



Equity and Resilience in Urban Flooding

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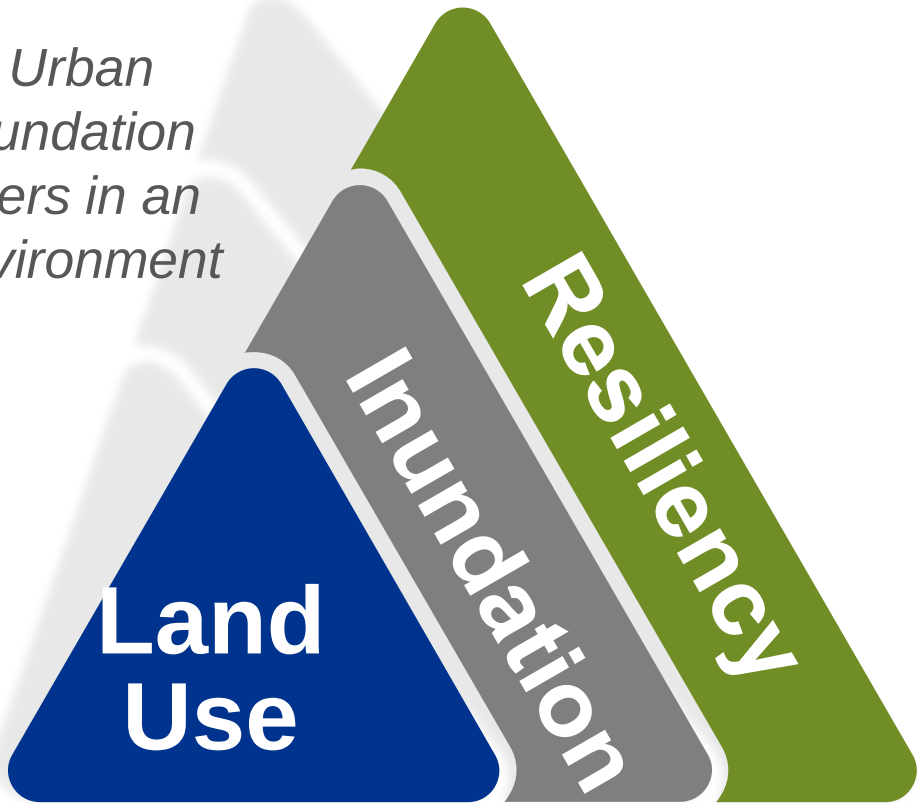
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Presentation Overview



Definition of Urban Flooding: Inundation by flood waters in an “urban” environment

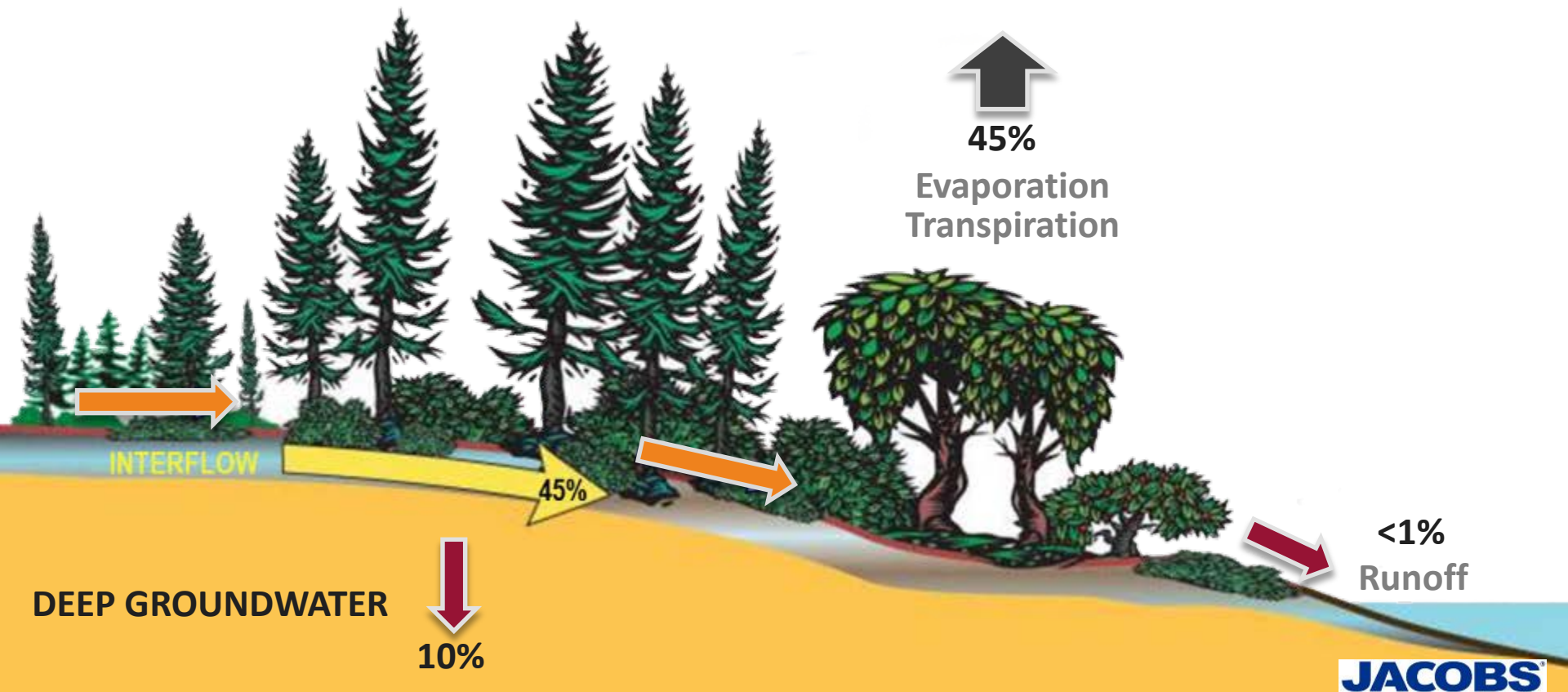


How does social vulnerability interact with each of these factors?

