


**Department of Commerce**  
 Innovation is in our nature.



## Protecting Infrastructure through Vulnerability Assessments

*Asset Resiliency in the face of a Changing Climate*




WA-APA Conference  
October 2014

### Presenter

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### Presenter

**Lara Whitely Binder**  
 (as depicted in Seattle Weekly)

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So I went to Lara Whitely Binder, the outreach specialist at UW's Climate Impacts Group, to ask an expert if Seattle was truly going to drown in a self-induced flood by 2100.

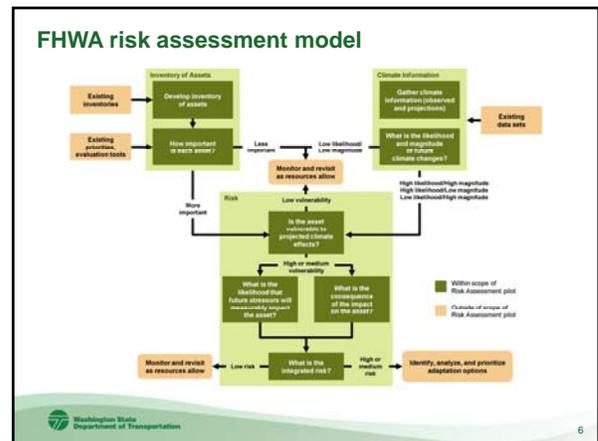
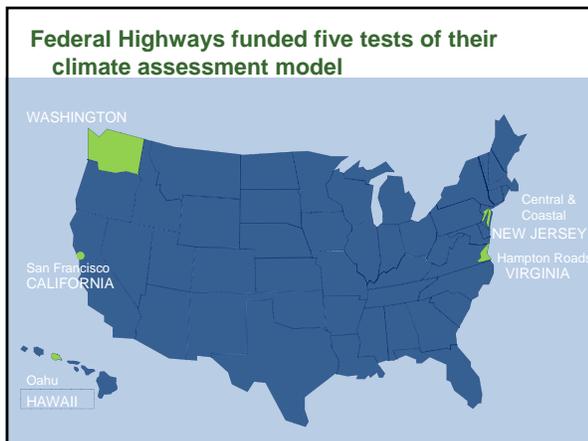
## Washington State DOT Vulnerability Assessment: Asking the "Climate Question"





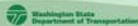

**Carol Lee Roalkvam**  
 Policy Branch Manager  
 Environmental Services Office

**WA APA**  
 Spokane, WA  
 October 17, 2014

### Washington State DOT's Climate Assessment Key Facts:

- FHWA \$189,500 funds matched by state staff time
  - One of 5 national climate risk assessment pilots (2011)
- WSDOT test of the FHWA's model leveraged:
  - Our asset management approach & cost/risk assessment tools
  - Pacific Northwest climate change data from UW
  - Field personnel intimate knowledge of current climate threats
- Easily replicable process
  - 14 workshops across state & simple Microsoft Excel & GIS tools
- Qualitative rankings for all state-owned assets!
  - State highway & interstate segments, ferry terminals,
  - State freight rail lines, state-managed airports



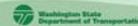
### How did we do the statewide climate impacts vulnerability assessment?

**Key Points:**

- Internal WSDOT staff ranked our assets
  - Local maintenance, bridge engineers, hydraulics, geotechnical, materials, project designer, planners, environmental staff
- Used our own asset risk assessment process combined the FHWA model
- Shared climate change information and why this was important & gathered info on current impacts from weather & tidal events
- We didn't question the science or try to define likelihood - took as "100% Probability"

**Workshop questions:**

- "What keeps you up at night?"
- "What if it gets worse (given the climate scenario)?"
- "How resilient is our existing state system?"



### We used our experience to gauge future impacts



Scour and damage to structures - Just off US 12 Davis Creek

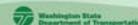


### Mount Rainier Kautz Creek 11-06-06

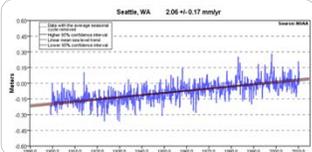


Only year-round road into and out of Park.

a new creek flowed down a service road, carving a channel through the park's helipad




### We've seen a 9 inch rise over 110 years









### Step 1 – Define roadway segments

WSDOT Methodology

Notice that along with the qualitative terms there is an associated scale of 1 to 10, this is to serve as a facilitation tool for some people who may find it useful to think in terms of a numerical scale - although the scoring by each individual is of course subjective. The scale is a generic scale of criticality where "1" is very low (least critical) and "10" is very critical.

