VIRTUAL FALL CONFERENCE
OCTOBER 25-27, 2022

EMBRACE THE FUTURE CHAMPION CHANGE

GBA GEOPROFESSIONAL BUSINESS ASSOCIATION

2022 Fall Conference

Adapting To a Changing Climate

by Bill Wallace

“Claims don’t produce large losses. Large losses produce claims.”

S. Wyatt McCallie
former CH2M Hill General Counsel

Walker, Louisiana: 2016 “1000-Year” Storm

2020 ruling: design firms can be sued for negligence although the barrier was built to state standards (50-year storm event).

Highway barrier acted as a dam.

$20 billion in damages to 100,000 homes and businesses.

The Victims Are Looking for Compensation

And Going After Other Players

- Extreme climate and weather are causing costly damage to buildings and infrastructure.
- Litigation against greenhouse gas emitters has been unsuccessful.
- So, they are going after the other players including design professionals.

California Says PG&E Power Lines Caused Camp Fire That Killed 85

Hurricane Harvey (2017): Multiple Lawsuits Against a Houston, Texas Engineering Firm

- 423 Homeowners' lawsuit against the designer of the levee and pumping systems
- Designer used agency-approved 100-year flood levels
  - Levee height: 3 feet + 1 foot* above FEMA guidelines
- Claim: failed to consider 5 previous rainfall events greater than Hurricane Harvey
- Harvey was the 3rd 500-year storm in the last three years

* The "Fort Bend County foot"

Flooding in the River Stone Subdivision in Fort Bend County due to Hurricane Harvey

“The future is already here. It's just not evenly distributed yet.”

William Gibson, Science Fiction Writer

The Economist, December 4, 2003

Summary

Imagery supplied by Clipart.com

- Climate change: its effects on the built environment and society
- What design professionals should be doing
- Opportunities and risks
- Project delivery methodologies for addressing a changing climate

Takeaways

- Climate change is a real, human caused and an urgent global problem.
  - With devastating and costly consequences
- Governments and industry are taking action.
- Geoprofessionals, engineers, et al. are best equipped to address.
  - Have the knowledge and experience.
  - Unfortunately, they are not doing much about it.
- The task ahead
  - Mitigation and adaptation
  - Opportunity of a lifetime!
    - Change the way civil infrastructure is planned, designed, built, and operated.
  - Methodologies are available and are being used.
- Importantly, not taking a changing climate into account on projects creates new risks.
  - Costly claims and litigation.

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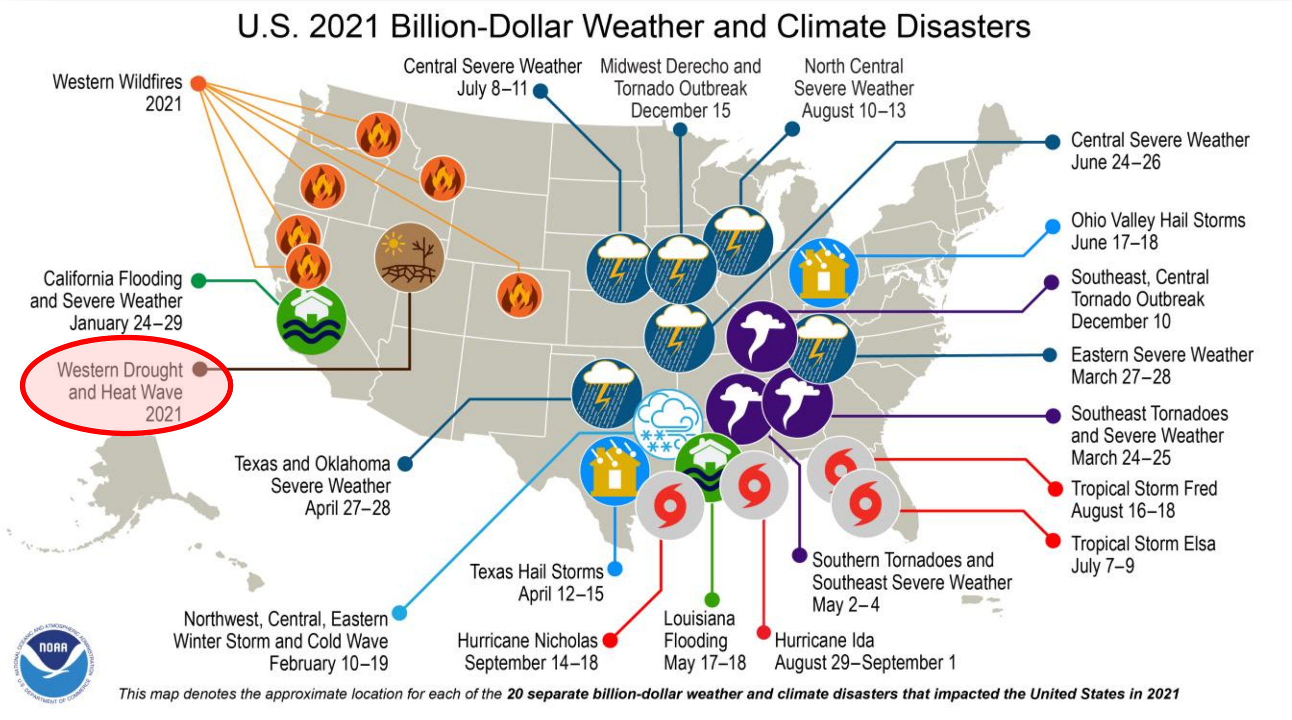


SITUATION TODAY

23-Year Drought In the Colorado River Basin

Demand for water outstrips supply.

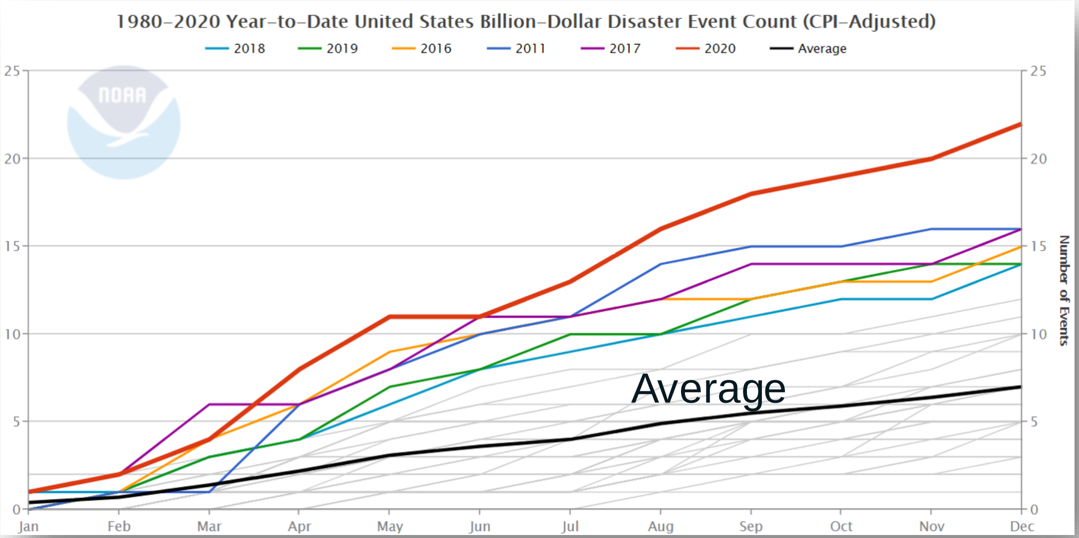
- Source of drinking water to 40 million people.
- Supports a $1.4 trillion in economic activity.*
  - 16 million jobs in California, Arizona, Nevada, Utah, Colorado, New Mexico and Wyoming.
- August 2022: U.S. Bureau of Reclamation is making cuts in state water allocations.

1/12 of the U.S. GDP

Colorado River Basin

Climate Change Is Having Devastating Effects on Civil Infrastructure and Society

- Greatest number of billion-dollar disasters occurred in the last decade: 2011-2020.
  - 123 disasters
  - 15,180 deaths
  - Cost: $1 trillion+
- Since 1980…
  - 310 disasters
  - Cost: $2.2 trillion



Month by month accumulation of billion-dollar U.S. weather and climate disasters: 1980 – 2020.

Source: NOAA Climate.gov. [https://www.climate.gov/news-features/blogs/beyond-data/2020-us-billion-dollar-w eather-and-climate-disasters-historical](https://www.climate.gov/news-features/blogs/beyond-data/2020-us-billion-dollar-weather-and-climate-disasters-historical)

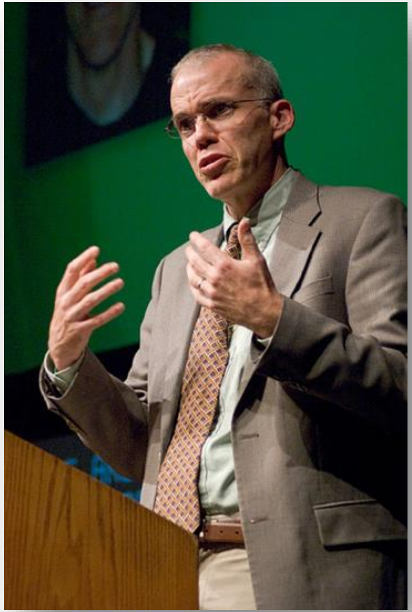
What Is Happening?

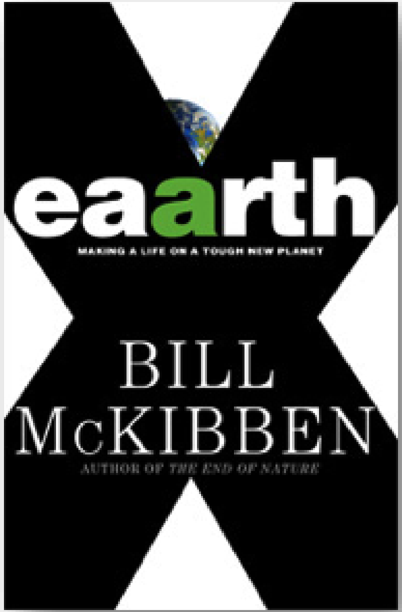
Imagery supplied by Clipart.com

- Extreme storms
- Extended droughts and heat waves
- Rising seas
- Temperature extremes

Bill McKibben, *Eaarth: Making a life on a tough new planet*

Comparing old Earth vs. new Eaarth





THIS ISN'T THE SAME PLANET WE HAD 50 YEARS AGO

Reference: Bill McKibben, *Eaarth, Making a Life on a Tough New Planet,* Henry Holt and Company, New York, 2010.

Source: Creative Commons

The Earth's Climate System Has Been in Relative Equilibrium For a Long Time

"For the last 10,000 years that constitute human civilization, we've existed in the **sweetest of sweet spots**…"

Bill McKibben

Earth

Average temperature: 58-60° F.

Seas: tame and level

Predictable heat and rainfall

Resources plentiful

Imagery supplied by Clipart.com

Conditions in the “Sweetest of Sweet Spots”

Source: McKinsey Global Institute

Current Design Standards Assume We’re In the “Sweetest of Sweet Spots”

- If environmental conditions are statistically stable...
  - Environmental systems in relative equilibrium
- …then infrastructure designs can be based on the assumption of stationarity:
  - Past conditions are good predictors of future conditions.

Imagery supplied by Clipart.com

Imagery supplied by Clipart.com
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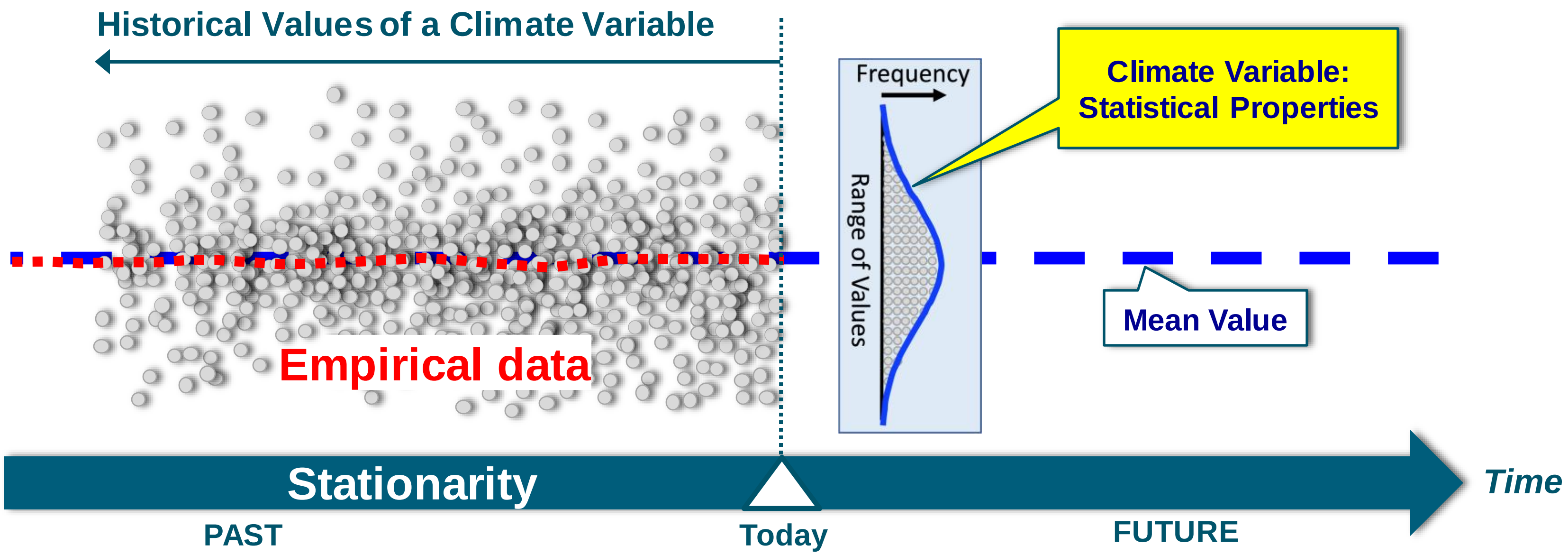
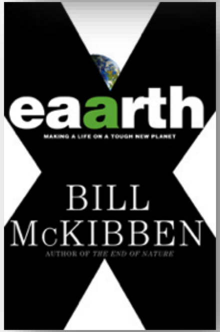
Visualizing Conditions of Stationarity

The statistical properties of engineering design variables will be the same in the future as they have been in the past.