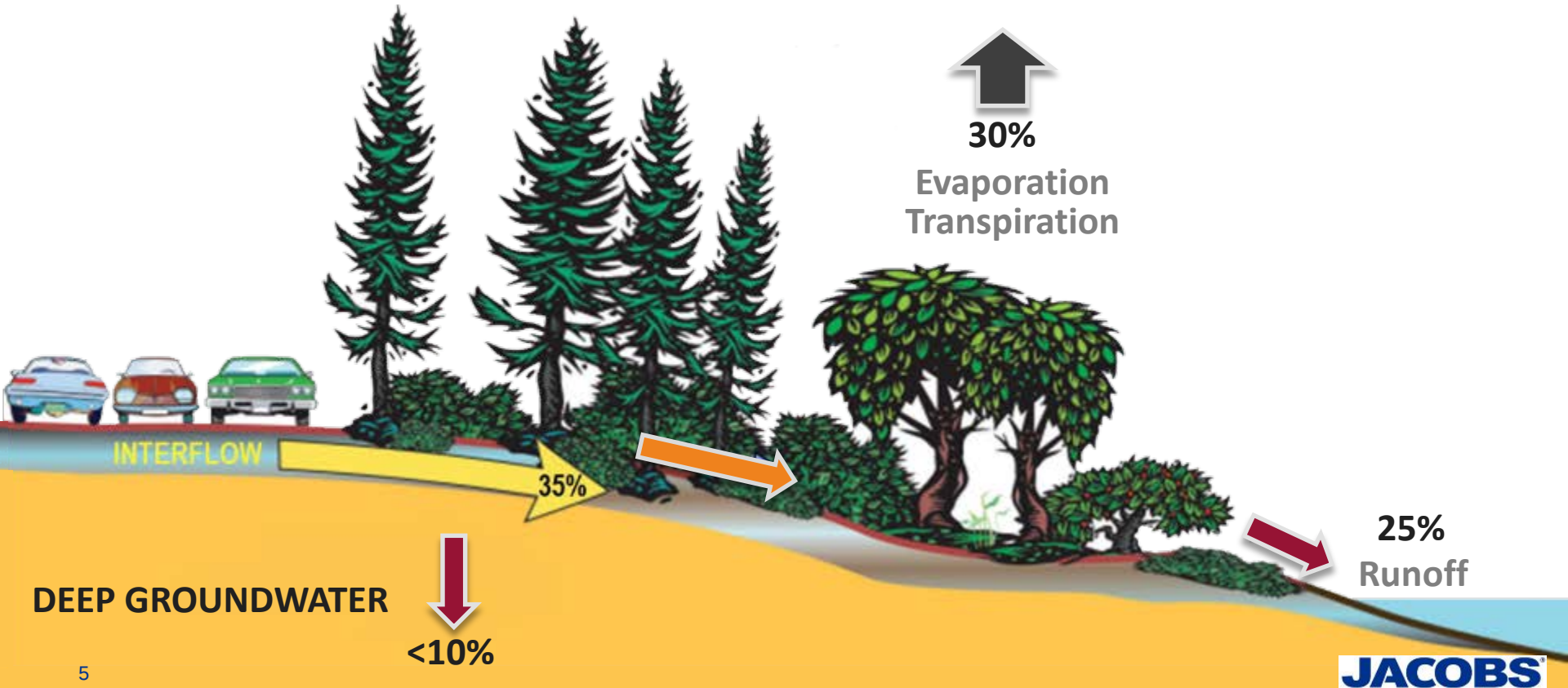
LAND USE



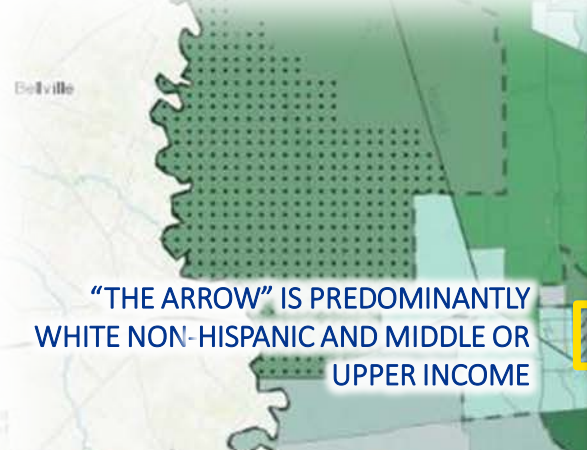
Under Natural Conditions Runoff is Limited