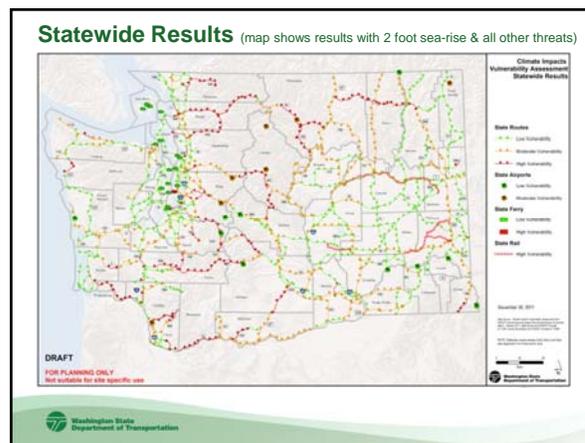
Typically involves: non-NHS low AADT alternate routes available	Typically involves: some-NHS non-NHS low to medium AADT serves as an alternative for other state routes	Typically involves: Interstate Lifetime some NHS sole access no alternate routes
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### Workshops: How might climate impact assets?

Primary climate drivers	Can lead to impacts on...
Temperature	Expansion joints, pavement, rail tracks, roadside habitat loss, heat stress on signals, timing of construction work in extreme heat
Precipitation	Flooding of surface roads & tunnels, road washout, pump capacity, drainage
Hydrologic shifts	Soil instability, water supply, bridge and road support structures
Sea level rise, Storm surge	Coastal erosion, coastal and upriver flooding, bridge footings, drainage, roadside stability, salt / corrosion

### Step 2 – Assess climate impact

<b>Complete catastrophic failure</b> Results in total loss or ruin of asset. Asset may be available for limited use after at least 60 days and would require major repair or rebuild over extended period of time. "Complete and/or catastrophic failure" typically involves: • Immediate road closure; • Disruptions to travel; • Vehicles forced to re-route to other roads; • Reduced commerce in affected areas; • Reduces or eliminates access to some destinations; • May sever some utilities located within right-of-way; • May damage drainage conveyance or storage systems.
<b>Temporary operational failure</b> Results in minor damage and/or disruption to asset. Asset would be available with either full or limited use within 60 days and may have immediate limited use still available. "Temporary Operational Failure" typically involves: • Temporary road closure, hours to weeks; • Reduced access to destinations served by the asset; • Stranded vehicles; • Possible temporary utility failures.
<b>Reduced capacity</b> Results in little or negligible impact to asset. Asset would be available with full use within 10 days and has immediate limited use still available. "Reduced capacity" typically involves: • Less convenient travel; • Occasional brief lane closures, but roads remain open; • A few vehicles may move to alternate routes;



### What did we find?

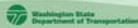
- Climate change will intensify known threats
- Reinforces value of our current maintenance and retrofit programs
- Unique way to capture knowledge of field staff
- New awareness of combinations of climate risks / extreme events

### Where can you find the results of WSDOT's climate change vulnerability assessment?

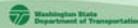
- General results are posted on-line
  - Our report to FHWA
  - NEPA/SEPA Guidance
- WSDOT employees
  - GIS layer
  - Narrative results