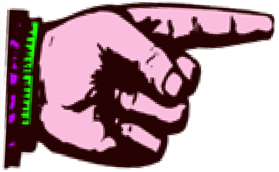


But Recent Human Activity Has Changed All That



Earth

ΔT°



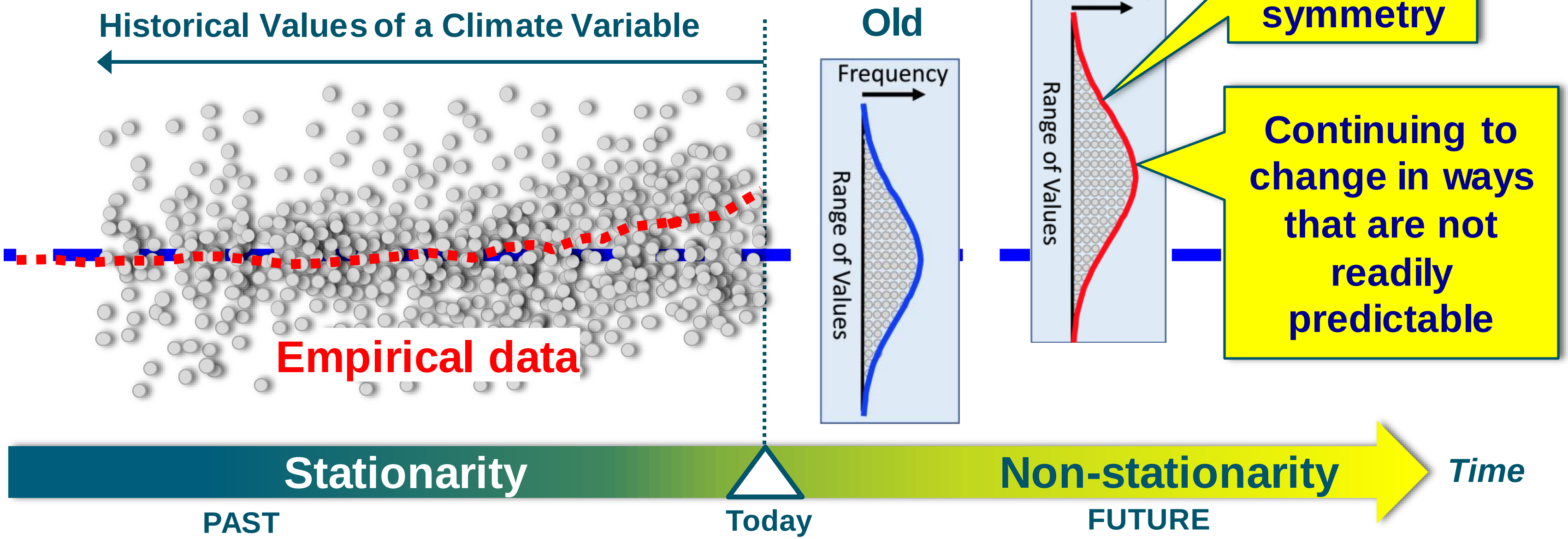
"Eaarth"

Increased thermal energy (warming) due to increased atmospheric greenhouse gas (GHG) concentrations has disrupted climate equilibrium.

Imagery supplied by Clipart.com

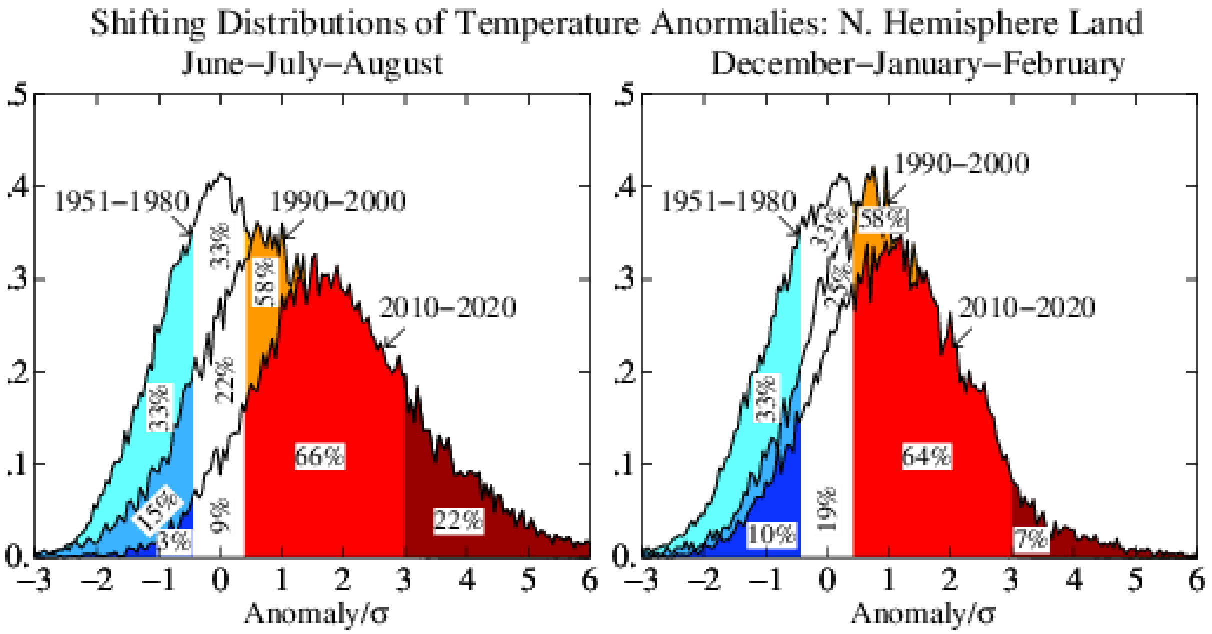
Visualizing Conditions of Non-Stationarity

The statistical properties of engineering design parameters are changing significantly and in ways that are not readily predictable!



How Average Land Temperatures Have Changed: 1951-2020

- Problem: engineering standards are based old climate conditions



Historical shifts in land temperature distributions in the northern hemisphere, winter and summer months. Source: *Makiko Sato & James Hansen,* "Updating the Climate Science", Climate Science, Awareness and Solutions (CSAS) Columbia University Earth Institute. http://www.columbia.edu/~mhs119/ Accessed on June 5, 2021.

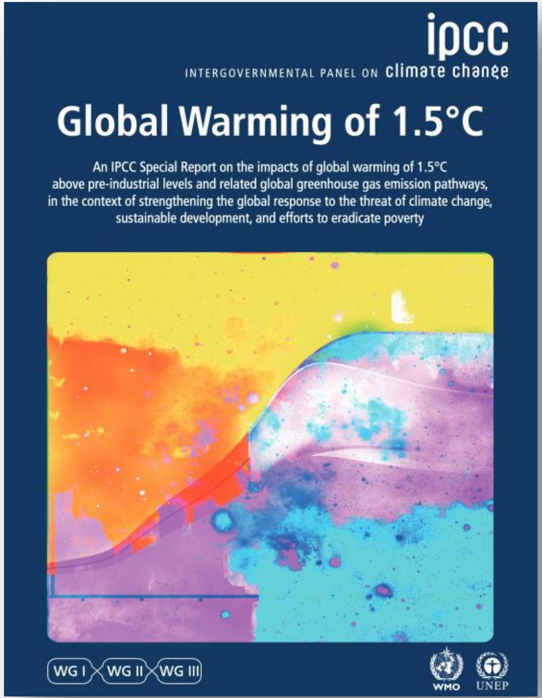
Watch the change: https://www.youtube.com/watch?v=xWpTGbZhZfQ

Today, There Is an Increased Urgency to Act

Global Warming of 1.5°C

IPCC Special Report

- Achieve net zero carbon* emissions by 2050 or climate-related disasters will become significantly worse.
- What is required:
  - Change out fossil energy sources for renewable energy sources.
    - ~70% emissions from infrastructure for heat, power and mobility.
  - Adapt civil infrastructure to changing climate conditions.

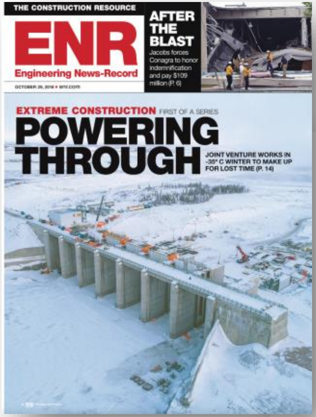


Greenhouse gases (GHGs) are reported in carbon dioxide equivalents.

Why Aren't Engineers Taking Advantage of This Opportunity?

- Stuck in the current paradigm
  - Business model: deliver projects in accordance with accepted standards and practices.
  - Doing anything else is risky.
  - New science is interesting but irrelevant.
- Engineers have struck a Faustian Bargain with society.

"Give us the exclusive right to design and deliver infrastructure and we will supply specialists indoctrinated and licensed in accepted standards and methods and liable for any deviations. Tell us what you want, and we'll do it at the expense of our professional souls."



ENR, 10/29/18


Viewpoint Engineering in the Climate Change Era By William A. Wallace

Lead—or Get Out of the Way

Global warming and climate change, subjects we generally don't discuss in polite company or with fossil-fuel industry clients, are in the news again. A U.N. panel's just-issued report on impacts of global warming 1.5° C above pre-industrial levels—the limit set in the 2015 Paris agreement—has a strong warning: If sharp cuts in greenhouse gas (GHG) emissions aren't made by 2030, it is essentially game over for many ecological systems and large population sectors.

Before this report, the generally-accepted target date was 2050—soon enough for a sense of urgency but far enough away to postpone serious action. Now it's only 12 years off. If nations aren't in lockstep to make emissions cuts now, there is little chance to stay within the warming target. The report says at 1.5° C and below (we're now at 0.8° C), climate-change mitigation and adaptation can be managed. Above that, conditions get really dicey, and fixes are really expensive.

WALLACE

Major GHG sources are in transportation, power and industrial sectors—our clients. As engineers who plan, design, build and operate facilities and infrastructure that produce emissions, we are part of the problem. Clearly, we should be part of the solution. What an opportunity! We must overhaul our engineering industry with new standards, processes and methods to radically cut GHG emissions and protect communities, facilities and infrastructure from devastating climate impacts.

We can build or rebuild transportation and energy systems. We can protect or relocate cities and towns. We have the technological chops. We know what works and what doesn't. Let's do it!

In my naïveté, I thought engineers would jump at the chance to get involved. But response has been at best sluggish; at worst it's denial. We keep doing what we've always done: respond to proposal requests, do what the contract says and position for the next job. Overwhelming scientific evidence of climate change? So what. All we care about is what's in our scope of work.

How did engineering work get this way? Oddly enough, the answer is stationarity, an obscure but foundational civil engineering assumption about how the world works. Engineers have always assumed, successfully until recently, that past environmental conditions are good predictors of future ones. That assumption allowed engineers to plan, design and deliver long-lived infrastructure, confident that projects would be safe, reliable and efficient throughout their design life. It allowed them to create codes and standards which, if followed, would produce consistently good results.

This also created a Faustian bargain between engineers and society: Give us the exclusive right to design and deliver infrastructure, and we will supply specialists indoctrinated and licensed in accepted standards and methods and liable for any deviations. Tell us what you want, and we'll do it at the expense of our professional souls. To us, new science is interesting but irrelevant. Working outside the box targets us for claims and litigation.

This works if conditions are stationary and standards and methods still apply. But the climate is changing in ways not readily predictable. Non-stationarity is the new normal. Long-held engineering assumptions about environmental conditions are no longer reliable, so projects may not function the way they're supposed to and can present a significant risk to public health, safety and welfare.

Today, many of us are sick and tired of trying to convince purposefully ignorant people that the climate is changing and civil infrastructure design must change with it. Maybe we should just do things as we always have done—apply old design standards and get paid for our work. When infrastructure projects fail, we fix them and get paid again. It's a new take on the old commercial slogan: Pay me now *and* pay me later.