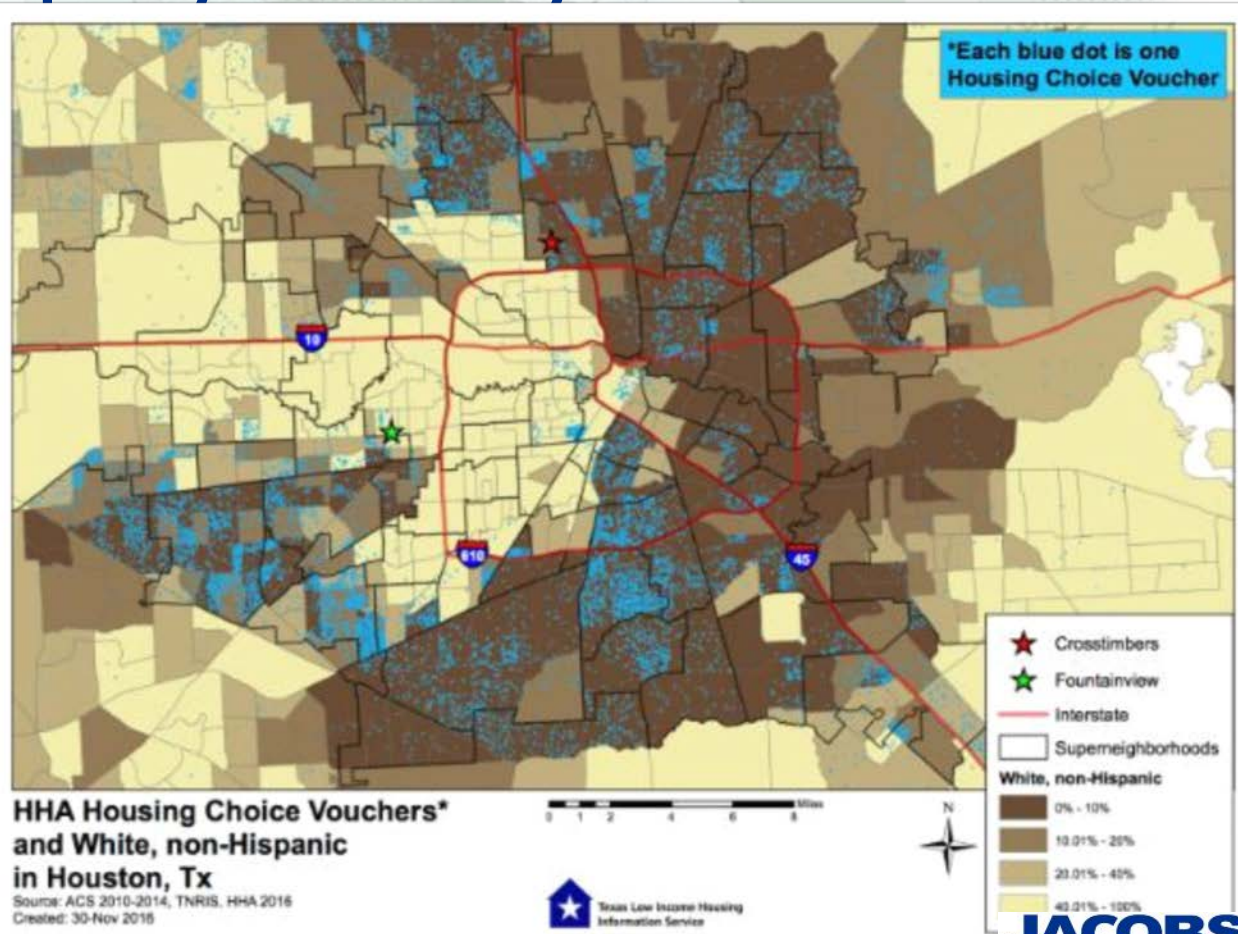
After Development Runoff is High



Urban Land Use Disparity Case Study: “The Arrow”



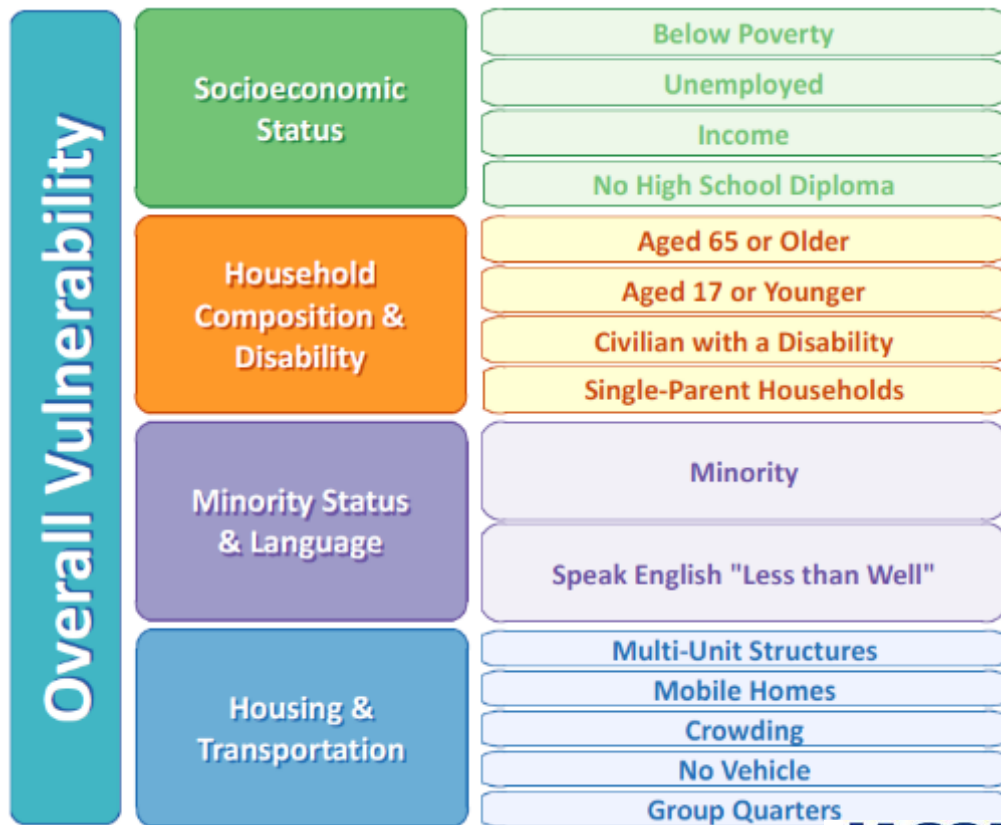
- Not all urban lands are economically equal!
- Does a drop of water know that or care?
- Nationwide issue
- Is there a comprehensive way to visualize this issue?



Social Vulnerability Index (SVI)

American Community Survey (ACS), 2010-2014 (5-year) data for the following estimates:

- Created by ATSDR's Geospatial Research, Analysis & Services Program (GRASP)
- Data available 2000-2016
- <https://svi.cdc.gov/>
- Indicates the relative vulnerability of every U.S. Census tract.