### How are our folks starting to integrate vulnerability assessment results?

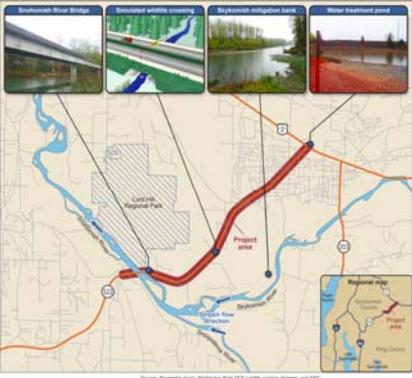
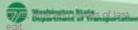
<b>Planning</b>	Bring awareness of the potential climate vulnerabilities of WSDOT facilities when doing route development plans or corridor studies
<b>Design &amp; Environmental Review</b>	Evaluate potential risks to a project during the environmental and design phase (follow WSDOT's NEPA guidance) <a href="http://www.wsdot.wa.gov/NR/rdonlyres/084317DB-A25C-4COA-8055-3F62A8663AB10/WSDOT_ClimateGuidance.pdf">http://www.wsdot.wa.gov/NR/rdonlyres/084317DB-A25C-4COA-8055-3F62A8663AB10/WSDOT_ClimateGuidance.pdf</a> (pdf)
<b>Construction</b>	Look at potential for new issues: salt water corrosion, heat or precipitation changes for long-term impacts on materials
<b>Maintenance &amp; Operations</b>	Plan evacuation routes, hazard reduction, maintenance activities that may be affected by heat or extreme weather events



### Climate-Ready Highways: Incorporating what we know today with projected future

Example of a completed highway project with elements that add resilience

### Communicating “co-benefits” of current programs: Fish Passage/Habitat Connectivity Project

- Provides Steelhead, Bull Trout, & resident trout with access to 13.7 mi of stream habitat
- Provides deer with a safe crossing in one our worst deer-vehicle collision areas
- Uses 1.5 mi of fencing to funnel animals to the crossing
- More Resilient US 97!*

Before



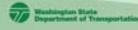


After





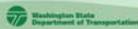
Butler Creek, north of Goldendale



### From Disaster to Resiliency: Highlighting current practices that are effective adaptation strategies



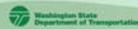

Drilled shaft bridges like this one on I-90 near Gold Creek make those structures more resistant to high-velocity flooding.

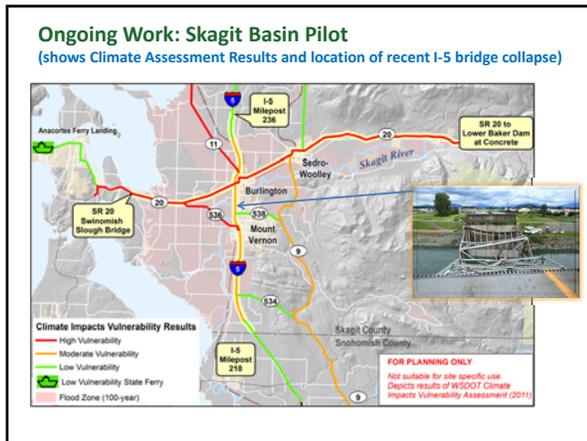


### Skagit River Bank Restoration along SR 20




Above: Emergency fix November 2004  
 Right: Long-term solution March 2014  
 ✓ Engineered Log Jams combined with concrete dolos





### Building a climate-ready transportation system

**Essential elements:**

- Understand the climate forecast
- Assess our risks
- Integrate into planning and design
- Look for co-benefits
- Partner with others

Washington State Department of Transportation

### Adapting to a changing climate

Statewide study of climate-related infrastructure risks

For more information:

- Carol Lee Roalkvam, Environmental Services Office, Policy Branch Manager 360-705-7126
- Sandy Salisbury, Headquarters Roadside and Site Development Manager 360-705-7245
- Mark Maurer, Highway Runoff Program Manager 360-705-7260

**WSDOT's website**  
<http://www.wsdot.wa.gov/SustainableTransportation/adapting.htm>

**FHWA's website**  
[http://www.fhwa.dot.gov/environment/climate\\_change/adaptation/](http://www.fhwa.dot.gov/environment/climate_change/adaptation/)

### Sound Transit Climate Risk Reduction Project

Lara Whitely Binder, UW Climate Impacts Group  
Amy Shatzkin, Sound Transit  
Carol Lee Roalkvam, WSDOT

October 17, 2014 | American Planning Association Washington Chapter Annual Conference

### What is Sound Transit?

- Multi-modal public transit agency serving Tacoma-Seattle-Everett region
- 28 million riders (and growing)
- Services operated via contractual partnerships with King County Metro, Pierce Transit, Community Transit, Amtrak, and Burlington Northern Santa Fe (BNSF)

### What is the Sound Transit Climate Change Risk Reduction Project?

- Funded by the FTA
- One of 7 climate change adaptation pilot projects
- A partnership between Sound Transit, the UW Climate Impacts Group, and WSDOT – a first look for ST

*Sound Transit Climate Change Risk Reduction Project*

## Project Objectives

- Assess climate change risks to Sound Transit operations, assets, and long-term planning;
- Identify initial adaptation strategies and how to best integrate information into ST processes; and
- Provide a state-to-local testing ground for WSDOT's pilot of the FHWA's climate change vulnerability assessment methodology.

