for community use	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
National or local data	National	National	National	Both	Local	Local	Local	National	Local	Local	National	Local	Both
Includes risk-based indicators	No	No	No	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Includes risk assessment method	N/A	N/A	N/A	No	N/A	N/A	N/A	No	No	No	No	Yes	Yes
Provides practical guidance	No	No	No	Yes	Broad guidance	Broad guidance	Yes	No	No	Broad guidance	Yes	Yes	Yes

Risk communication and human-centered design

- Intuitive cues
- Map process and navigation up front
- Consistent use of color, font, and terms
- Use plain language
- Provide anchors to daily experience
 - Provide a reference point for flood depths (e.g., waist-high water)

Melkonyan, 2011; National Oceanic and Atmospheric Administration, 2016; Vaughan and Buss, 1998



ASFPM Conference

June 2018



WELCOME

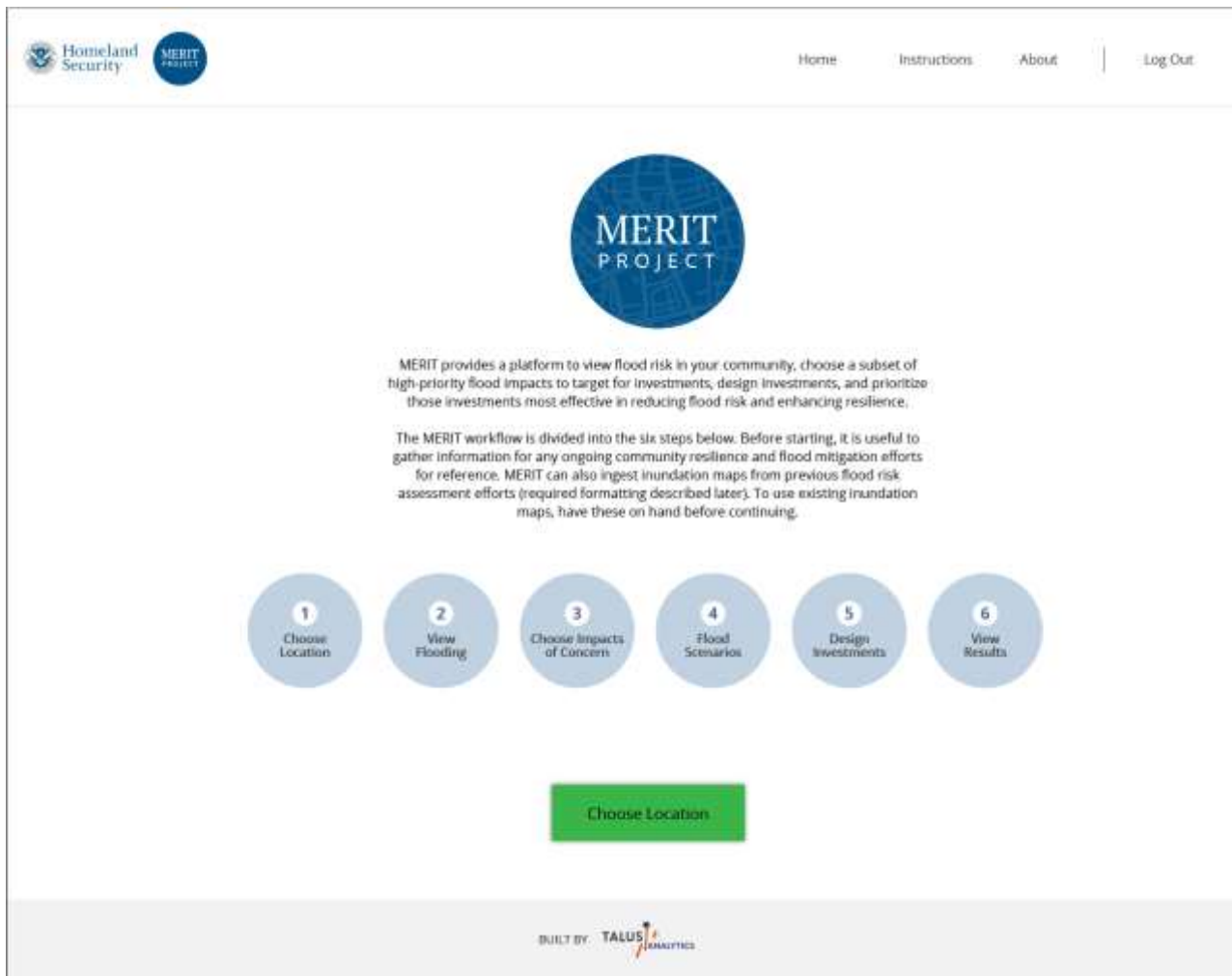
Linking Flood Risk to Resilience

The Mitigation Evaluation and Risk Reduction Investment Tool (MERIT) is an integrated platform to assess flood risk and design community-level investments to mitigate that risk and enhance resilience.

[Learn how MERIT works](#)

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What are you getting yourself into?



