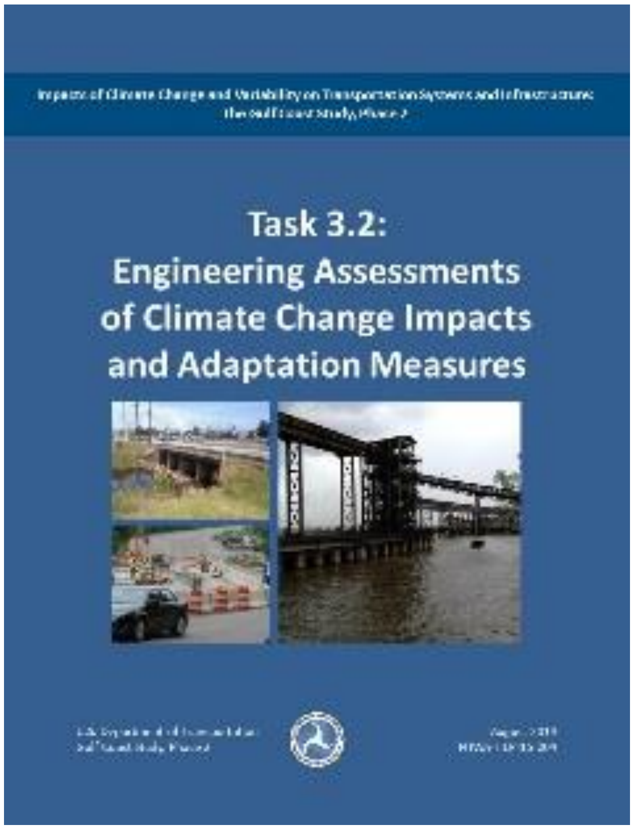


The Engineering Assessment Process Used in the Gulf Coast Study, Phase 2

Jake Keller, WSP | Parsons Brinkerhoff

AASHTO Subcommittee on Design

Seattle, WA

September 2015

WSP | PARSONS BRINCKERHOFF

ICF INTERNATIONAL

Overview

- Context
- Engineering Assessment
- Putting Studies into Practice

Why do this?

