

# Hydropower Breakout Session

Projections for the next century suggest climate change will have important impacts on Washington State's economy and natural resources. In order to both control the costs and maximize the benefits of a changing climate, we must begin preparing now. To stimulate discussion in this session, we summarize projected climate impacts from the conference white paper, enumerate previously suggested adaptation strategies, and provide case studies to illustrate planning techniques, vulnerabilities, and/or opportunities.



Prepared by Jennifer Kay, Joe Casola, Amy Snover, and the Climate Impacts Group (CIG) at the University of Washington for King County's October 27, 2005 Climate Change Conference.

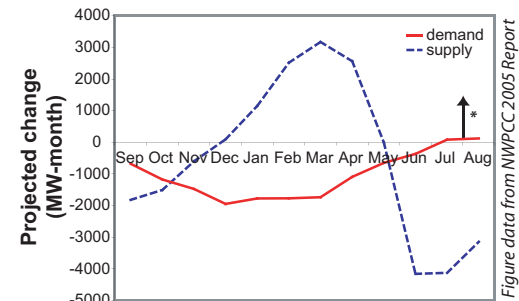
## Summary of projected climate change impacts on hydropower operations

### Changes in the annual pattern of electricity demand.

Projected year-round temperature increases would increase electricity demand in the summer and decrease electricity demand in the winter.

### Changes in the annual pattern of electricity production.

Projected higher winter, earlier peak- and lower summer streamflows would increase electricity production during the winter/spring but decrease production in the summer. As a result, it may be more difficult to satisfy competing summer in-stream flows demands for hydropower, fish, irrigation and recreation.



Projected change in 2040s hydropower demand and supply

\* Summertime electricity demand may exceed projection if air conditioning use becomes more prevalent.

## Adaptation discussion starters

### Guiding principles for planning:

1. Recognize that the past may no longer be a reliable guide to the future.
2. Integrate climate change projections into all planning processes.
3. Monitor regional climate and resources for ongoing change.
4. Expect surprises. Design policies and management practices to be flexible to changing conditions.

### Could these strategies help Washington prepare for change?

**Adjust reservoir operations for a changing climate.** Project changes in electricity demand and basin-specific flows and adjust hydropower generation rule curves accordingly.

**Conserve electricity to reduce overall demand.** By 2025, the NWPCC estimates 2,800 avg. MW of cost-effective conservation potential for the PNW.

**Use market forces to reduce electricity demand during critical periods.** For example: use demand response incentives; connect consumer usage to electricity availability through wholesale prices; increase cooperation and coordination between different market players during shortages.

**Increase capacity, diversity, and interconnectivity of hydropower generation.** For example: encourage innovations to improve efficiency of hydropower operations; negotiate streamflow timing with upstream users; promote interconnectivity of hydropower transmission lines; build more dams.

**Shift electricity production toward renewables, nuclear or thermal generation.** Renewables (wind, solar) and nuclear do not contribute additional greenhouse gases to the atmosphere, but make up a small percentage of current electricity generation. Thermal generation (i.e., burning natural gas or coal) and nuclear power may be viable alternatives although the costs and benefits of such choices must be weighed carefully. Costs include additional greenhouse gases emissions (thermal) and longterm hazardous waste disposal (nuclear).

**Sources:** 1) Northwest Power and Conservation Council (NWPCC) 5th report: <http://www.nwcouncil.org/energy/powerplan/plan/Default.htm> 2) Snover, A., Miles, E. and B. Henry, OSTP/USGCRP Regional Workshop of the Impacts of Global Climate Change on the Pacific Northwest Annex D, NOAA Climate and Global Change Program, Special Report Number 11, 1997.

### Planning case study - Climate change stream flow scenarios:

The CIG and the NWPCC evaluated the potential impacts of climate change on hydropower and in-stream flow management by developing climate change stream flow scenarios and incorporating them into existing NWPCC planning models. To facilitate the use of this research in PNW basin planning studies, climate change stream flow scenarios are available for locations on the Columbia River at no cost through the CIG website: <http://www.cses.washington.edu/cig/fpt/ccstreamflowtool/sft.shtml>.