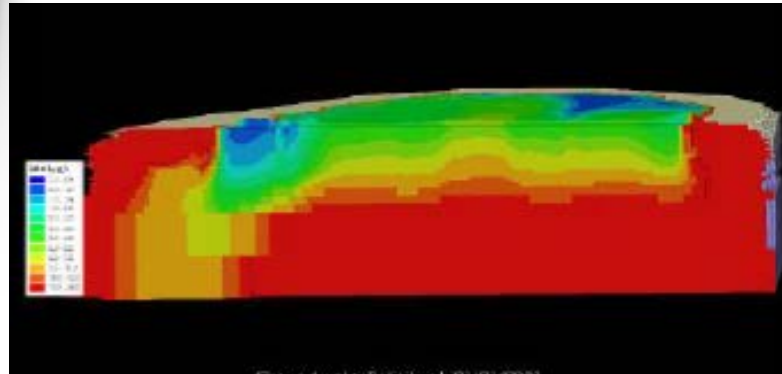
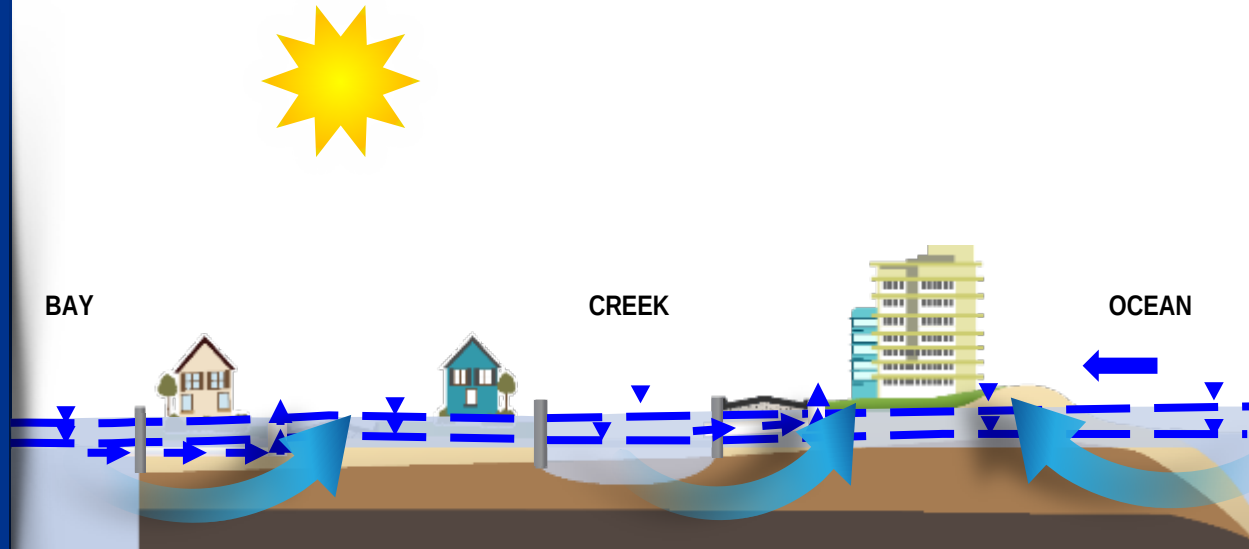
INUNDATION



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Coastal Flooding-Tidal

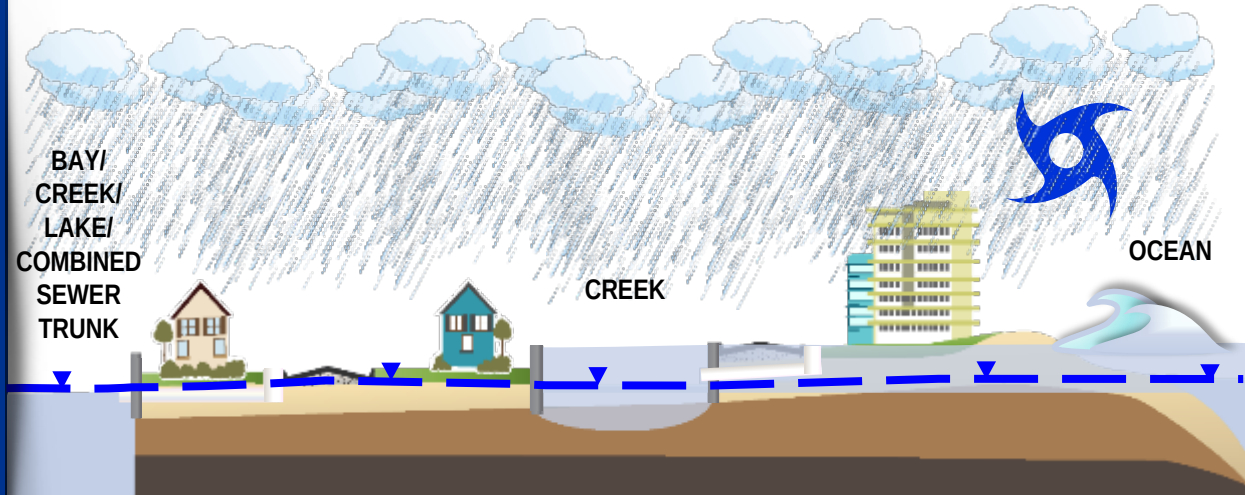
- **Tidal flooding:**
 - Through storm drains
 - Through groundwater
 - Exacerbated with SLR