The screenshot shows the MERIT Project website. At the top left are the Homeland Security and MERIT Project logos. The top right has navigation links: Home, Instructions, About, and Log Out. In the center is a large blue circular logo with 'MERIT PROJECT' text. Below it, a paragraph explains the platform's purpose: 'MERIT provides a platform to view flood risk in your community, choose a subset of high-priority flood impacts to target for investments, design investments, and prioritize those investments most effective in reducing flood risk and enhancing resilience.' Another paragraph describes the workflow: 'The MERIT workflow is divided into the six steps below. Before starting, it is useful to gather information for any ongoing community resilience and flood mitigation efforts for reference. MERIT can also ingest inundation maps from previous flood risk assessment efforts (required formatting described later). To use existing inundation maps, have these on hand before continuing.' Below the text is a horizontal sequence of six numbered steps in light blue circles: 1 Choose Location, 2 View Flooding, 3 Choose Impacts of Concern, 4 Flood Scenarios, 5 Design Investments, and 6 View Results. A green rectangular button labeled 'Choose Location' is positioned below the first step. At the bottom center, it says 'BUILT BY: TALUS ANALYTICS' with the Talus Analytics logo.

Homeland Security MERIT PROJECT

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MERIT PROJECT

MERIT provides a platform to view flood risk in your community, choose a subset of high-priority flood impacts to target for investments, design investments, and prioritize those investments most effective in reducing flood risk and enhancing resilience.



The MERIT workflow is divided into the six steps below. Before starting, it is useful to gather information for any ongoing community resilience and flood mitigation efforts for reference. MERIT can also ingest inundation maps from previous flood risk assessment efforts (required formatting described later). To use existing inundation maps, have these on hand before continuing.

- 1 Choose Location
- 2 View Flooding
- 3 Choose Impacts of Concern
- 4 Flood Scenarios
- 5 Design Investments
- 6 View Results

Choose Location

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Who are you? Identify your community



HomeInstructionsAboutLog Out

1 CHOOSE LOCATION

2 VIEW FLOODING

3 CHOOSE IMPACTS OF CONCERN

4 DESIGN INVESTMENTS

5 CHOOSE SCENARIOS

6 VIEW RESULTS

COMMUNITY OF INTEREST

Select a location for the simulated flooding event to occur. Select a region type: County, Metropolitan Statistical Area, NFIP codes, or CRS codes. Then select a specific community of interest.

Select a Region Type

County

CRS

NFIP

FIMA

MSA

Zipcode

Select a county(s)

Texas

Harris County

Add County

Regions Selected

Harris County

Next

Building on what you already know

The screenshot shows the Merit Project web application interface. At the top left are the Homeland Security and Merit Project logos. The top right has navigation links: Home, Instructions, About, and Log Out. A left sidebar contains a vertical list of steps: 1 CHOOSE LOCATION, 2 VIEW FLOODING, 3 CHOOSE IMPACTS OF CONCERN, 4 DESIGN INVESTMENTS, 5 CHOOSE SCENARIOS, and 6 VIEW RESULTS. The main content area is titled 'COMMUNITY OF INTEREST' and includes instructions: 'Select a location for the simulated flooding event to occur. Select a region type: County, Metropolitan Statistical Area, NFIP codes, or CRS codes. Then select a specific community of interest.' Below this, there are two dropdown menus: 'Select a Region Type' (with options: County, CRS, NFIP, FIMA, MSA, Zipcode) and 'Select a county(s)' (with 'Texas' selected). An 'Add County' button is next to the second dropdown. To the right, a 'Regions Selected' box lists 'Harris County'. A modal window titled 'UPLOAD SCENARIO' is open in the center, containing the text 'City data are available in some regions and can be uploaded into Merit.' and a 'Select file' button. At the bottom of the modal is an 'Upload' button. At the bottom right of the main content area is a 'Next' button with a right arrow.

Flood mapping: Rapid risk assessment

- Developed a rapid risk assessment method in collaboration with FEMA, drawing on NFIE and NWM methods
- Supports rapid overlay with infrastructure and population
- No subject matter expertise required
- Deterministic; assesses range of events

Flood mapping: Rapid risk assessment

Riverine

- Interpolation of riverine gage flows
- Lateral projection and compare water level to DEM for inundation