### Vulnerability case study - West Coast electricity markets:

While many non-climatic factors contributed to the 2001 West Coast energy crisis, low 2000-2001 PNW snowpack and the resulting PNW energy shortage exposed the vulnerability of electricity markets to poor climate conditions. PNW power deficits contributed to high and volatile prices on the wholesale market, 25-50% increases in PNW retail prices, marked decreases in PNW energy available for export to California, and the threat of blackouts. Climate change is projected to alter streamflows and if not accounted for, could expose new vulnerabilities in West Coast electricity markets.

# Municipal/Industrial Water Breakout Session



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## Summary of projected climate change impacts on water supplies

### Changes in the annual patterns of streamflow.

Projected changes in the timing and volume of streamflow are elevation dependent. For transient and snow-melt dominated basins, projected climate change would increase winter streamflow and shift peak streamflows to earlier in the spring. This could result in more incidences of low streamflow in the summer and make it more difficult to fulfill summer demands for consumptive water use and in-stream flows.



Credit: Seattle Public Utilities

Chester Morse Reservoir,  
Cedar River Watershed

## Adaptation discussion starters

### Guiding principles for planning:

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3. Monitor regional climate and resources for ongoing change.
4. Expect surprises. Design policies and management practices to be flexible to changing conditions.

### Could these strategies help Washington prepare for change?

**Adjust reservoir operations for a changing climate.** Understand basin-specific vulnerability to climate change and manage accordingly.

**Encourage conservation.** For example: provide incentives for purchase and use of high efficiency plumbing, appliances and irrigation systems; support outreach programs and advertising to promote conservation.

**Use market forces to reduce demand during critical periods.** For example: use demand response incentives to pay people to not use water during shortages; increase the cost of water during shortages.

**Connect and expand water infrastructure.** For example: connect regional water systems; diversify sources of water supply including groundwater; increase usable storage (including surface water storage, off-stream storage, and aquifer storage and recovery).

**Support technical innovations.** For example: develop advanced wastewater treatment and reuse; assess potential for desalinization through reverse osmosis.

**Encourage flexibility in water allocation using water banks, water pools, and water markets.**

**Sources:** 1) Hamlet, A. F., Preparing for Climate Change in the Pacific Northwest: A Discussion of Water Resources Adaptation Pathways. Preparatory White Paper for Climate and Water Policy Meeting, Skamania, Washington, July 2001.  
2) Snover, A., Miles, E. and B. Henry, OSTP/USGCRP Regional Workshop of the Impacts of Global Climate Change on the Pacific Northwest Annex D, NOAA Climate and Global Change Program, Special Report Number 11, 1997.

**Planning case study - Seattle Public Utilities Climate Change Study:** Seattle Public Utilities and the University of Washington's Dept. of Civil Engineering explored the potential impacts of climate change on Seattle's Cedar and Tolt River water supplies.<sup>3</sup> Assuming the amount of water demanded by the system remains constant at present levels, their results indicate the watersheds' combined reservoir inflow from June – September would fall at an average rate of 6% per decade through 2040.

<sup>3</sup>Wiley, M.W. (2004). "Analysis Techniques to Incorporate Climate Change Information into Seattle's Long Range Water Supply Planning," Master's thesis, University of Washington. 214 pp.

### Planning case study – Lake Tapps

**Municipal Water Supply Project:** The Cascade Water Alliance has plans to develop Lake Tapps as the primary municipal water supply for the urban areas East of Seattle. The White River, the river that supplies water to Lake Tapps, is a snow/glacier-melt dominated system. Climate change may result in earlier snow melt, reduced glacier extent, and decreased summer water supply. As a result, a recent study<sup>1</sup> found summer water competition between municipal water supply, recreation, and in-stream flow requirements for fish could be worse in a warmer climate.

<sup>1</sup>Ball, J.A. (2004). "Impacts of Climate Change on the Proposed Lake Tapps-White River Water Supply," Master's thesis, University of Washington, 55 pp.