Model Tools:
MODFLOW, MODHMS,
SUTRA, FEFLOW,
SEAWAT

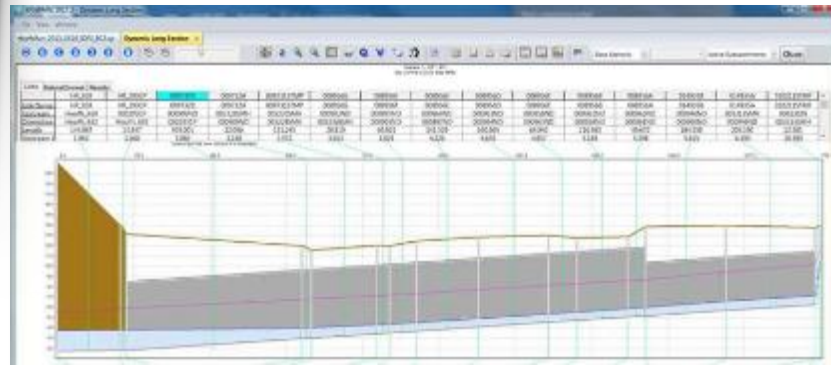
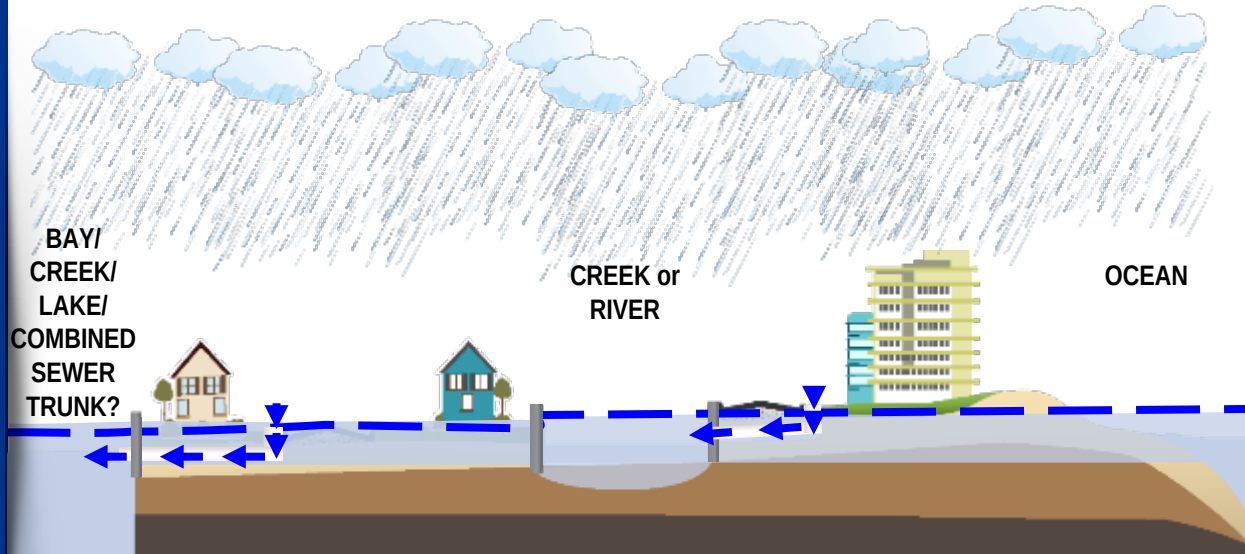
Coastal Flooding: Storms

- **Storm surge**
 - Coastal Impacts
 - Interacts with Rainfall Runoff and Tidal
 - Detailed inland propagation modeling for urban areas-or simple “bathtub” mapping



Inland Flooding: Rainfall Runoff Driven

- **Conveyance Type:**
 - Creek/Riverine
 - MS4 (Separate)
 - Combined Sewers
- **Complications:**
 - Depths and extents vary widely
 - Aging Infrastructure & Maintenance Issues
 - Capacity Limits & Combined Sewer Overflows
 - Funding priorities (Quality vs. Quantity?)
 - Levee/Floodwall Boundaries
 - Sensitive to increases in peak intensity, saturated soils



Model Tools: SWMM,
MIKE Urban, MIKE
Flood, InfoWorks-ICM

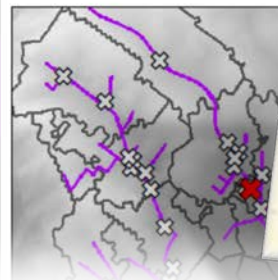
EXAMPLE: COUPLED 1D+2D URBAN SWMM MODEL

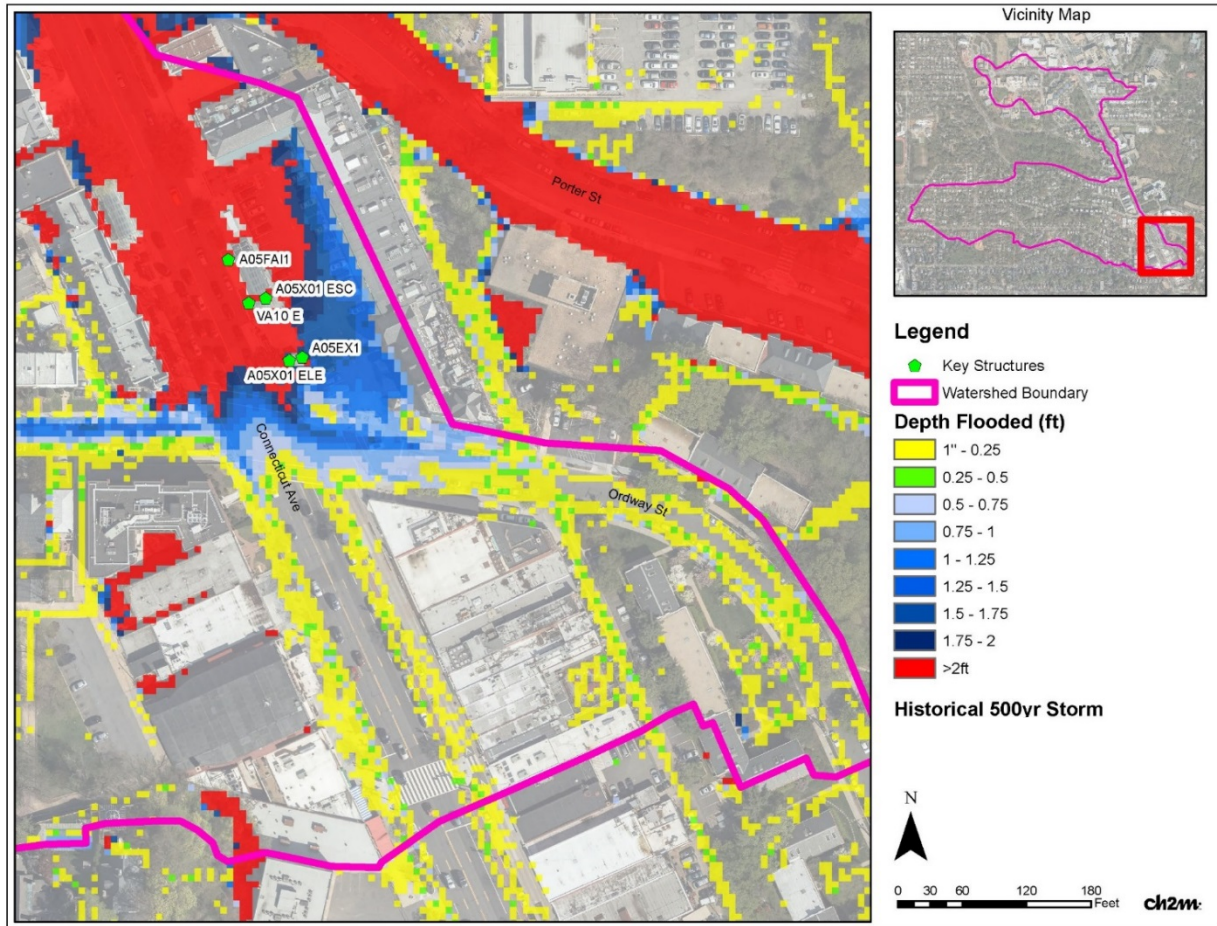


Max. Depth (ft)