Projected Changes in PNW Climate



**Increasing average temps, more extreme heat events**  
 Projected increase in average temp by mid-century: +4.3°F to +5.8°F (range: +2° to 8.5°F) (Mote et al. 2013)



**Increasing winter precip, more extreme precip events**  
 24-hour storm events in Seattle-Tacoma area projected to increase 14-28% by 2050s, relative to 1970-2000. (Rosenberg et al 2010)

Projected Changes in PNW Climate



**Increased flood risk west of the Cascades**  
 More and larger fall/winter floods possible, compounded by sea level rise in coastal rivers and streams.



**Rising sea level**  
 Sea level in Seattle projected to rise +24.3 inches (range: +4 to +56 in.) by 2100. (NRC 2012)

*Sound Transit Climate Change Risk Reduction Project*

## What Do These Changes Mean for ST?







*Sound Transit Climate Change Risk Reduction Project*

## Overarching Key Findings & Considerations

1. Climate change exacerbates many existing issues already facing Sound Transit.
2. If, when, and how much climate change affects Sound Transit varies by mode, location, and the size and rate of projected change.
3. Overall, many impacts will likely be minor to moderate, although more significant impacts are possible.
4. Sound Transit already possesses some degree of climate resilience and capacity to address climate impacts.

## Project Approach

- Used existing research for regional climate projections
- Formed a ST climate adaptation advisory group
- Staff survey to establish baseline information on experience, perceptions about climate impacts on ST
- Facilitated workshops (~12) based on WSDOT approach:
  - Kick off events
  - Risk assessment & prioritization for facilities and modes
  - Identification of adaptation strategies (by mode)
  - Potential integration pathways (senior managers)
- Report development, Executive Team briefings, and dissemination

### Lessons Learned: Approach

- Drawing on existing research saved time, resources but was not always specific to geographic scale of interest.
- Advisory group provided senior-level buy-in (and push) for staff participation.
- Facilitated workshops provided:
  - “Real world” information;
  - More staff engagement and learning opportunities (climate change “ambassadors”);
  - Opportunities to ground-truth findings

*However....*

- Needed more time for discussion
- Results are shaped by who is sitting at the table
- Limits to group size for this type of engagement (survey helped)
- Limited institutional history with climate and weather events – required people to think outside the box

### Potential Impacts Related to ST

Related to Temperature <i>Increased potential for...</i>	Related to Precipitation <i>Increased potential for...</i>	Related to Sea Level Rise <i>Increased potential for...</i>
<ul style="list-style-type: none"> <li>• Rail buckling</li> <li>• Heat stress on electrical and safety equipment</li> <li>• Heat stress on overhead catenary system</li> <li>• Heat stress on pavement, structures</li> <li>• Heat stress on landscaping and environmental mitigation sites</li> </ul>	<ul style="list-style-type: none"> <li>• Mudslides and slope instability</li> <li>• Larger and/or more frequent river and stream flooding</li> <li>• Increased localized flooding due to more stormwater runoff or poor drainage</li> <li>• Seepage due to higher groundwater tables</li> <li>• Summer drought</li> </ul>	<ul style="list-style-type: none"> <li>• Temporary flooding of low-lying areas</li> <li>• Permanent inundation of low-lying areas</li> <li>• Higher tidal and storm surge reach</li> <li>• Erosion</li> <li>• Drainage problems</li> <li>• Corrosion from more frequent or prolonged exposure to saltwater</li> </ul>

### Prioritizing Potential Impacts and Services

*Two questions assessed:*

1. Which climate change impacts matter more across all services?
2. Which services may become higher (or lower) adaptation priorities?