### Planning case study - Portland Public Utilities Climate Change Study:

A study of the Bull Run watershed (Portland, Oregon)<sup>2</sup> found that while population growth has the largest impact on future water demand, climate change influences both water supply and customer demand. By 2040, climate change impacts on Portland's water supply system could be half those of regional population growth alone. As a result, Portland must find additional capacity to offset changes in hydrology and demand to meet the typical 98% reliability standard.

<sup>2</sup>Palmer, R.N., and M. A. Hahn. 2002. The Impacts of Climate Change on Portland's Water Supply: An Investigation of Potential Hydrologic and Management Impacts on the Bull Run System. Report prepared for the Portland Water Bureau, University of Washington, Seattle. 139 pp.

# Stormwater/Floods Breakout Session

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Prepared by Jennifer Kay, Joe Casola, Amy Snover, and the Climate Impacts Group (CIG) at the University of Washington for King County's October 27, 2005 Climate Change Conference.

## Summary of projected climate change impacts on stormwater/floods

***In a warmer climate, precipitation falling as rain instead of snow could increase winter flooding in transient river basins.***

***We are still learning how climate change may affect the frequency and intensity of storms in Washington.***

Projecting changes in winter and summer precipitation frequency and intensity requires high resolution modelling expertise which is still being developed.



Credit: National Weather Service Northwest River Forecast Center

October 2003 Flooding in Northwest Washington

## Adaptation discussion starters

### ***Guiding principles for planning:***

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3. Monitor regional climate and resources for ongoing change.
4. Expect surprises. Design policies and management practices to be flexible to changing conditions.

### ***Could these strategies help Washington prepare for change?***

**Encourage communication between planners and scientists.** Understand what is and is not known about climate change impacts on Washington floods and stormwater.

**Incorporate climate change projections into design requirements for stormwater control systems.** For example: modify the capacity of existing stormwater control structures as information about climate change impacts becomes available.

**Discourage development in flood hazard areas.** For example: privatize the risk of insuring and financing in sensitive areas where small changes in climate could have large impacts on property.

**Preserve ecological buffers.** For example: restore pervious surface area to help control stormwater runoff.

**Move or abandon infrastructure.** Move houses and development in floodplains or in areas prone to landsliding.

**Sources:** 1) Snover, A., Miles, E. and B. Henry, OSTP/USGCRP Regional Workshop of the Impacts of Global Climate Change on the Pacific Northwest Annex D, NOAA Climate and Global Change Program, Special Report Number 11, 1997. 2) H. John Heinz III Center, Evaluation of Erosion Hazards: Summary. Prepared for the Federal Management Agency, Washington D.C., 2000.

### **Planning Case Study – Vancouver Storm Water:**

The Greater Vancouver Regional District (GVRD) is incorporating variations in monthly total precipitation from climate change scenarios into their stormwater management planning. The GVRD has also outlined the sensitivity of their stormwater system to increases in storm frequency and intensity that could result from climate change. By considering future climate and population growth in their scenario planning, the GVRD can assess management strategies based on a range of projected future needs.

More information:

Hicks, R. W. B., and E. L. von Euw, Integrated stormwater management planning process to address climate and landuse changes in urban watersheds in the GVRD, 16th International Conference, Society for Ecological Restoration, August 24-26, 2004.  
<http://wlapwww.gov.bc.ca/epd/epdpa/mpp/stormwater/stormwater.html>

### **Planning Case Study – Projections of Future Flooding From High Spatial Resolution Weather Models:**

Researchers from the Department of Atmospheric Sciences at the University of Washington and the CIG are attempting to couple global climate models to high resolution weather models (minimum spatial resolution ~ 2 miles) to examine how the frequency and intensity of storms in the Pacific Northwest could change as a consequence of global warming. In the future, their results could be combined with existing models of the land surface and the local and regional hydrologic system to provide projections of future stormwater flooding statistics for cities and communities.

# Forestry Breakout Session

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Prepared by Jennifer Kay, Joe Casola, Amy Snover, and the Climate Impacts Group (CIG) at the University of Washington for King County's October 27, 2005 Climate Change Conference.