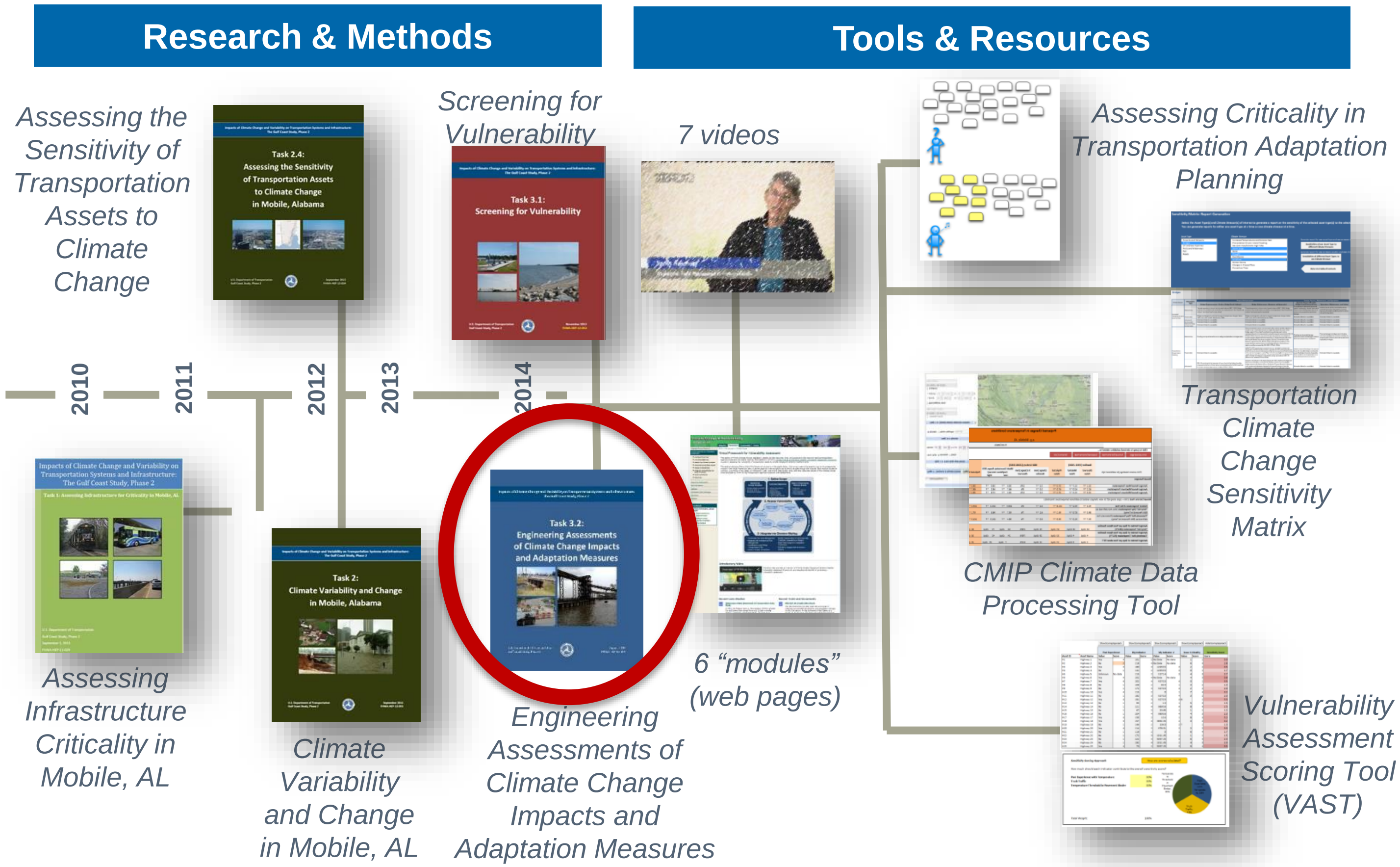
There is limited guidance on how to incorporate climate change projections into transportation engineering design.

Intended audience

- Department of transportation (roadways and transit) officials
- Planning and engineering staff
- Risk managers
- Metropolitan Planning Organization staff and leadership
- Private facilities owners/operators (airports, marine ports, rail)
- Political stakeholders needing technical support

Researching Vulnerability Implications for Engineers

- Gulf Coast, Phase 2 Study Outcomes



CONTEXT

Undertaking Asset-Specific Engineering Assessments

Columbus Street Terminal in Charleston, SC
After Hurricane Hugo

- Goals

1. Develop and test a systematic assessment process that:
   - Evaluates climate vulnerabilities
   - Develops and compares possible adaptation strategies