Or, we could try something different—create new standards, methods and processes needed for infrastructure to work in a changing environment. Some already are. Olympia, Wash., has an incremental approach to deal with sea-level rise by observing trends and building preplanned responses as needed. As engineers working in the built environment, our choices are clear: Lead, follow or get out of the way. ■

William A. "Bill" Wallace is president of Wallace Futures Group LLC, Wilsonville, Ore. A 2014 ENR Newsmaker as lead designer of the Envision sustainable infrastructure rating system, he can be reached at bill.wallace@wallacefutures.com.

If you have an idea for a column, please contact Viewpoint Editor Richard Korman at kormanr@enr.com.

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What Needs To Be Done?

1. Change out fossil fuel-based energy sources with low- or no-carbon renewable energy sources.
2. Use construction materials with low embodied carbon.
3. Expand the use of natural systems.
4. Revise codes and standards to address changing climate conditions.
5. Adapt new and refurbish existing civil infrastructure climate conditions.
6. Devise and implement plans for managed retreat.
7. Develop carbon capture and storage (CCS) technologies.

Orange County California Water District's Prado Constructed Wetlands

An Opportunity of a Lifetime!

Photo source: Shutterstock

- Change the way civil infrastructure is planned, designed, constructed and operated.
- Get away from prescriptive standards.
  - Change out climate-based prescriptive standards for performance-based standards.
- Be valued for your knowledge and experience.
- Be part of the solution to a global problem.

What Happens If Geoprofessionals Don't Respond?

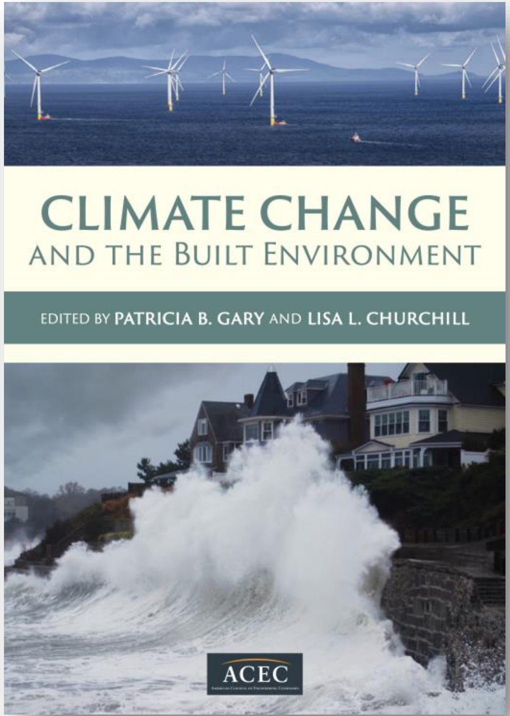
Multiple avenues for claims of negligence

- The stakes are high!
- Claims and litigation for NOT taking climate change into account on infrastructure projects are starting to appear.
  - Example: City of Walker vs. State of Louisiana, et al.
- Basic argument: design professionals should have known that the climate is changing and factored that into their designs.

Sometimes I wear this in court. It's my frivolous lawsuit.

Climate Change Lawsuits: Trends and Analysis

- Cases against large GHG emitters have not faired well.
  - Example: American Electric Power Company vs. Connecticut (2011):
    - Corporations cannot be sued for GHG emissions, contribution to global warming.
- Result: cases against other players
  - For example, design professionals



Reference: Elena Mihaly and Deanna Moran, “Climate Change Lawsuits: Trends and Analysis of Legal Actions,” in Patricia B. Gary and Lisa L. Churchill, eds., *Climate Change and the Built Environment*, American Council of Engineering Companies, Washington, DC, 2021

The Standard of Care Is Changing

- Relying on codes and standards that do not reflect climate change may be viewed by judges and juries as falling below the standard of care.
- Creates multiple legal avenues for holding design professionals liable for negligence
  - Not meeting the standard of care

Reference: Mihaly and Moran

Imagery supplied by Clipart.com

There Are Multiple Legal Avenues for Holding Design Professionals Liable

- Negligence: not met the standard of care
- Factors for asserting negligence
  - Standards in the contract
  - Knowledge of risks posed by climate change
  - Applicable codes and standards
  - Foreseeability of harm
  - Industry custom

Reference: Mihaly and Moran

Multiple Legal Avenues…

Standards in the Contract

- Standard of Care definition:
  - “The care and skill ordinarily used by members of the subject profession practicing under similar circumstances at the same time and in the same locality.*
- Source of claims: not considering local climate differences that change over time

* EJCDC Document E-500, from Mihaly and Moran, p 121.

Photo source: Shutterstock

Reference: Mihaly and Moran

Multiple Legal Avenues…

Knowledge of Risks Posed by Climate Change

- Should the design professional have considered the risk posed by climate change?
- There are multiple credible sources of climate information
  - Examples:
    - U.S Global Change Research Program https://www.globalchange.gov/
      - Fourth National Climate Assessment mandated by Congress
    - NOAA Climate.gov https://www.climate.gov/

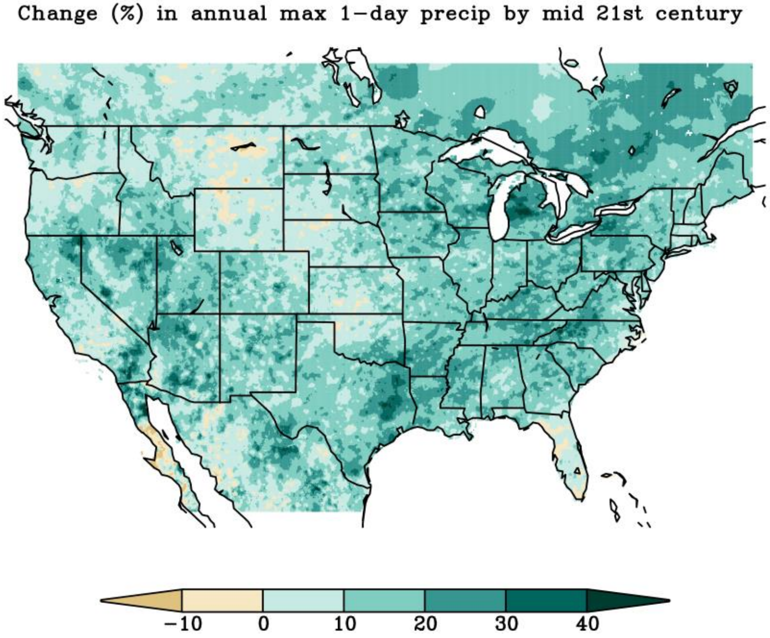
Roadways damaged by heavy rains and mudslides along the Coquihalla Highway near Hope, B.C, Canada
Photo source: Jonathan Hayward/The Canadian Press

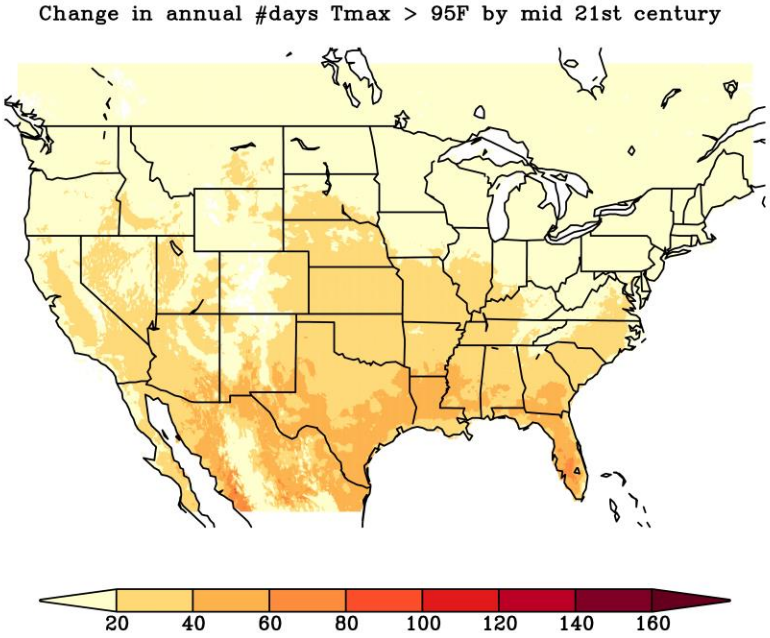
Reference: Mihaly and Moran

Multiple Legal Avenues…Knowledge of Risks

Precipitation and Temperature Projections-Mid Century

Example Localized Constructed Analogs (LOCA) for % change in max 1-day precipitation, max temperature above 95℉ by mid-21st century.





Source: LOCA Viewer: https://scenarios.globalchange.gov/loca-viewer/

Applicable Codes and Standards

- Compliance with codes and standards does not necessarily shield a design professional from claims.
- Example: City of Walker vs. State of Louisiana, et al.

Multiple Legal Avenues…

City of Walker vs. State of Louisiana, et al.

Flooded west bound lanes of I-12.
Source: Photo by Mayor of Walker, Rick Ramsey

- Highway barrier on I-12 acted as a dam
  - 1000-year flood event flooded over 100,000 homes and businesses.
  - $20 billion in damages
  - Many not insured; outside of mapped flood zones
- Built in accordance with state standards.
  - Protection from a 50-year flood
- District Court: companies involved could be held liable

Multiple Legal Avenues…

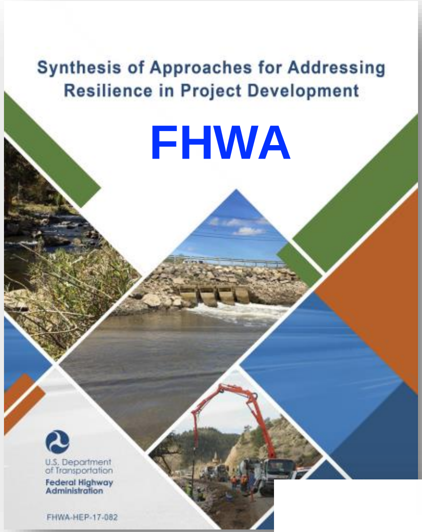
Foreseeability of Harm

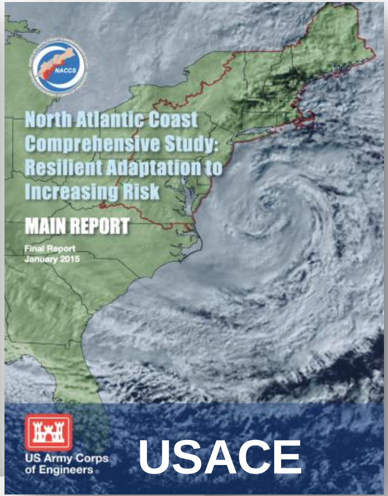
- Strong, credible and expanding body of evidence of a changing climate exists.
  - Examples: NOAA's Climate.gov, U.S Global Change Research Program
- Hard to make the case that unprecedented climate or weather events were not foreseeable.
- Acts of God defense in question.
  - Extreme climate and weather events are now foreseeable.

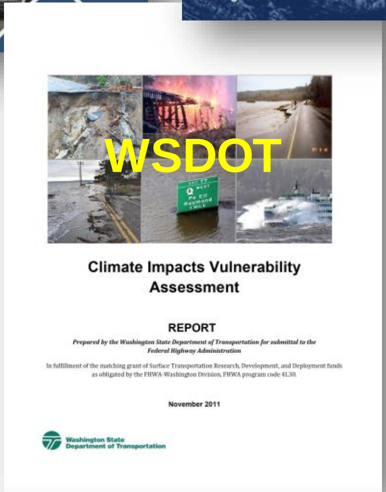
Multiple Legal Avenues…

Industry Custom

- Because the design professional community has lagged in considering climate change does not exclude individuals from liability.
- **Fact**: many design professional organizations are considering climate change in infrastructure projects
  - Example: AECOM, Olympia Sea Level Rise Response Plan
- **Fact**: Federal and state agencies have published guidance for handling climate change in infrastructure projects
  - U.S. Federal Highway Administration (FHWA)
  - U.S. Army Corps of Engineers (USACE)
  - Washington State Department of Transportation



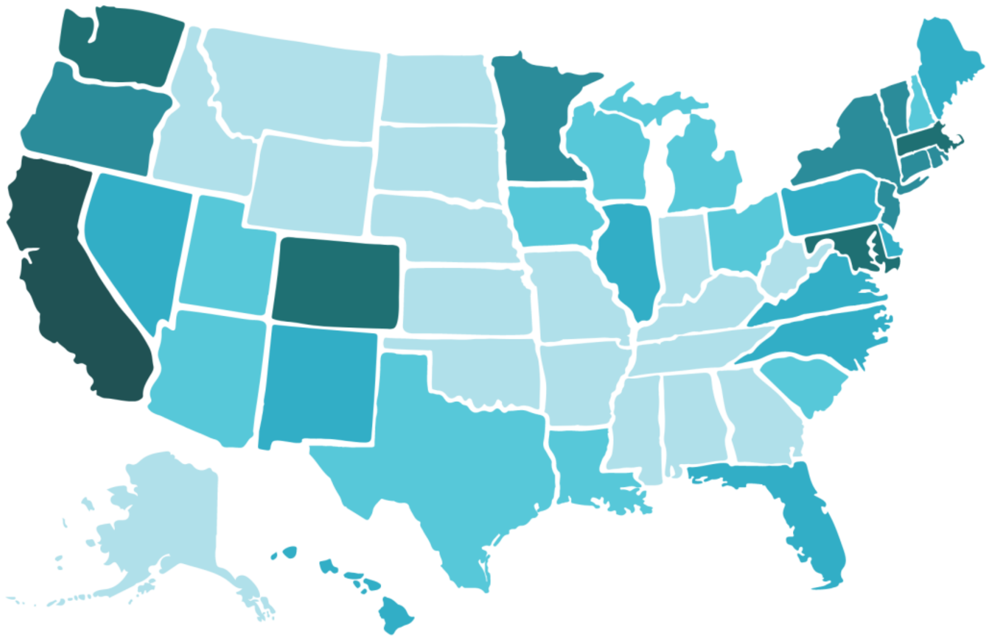




State Climate Adaptation Has Been Slow

"To date, few transportation agencies in the United States have explicitly required design changes in anticipation of future climate change due, in part, to the lack of understanding of how best to incorporate projections into designs."