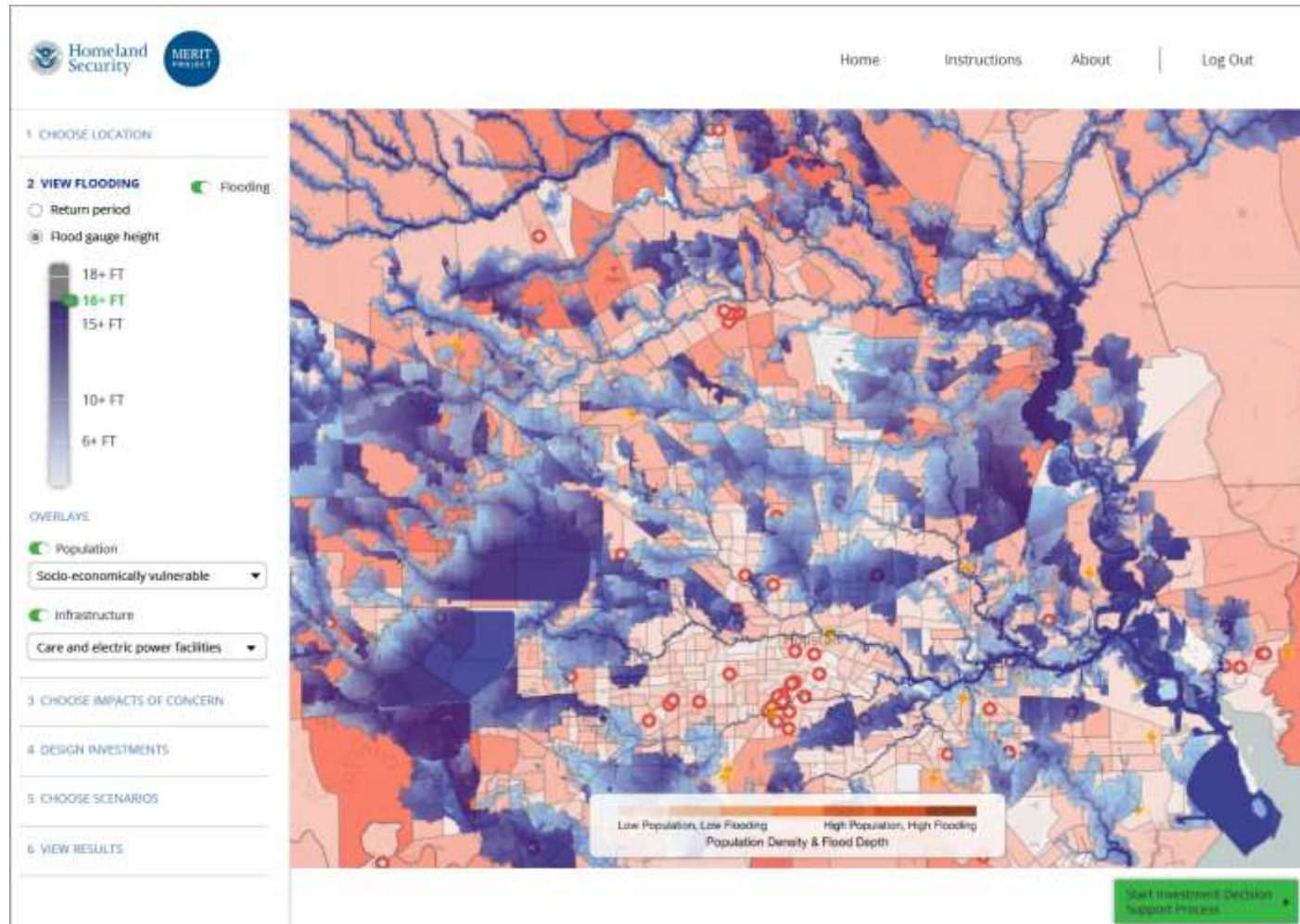
Coastal

- Interpolate select coastal gages with still water elevations linked to AEP (from RENCi)
- Project inland, comparing water elevation to DEM

Estuarine

- Proof of concept takes simple maximum between riverine and coastal inundation estimates

What goes underwater?



Which impacts are of highest priority?

Choose infrastructure priorities

1 CHOOSE LOCATION

2 VIEW FLOODING

3 CHOOSE IMPACTS OF CONCERN

4 DESIGN INVESTMENTS

5 CHOOSE SCENARIOS

6 VIEW RESULTS

Select investment priority(s)

Select and drag from table on left to blue investment priorities selected list on right.

POPULATION

INFRASTRUCTURE

Care Facilities	Facility Type	Damage Level	Water Depth
Center For Psychiatric Info	Care Facility	EXTREME	7.5
Ben Taub General Hospital	Care Facility	EXTREME	6.7
Intracare North Hospital	Care Facility	EXTREME	6.3
Healthsouth Rehabilitation Institute	Care Facility	EXTREME	6.1
Houston Community Hospital	Care Facility	EXTREME	5.4
Bayshore Medical Center	Care Facility	EXTREME	5.4
Healthsouth Rehabilitation Hospital	Care Facility	EXTREME	5.4

INFRASTRUCTURE DAMAGE LEVELS

Show by Resilience Characteristics



Search

INVESTMENT PRIORITIES SELECTED

3

Select priorities from table on left and drop in any order in the containers below.

Population aged 65+

X

Intracare North Hospital

X

Houston Community Hospital

X

Priority 0

Priority 1

Priority 2

Design Investments

FLOOD LEVELS

Water depth

18+ FT

16+ FT

15+ FT

10+ FT

6+ FT

Return period

Flood gauge height

Which impacts are of highest priority?

Choose population priorities

1 CHOOSE LOCATION

2 VIEW FLOODING

3 CHOOSE IMPACTS OF CONCERN

4 DESIGN INVESTMENTS

5 CHOOSE SCENARIOS

6 VIEW RESULTS

Select investment priority(s)

Select and drag from table on left to investment priorities list on right.

POPULATION

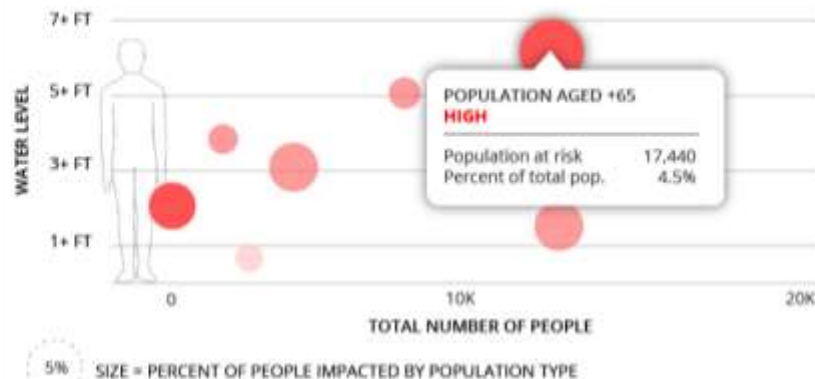
INFRASTRUCTURE

All Vulnerable Populations

	Impact Level	POPULATION	
		Number People	Percent (%)
Population aged 65+	HIGH	17,440	4.5
Population under the age of 5	HIGH	14,902	3.5
Socioeconomically vulnerable population	MEDIUM	11,297	8.5
Non-English speaking population	MEDIUM	11,208	9.2
Population without personal vehicle	MEDIUM	11,121	7.6
Population in mobile homes	LOW	10,240	10.5
EDME-dependent population	LOW	7,251	5.2

VULNERABLE POPULATIONS AT GREATEST RISK

Show by Resilience Characteristics



Search

INVESTMENT PRIORITIES SELECTED

1

Select priorities from table on left and drop in any order in the containers below.