2. Explain and document Mobile-specific findings, including those that may apply in other locations.

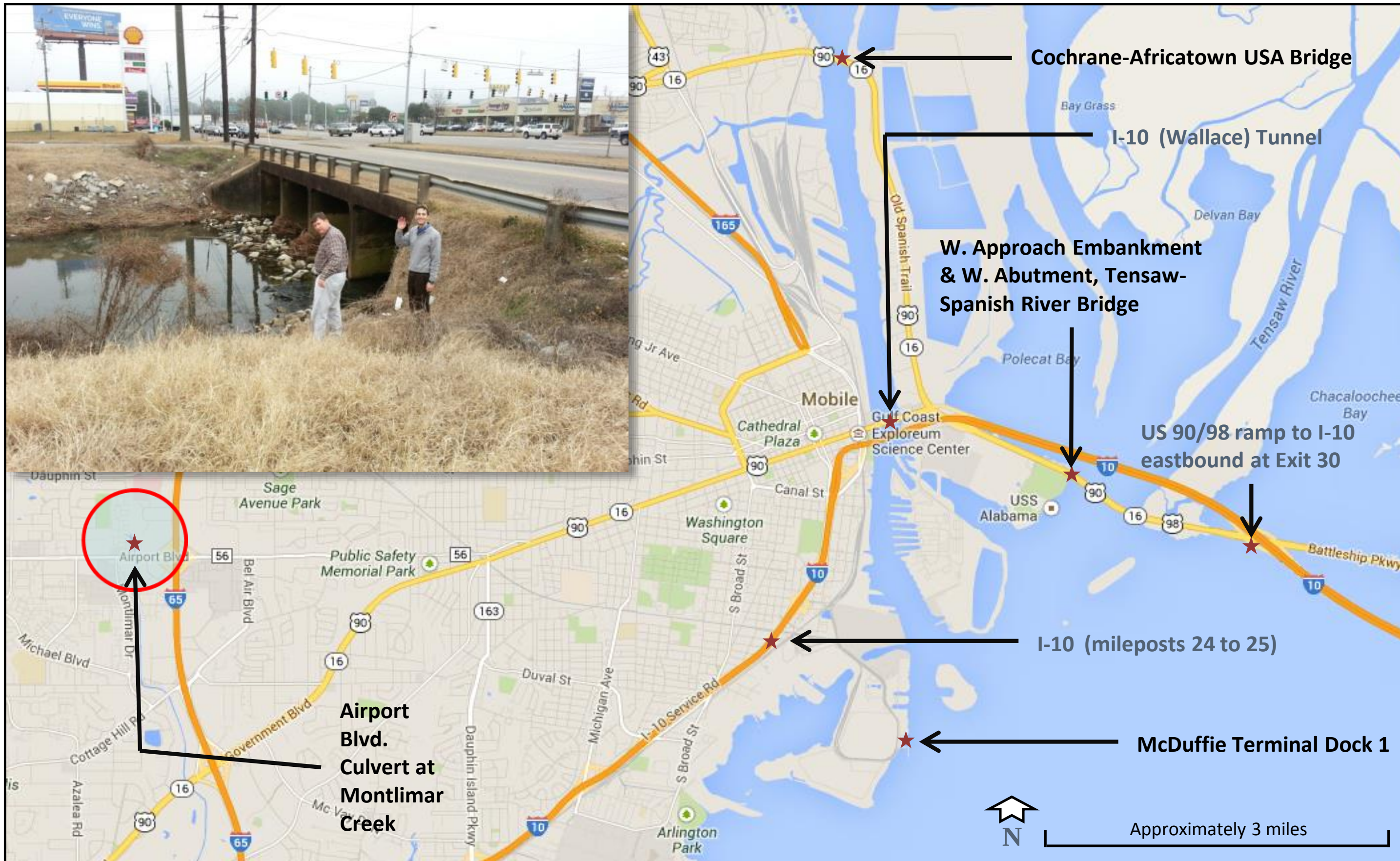
Unique Features of Engineering Assessments

- Employs a systematic process for conducting engineering assessments specifically to address climate/weather risks
  - Establishes first ‘guidance’ of its kind
  - Yields asset-specific findings
  - Addresses multi-modal vulnerabilities
  - Addresses a range of climate hazards
- Emphasizes relationship of climate information to design input data
  - Demonstrates ability to ‘localize’ climate information for analysis
  - Identifies and accommodates data needs for engineering assessment (e.g., temporal and spatial scales)
  - Utilizes ranges of data, rather than singular input values
- Employs scenarios that acknowledge historic “design” storms as well as modeled future storms
  - Respects institutional knowledge and historic data
  - Enables scenario analysis

11-Step Process

1. Describe the site context
2. Describe the existing or proposed facility
3. Identify environmental factors that may impact infrastructure components
4. Decide on climate scenarios and determine magnitude of changes
5. Assess performance of the existing or proposed facility
6. Develop adaptation option(s)
7. Assess performance of the adaptation option(s)
8. Conduct an economic analysis
9. Evaluate additional decision-making considerations
10. Select a course of action
11. Plan and conduct on-going activities