U.S. Department of Transportation Federal Highway Administration, Vulnerability Assessment and Adaptation Framework, 3rd Edition, FHWA-HEP-18-020, December 2017, p. 60.



Occurrence of state climate change policies

Source: Climate Change Resources, https://climatechangeresources.org/states/

Federal Highway Administration Guidance

2014: FHWA's Transportation Engineering Approaches to Climate Resiliency (TEACR)

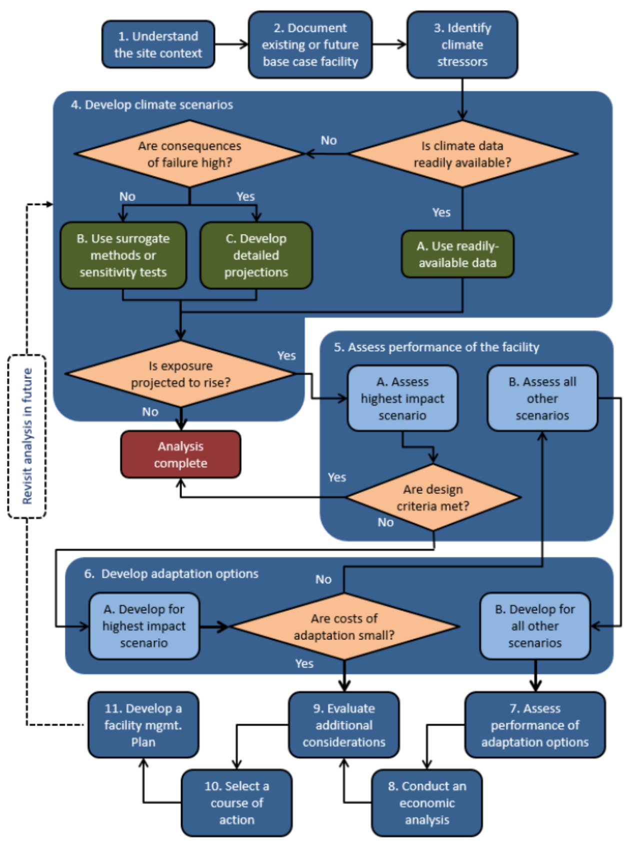
- Best engineering practices for evaluating project-specific vulnerabilities to climate change.
- Case studies

2016: Adaptation Decision-Making Assessment Process (ADAP)

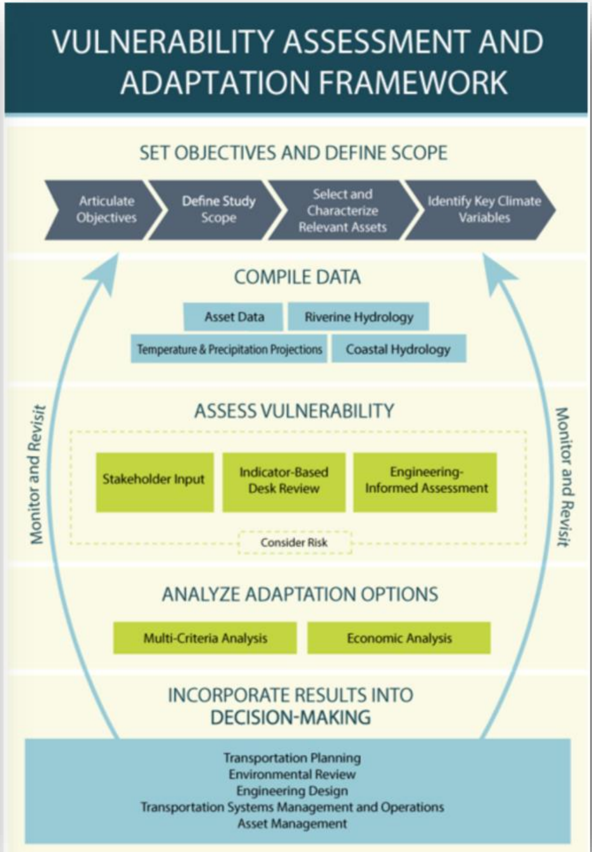
- 11-step process for facility-level vulnerability assessments.

2018: Vulnerability Assessment and Adaptation Framework

- Guide for analyzing the impacts of climate change and extreme weather on transportation infrastructure systems.



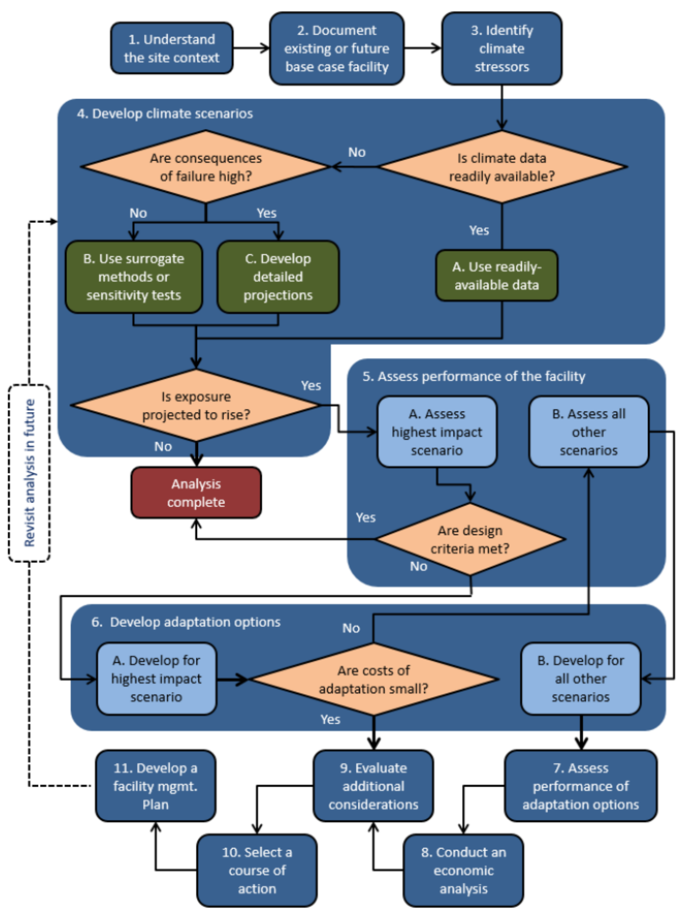
Adaptation Decision-Making Assessment Process (ADAP)



Vulnerability Assessment and Adaptation Framework.

FHWA Adaptation Decision-Making Assessment Process (ADAP)

- Proposed tool for planners and designers to account for the effects of climate change on civil works projects.
- Designed to assess a single civil infrastructure asset.
  - Could be expanded to system level assessments
- Simple 11 step process
- 10-page description of steps

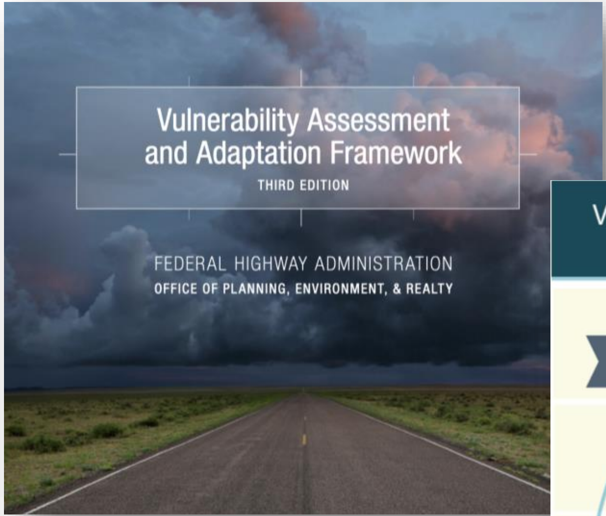


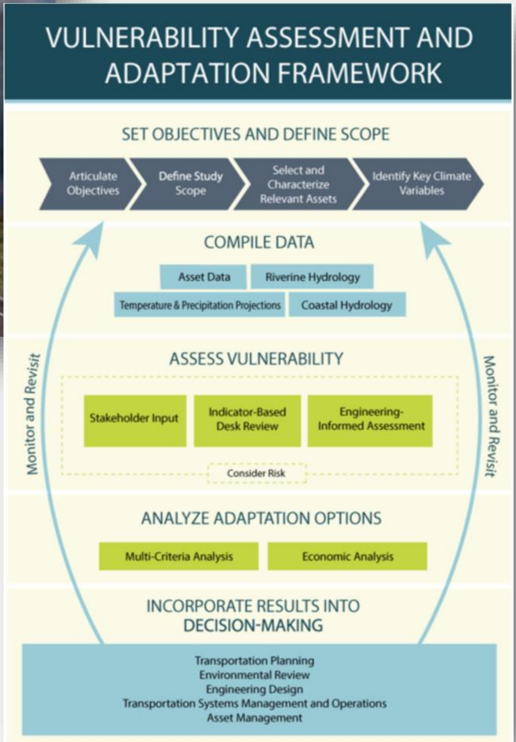
Access at: https://www.fhwa.dot.gov/environment/sustainability/resilience/ongoing_and_current_research/teacr/adap/

FHWA Vulnerability Assessment and Adaptation Framework

Detailed collection of information and resources to assist transportation agencies.

- Conducting vulnerability assessments
- Incorporating climate change considerations into transportation systems decision-making



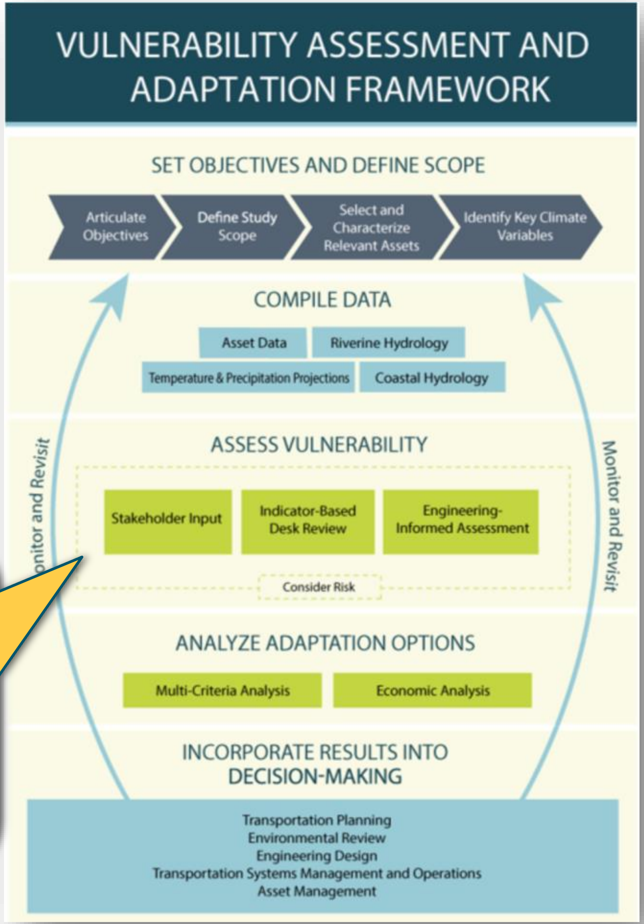


FHWA's Vulnerability Assessment and Adaptation Framework

Process

- Set Objectives and Define Scope
- Compile Data
- Assess Vulnerability
- Analyze Adaptation Options
- Incorporate Results into Decision-Making

Click any section in the diagram to navigate to that section or use the browser's back button to return to the previous page.