### Q1: Which climate change impacts matter more across all services?

Potentially Significant Impacts	Potentially Moderate Impacts	Potentially Minor Impacts
<ul style="list-style-type: none"> <li>• Increased mudslide activity</li> <li>• Sea level rise and related impacts</li> </ul>	<ul style="list-style-type: none"> <li>• Larger and/or more frequent river and stream flooding</li> <li>• Increased localized flooding due to more stormwater runoff or poor drainage</li> <li>• Potential for rail buckling</li> </ul>	<ul style="list-style-type: none"> <li>• Increased heat stress on electrical equipment</li> <li>• Increased heat stress on the overhead catenary system</li> <li>• Increased heat stress on facility structures and landscaping</li> <li>• Increased heat stress on environmental mitigation sites</li> <li>• Increased tunnel seepage</li> </ul>

*\* Assumes size of the projected impact is at the high end of what would be expected*

### Q2: Which services may become higher adaptation priorities?

<p><b>Potential high adaptation priority services:</b></p> <ul style="list-style-type: none"> <li>• North Sounder</li> <li>• Edmonds and Mukilteo Sounder Stations</li> </ul>	<p><b>Potential medium adaptation priority services:</b></p> <ul style="list-style-type: none"> <li>• South Sounder; Tukwila and Kent Sounder stations</li> <li>• At-grade or aboveground Link alignments</li> </ul>
<p><b>Potential low adaptation priority services:</b></p> <ul style="list-style-type: none"> <li>• ST Express</li> <li>• Environmental mitigation</li> <li>• Other customer facilities</li> <li>• Underground Link</li> </ul>	

### Sound Transit has many options for adaptation...

<p><b>Raise</b> sensitive ground-level infrastructure</p> <p><b>Build</b> berms around sensitive ground-level infrastructure</p> <p><b>Increase</b> visual &amp; electronic monitoring of infrastructure in vulnerable areas</p> <p><b>Move</b> or relocate infrastructure in hazard zones</p> <p><b>Modify drainage patterns</b> to re-direct flows, improve drainage</p>	<p><b>Add flexibility</b> by building in capacity to relocation, raise, add higher capacity in future</p> <p><b>Modify design standards</b> to provide higher level of flood &amp; stormwater management, seepage management, heat impacts</p> <p><b>Partner</b> with communities to target problem drains/drainages</p>
<p>70+ options identified</p>	

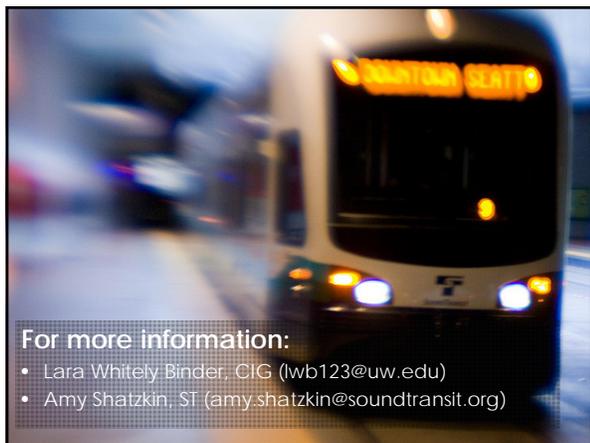
...And many opportunities for integrating climate change into agency processes

- Climate impacts *may* influence decisions including:
  - Policy setting
  - Environmental review
  - Strategic system planning
  - Preliminary engineering and final design
  - Operations and maintenance
  - Asset management
  - Intergovernmental relations



**Acknowledgements and Thank You's**

- Leadership at Sound Transit, WSDOT, and CIG
- Amy Shatzkin (Sound Transit)
- Carol Lee Roalkvam (WSDOT)
- Mike Strong (Sound Transit GIS)
- Amy Snover, Ingrid Tohver, and Rob Norheim (CIG)
- The many Sound Transit directors, managers, and technical staff who participated in the workshops



**For more information:**

- Lara Whitely Binder, CIG (lwb123@uw.edu)
- Amy Shatzkin, ST (amy.shatzkin@soundtransit.org)

**The UW Climate Impacts Group**

*Science for climate resilience*

- Linking science with public and private decision making
- Catalyzing decision-relevant climate science
  - Identifying emerging risks
  - Illuminating response options
- Supporting the interpretation and application of climate science
  - Local climate change information
  - Expert guidance on climate risk assessment & adaptation planning
  - Synthesis & assessment of emerging climate science