Case Study Locations



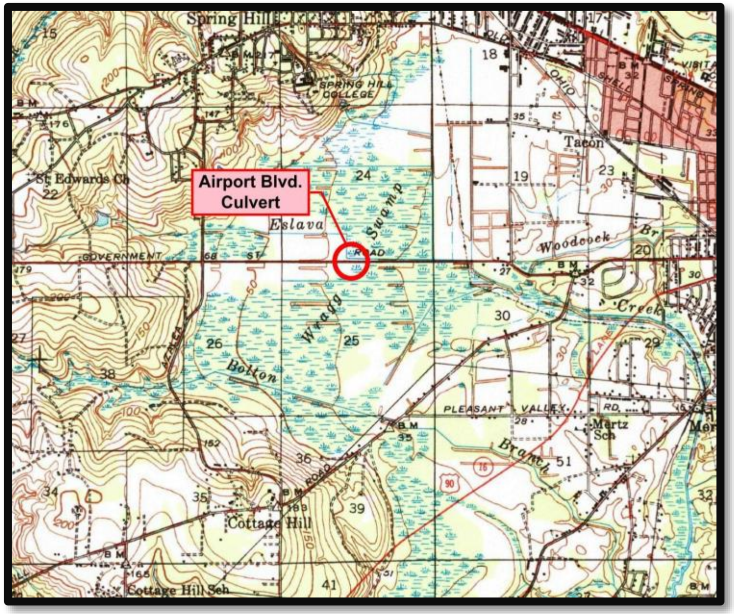
Asset Type / Climate Stressor Relationships Studied

Climate Stressor	Asset Type	Damage Mechanism	Asset Location
Precipitation	Culvert	Overtopping	Airport Blvd @ Montlimar Creek
Sea Level Rise	Bridge	Clearance	Cochrane Africatown USA Bridge
Sea Level Rise	Slope	Slope erosion	US 90/98 Tensaw Bridge
Storm Surge	Pier	Waves	McDuffie Coal Terminal, Dock 1
Storm Surge	Bridge	Waves/scour	US 90/98 Tensaw Bridge
Storm Surge	Bridge	Wave forces	Exit 30, EB Ramp I-10 Bayway Brdg
Storm Surge	Roadway	Flood/erosion	I-10, Between Mileposts 24 and 25
Storm Surge	Tunnel	Flood	Wallace Tunnel
Temperature	Pavement	Ruts, heaves	Generic
Temperature	Rail	Buckling	Generic
All	O&M	Wear/tear	Generic

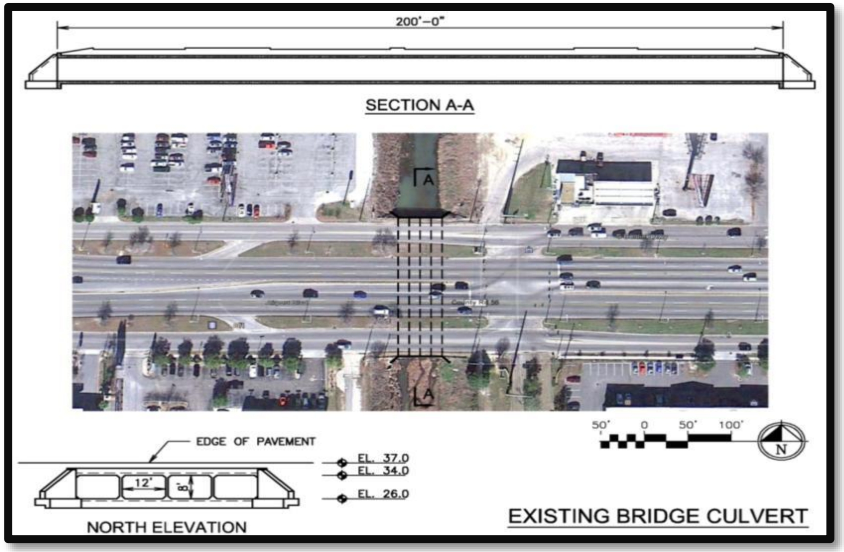
WSP | PARSONS BRINCKERHOFF

ICF INTERNATIONAL

Applying the 11-Step Process: Steps 1 - 3



1. Describe the site context
2. Describe the existing or proposed facility
3. Identify environmental factors that may impact infrastructure components