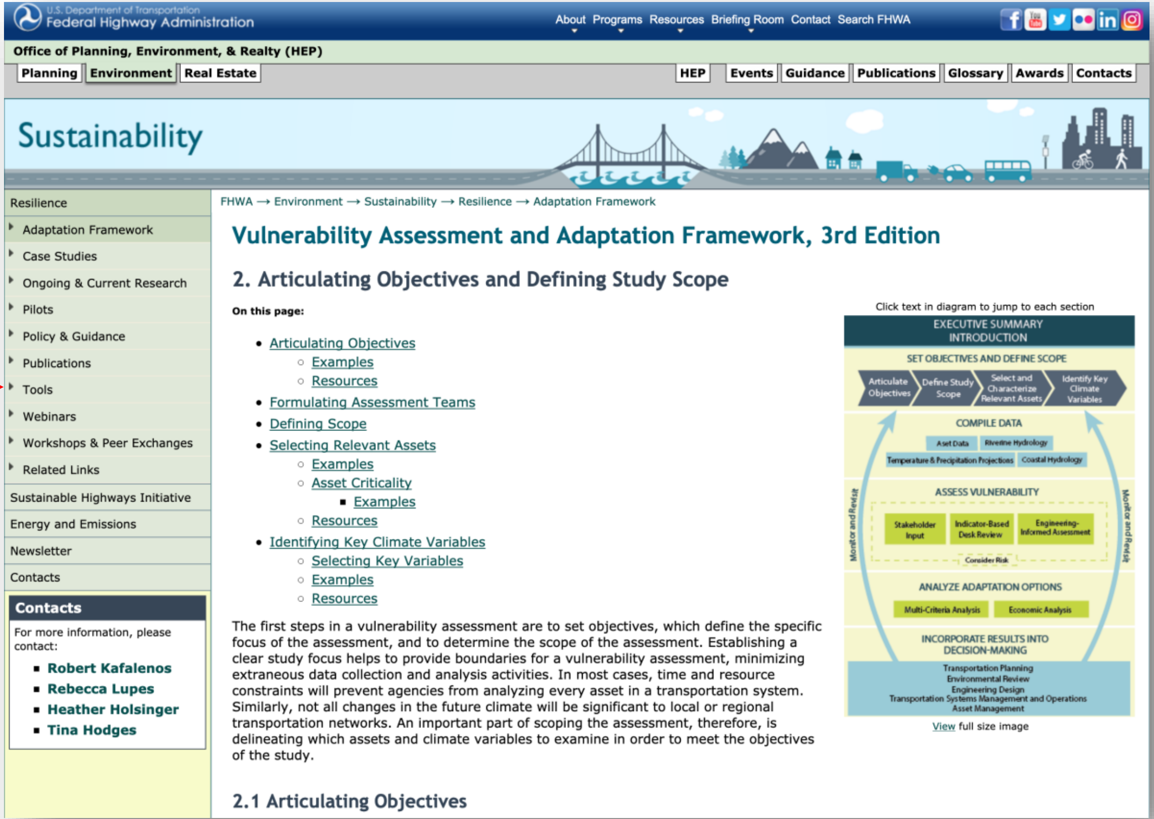


Access at https://www.fhwa.dot.gov/environment/sustainability/resilience/adaptation_framework/chap01.cfm

FHWA's Vulnerability Assessment and Adaptation Framework

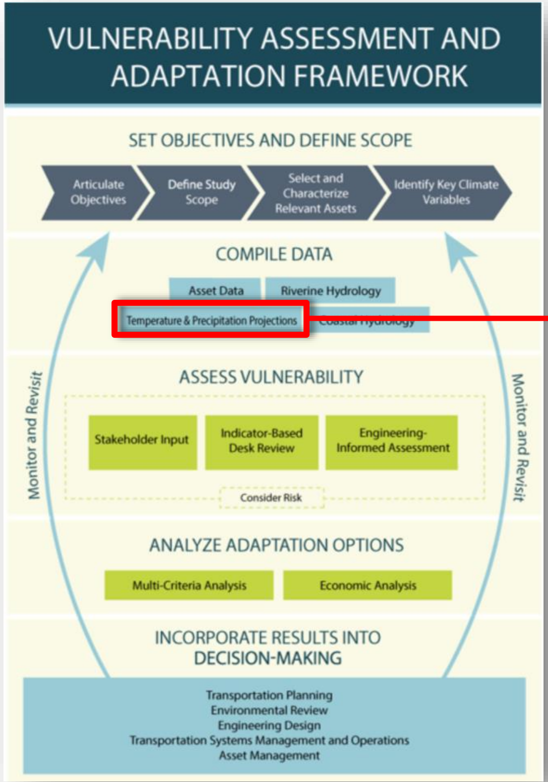
Articulate Objectives

From FHWA Website



FHWA's Vulnerability Assessment and Adaptation Framework

Temperature and Precipitation Projections



Vulnerability Assessment and Adaptation Framework, 3

4. Obtaining Climate Data for the Vulnerability Assessment

On this page:

- Temperature & Precipitation
  - Examples
  - Resources
- Riverine Hydrology
  - Examples
  - Resources
- Coastal Hydrology
  - Sea Level Rise Projections
  - Storm Surge Analysis

In addition to collecting asset data, the vulnerability assessment team also needs to obtain climate data for the study area in order to establish the projected future climate conditions to which assets will be (or are projected to be) exposed.

A variety of resources provide information on how to obtain data on projected changes in climate, depending on the type of climate variable and the level of detail needed for the vulnerability assessment. The following sections outline various ways agencies can obtain projections for changes in temperature, precipitation, hydrology, floodplains, sea level, and storm surge. Each section begins with a basic approach to obtaining climate data and then builds on that by adding more detailed methods that are useful for in-depth analyses. The level of detail in the analysis may vary depending on the type of agency decisions or actions that the assessment results will inform, as well as what the assessment budget allows.

Online Databases and Tools

Vulnerability Assessment and Adaptation Framework, 3

4. Obtaining Climate Data for the Vulnerability Assessment

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Online Databases and Tools

Data sources that have projections of future climate change from many different models for various emissions scenarios include:

USDOT’s CMIP Climate Data Processing Tool. This tool processes statistically downscaled climate model data from the World Climate Research Programme’s CMIP3 and CMIP5 into relevant temperature and precipitation statistics for transportation planners. These statistics include changes in the frequency of very hot days and extreme precipitation events and other climate variables that may affect transportation infrastructure and services in the near-term, mid-term, and end-of-century.

The U.S. Geological Survey’s National Climate Change Viewer. The web viewer shows climate projections at the county and State level, based on statistically downscaled CMIP5 data for moderate and high emissions scenarios. This resource includes projections of climate variables based on daily high temperatures, low temperatures, and precipitation for near-term, mid-term, and end-of-century. In addition, these statistically downscaled projections were used to drive a simple water balance model to estimate runoff, snow, soil water storage, and evaporative deficit.

Downscaled CMIP3 and CMIP5 Climate and Hydrology Projections. This archive provides downloadable climate and hydrological simulations at fine spatial resolution from 1950 to 2099 (as well as climate and hydrological gridded observation data). It contains climate projections for the contiguous U.S, CMIP3 hydrologic projections over the western U.S., and CMIP5 hydrology projections over the contiguous U.S. This resource provides: statistically downscaled climate model data of high temperatures, low temperatures, and precipitation that is used by the USDOT CMIP Climate Data Processing Tool; soil moisture content, snow water equivalent, total runoff, and actual and potential evapotranspiration.

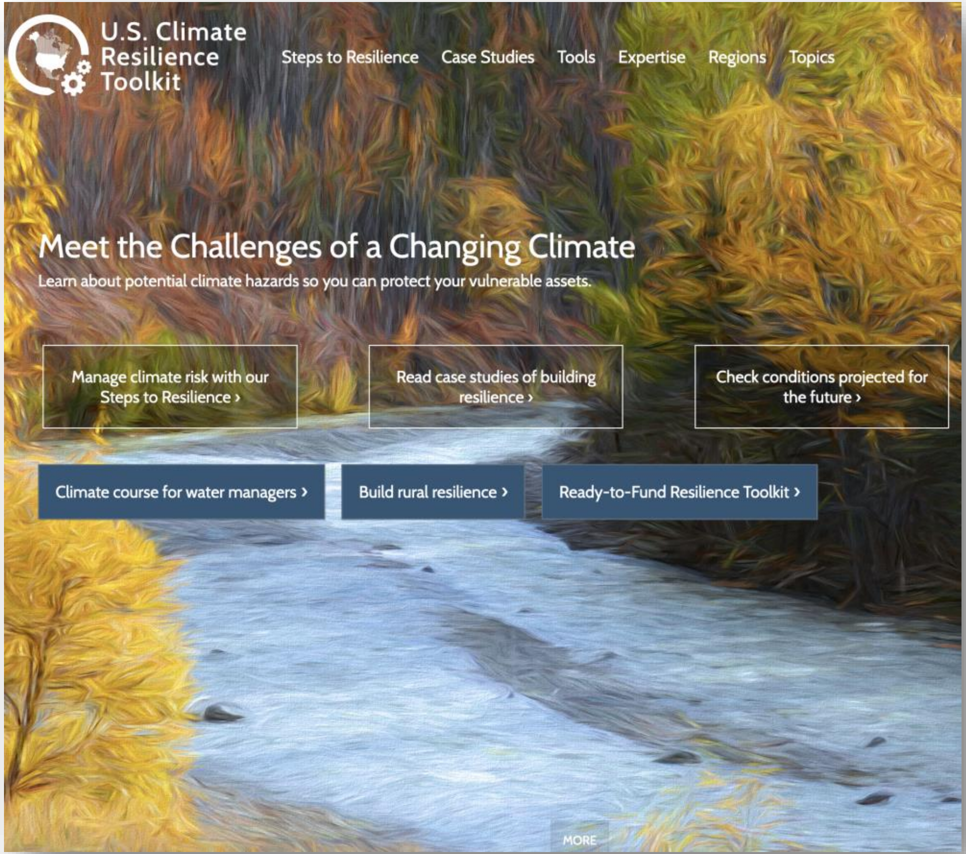
The U.S. Geological Survey’s USGS Geo Data Portal. The data portal provides access to numerous climate datasets for particular areas of interest. Through the portal, users can create tailored projections for impact analysis by identifying the regional area and projection datasets of interest, along with a choice of treatment for averaging across model grid cells within the regional area.

North American Regional Climate Change Assessment Program (NARCCAP). The website provides access to a set of regional climate models (RCMs) driven by a set of atmosphere-ocean general circulation models (AOGCMs) over a domain covering the contiguous U.S. and most of Canada.

U.S. Geological Survey’s StreamStats. This Web application incorporates GIS to provide users with access to an assortment of analytical tools that are useful for a variety of water-resources planning and management purposes, and for engineering and design purposes.

U.S. Climate Resilience Toolkit

- Produced by NOAA Climate.gov
- Steps to Resilience Framework
  - Steps description
  - Case examples
- Projected future climate conditions
  - “The Climate Explorer.”
    - Climate projections for any U.S. city or county
- On-line training for water utility managers



Source: https://toolkit.climate.gov/

U.S. Army Corps of Engineers
Risk Management Strategies for Coastal Communities

Coastal storm damage risk management strategies for coastal communities

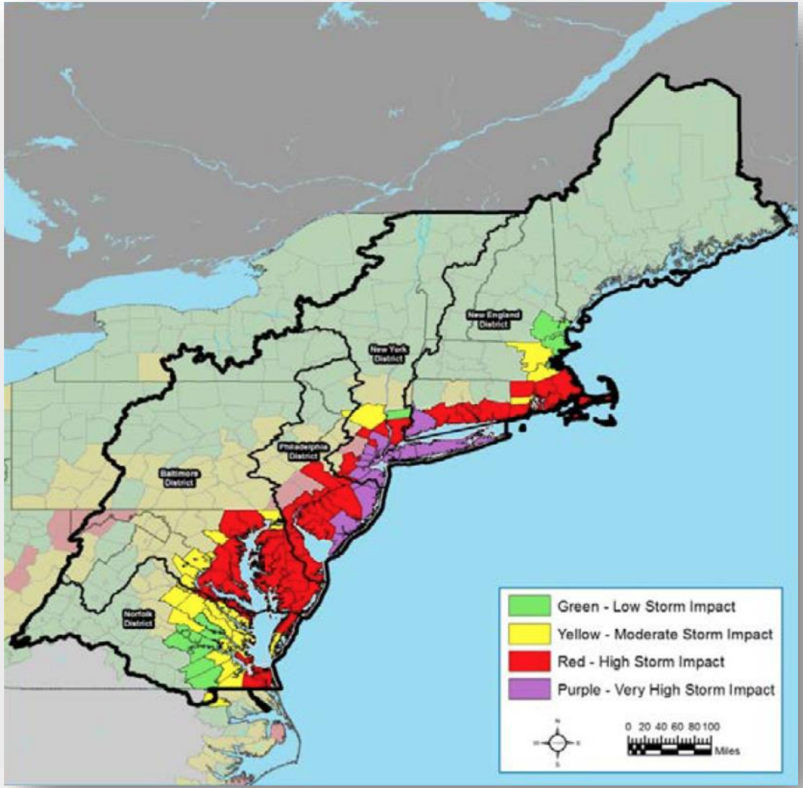
- Non-structural
- Structural
- Natural, nature-based

Many related reports, presentations, modeling products.

Source: https://www.nad.usace.army.mil/CompStudy/

Summary

- Study to address coastal storm and flood risk and vulnerabilities.
  - Affected by Hurricane Sandy in the United States' North Atlantic region.
- Results:
  - 9-step Coastal Storm Risk Management Framework
  - Can be customized for any coastal watershed.