## Summary of projected climate change impacts on forestry

**Tree species may migrate or have trouble adapting.** Direct impacts of climate change could force migration of some tree species to higher elevations and latitudes, while other species may be unable to adapt to changing climate conditions.

**Increased threat of fire and insect outbreaks.** Rising temperatures could indirectly impact forests by creating more favorable conditions for fire and insect outbreaks.



Credit: Norm Johnson, USDA Forest Service, www.forestryimages.org

Doug fir beetle in wind throw, Gifford Pinchot National Forest, WA

## Adaptation discussion starters

### Guiding principles for planning:

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4. Expect surprises. Design policies and management practices to be flexible to changing conditions.

### Could these strategies help Washington prepare for change?

**Maintain genetic and species biodiversity and minimize forest fragmentation to allow species migration.**

**For timber harvest, plant tree species (or genotypes) known to have a broad range of environmental tolerance.**

For example: may need to switch from Douglas Fir trees which are relatively sensitive to low soil moisture to more drought-resistant timber species.

**Incorporate understanding of elevation-specific climate sensitivities into management strategies.**

**Manage forests understanding changing fire risk.** Minimize development in vulnerable fire regimes.

**Monitor and control insects and invasive species.** Be prepared for insects and invasive species to both expand their current range and increase their number of lifecycles.

**Sources:** 1) Snover, A., Miles, E. and B. Henry, OSTP/USGCRP Regional Workshop of the Impacts of Global Climate Change on the Pacific Northwest Annex D, NOAA Climate and Global Change Program, Special Report Number 11, 1997. 2) Innes, J. L., and D. L. Peterson, Proceedings introduction: Managing forests in a greenhouse world – context and challenges. Proceedings of the Climate Change, Carbon and Forestry in Northwestern North America Workshop held November 13-14, 2001. United States Department of Agriculture, Forest Service, Pacific Northwest Research Station, General Technical Report PNW-GTR-614, April 2004.

### Opportunity case study - Develop management systems to sequester carbon:

In Western Washington, one study<sup>1</sup> suggests 110 million tons of carbon could be sequestered over a 50-year period in riparian areas set aside by the Forest and Fish Rules alone. Assuming an average value of carbon sequestration at \$2 a ton, \$240 million dollars in revenue would be generated. Credits for carbon sequestration can be obtained from trading systems such as the Chicago Climate Exchange (More information and current carbon prices at: <http://www.chicagoclimatex.com/>).

<sup>1</sup>Perez-Garcia, J., Edelson, J., and H. Rogers, Economic incentives for carbon storage in Western Washington's forested riparian management areas. Proceedings of the Climate Change, Carbon and Forestry in Northwestern North America Workshop held November 13-14, 2001. United States Department of Agriculture, Forest Service, Pacific Northwest Research Station, General Technical Report, PNW-GTR-614, April 2004.

### Planning case study – Balancing fire risk and carbon sequestration:

A planning study<sup>1</sup> for the Okanogan and Freemont National Forests simulated fire risk reduction, economic cost, habitat protection, and carbon sequestration for a range of thinning strategies. Without wildfires, the no-action alternative results in the greatest comparative storage of carbon. However, fire would release all of the stored carbon and is a likely outcome without fuel reduction treatment. By balancing the costs and benefits of thinning, the study identified management plans that could both reduce fire risk and allow a high level of carbon sequestration.

<sup>1</sup>Mason, C. L., Cedar, K., Rogers, H., Bloxton, T., Connick, J., Lippke, B., McCarter, J., and K. Zobrist. Investigation of alternative strategies for design, layout and administration of fuel removal projects. Rural Technology Initiative, College of Forest Resources, University of Washington, July 2003

# Fish and Shellfish Breakout Session

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Prepared by Jennifer Kay, Joe Casola, Amy Snover, and the Climate Impacts Group (CIG) at the University of Washington for King County's October 27, 2005 Climate Change Conference.

## Summary of projected climate change impacts on fish and shellfish

**Changes in the annual patterns of streamflow.** For snowmelt-dominant and transient basins, projected climate change would increase winter flow and shift peak flows to earlier in the spring. These changes could be detrimental to salmon rearing, migration and spawning by increasing scouring events, reducing the freshet, and increasing incidences of low summer flows.