Applying the 11 Step Process: Step 4

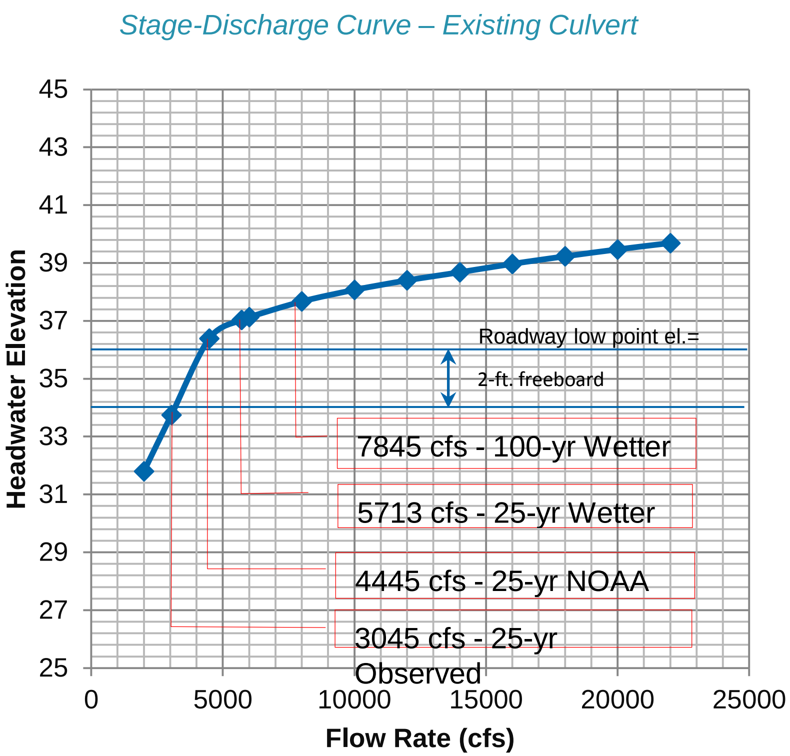
24-Hour Precipitation Projections

24-hour Storm Event Return Period	NOAA Average Baseline (inches)	"Wetter" Narrative			"Drier" Narrative		
		2010–2039 (inches)	2040–2069 (inches)	2070–2099 (inches)	2010–2039 (inches)	2040–2069 (inches)	2070–2099 (inches)
100-yr storm	14.9	21.0	20.4	22.3	12.6	14.2	13.4
50-yr storm	12.8	19.1	18.5	20.2	11.7	13.1	12.5
25-yr storm	10.9	15.7*	15.2*	16.7*	9.3*	10.4*	9.9*
20-yr storm	Unavailable	14.8	14.4	15.8	8.8	9.9	9.4
10-yr storm	8.6	12.9	12.5	13.7	7.9	8.8	8.4
5-yr storm	7.1	10.5	10.3	11.1	6.6	7.3	7.0
2-yr storm	5.3	6.7	6.7	7.1	4.4	4.8	4.6

* Asterisks denote interpolated values

1. Describe the site context
2. Describe the existing or proposed facility
3. Identify environmental factors that may impact infrastructure components
4. **Decide on climate scenarios and determine magnitude of changes**

Applying the 11 Step Process: Steps 5



1. Describe the site context
2. Describe the existing or proposed facility
3. Identify environmental factors that may impact infrastructure components
4. Decide on climate scenarios and determine magnitude of changes
5. **Assess performance of the existing or proposed facility**