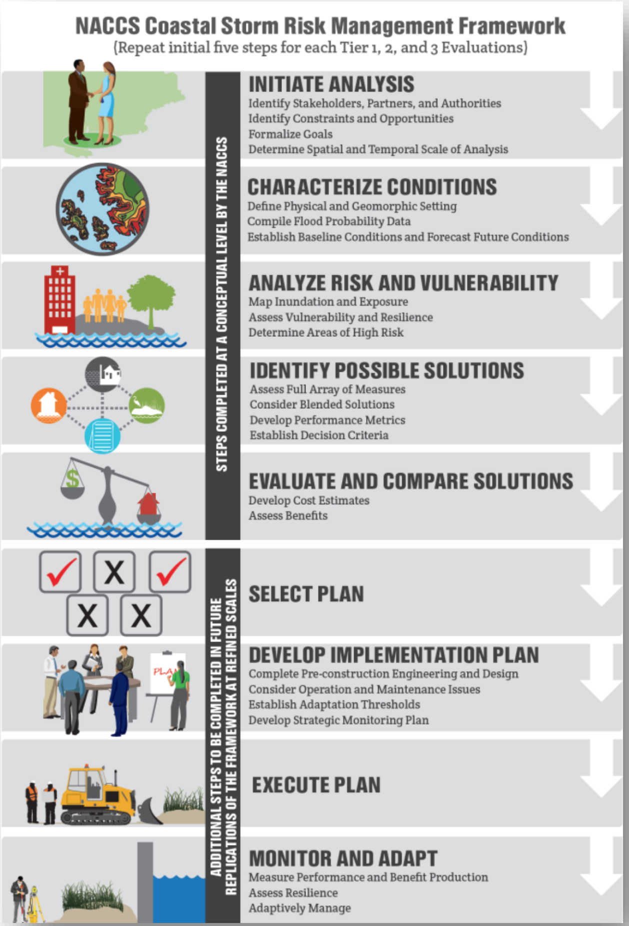
Areas Impacted by Hurricane Sandy with highlighted counties Included in NACCS Study

Source: https://www.nad.usace.army.mil/CompStudy/

USACE's Risk Management Strategies for Coastal Communities

9-Step Coastal Storm Risk Management Framework

- Identification of coastal storm risk, exposure, vulnerability
- Coastal storm risk management strategies
- Measures to reduce risk and promote resilience
- Three-tiered evaluation defined by different scales
  - Tier 1: North Atlantic Coast Study Area
  - Tier 2: State and large watershed scale
  - Tier 3: Local and small watershed scale



Back To Climate Uncertainty…

Uncertainty has always been part of our daily lives.

Have developed a personal appetite for risk.

Set up ways to handle an uncertain future.

Same is true for engineering projects.

Project management ≈ change management.

DESIGN PROFESSIONALS HAVE ALWAYS HANDLED HIGH LEVELS OF UNCERTAINTY

Change is good!

(You go first)

Throughout Our Daily Lives We Face Uncertainties to Our Overall Well-being

Life's Uncertainties

Photo source: Shutterstock

Conditions for Success

Security
- Personal Safety
- Secure resource access…

Good Life
- Food
- Shelter
- Sufficient livelihoods…

Health
- Wellness
- Access to clean air, water…

Social Relations
- Social cohesion
- Mutual respect
- Ability to help others…

Freedom of Choice and Action
Opportunity to achieve what an individual values doing and being

Imagery supplied by Clipart.com

We Find Ways To Manage These Uncertainties

Photo source: Shutterstock

- Determine your life's objectives, definition of success.
- Define conditions for success.
  - Security, good life, health, social relations…
- Manage change.
  - Deviations from conditions for success
  - Vulnerabilities or opportunities
- Tools
  - Savings
  - Backups
  - Supporting relationships
  - Insurance
  - Availability of government assistance

We Also Managed Uncertainty In Infrastructure Project Delivery

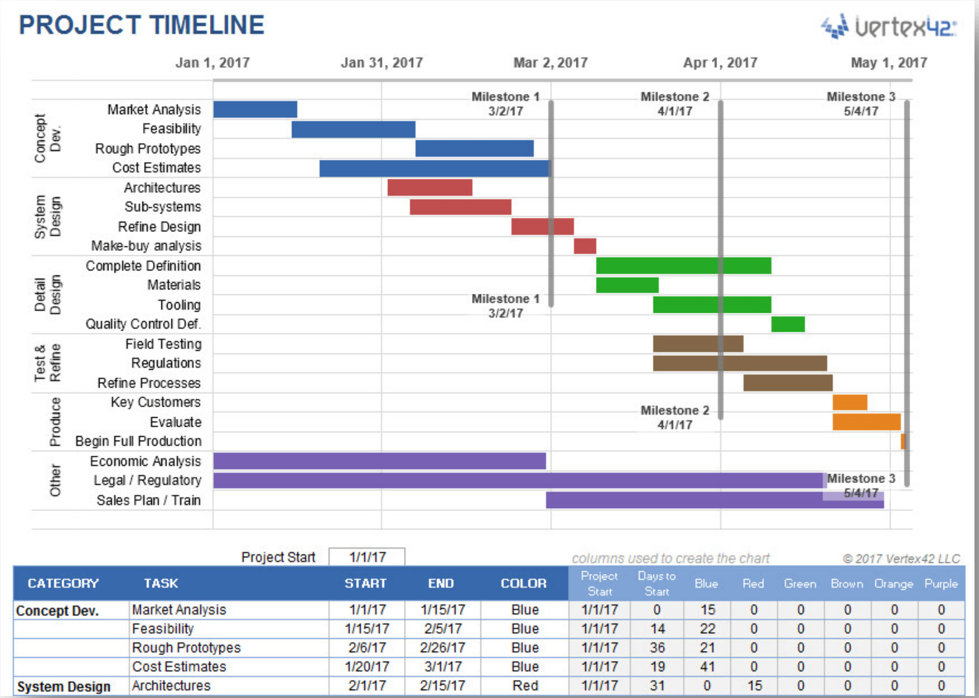
- Start with project objectives, definition of project success.
  - Meet specifications, functions
  - Stay within scope, schedule and budget.
- Manage change.
  - Define conditions for success.
  - Monitor and respond to change.
    - Deviations from conditions for success
    - Treat as vulnerabilities or opportunities

"What if we don't change at all ...
and something magical just happens?"

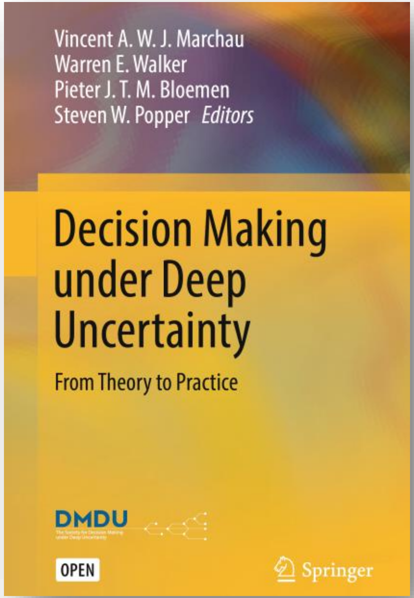
Photo source: Shutterstock

Vulnerabilities and Opportunities To Improve Chances of Success Can Show Up During Project Delivery

- Vulnerabilities:
  - Labor strike
  - Construction materials not delivered on time
  - Key team member leaves the project
  - COVID-19 pandemic
- Opportunities:
  - Schedule improvements
  - New technologies



CATEGORY	TASK	START	END	COLOR	Project Start	Days to Start	Blue	Red	Green	Brown	Orange	Purple
Concept Dev.	Market Analysis	1/1/17	1/15/17	Blue	1/1/17	0	15	0	0	0	0	0
	Feasibility	1/15/17	2/5/17	Blue	1/1/17	14	22	0	0	0	0	0
	Rough Prototypes	2/6/17	2/26/17	Blue	1/1/17	36	21	0	0	0	0	0
	Cost Estimates	1/20/17	3/1/17	Blue	1/1/17	19	41	0	0	0	0	0
System Design	Architectures	2/1/17	2/15/17	Red	1/1/17	31	0	15	0	0	0	0



Protection of infrastructure assets →

Climate hazard exposure reduction →

Robust Decisionmaking (RDM)

Dynamic Adaptative Planning (DAP)

Dynamic Adaptive Policy Planning (DAPP)

Info-Gap Decision Theory (IG)

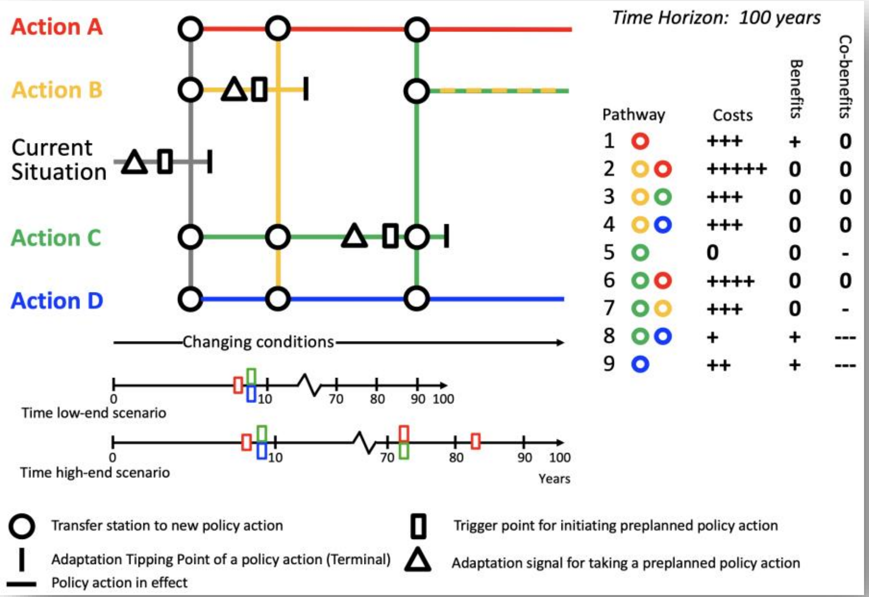
Engineering Options Analysis (EOA)

Adapted from V. A. W. J. Marchau et al. (eds.).

7 steps

Case examples:

- **Water scarcity adaptation in southern Portugal**
- Flood adaptation in the City of Olympia
- Water supply/flood prevention in the Netherlands

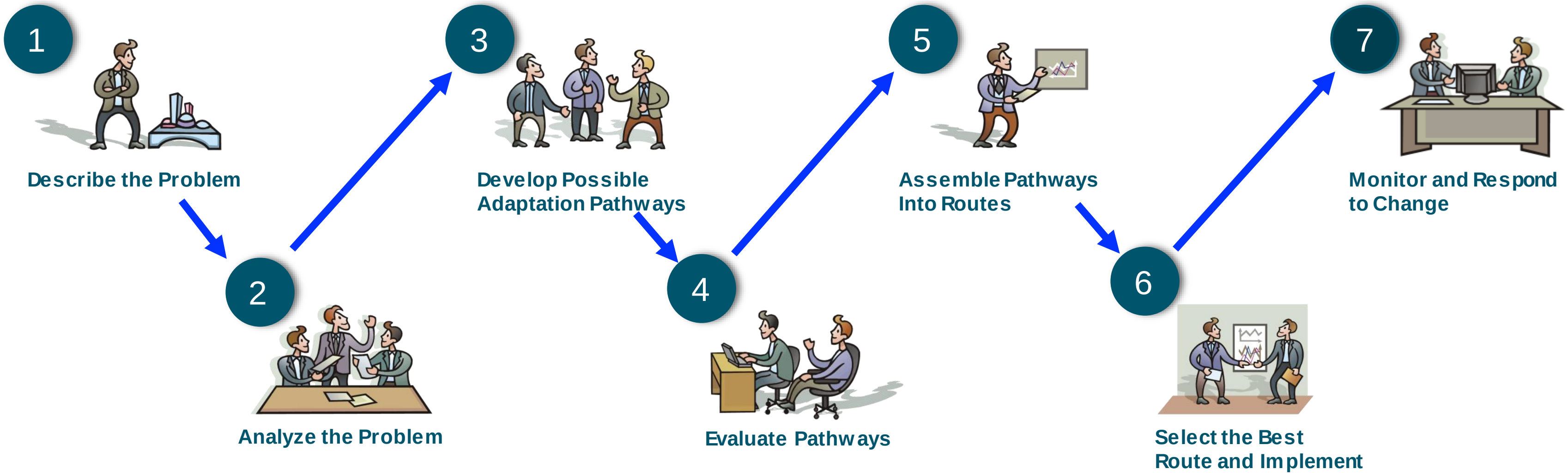


DYNAMIC ADAPTIVE POLICY PLANNING (DAPP)

Dynamic Adaptive Policy Planning (DAPP) Application

- Appropriate for regional problems with multiple communities, infrastructure assets
- Sequence of contingent actions: pathways
  - London Underground subway map as a pathway metaphor
- Adaptation Tipping Points are established.
  - Point at which the current pathway fails to deliver the desired outcome
  - Signals (signposts): indicate impending pathway failure.
  - Trigger Points: when an alternative pathway must be taken to avoid failure
  - Transfer Stations: points at which alternative pathways are taken

The official London Underground map designed by Harry Beck in 1933 and arguably the most recognizable transit map in the world.



DYNAMIC ADAPTIVE POLICY PLANNING 7 STEPS

Imagery supplied by Clipart.com

1

Imagery supplied by Clipart.com

Dynamic Adaptive Policy Planning (DAPP) Steps

Describe the Problem

Understand the system.

- Describe the study area under consideration:
  - Location, scope, boundaries
  - Threats. What are the threats common to the communities within the study area?
- Determine important characteristics.
  - Physical, economic, and social makeup
    - Environment, infrastructure assets, commercial and industrial activities
    - Social and cultural aspects of the communities

Study area for the City of Olympia Sea Level Rise Response Plan

Imagery supplied by Clipart.com

Dynamic Adaptive Policy Planning (DAPP) Steps

Describe the Problem

Define the situation.