☐ Flood District

— No
— Yes

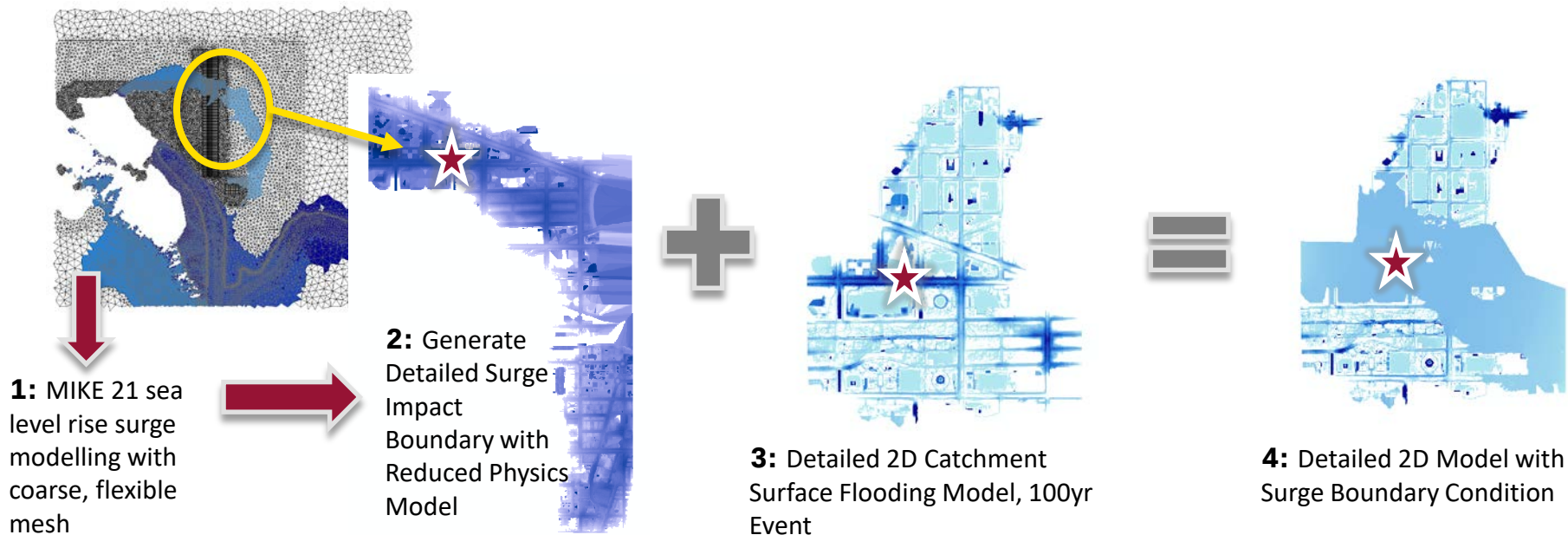




Detailed 2D Urban Direct
Rainfall Application
Modeling

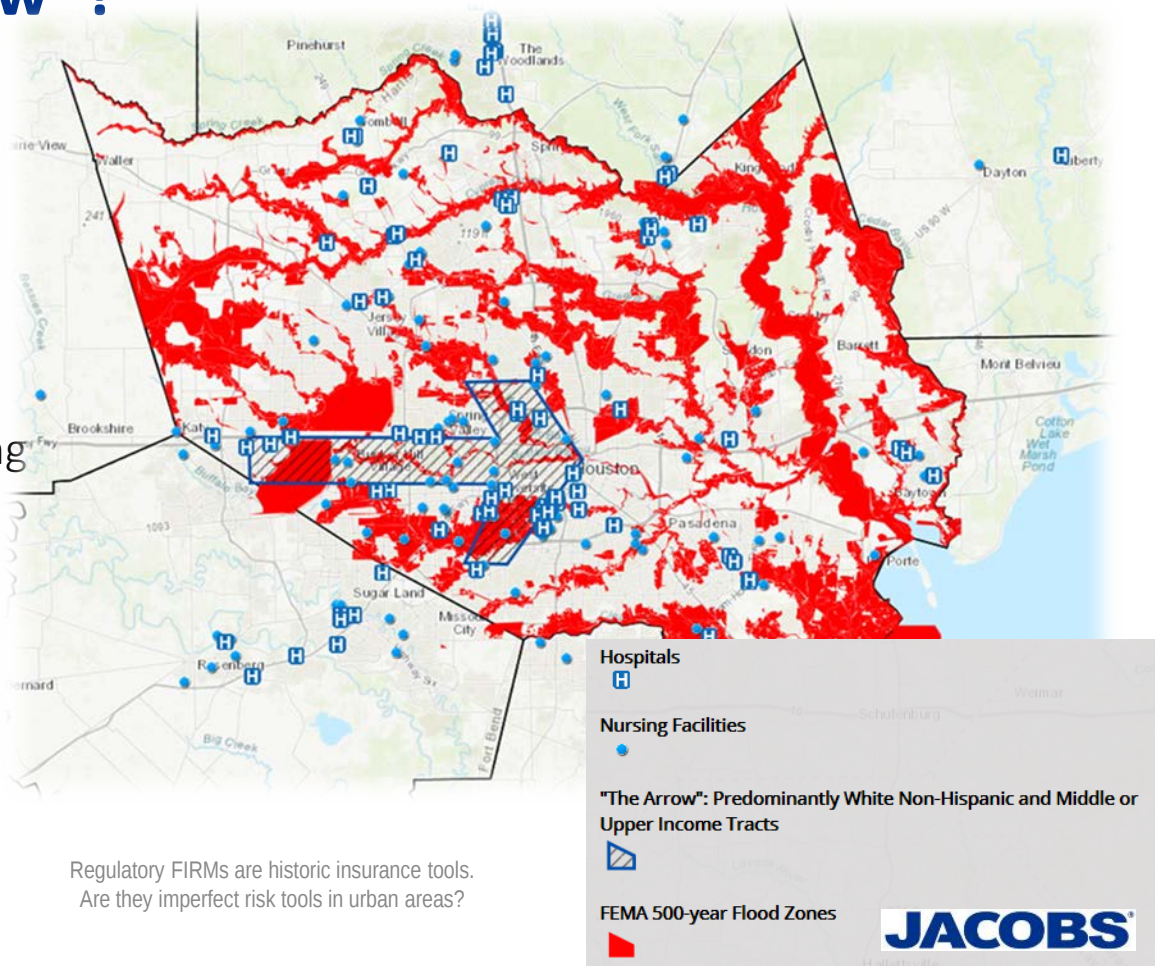
2D Boundary Conditions Example:

100-yr Rainfall and Levee Breach during Storm Surge with SLR



Remember “The Arrow”?

- Are homes and businesses outside the 100/500-year traditional floodplain at risk?
- Does urban flooding stop at the mapped floodplain?
- What would flood mapping using more “Urban” techniques look like?
- Are homes and businesses outside the 100-yr floodplain likely to have flood insurance?



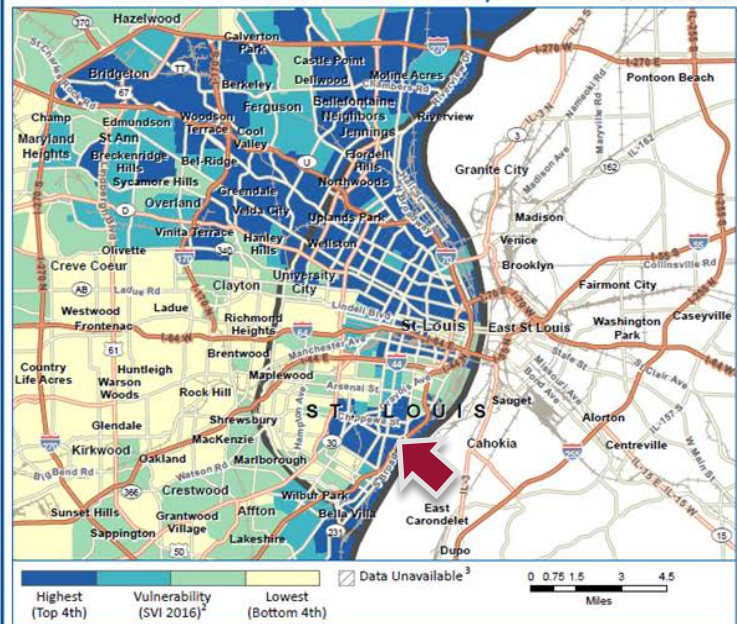
Regulatory FIRMs are historic insurance tools.
Are they imperfect risk tools in urban areas?

CDC's Social Vulnerability Index 2016

St. Louis City, Missouri

PART 1

Overall Social Vulnerability¹



Social vulnerability refers to a community's capacity to prepare for and respond to the stress of hazardous events ranging from natural disasters, such as tornadoes or disease outbreaks, to human-caused threats, such as toxic chemical spills. The **Social Vulnerability Index (SVI 2016)² County Map** depicts the social vulnerability of communities, at census tract level, within a specified county. SVI 2016 groups fifteen

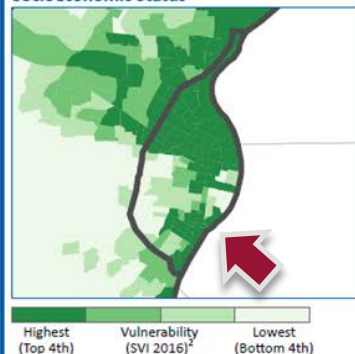
social-derived factors into four themes that summarize the extent to which the area is socially vulnerable to disaster. The factors include economic data as well as data regarding education, family characteristics, housing, language ability, ethnicity, and vehicle access. Overall Social Vulnerability combines all the variables to provide a comprehensive assessment.

SVI 2016 - ST. LOUIS CITY, MISSOURI

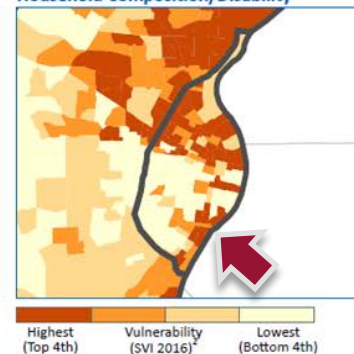
PART 2

SVI Themes

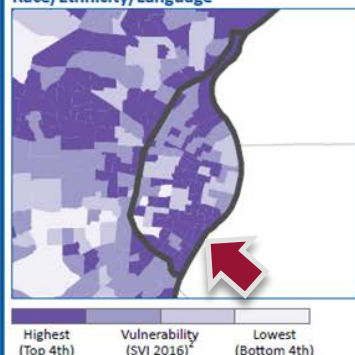
Socioeconomic Status⁵



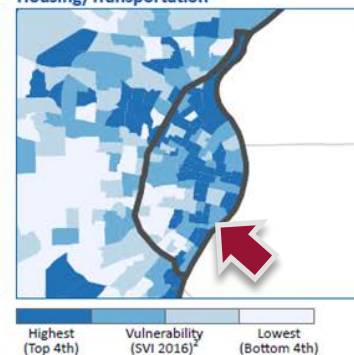
Household Composition/Disability⁶



Race/Ethnicity/Language⁷



Housing/Transportation⁸



Data Sources: ¹CDC/ATSDR/BRASP; U.S. Census Bureau, Esri[®] StreetMap[™] Premium.