**Increased water temperatures.** Increased summer in-stream temperatures may exceed tolerable limits for coldwater fish populations.

**Increased water stratification.** Increased stratification in lakes, Puget Sound, and the coastal ocean could decrease nutrient availability.

**Future changes in coastal and marine habitat are uncertain.**



Credit: Mercer Island Parks

Salmon in Lake Washington

## Adaptation discussion starters

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4. Expect surprises. Design policies and management practices to be flexible to changing conditions.

### Could these strategies help Washington prepare for change?

**Evaluate climate change impacts through entire fish life cycles and manage accordingly.**

**Integrate climate change information into salmon recovery planning.** The sensitivity of salmon vitality to climate change depends on basin-specific cumulative impacts of land and water use.

**Improve water quality by reducing pollution.** For example: reduce stormwater runoff, which transports pollution to water bodies.

**Maintain biodiversity and protect diverse fish habitats.** Genetic, life history, and behavioral diversity decreases sensitivity of species to a changing environment.

**Find ways to minimize elevated water temperatures and low streamflow in the summer.** Reduce removal of riparian vegetation and secure strict in-stream flow requirements.

**Consider creative engineering solutions that will aid fish migration and improve fish environments.**

**Sources:** 1) Snover, A., Miles, E. and B. Henry, OSTP/USGCRP Regional Workshop of the Impacts of Global Climate Change on the Pacific Northwest Annex D, NOAA USGCRP, Special Report Number 11, 1997. 2) Mantua, N. and R. Francis – Natural climate insurance for Pacific Northwest salmon and salmon fisheries: Finding our way through the entangled bank. American Fisheries Society Symposium, 43, 2004. 3) Glick, P., Fish out of water: A guide to global warming and Pacific Northwest rivers, National Wildlife Federation, March 2005.

**Planning case study - Snohomish Utility Salmon Habitats Improvement (SUSHI):** The Northwest Fisheries Science Center (NWFSC) is collaborating with the CIG<sup>3</sup> to explore the impacts of climate change on salmon recovery plan alternatives in the Snohomish River Basin. By inputting climate change scenarios into a salmon life cycle model, researchers are linking habitat changes to fish population dynamics in a changing climate. Comparing results from a range of management options will allow NWFSC to choose the recovery plan projected to have the best influence on salmon survival.

<sup>3</sup>see <http://www.tag.washington.edu/projects/sushi.html>

**Vulnerability case study - Salmon in the Columbia River Basin (CRB):** Using existing CRB infrastructure, Martin<sup>1</sup> developed a plan that could accommodate both flood control and in-stream flow interests in a warmer world. With Martin's plan, water would be held in the winter and released in the spring to simulate historic flows important for juvenile salmon migration. Thus, both natural river flows and protection from the risk of uncontrolled flooding would be achieved. However, managing for fish, flood control, and hydropower in a warmer world could be more challenging. A recent study<sup>2</sup> concludes earlier reservoir refill and greater storage allocations for summer in-stream flow targets could mitigate some of the negative impacts of climate change on CRB salmon, but only with significant losses in firm hydropower (up to -35%). If increased temperatures increase summer electricity demand, however, there may be some synergy between releasing water for hydropower generation and in-stream flows in the summer.

<sup>1</sup>Martin, K., Altered Flood Control, Climate Change, And Rebuilding Pacific Northwest Salmon Stocks, Columbia River Inter-tribal Fish Commission Technical Report, Winter 2004. [http://www.critfc.org/text/nat\\_riv.html](http://www.critfc.org/text/nat_riv.html)

<sup>2</sup>Payne, J. T., Wood, A. W., Hamlet, A. F., Palmer, R. N., and Dennis P. Lettenmaier, Mitigating the effects of climate change on the water resources of the Columbia River Basin, Climatic Change, 62, 233-256, 2004.