- What problems will the system face that will affect the communities?

Determine objectives and constraints.

- What are the objectives for addressing the problems?
  - Stakeholders, decisionmakers
- What are the constraints?

- Examples

***Algarve**: Manage water stress but maintain current agricultural economy.*

***City of Olympia**: Prevent flooding and keep city in its current configuration, i.e., no managed retreat.*

***The Netherlands**: No flooding from the North Sea and provide adequate fresh water to a growing population.*

Imagery supplied by Clipart.com

1

Dynamic Adaptive Policy Planning (DAPP) Steps

Describe the Problem

Define success.

- What are the desired outcomes?
- Convert outcomes into targets, measures.

Algarve Region in Portugal set a Water Exploitation Index (WEI) target at 43%.

The Thames Barrier that protects the City of London from flooding due to storm surges, was designed with an annual exceedance probability (AEP) of 0.001, i.e., a 0.1% chance of flooding in any year.

Photo source: Shutterstock

Photo source: Shutterstock

1

Imagery supplied by Clipart.com

Dynamic Adaptive Policy Planning (DAPP) Steps

Describe the Problem

Determine significant uncertainties.

- Climate uncertainties examples:
    - Storm frequency and intensity.
    - Intensity and duration of heat waves, droughts
- Examples of other uncertainties:
    - Future funding for operations and maintenance
    - Demand for services by an increasing population

Ijsselmeer area in the Netherlands. Flood protection and water supply related uncertainties include changes in temperature and precipitation, population growth, and sea level rise.

Photo source: Shutterstock

2

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Dynamic Adaptive Policy Planning (DAPP) Steps

Analyze the Problem

Determine what measures can be applied.

- Possible adaptation approaches for achieving objectives
- Effective across a range of expected conditions.
  - What climate scenario(s)?

- Example: measures considered in the Algarve Region of Portugal to keep WEI at 43% or better
  - Improve water use efficiency.
  - Decrease irrigation needs.
  - Recycle wastewater.
  - Build new reservoirs.
  - Improve landscape water retention.
  - Build desalination plants.

$$\textit{Water Exploitation Index}\ (WEI) = \frac{\textit{Fresh water abstraction} \times 100}{\textit{Renewable water resources}}$$

Imagery supplied by Clipart.com

Dynamic Adaptive Policy Planning (DAPP) Steps

3

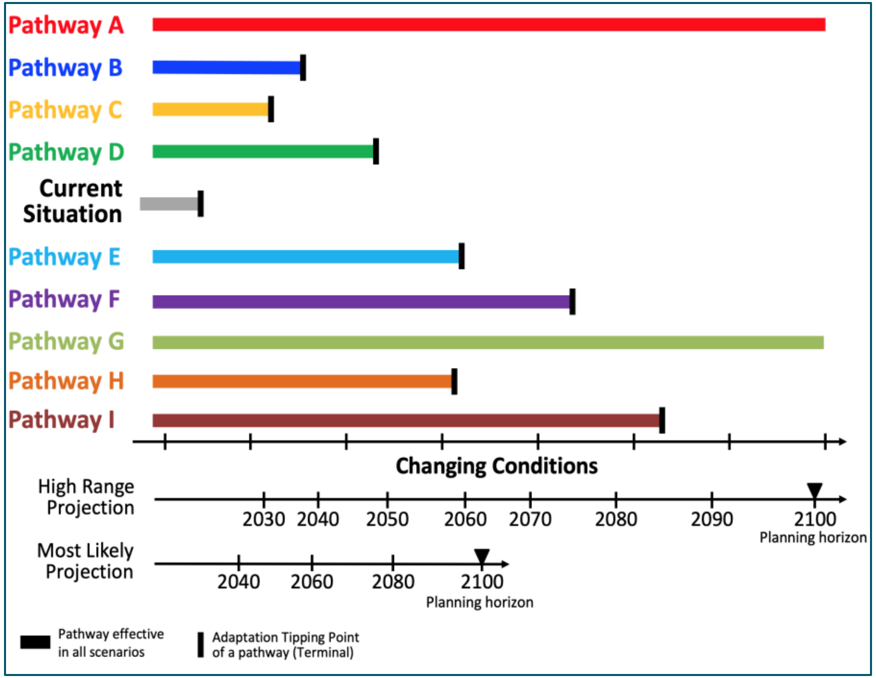
Devise Possible Adaptation Pathways

Convert measures into adaptation pathways.

- Can be:
  - **Physical**: constructed works
  - **Operational**: altered operating procedures
  - **Policy**: rules or guidance to change behavior

Identify the pathway sell-by dates: adaptation tipping points (ATPs) or "sell-by" dates.

- Depends on scenario projections



Example pathways mapped against two projections of climate conditions out to 2100

4

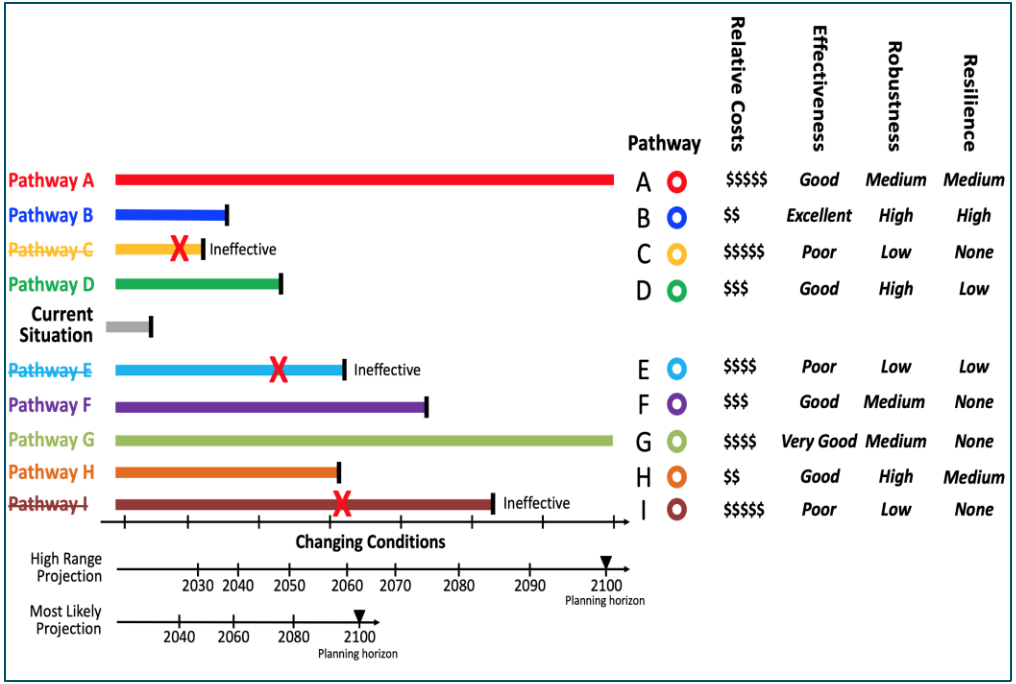
Dynamic Adaptive Policy Planning (DAPP) Steps

Evaluate Pathways

Imagery supplied by Clipart.com

Evaluate and score each pathway against outcomes, conditions for success.

- Relative costs
  - Cost to implement
- Effectiveness
  - Ability to get on track to achieve success
- Robustness.
  - Ability to stay on track for achieving success
- Resiliency.
  - Ability to recover quickly at low cost from extreme events



Qualitative evaluation of possible pathways

5

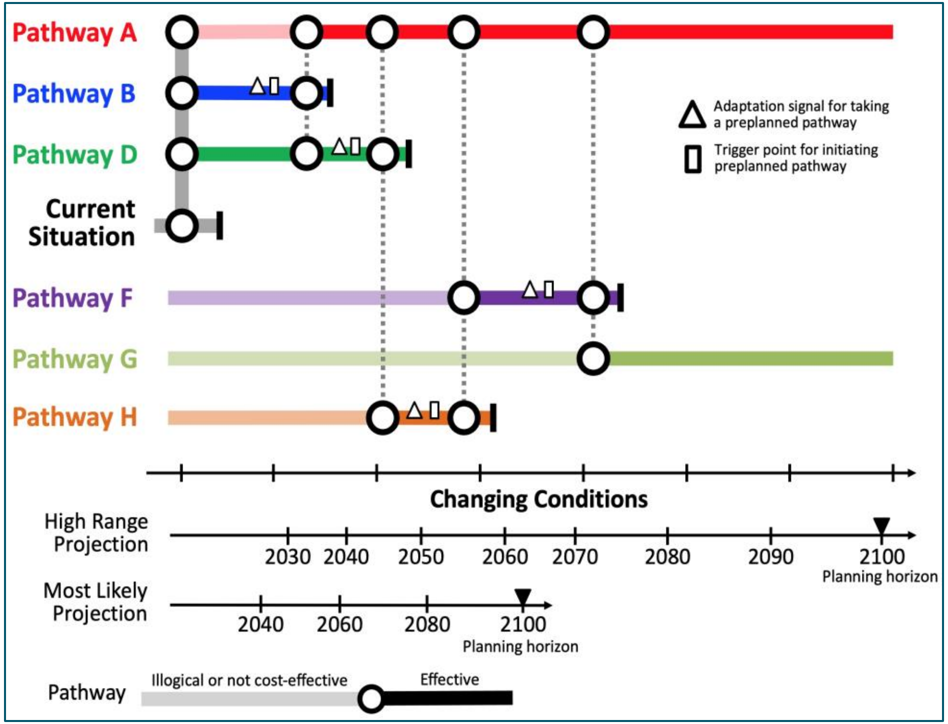
Imagery supplied by Clipart.com

Dynamic Adaptive Policy Planning (DAPP) Steps

Assemble Pathways Into Routes

Concatenate pathways into routes that can feasibly achieve success.

- Sequence pathways.
  - Move to new pathway when previous pathway is no longer effective.
- Start with pathways that keep most options open.



Pathways concatenated into multiple logical, effective routes.

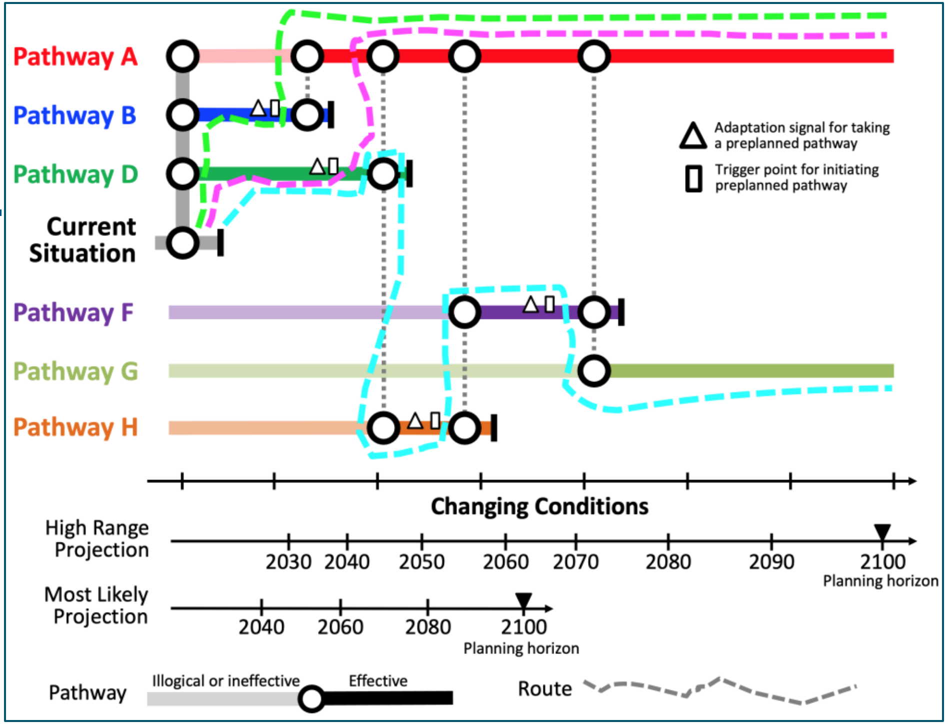
Dynamic Adaptive Policy Planning (DAPP) Steps

Assemble Pathways Into Routes

Imagery supplied by Clipart.com

Produce an adaptation map.

- Show logical potential routes that achieve success.
- Show adaptation tipping points (ATPs or "sell by" dates).
- Show adaptation signals, trigger points for moving to next pathway.