Notes: ²Overall Social Vulnerability: All 12 variables. ³Census tracts with 0 population. ⁴The SVI combines percentile rankings of US Census American Community Survey (ACS) 2012-2016 variables, for the state, at the census tract level. ⁵Socioeconomic Status: Poverty, Unemployed, Per Capita Income, No High School Diploma. ⁶Household Composition/Disability: Aged 65 and Over, Aged 17 and Younger, Single-parent Household, Aged 5 and over with a Disability. ⁷Race/Ethnicity/Language: Minority, English Language Ability. ⁸Housing/Transportation: Multi-unit, Mobile Homes, Crowding, No Vehicle, Group Quarters.

Projections: NAD 1983 UTM Zone 12N.
References: Flanagan, B.E., et al., A Social Vulnerability Index for Disaster Management. *Journal of Homeland Security and Emergency Management*, 2011. 8(1).
CDC's SVI web page: <http://svi.cdc.gov>

AREA OF MINIMAL FLOOD HAZARD

- “Area of Minimal Flood Hazard” on FIRM
- Detailed 1D models exist to identify risk
- Urban floodplain mapping is not readily available



Woman in Floodwater, Source St. Louis Post-Dispatch – August 3, 1995, Photographer – Bill Greenblat

Social Vulnerability

WHAT HAPPENS WHEN URBAN FLOOD RISK IS SHOWN AND KNOWN?

Concerns?

- Property Value Implications
- Band of Accuracy in Mapping Data
- Financial Assistance Availability

Benefits?

- Public Health, Safety, and Welfare; More insurance policies
- Call to Action-Enable community to be part of the solution
- Resilient properties see value increases
- **Community Engagement is Essential**

Ethical Obligation?

- ASCE Canon 8:

“Engineers shall consider the diversity of the community, and shall endeavor in good faith to include diverse perspectives, in the planning and performance of their professional services.”

**JUST
BECAUSE
YOU CAN-
DOES IT
MEAN YOU
SHOULD?**

RESILIENCY



How did we get here?



**Explaining urban flooding
in layman terms is hard!**

Significant Urban Flooding Challenges

- Root causes vary widely and are significant for similarly varying solutions
- Challenges can be unique to each community or neighborhood
- Often is a lack of a committed funding stream-out of sight, out of mind
- Multi-disciplinary causes and solutions
- Rainfall frequency increases
- Need to adapt/transform to a new reality
 - Are traditional (20yr) planning horizons still applicable? 2100?
- Problems come in many scopes and sizes, and so do mitigation actions
- There is a need to do things differently
- Coastal and inland flooding are related
- Benefit/Cost ratio calculations can neglect social equity, which is important in urban areas
- There are often many unknowns that first need to be understood regarding both cause and potential solutions
- Stakeholder engagement
- Policy-Problems can be highly localized; not necessarily a state or federal issue

What are the options for managing Urban Flooding?

1. Choose to Build Bigger

- Systems that are able to cope
- Becomes increasingly unaffordable
- At some point, rainfall will still exceed the capacity

2. Choose to Ignore it and Deal With Consequences

- Dangerous
- Distressing & Costly to those impacted, including physically and in terms of health and well-being

3. Choose to Manage It and Design for Exceedance

- Use urban areas and infrastructure to temporarily manage the water on the surface
- Use roads to channel
- Use Open Space to store
- Erect temporary barriers
- Flood-resilient homes and businesses
- Community engagement is vital
- Local development/redevelopment regulations

*Source: Managing urban flooding from heavy rainfall, CIRIA
2014, Recommendations and Summary*

What makes a Resilient Urban Community Different?

A RESILIENT COMMUNITY:

- Understands its risk
- Understands the history and cause of the problem
- Has chosen to anticipate and adapt to future change
- Is capable of tolerating and rebounding from events
- Has adapted at a community and individual level
- Values a fully integrated water cycle solution, including CWA obligations
- Shapes policy for all socioeconomic stakeholders
- Engages with the community
- Partners with stakeholders, nonprofits, agencies, and neighborhoods
- Partners with low-income financial programs and institutions-including those that fund simple home repairs and assist with code violation repairs
- Financially invests in mitigation strategies
- Increases flood insurance policy coverage

Toolkit for Resilient Urban CWA Communities

Multi-Function Solutions Are Essential

STRUCTURAL

- Tunnels (CSO + flood)
- Storage (CSO + flood)
- Conveyance (CSO + flood)
- Green Infrastructure (CSO + flood)
- Barriers, Gates, Levees, Pumps
- Floodproofing
- Structural Elevation
- Small-Scale Property Specific Improvements
- Design-factor of safety
- Design for Exceedance

NON-STRUCTURAL

- Emergency Action Plans (manage impacts)
- Understand the problem (studies/data)
- Policy Modifications (including local development/redevelopment)
- Community Engagement
- Risk Education/Data
- Property Acquisition + Relocation
- Incorporate cloudburst-based rainfall into design standards
- Homeowner financial assistance and how-to resources for localized issues (ie, backflow prevention, simple floodproofing)
- Realtime Monitoring/Controls
- Insurance
- Integration with CWA obligations

Social Equity in Urban Flood Mitigation

Project Prioritization

- Are *property values* driving prioritization factor for Capital Improvement Planning?

Prioritization Methodologies that avoid using property value

- Severity Points to Planning Level Cost Ratios
- Deliberately include SVI-type factors
- Set aside funding specifically for disadvantaged areas

Federal Funding does not consider Social Vulnerability

- But...can we help more people if property value isn't a significant driver?



URBAN DESIGN...

visualize solutions at the
neighborhood scale

INTEGRATING

Conveyance
Green Infrastructure
Open Space
Small-Scale Solutions
Policy
Outreach
Education
Financial Assistance

**....INCLUSIVE DESIGN,
MULTI-FACETED
SOLUTIONS**



Resiliency: Food for Thought

Does true urban resiliency mean that urban mitigation plans include multiple, concurrent mitigation resources?

- Physical Mitigation
- Policy
- Outreach/Risk Portrayal
- Financial Assistance
- Insurance
- Emergency Planning

What roles should policy play?

- Local?
- Regional?
- National?

Should a “One Water” approach go beyond engineering?

- Integrate and Coordinate Water Systems (and more?)
- Economic, Social, and Environmental Benefits
- Agencies, Stakeholders, Non-profits





Questions?

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