Applying the 11 Step Process: Steps 6 - 8

Results of the Economic Analysis of Adaptation Options

Six12'x8' Cells Option

Climate Scenario	1	2	4	5	
Description of Scenario	Observed 1980–2009 with Current Land-use	Observed 1980–2009 with Future Land-use	"Wetter" Narrative	"Drier" Narrative	Average (mean) of All Scenarios
Present Value of Costs	$1.7m	$1.7m	$1.7m	$1.7m	$1.7m
Present Value of Benefits	$9.7m	$11.5m	$83.3m	$8.2m	$26.1m
NPV	$8.0m	$9.7m	$81.6m	$6.4m	$24.4m
BCR	5.6	6.6	47.9	4.7	15.0
Probability that BCR will be over 1	44%	50%	99%	41%	N/A

Four 21'x9' Cells Option

Present Value of Costs	$2.5m	$2.5m	$2.5m	$2.5m	$2.5m
Present Value of Benefits	$10.3m	$11.8m	$97.5m	$8.9m	$29.4m
NPV	$7.8m	$9.3m	$95.0m	$6.4m	$26.9m
BCR	4.1	4.7	38.9	3.6	11.7
Probability that BCR will be over 1	38%	44%	99%	35%	N/A

1. Describe the site context
2. Describe the existing or proposed facility
3. Identify environmental factors that may impact infrastructure components
4. Decide on climate scenarios and determine magnitude of changes
5. Assess performance of the existing or proposed facility
6. **Develop adaptation option(s)**
7. **Assess performance of the adaptation option(s)**
8. **Conduct an economic analysis**

.

Applying the 11 Step Process: Step 9

While the statistical analyses provide a starting point for making decisions, the numerical results by no means represent a final decision in the decision making process.

"The Triple Bottom Line"

1. Describe the site context
2. Describe the existing or proposed facility
3. Identify environmental factors that may impact infrastructure components
4. Decide on climate scenarios and determine magnitude of changes
5. Assess performance of the existing or proposed facility
6. Develop adaptation option(s)
7. Assess performance of the adaptation option(s)
8. Conduct an economic analysis
9. **Evaluate additional decision-making considerations**

Applying the 11 Step Process: Steps 10 & 11

Source: National Weather Service

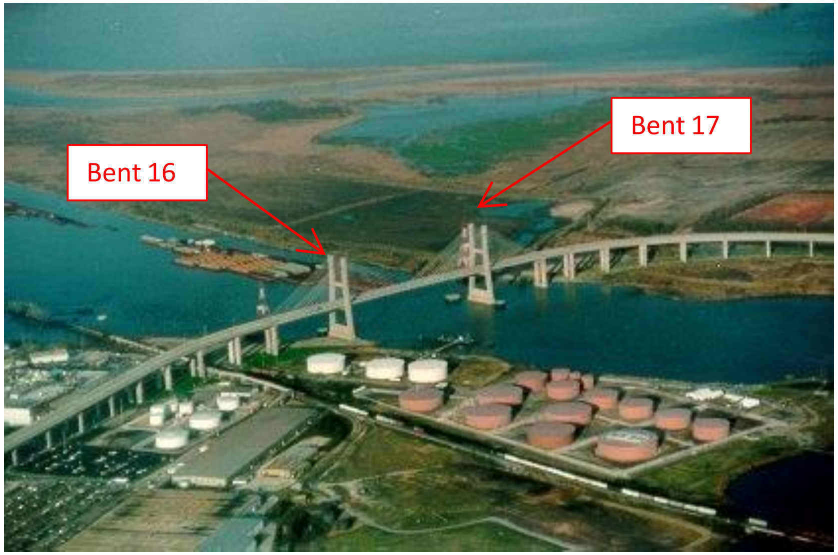
1. Describe the site context
2. Describe the existing or proposed facility
3. Identify environmental factors that may impact infrastructure components
4. Decide on climate scenarios and determine magnitude of changes
5. Assess performance of the existing or proposed facility
6. Develop adaptation option(s)
7. Assess performance of the adaptation option(s)
8. Conduct an economic analysis
9. Evaluate additional decision-making considerations
10. **Select a course of action**
11. **Plan and conduct on-going activities**