# Agriculture Breakout Session

Projections for the next century suggest climate change will have important impacts on Washington State's economy and natural resources. In order to both control the costs and maximize the benefits of a changing climate, we must begin preparing now. To stimulate discussion in this session, we **summarize projected climate impacts from the conference white paper**, **enumerate previously suggested adaptation strategies**, and **provide case studies to illustrate planning techniques, vulnerabilities, and/or opportunities**.



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## Summary of projected climate change impacts on agriculture

**Impacts will vary throughout the region depending on the crops being produced and water availability.** Projected increases in atmospheric temperature and carbon dioxide concentrations (CO<sub>2</sub>) could increase yields for some crops in some places. However, earlier peak flow in rivers and decreasing soil moisture could reduce the availability of irrigation water. In some areas, projected changes could result in the need for more irrigation water to support the same acreage. In addition, climate change may increase the prevalence of some agricultural pests and diseases.

## Adaptation discussion starters

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4. Expect surprises. Design policies and management practices to be flexible to changing conditions.



Artists Rendition of Black Rock Reservoir

Credit: Benton County, WA

### Could these strategies help Washington prepare for change?

**Manage agricultural industry for a changing climate.** For example: promote greater use of plants that benefit from a longer growing season and enhanced atmospheric CO<sub>2</sub>; consider double cropping where longer growing seasons allow; promote greater use of heat-resistant, pest-resistant, and disease-resistant crops.

**Promote water conservation.** For example: install high efficiency delivery systems (sprinkler systems or drip irrigation systems); change to less water intensive crop species.

**Use market forces to distribute water.** Water banking and water markets can be used to trade water rights between users and distribute impacts during periods of water shortage.

**Diversify and expand water infrastructure.** For example: diversify sources of water supply; increase usable storage (including surface water storage, off-stream storage, and aquifer storage and recovery).

**Be aware of how climate change affects global agriculture.** WA commodity pricing is sensitive to the world agricultural market and global agricultural production.

**Sources:** 1) Hamlet, A. F., Preparing for Climate Change in the Pacific Northwest: A Discussion of Water Resources Adaptation Pathways. Preparatory White Paper for Climate and Water Policy Meeting, Skamania, Washington, July 2001. 2) Snover, A., Miles, E. and B. Henry, OSTP/USGCRP Regional Workshop of the Impacts of Global Climate Change on the Pacific Northwest Annex D, NOAA Climate and Global Change Program, Special Report Number 11, 1997.

**Vulnerability case study – Yakima River Basin (YRB):** Agriculture in the YRB produces crops worth ~ \$1 billion annually, mostly from perennial crops. Approximately half of YRB water users have junior water rights, including many of the perennial crop growers. In the low water years 1994 and 2001, junior water rights holders received only 37% of their water allocation, resulting in economic losses of up to \$140 million per year. Climate change in the YRB, a snow-melt driven basin, could cause peak stream flows to arrive earlier and reduce summer stream flow. One study<sup>2</sup> found peak flows could occur in April instead of June by the end of the century. Another study<sup>3</sup> projects global warming would decrease the amount of water available for irrigation in the YRB by an average of 20 to 40% in a typical year by 2050. Although proposals for building additional storage on the YRB have been identified, they are expensive. For example, the proposed Black Rock Reservoir has an estimated cost of \$3.5-4 billion.

<sup>2</sup>Salathe, Eric. P. Downscaling simulations of future global climate with application to hydrologic modeling, *International Journal of Climatology*, 25, 419-436, 2003.

<sup>3</sup>Scott, M.J., L.W. Vail, C.O. Stöckle, A. Kemanian. 2004. "Climate Change and Adaptation in Irrigated Agriculture-A Case Study of the Yakima River." In *Proceedings of the UCOWR/NIWR Annual Conference*, July 20-22, 2004, Portland, OR. PNWD-SA-6448. Pacific Northwest National Laboratory, Richland, WA.