Adaptation map with alternative routes

6

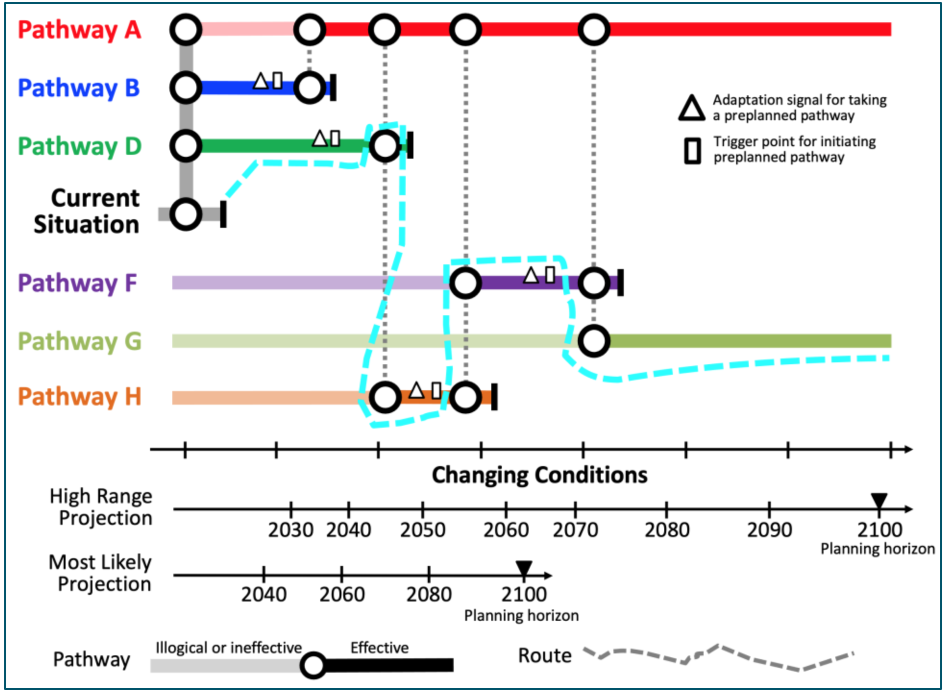
Imagery supplied by Clipart.com

Dynamic Adaptive Policy Planning (DAPP) Steps

Select the Best Route and Implement

Determine what route should be taken.

- Select the route that achieves objectives but keeps most options open for future changes in conditions, events.



Selected route with signposts, signals and trigger levels established.

7

Imagery supplied by Clipart.com

Dynamic Adaptive Policy Planning (DAPP) Steps

Monitor and Respond to Change

Set up monitoring programs to detect and respond to changes.

- Monitor established signposts for changes in conditions.
- Transfer to new pathway before the Adaptation Tipping Point (ATP) date is reached.

NOAA water level monitoring station with an acoustic sensor on Dauphin Island, Alabama.

Source: NOAA, Climate.gov

Case Example: Water Scarcity in Southern Portugal

Using Dynamic Adaptive Policy Planning to address water scarcity in the Algarve Region.

Photo source: Shutterstock

Case Example: Water Scarcity in Southern Portugal

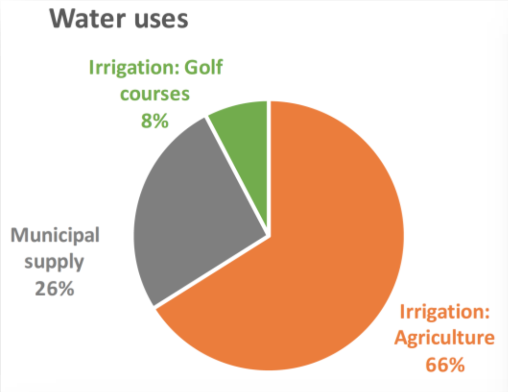
Problem Description

- Water is a scarce resource in the Algarve, southern Portugal.
  - Essential for irrigated agriculture (2/3rd use)
  - Essential for population and tourism (1/3rd use)
  - Current demands are 43% of available resources: Severe water stress
- Climate is dry and getting drier.

Source: Joao Pedro Nunes, et al., “Using Dynamic Adaptive Policy Pathways and hydrological modeling to co-create water resource adaptation policies for climate change.” Presentation by Joao Pedro Nunes, jpnunes@fc.ul.pt

Case Example: Water Resource Policies for Southern Portugal

Water Resources in Algarve Today



Adapted from Nunes, et al.

Available water resources:

- Intermittent rivers with torrential flow, with dams in the largest rivers
- Large and productive coastal aquifers, some are contaminated

Water requirements are 43% of available resources:

- Threshold of severe water stress

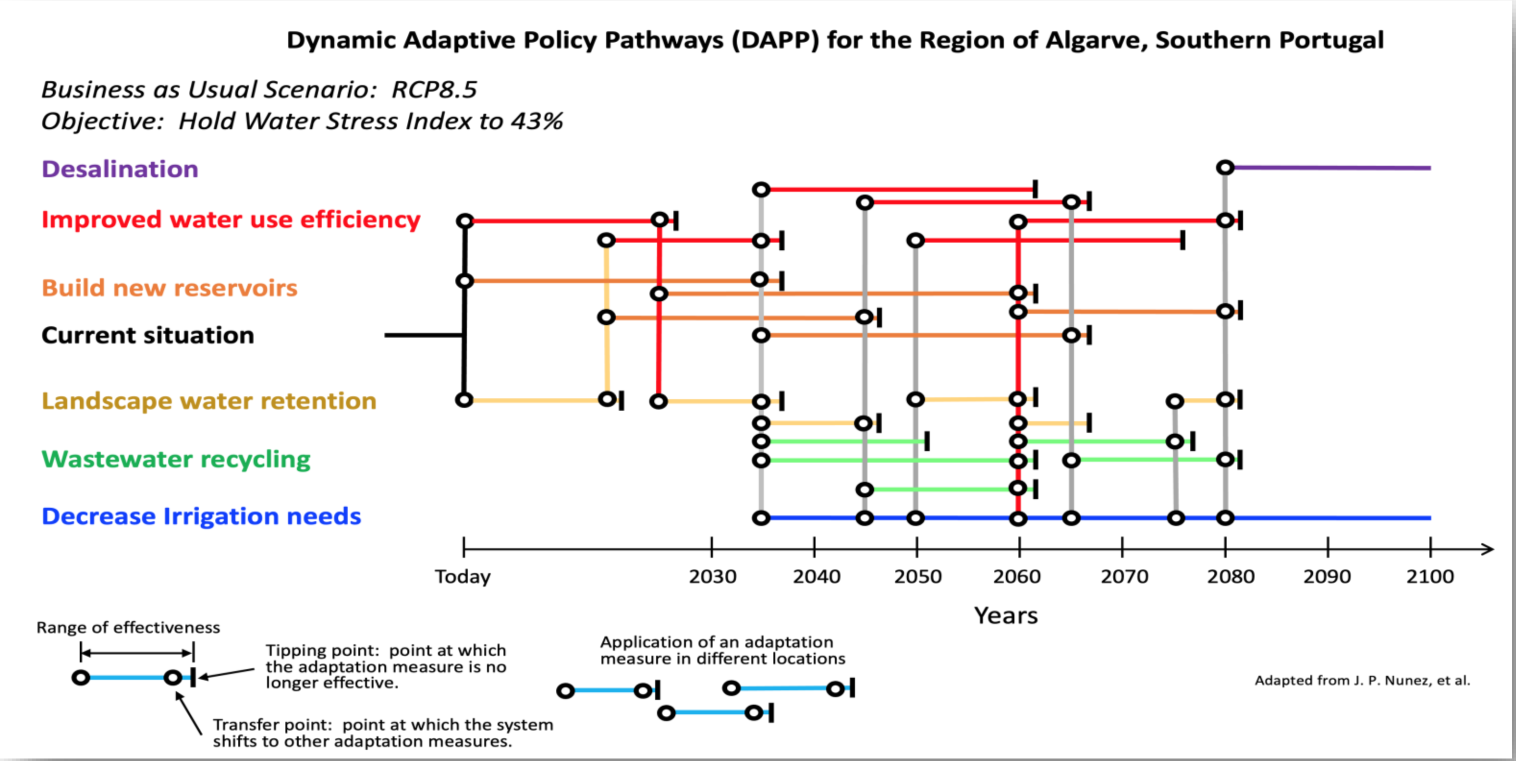
Climate Change Adaptation Options

Adaptation Solutions	WEI* in 2100 (RCP8.5)	Assessment by stakeholders and researchers
Target	**43%**	**Keep WEI at 43%**
No action	78%	Severe water stress – unacceptable.
1. Improve water efficiency	74%	Region is already drought aware. Irrigation is efficient.
2. 1 + Decrease irrigation needs	53%	Already tried in the past. Not socially acceptable. DISCARD!
3. 1 + Wastewater recycling	66%	Not much wastewater to recycle. Costly to distribute.
4. 3 + Build new reservoirs	60%	The best places for dams already have them.
5. 4 + Landscape water retention	Scalable until ~45%	Improve traditional water conservation. Many small-scale works.
6. Desalination	Scalable until <20%	Costly and energy-intensive now. May become cheaper over time.

*WEI = Water Exploitation Index. <20%: No stress; 20-40%: Moderate Stress; 40-70%: Severe Stress: >70%: Scarcity

Adapted from Nunes, et al.

Initial Set of Pathways



Adapted from Nunes, et al.

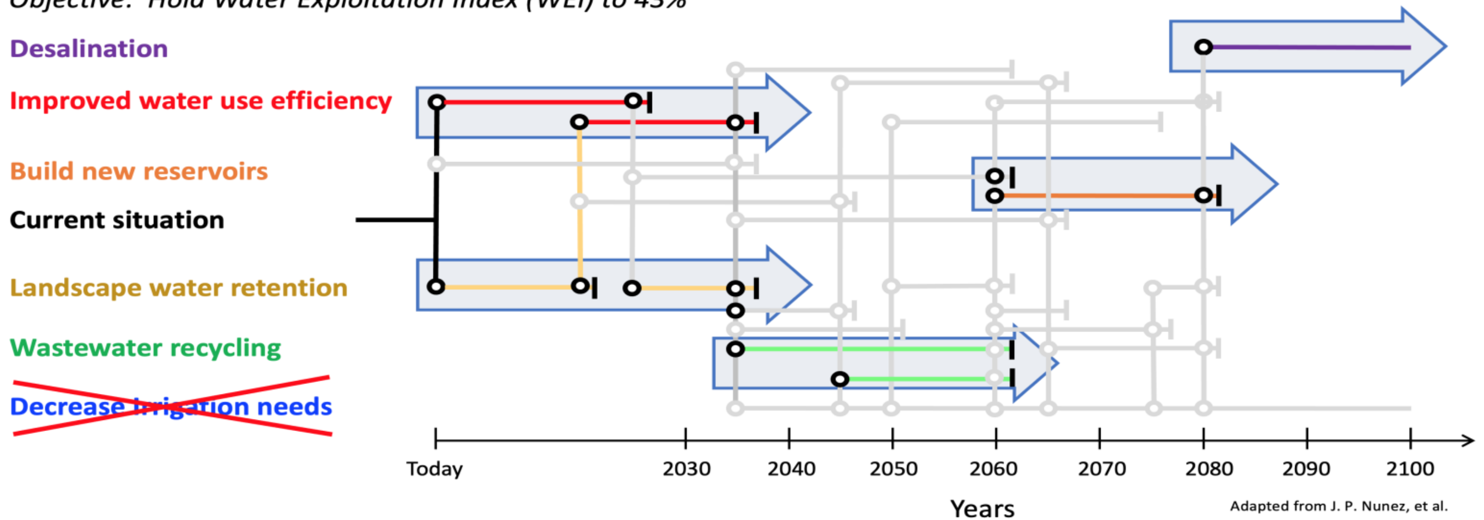
Adapted from Nunes, et al.

Case Example: Water Resource Policies for Southern Portugal

Selected Approaches

Dynamic Adaptive Policy Pathways (DAPP) for the Region of Algarve, Southern Portugal

Business as Usual Scenario: RCP8.5
Objective: Hold Water Exploitation Index (WEI) to 43%



Sequence of Adaptation Measures

Near term:
Improved water use efficiency
Landscape water retention

Mid-term:
Wastewater recycling

Long-term:
Build new reservoirs

If all else fails:
Desalination

Do not:
Decrease irrigation needs
(further social discussion needed)

Adapted from Nunes, et al.

Adapted from Nunes, et al.

Update: Reduced Irrigation Begins

The Portugal News, 30 June 2022

Algarve water restrictions begin

The Association of Irrigators of the Irrigation Perimeter of Silves, Lagoa and Portimão have activated the contingency plan for this year's agricultural campaign, reducing the water supply for non-permanent crops by 50%.

Conclusion and Recommendations

In Summary…

- Climate change brings new uncertainties to civil infrastructure design and operation.
  - Also brings additional risk to design professionals
- Design professionals have always managed uncertainty.
  - But probably not to this degree
- Methodologies for handling climate uncertainty are available and are being applied.

Recommendations

- Recognize the climate is changing rapidly.
  - And the science behind it.
- Understand its impacts on your projects and your business.
  - Project risk and business risk
- Have serious conversations with your clients.
  - Projects need to account for changing climate conditions.
- Design and build the 'right' project.

References

- Climate Explorer: https://crt-climate-explorer.nemac.org/
- USACE North Atlantic Coast Comprehensive Study Report: https://www.nad.usace.army.mil/CompStudy/
- Climate Adaptation Knowledge Exchange (CAKE): https://www.cakex.org/
- Institute for Sustainable Infrastructure (Envision): https://sustainableinfrastructure.org/
- How to Consider a Changing Climate in Transportation Project Development: https://scoe.transportation.org/wp-content/uploads/sites/11/2017/08/How-to-Consider-a-Changing-Climate-in-Transportation-Project-Development.pdf
- Adaptation Clearinghouse: https://www.adaptationclearinghouse.org/

Thank you!

Questions?