Population aged 65+

Priority B

Priority C

Priority D

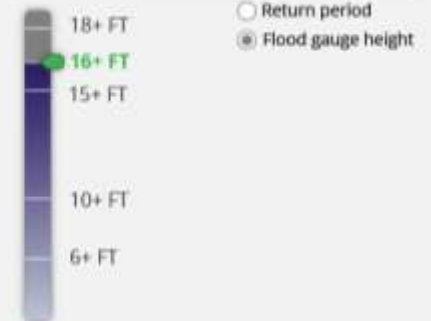
Priority E

Priority F


View Infrastructure Impacts

FLOOD LEVELS


Water depth



Choose scenarios for investment ranking



Homeland
Security



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1 CHOOSE LOCATION

2 VIEW FLOODING

3 CHOOSE IMPACTS OF CONCERN

4 DESIGN INVESTMENTS

5 CHOOSE SCENARIOS

6 VIEW RESULTS

Select scenarios to evaluate investments

FLOOD LEVELS

Flood return period

500 YEAR FLOOD

100 YEAR FLOOD

50 YEAR FLOOD

10 YEAR FLOOD

5 YEAR FLOOD

☒ Return period

☐ Flood gauge height

Choosing flooding scenarios

500 YEAR FLOOD

100 YEAR FLOOD

50 YEAR FLOOD

10 YEAR FLOOD

5 YEAR FLOOD

Slider can be used to select a range of return periods. This position shows selection of: 10 Year 50 Year 100 year

Choose a range of flood scenarios (severities) for use in evaluating investments. Utilizing the flood scenarios slider, individual scenarios may be selected, or a range may be selected which designates all the return periods within the range.

Only scenarios included at this step are used to determine the benefits of an investments and corresponding ranking in the results.

Choose Scenarios

INVESTMENT

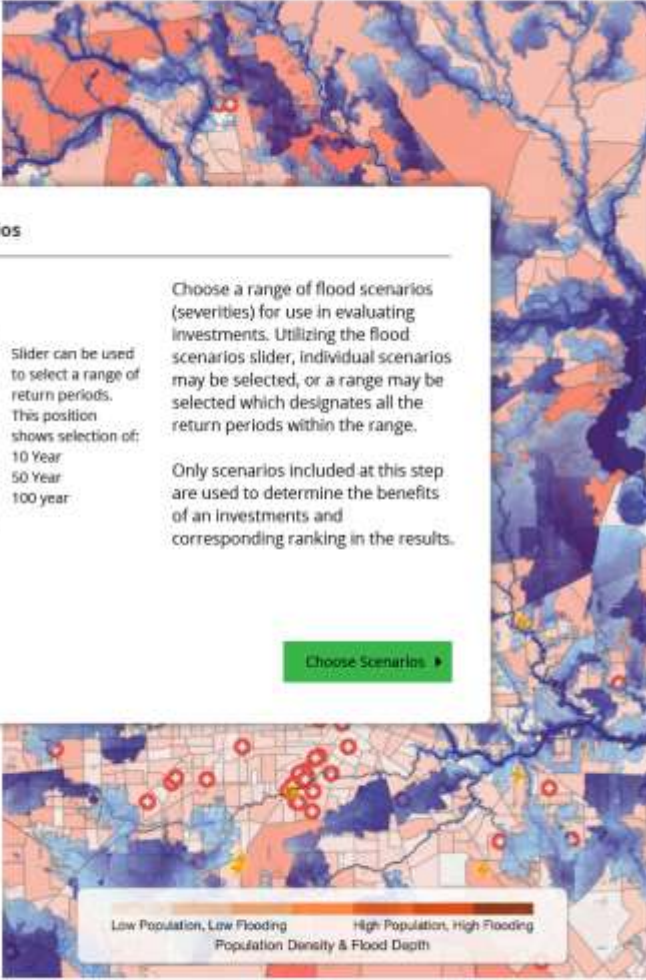
Priority A: Population aged +65, High Write Resilience Plan

Priority B: Intracare North Hospital Update Evacuation Plan

Priority C: Houston Community Hospital Sandbag

\$23,000

Submit




Low Population, Low Flooding

High Population, High Flooding

Population Density & Flood Depth

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How do these investments address resilience?

1 CHOOSE LOCATION

2 VIEW FLOODING

3 CHOOSE IMPACTS OF CONCERN

4 DESIGN INVESTMENTS

5 CHOOSE SCENARIOS

6 VIEW RESULTS

Select investment priority(s)

Select and drag from table on left to blue investment priorities selected list on right.

POPULATION

INFRASTRUCTURE

Care Facilities

Facility Type

Resilience Characteristics

Center For Psychiatric Info	Care Facility	Access to healthcare, Access to meds
Ben Taub General Hospital	Care Facility	Access to healthcare, Buildings in mitg...
Intracare North Hospital	Care Facility	Access to healthcare, Access to meds
Healthsouth Rehabilitation Institute	Care Facility	Access to healthcare, Infrastructure in ml...
Houston Community Hospital	Care Facility	Access to healthcare, Access to meds
Bayshore Medical Center	Care Facility	Access to healthcare, Buildings in mitg...
Healthsouth Rehabilitation Hospital	Care Facility	Access to healthcare, Buildings in mitg...