W COLLEGE OF THE ENVIRONMENT  
UNIVERSITY OF WASHINGTON



**Integrated Scientific Synthesis and Assessments**

2009

2013

2013

<http://cig.uw.edu/reports.shtml>

**Community & Sector-based Impacts and Risk Assessment**

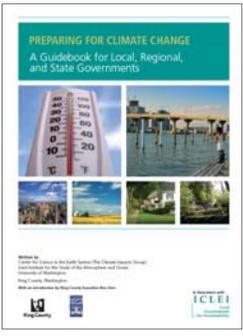
2010

2010

2014

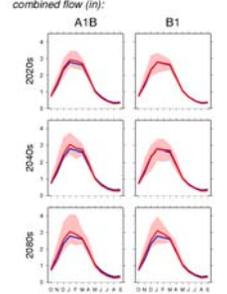
### CIG/King County Adaptation Planning Guidebook

- Written by the CIG and King County, WA in association with ICLEI – Local Governments for Sustainability
- Written to compliment ICLEI’s “Climate Resilient Communities” Program
- Focused on the process (not a sector), and written for a national audience**



<http://cig.uw.edu/reports.shtml>

### PNW Climate Change Data




Example of available products  
Chehalis at Grand Mound

<http://hydro.washington.edu/2860>  
Developed with support from the Dept of Ecology

### Planning for Uncertainty

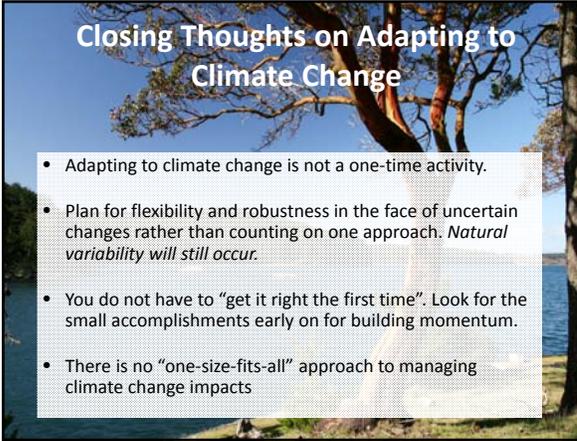
Look to implement

- “No regrets” strategies**  
*Provides benefits now with or without climate change*
- “Low regrets” strategies**  
*Provide climate change benefits for little additional cost or risk*
- “Win-win” or “Co-benefit” strategies**  
*Reduce climate change impacts while providing other environmental, social, or economic benefits*



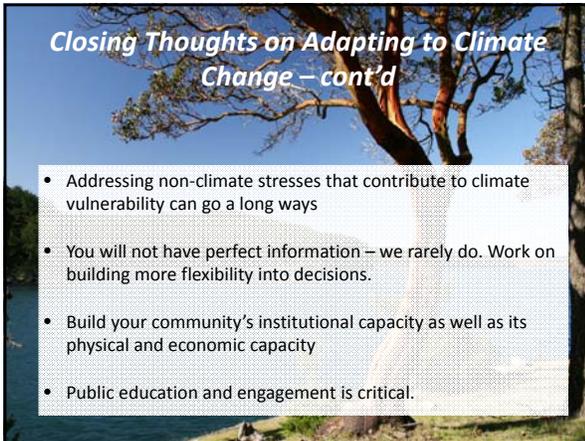
### Closing Thoughts on Adapting to Climate Change

- Adapting to climate change is not a one-time activity.
- Plan for flexibility and robustness in the face of uncertain changes rather than counting on one approach. *Natural variability will still occur.*
- You do not have to “get it right the first time”. Look for the small accomplishments early on for building momentum.
- There is no “one-size-fits-all” approach to managing climate change impacts



### Closing Thoughts on Adapting to Climate Change – cont’d

- Addressing non-climate stresses that contribute to climate vulnerability can go a long ways
- You will not have perfect information – we rarely do. Work on building more flexibility into decisions.
- Build your community’s institutional capacity as well as its physical and economic capacity
- Public education and engagement is critical.




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