How The Case Studies Can Help You

Summary highlights at beginning of case studies

Case Study Highlights

- **Purpose**
- **Approach**
- **Findings**
- **Other Conclusions**



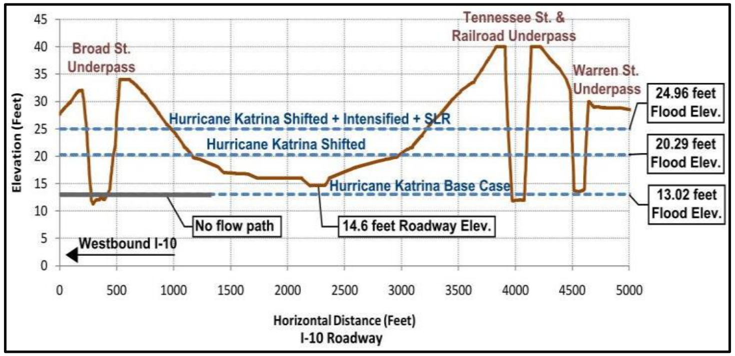
Each case study includes:

- A detailed analysis that follows the 11 step process
- A description of the methodology used to conduct the assessment including:
  - Required data
  - Models and equations
  - Graphs and figures
  - Results
- Was the asset vulnerable?
  - What adaptation options are viable?
  - What are the key takeaways?
- Lessons learned