INFRASTRUCTURE RESILIENCE CATEGORY

Show by Damage Level

Physical

Health

Financial

5%

SIZE = TOTAL NUMBER OF RESILIENCE CHARACTERISTICS RELATED TO INVESTMENT PRIORITIES.

Search

INVESTMENT PRIORITIES SELECTED

3

Select priorities from table on left and drop in any order in the containers below.

Population aged 65+

Intracare North Hospital

Houston Community Hospital

Priority D

Priority E

Priority F

Design Investments

FLOOD LEVELS

Water depth

18+ FT

16+ FT

15+ FT

10+ FT

6+ FT

Return period

Flood gauge height

Prioritizing resilience characteristics

- Research-based crosswalk between investments and relevant community resilience characteristics
 - How might this mitigation investment also enhance community resilience?
- Used core domains to categorize resilience characteristics and to summarize in terms familiar to users (e.g., health, environmental, economic, social, etc.)

Design Investments:

What can you do to mitigate flood impacts?

The screenshot shows a web application titled "Design Investments" for the "Homeland Security MERIT PROJECT". The interface includes a navigation sidebar with six steps: 1. CHOOSE LOCATION, 2. VIEW FLOODING, 3. CHOOSE IMPACTS OF CONCERN, 4. DESIGN INVESTMENTS (highlighted), 5. CHOOSE SCENARIOS, and 6. VIEW RESULTS. The main content area is titled "Design investments for each priority" and includes a sub-instruction: "Select one investment from the column on the left and drop it in the investments selected on the right. Each priority has several investment options, located on the corresponding tab." There are three tabs for priorities: "A: POPULATION AGED 65+", "B: INTRACARE NORTH HOSPITAL", and "C: HOUSTON COMMUNITY HOSPITAL". A table of "AVAILABLE INVESTMENTS" for priority A is shown, with columns for the investment name and its "Approximate Cost (change as needed)". The investments listed are: "Write resilience plan" (\$2,000), "Distribute backup generators" (\$30,000), "Develop reliable transportation to emergency shelters" (\$50,000), and "Establish low income housing plans outside floodplain" (\$250,000). A link "View population aged +65 on map" is also present. On the right, an "INVESTMENTS SELECTED" panel contains a "Drop investment for priority A" button and a "Choose investments for priority B" button with a right-pointing arrow. The footer of the application states "BUILT BY TALUS ANALYTICS".

Homeland Security MERIT PROJECT

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1 CHOOSE LOCATION

2 VIEW FLOODING

3 CHOOSE IMPACTS OF CONCERN

4 DESIGN INVESTMENTS

5 CHOOSE SCENARIOS

6 VIEW RESULTS

Design investments for each priority
Select one investment from the column on the left and drop it in the investments selected on the right. Each priority has several investment options, located on the corresponding tab.

A: POPULATION AGED 65+ B: INTRACARE NORTH HOSPITAL C: HOUSTON COMMUNITY HOSPITAL INVESTMENTS SELECTED

AVAILABLE INVESTMENTS	Approximate Cost (change as needed)
Write resilience plan	\$2,000
Distribute backup generators	\$30,000
Develop reliable transportation to emergency shelters	\$50,000
Establish low income housing plans outside floodplain	\$250,000

[View population aged +65 on map](#)



Drop investment for priority A

Choose investments for priority B

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Design Investments:

View on map for context



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1. CHOOSE LOCATION

2. VIEW FLOODING

3. CHOOSE IMPACTS OF CONCERN

4. DESIGN INVESTMENTS

5. CHOOSE SCENARIOS

6. VIEW RESULTS

Design Investments for each priority

Select one investment from the column on the left and drop it in the investments selected on the right. Each priority has several investment options, located on the corresponding tab.

A: POPULATION AGED 65+ | **B: INTRACARE NORTH HOSPITAL** | **C: HOUSTON COMMUNITY HOSPITAL** | **INVESTMENTS SELECTED**

AVAILABLE INVESTMENTS

Approximate Cost (change as needed)

Write resilience plan \$2,000

Distribute backup generator

Develop reliable transportation

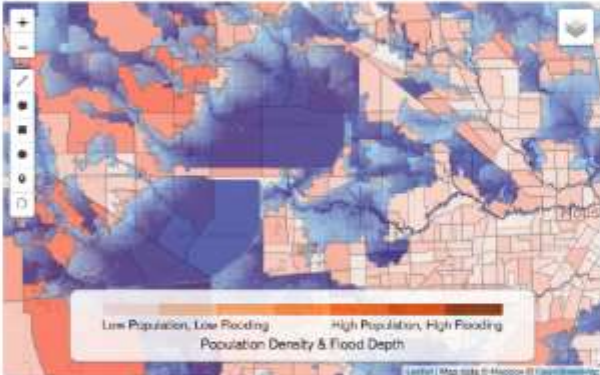
Establish low income housing

View population aged 65+

Drop investment for priority A

Choose investments for priority B

Population aged +65





Low Population, Low Flooding | High Population, High Flooding
Population Density & Flood Depth

Upload

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Design Investments – Completed

 **Homeland Security** 

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1 CHOOSE LOCATION

2 VIEW FLOODING

3 CHOOSE IMPACTS OF CONCERN

4 DESIGN INVESTMENTS

5 CHOOSE SCENARIOS

6 VIEW RESULTS

Design investments for each priority

Select one investment from the column on the left and drop it in the investments selected on the right. Each priority has several investment options, located on the corresponding tab.