**Vulnerability case study - Water transfer barriers:** On the Snake River, the state of Idaho operates a water bank and several water districts run rental pools for privately held storage in Bureau of Reclamation reservoirs. On the Klamath River in Oregon, there are no established water banks or rental pools and proof of no third party injury is required for water use transfer. While Idaho policies encourage the transfer of water rights, Oregon law tends to discourage these transfers. The reasons for the development and flexibility of differing water laws are complex. Regardless, as illustrated by the 2001 drought on the Klamath, vulnerability to climate is higher when water transfers are limited.<sup>1</sup>

<sup>1</sup>Slaughter, R. A., Water allocation under stress: Institutional comparison of the Snake and the Klamath Rivers, *Journal of the American Water Resources Association* (in review).

# Coasts Breakout Session

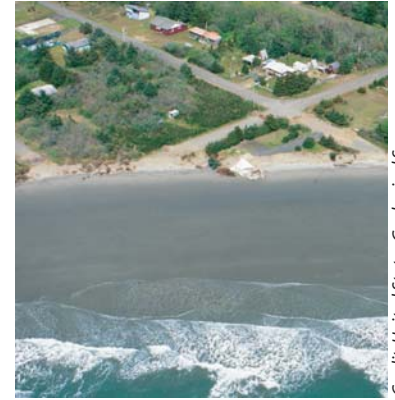
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## Summary of projected climate change impacts on coasts

- **Projected sea level rise would increase coastal flooding and erosion, especially at flat beaches and in areas of tectonic subsidence.**
- **Increased winter precipitation could increase the risk of landslides and coastal flooding.**
- **Changes in ocean circulation, which are important for coastal ecosystems, are uncertain.**



Credit: United States Geological Survey

Endangered homes at Cape Shoalwater, Pacific Co., WA

## Adaptation discussion starters

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4. Expect surprises. Design policies and management practices to be flexible to changing conditions.

### Could these strategies help Washington prepare for change?

**Discourage development in coastal hazard areas.** For example: privatize the risk of insuring and financing coastal development; adjust zoning and modify design and engineering requirements for coastal structures based on projected climate change impacts on sea level and flood frequencies.

**Move or abandon shoreline infrastructure.** Move existing houses and development in response to shoreline changes.

**Preserve ecological buffers to allow for inland beach migration.**

**Restore wetlands for run-off storage and flood control.**

**Enhance shoreline protection recognizing the negative consequences for shoreline habitat.** For example: use dikes, levies, armoring, filling and/or beach replenishment in vulnerable areas.

**Make a disaster relief plan for flooding and erosion events.**

**Monitor and control invasive species.**

**Sources:** 1) Snover, A., Miles, E. and B. Henry, OSTP/USGCRP Regional Workshop of the Impacts of Global Climate Change on the Pacific Northwest Annex D, NOAA Climate and Global Change Program, Special Report Number 11, 1997. 2) H. John Heinz III Center, Evaluation of Erosion Hazards: Summary. Prepared for the Federal Management Agency, Washington D.C., 2000.

### Planning Case Study – Alaska Way Viaduct Seawall and Seattle Department of Transportation (SDOT):

The Office of the City Auditor has initiated a series of reviews on how changes in PNW climate could impact various City Departments. The first review focused on the SDOT's operations, services and infrastructure. In the report, the City recognized the sea level rise figure used in design standards for the Alaskan Way Seawall replacement may be too small. The seawall was designed to accommodate a sea level rise of 0.9 feet in the next 75 years. According to the CIG, sea level could rise up to 2.8 feet over this period.

More information at: <http://seattle.gov/audit>

### Vulnerability Case Study – Sea level rise in Olympia, WA:

Sea level at Olympia is currently rising at ~1 foot per century due to land subsidence in Southern Puget Sound. The Intergovernmental Panel on Climate Change (IPCC)<sup>1</sup> estimates global sea level will rise from 0.3 to 2.9 feet by 2100. Olympia's downtown lies only a few feet above the high water mark. A study funded by the City of Olympia<sup>2</sup> found sea level rise due to subsidence and climate change may lead to a rising water table, reduced surface drainage, port district inundation, and central business district flooding.

<sup>1</sup> see Policy FAQ #1 for description of the IPCC TAR.

<sup>2</sup> Craig, D., Preliminary assessment of sea level rise in Olympia, WA: Technical and policy implications, Policy and Program Development Division, Olympia Public Works Department, Olympia, June 1993