Key Lessons Learned

Localized temperature projections helped assess the potential of heat kinks

Elevated roadway clearance under variations of Hurricane Katrina

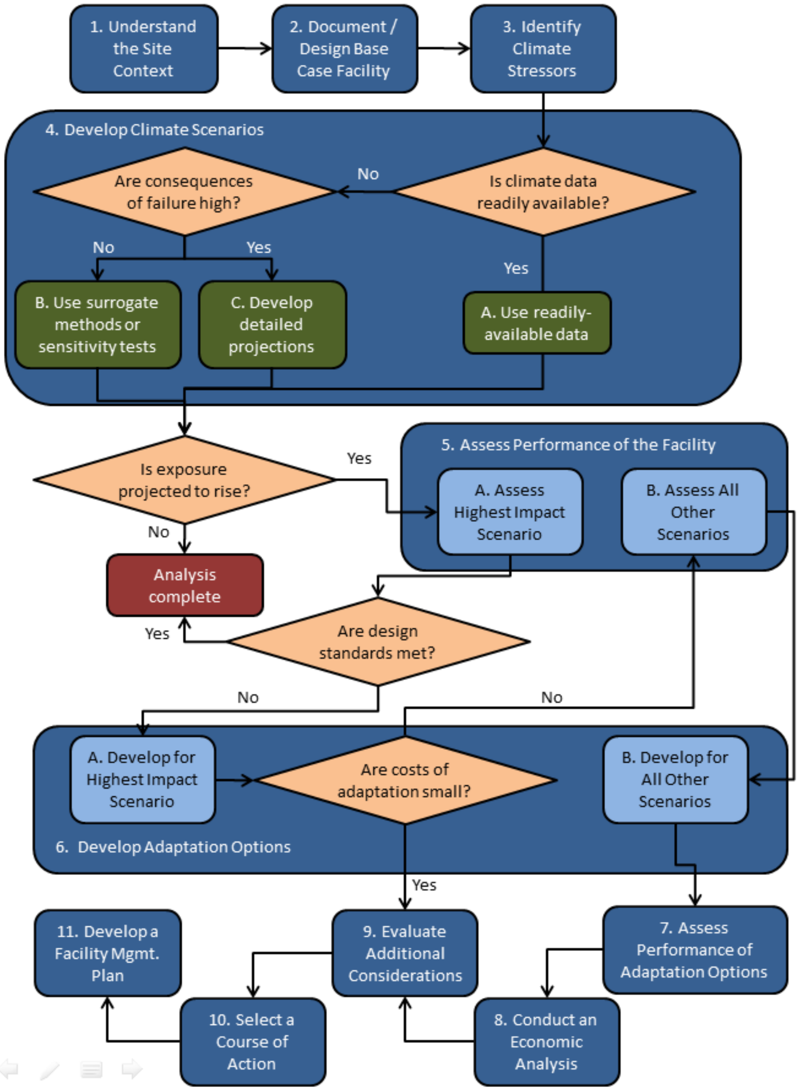


- The 11-step Process is a **useful and versatile** framework
- **Climate data** can be localized
- **Scenario planning** is key to considering climate variables
- **Benefit-cost analysis** is helpful for finding the best performing adaptation option across scenarios

Other Interesting Findings

- **Ship Navigation:** Sea level rise could limit navigational clearances at bridges affecting transport even if the assets themselves are not vulnerable
- **Systems Perspective:** Riprap, willow matting, etc. work in unison to provide protection. Make sure these are evaluated as a system.
- **Storm Surge:** The "worst case" storm surge scenario does not always translate to more damage. Higher surges can completely inundate assets and protect them from the breaking waves.
- **Selecting Adaptation Measures:** Sometimes protecting a structure too much can actually result in more damage (e.g. tying down a bridge deck to its piers could cause substructure damage)
- **Hurricanes:** The Saffir-Simpson Hurricane scale, which is based on sustained wind speed, doesn't have a one-to-one relationship with magnitude or duration of storm surge

Additional Engineering Assessments Are Ongoing Nationwide



- Transportation Engineering Approaches to Climate Resiliency (TEACR) study
- Hurricane Sandy Follow-up, Vulnerability Assessment and Adaptation Analysis
- FHWA pilot studies
- Other state & local efforts

Implementation Challenges

- Difficulty convincing agencies that adaptation is "pressing"
- Perception that there is too much uncertainty in future climate to warrant changes to design practices
- Higher up-front costs for
  - Undertaking the adaptation actions
  - Conducting the 11-Step process
- Risk-based analyses not traditionally used to drive engineering decisions
- Worry that assessments like these could expose agencies to criticism if assets fail
- Remaining knowledge gaps that can make these studies difficult

The Study Team

Client: United States Department of Transportation

Client's Managing Agency: Federal Highway Administration

- Robert Hyman
- Robert Kafalenos
- Brian Beucler

Engineering Analysis Consultant and Study Author:

- Parsons Brinckerhoff

Climate and Planning (Prime) Consultant:

- ICF International

The Consultant Study Team

Project Management:
- Jake Keller

Hydrology, hydraulics, bridge scour:
- Glenn Bottomley
- Lewis White
- Justin Lennon
- Eric Gupton

Storm surge modeling:
- Jerald Ramsden

Bridge structures:
- Rex Gilley
- Benny Louie

Marine structures:
- Robert Snyder
- Blair Garcia

Economic & statistical analyses:
- Robert Kinghorn
- Lisa Bass

Climate data:
- Anne Choat
- Beth Rodehorst
- Cassandra Bhat
- Brenda Dix

Pavement analyses:
- Mary Erchul

Rail analyses:
- Victor Solkol

Operation & maintenance
- Gary McVoy
- Tiffany Batac

Geotechnical analyses:
- Ismail Karatas

Planning:
- Michael Flood
- Chris Dorney

WSP | PARSONS BRINCKERHOFF

ICF INTERNATIONAL

More Information?

Jake Keller

National Technical Director of Civil Engineering

Parsons Brinckerhoff

Keller@PBWorld.com

Cassandra Bhat

Bhat, Cassandra

Senior Associate

Cassandra.Bhat@icfi.com

Project Web Site

http://www.fhwa.dot.gov/environment/climate_change/adaptation/ongoing_and_current_research/gulf_coast_study/index.cfm

OR:

Search for “FHWA Gulf Coast Study”