A: POPULATION AGED 65+

B: INTRACARE NORTH HOSPITAL

C: HOUSTON COMMUNITY HOSPITAL

INVESTMENTS SELECTED

AVAILABLE INVESTMENTS	Approximate Cost (charge as needed)
Distribute backup generators	\$30,000
Sandbag Hospital	\$47,000

[View Houston Community Hospital on map](#)

Priority A: Population aged +65 **Write Resilience Plan** \$1,000


Priority B: Intracare North Hospital **Update Evacuation Plan** \$2,000

Priority C: Houston Community Hospital **Sandbag** \$23,000


Choose Scenarios ▶

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Confirm and submit to view results



Homeland Security



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1 CHOOSE LOCATION

2 VIEW FLOODING

3 CHOOSE IMPACTS OF CONCERN

4 DESIGN INVESTMENTS

5 CHOOSE SCENARIOS

6 VIEW RESULTS

Select scenarios to evaluate investments

FLOOD LEVELS

Flood return period

500 YEAR FLOOD

100 YEAR FLOOD

50 YEAR FLOOD

10 YEAR FLOOD

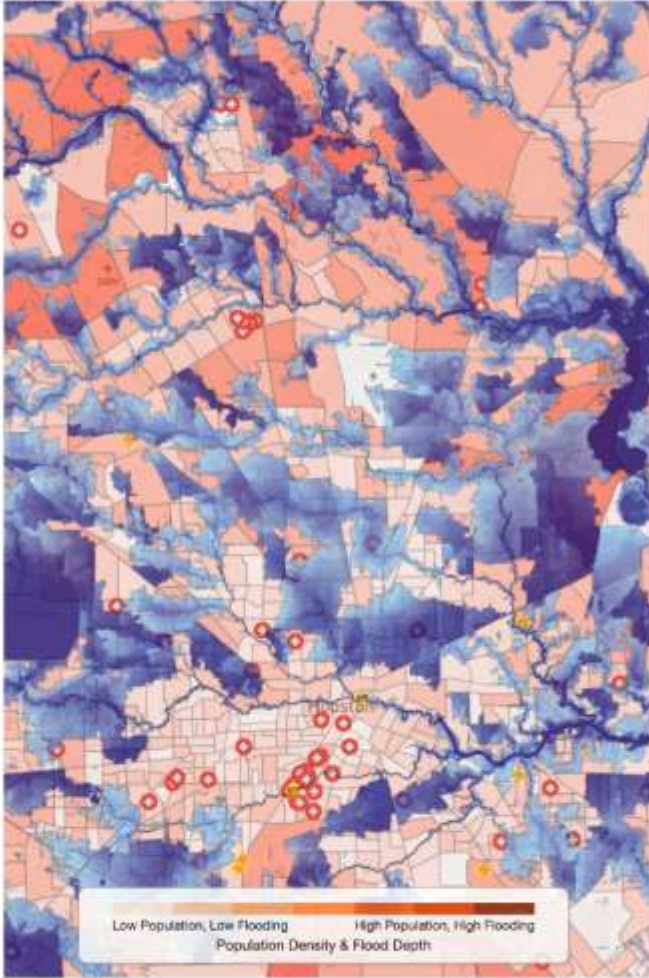
5 YEAR FLOOD

☒ Return period


☐ Flood gauge height

INVESTMENT	COST
Priority A: Population aged +65, High Flooding Write Resilience Plan	\$1,000
Priority B: Intracare North Hospital Update Evacuation Plan	\$2,000
Priority C: Houston Community Hospital Sandbag	\$23,000

Submit



BUILT BY



Linking Impacts to Benefit

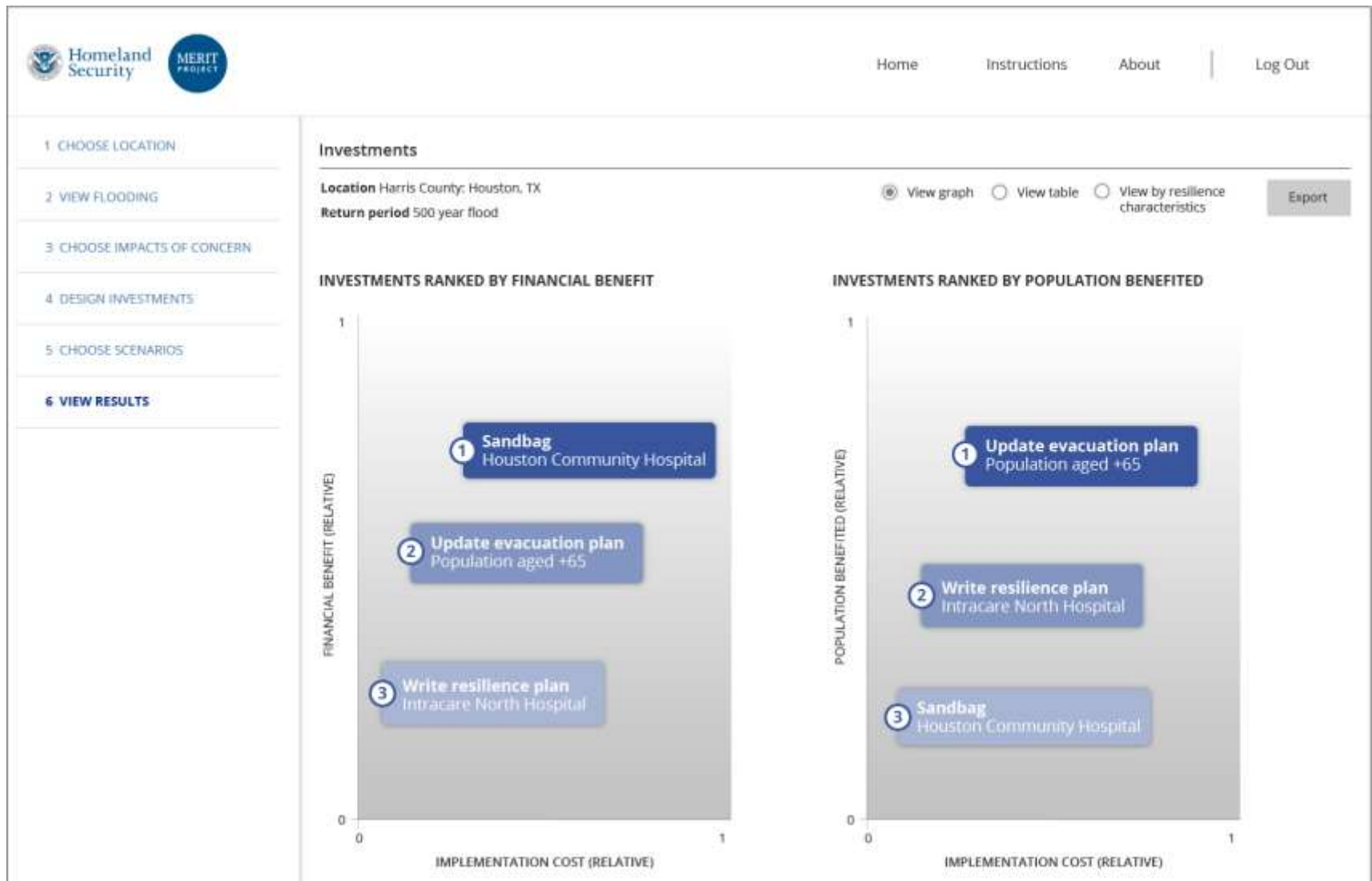
- Mean investment benefit is used to rank investments relative to each other
- Benefit weighted by the probability the flood will occur (from water gage history statistics)
- Weights are calculated as:

$$m(w_i) = AEP(w_{i+1}) - AEP(w_i)$$

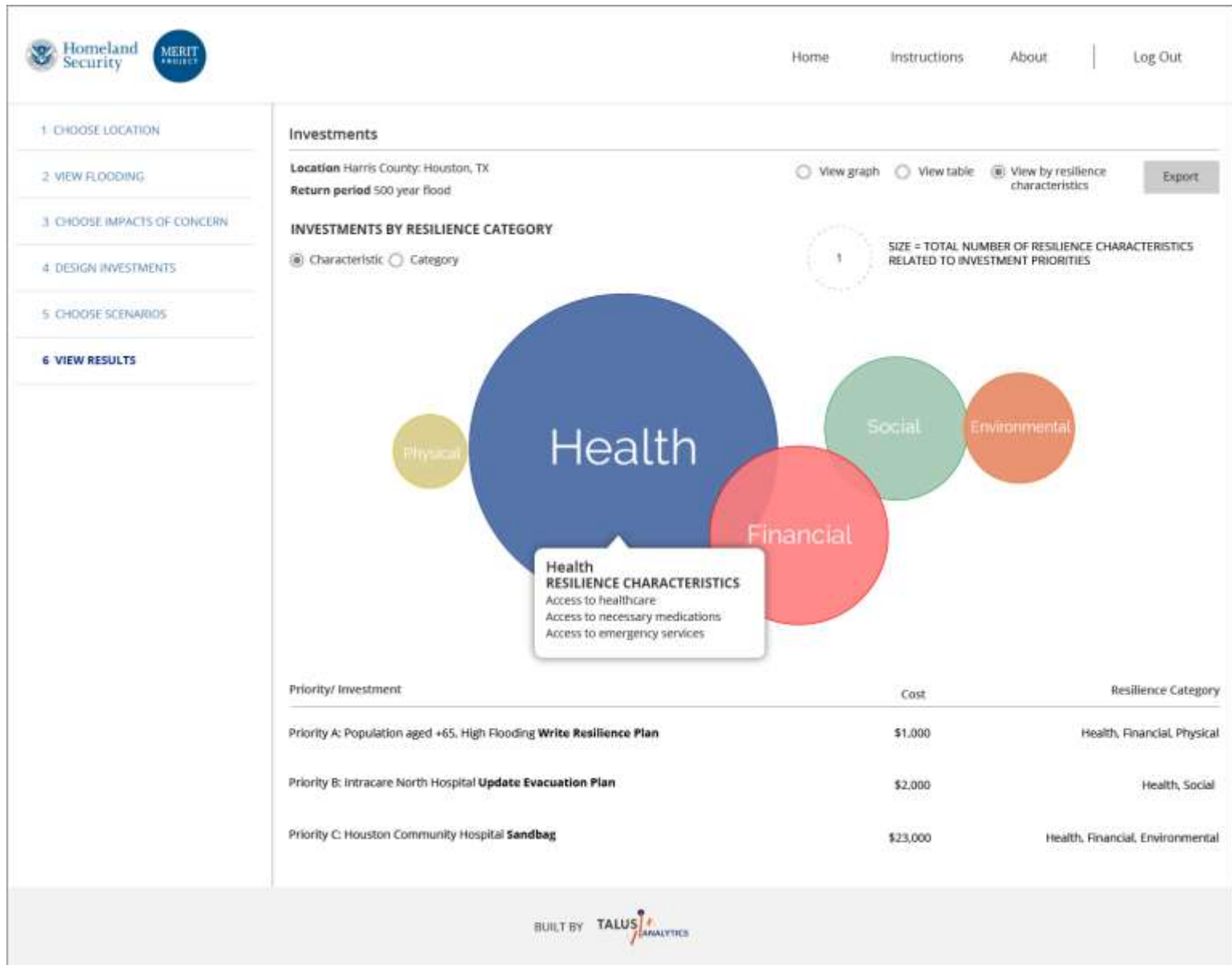
- Mean investment benefit is weighted sum:

$$\langle b \rangle = \sum_i m(w_i) b(w_i)$$

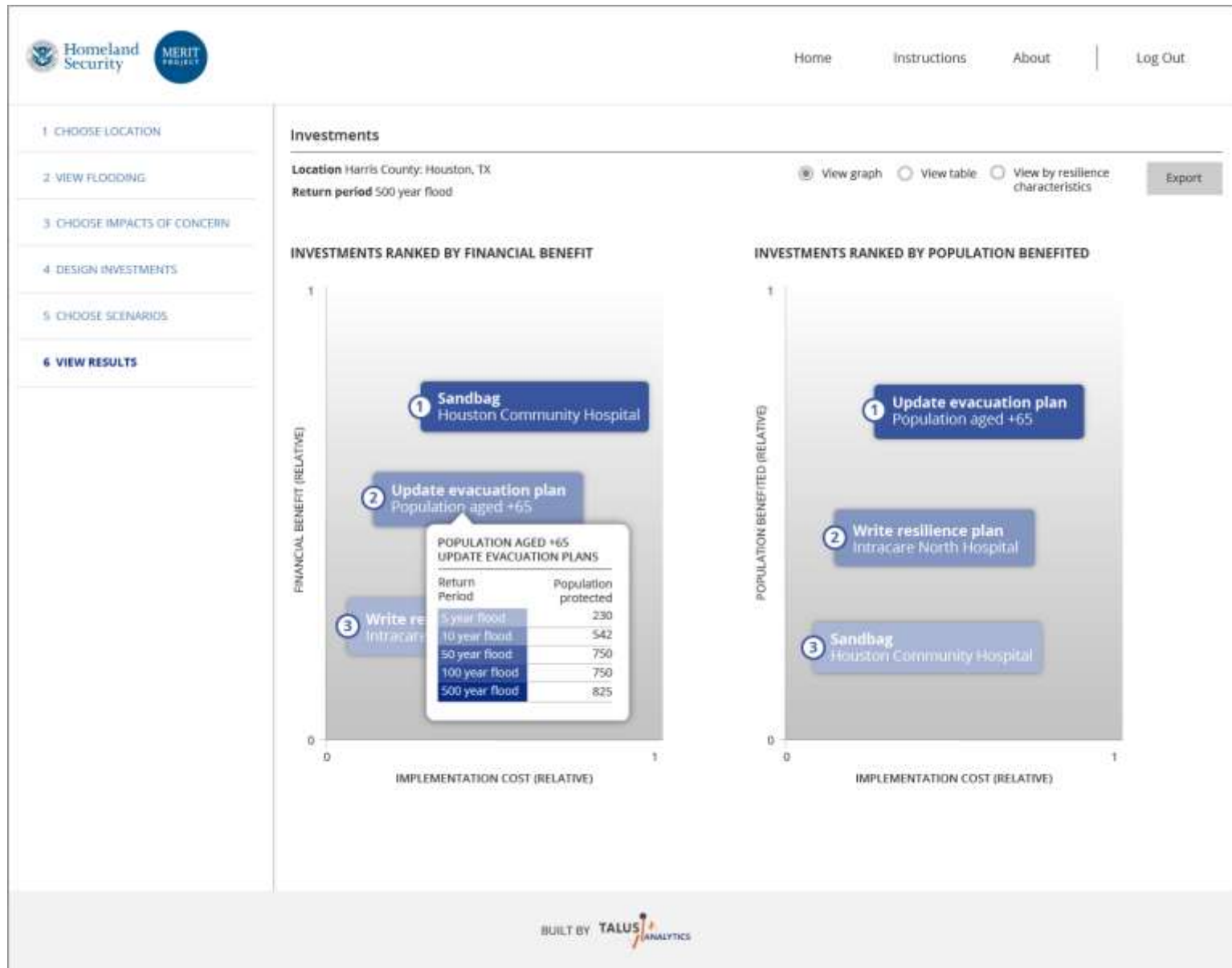
Rank investments for comparative analysis and communication



Link investments to resilience



Keep it simple. Drive discussion.



Next Steps

- Complete initial MERIT prototype
 - Gather feedback from Federal stakeholders and community end-users
- Revise prototype workflow and visualizations
- Publish inundation mapping and resilience cross-walk
- Define integrations with Federal partners
 - FEMA programs (Community Hazard Mitigation Plans, CRS, HMGP)
 - NIST Community Resilience Guide
- Build the fully-integrated, robust platform

Contact information

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