Chehalis River Basin
Climate Change Predictions

Chehalis Basin Board Meeting

July 11, 2019

Outline

- Latest Climate Change predictions
- Process used to develop predictions
  - Metrological data (UW CIG)
  - Hydrologic Modeling (WSE)
  - Analysis and Application (WSE & Anchor)
- Comparison to previous predictions
- Q&A Discussion

Climate Change Predictions

- The current modeling and analysis of the Chehalis Basin predicts that climate change will result in an increase in peak flows of 12% by the middle of the century (2050) and by 12 to 26% by the late century (2080).
- Similar results for the middle of the century are predicted for either a low greenhouse gas scenario (RCP 4.5) or high greenhouse gas scenario (RCP 8.5).
- Results for the late century vary depending on greenhouse gas assumptions.

Climate Change Predictions

Effect of Climate Change on Peak Flows at Grand Mound

Return Period	Historical (1929-2013)	Mid Century (2050)	Late Century (2080)
2-year	25,600 cfs	28,700 cfs	32,300 cfs
10-year	44,600 cfs	50,000 cfs	56,200 cfs
25-year	55,800 cfs	62,500 cfs	70,300 cfs
100-year	74,700 cfs	83,700 cfs	94,100 cfs
500-year	100,300 cfs	112,300 cfs	126,400 cfs

Process Used to Develop New Climate Change Predictions

- Develop and calibrate a hydrologic model of the Chehalis River basin
- Obtain latest meteorological data for climate change scenarios
- Simulate historical and future flows
- Evaluate changes due to climate change
- Summary and recommendations

Hydrologic Model

- **D**istributed **H**ydrology **S**oil **V**egetation **M**odel (DHSVM)

  DHSVM is a gridded, physically based, distributed parameter model that provides an integrated representation of watershed processes at the spatial scale described by the digital elevation model (DEM)

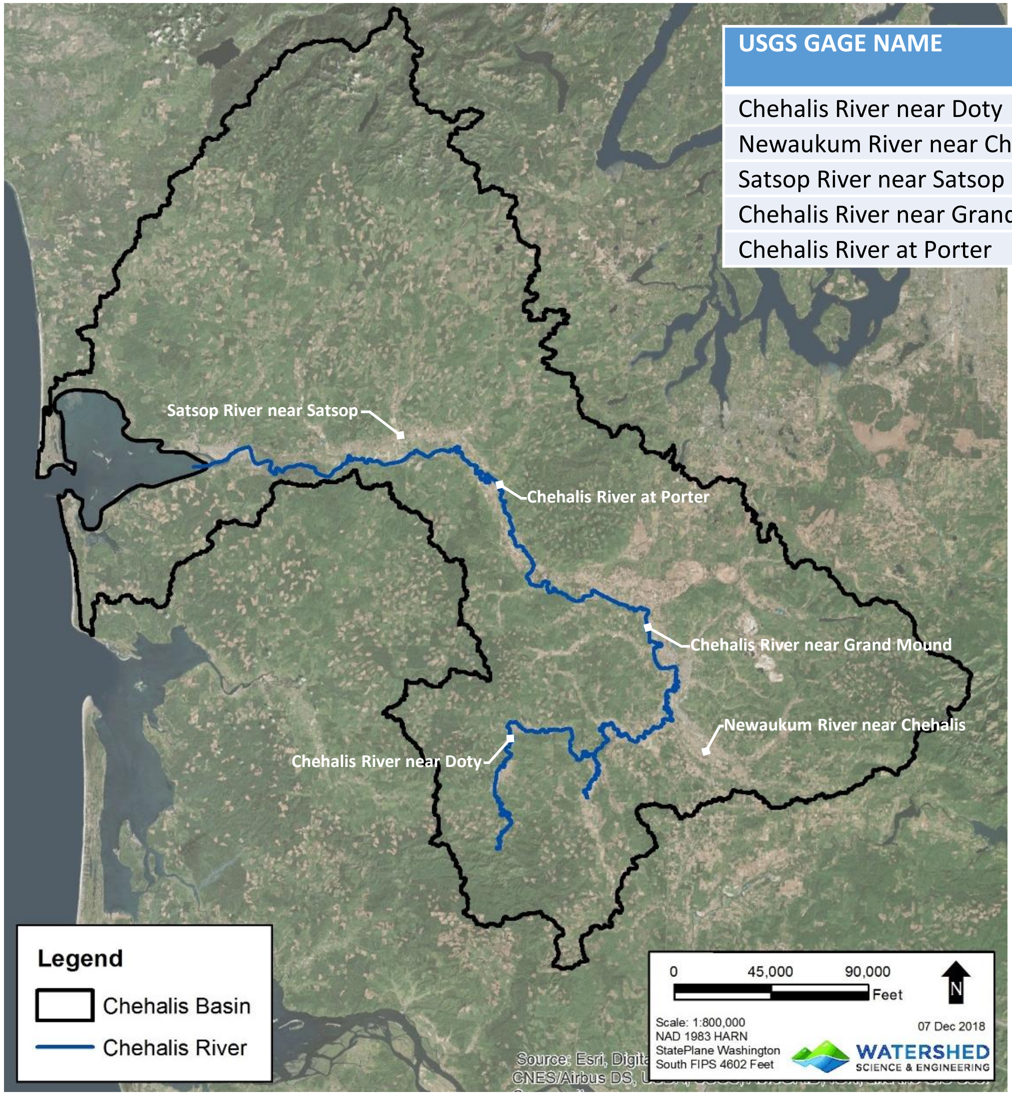
- Key Concepts
  - spatial scale – based on current project purposes
  - physically based – from mapped properties
  - distributed – parameters defined for each grid
  - watershed processes – directly simulated
  - calibrated – model “tuned” to replicate historical observations, then used to predict furture

Meteorologic Inputs

- University of Washington Climate Impacts Group (CIG)
  - temperature, precipitation, wind, surface pressure, shortwave radiation, longwave radiation
  - hourly time step
  - historical reanalysis (PNNL)
  - historical (statistical) and future (UW CIG)

DATA SOURCE	TIME PERIOD	MODEL	RESOLUTION	TIME STEP	DRIVING DATASET
PNNL	1979-2015	WRF	6 km	1 hour	NARR*
UW CIG	1970-2099	WRF	12 km	1 hour	GFDL CM3, RCP 8.5†
UW CIG	1970-2099	WRF	12 km	1 hour	ACCESS 1.0, RCP 4.5‡

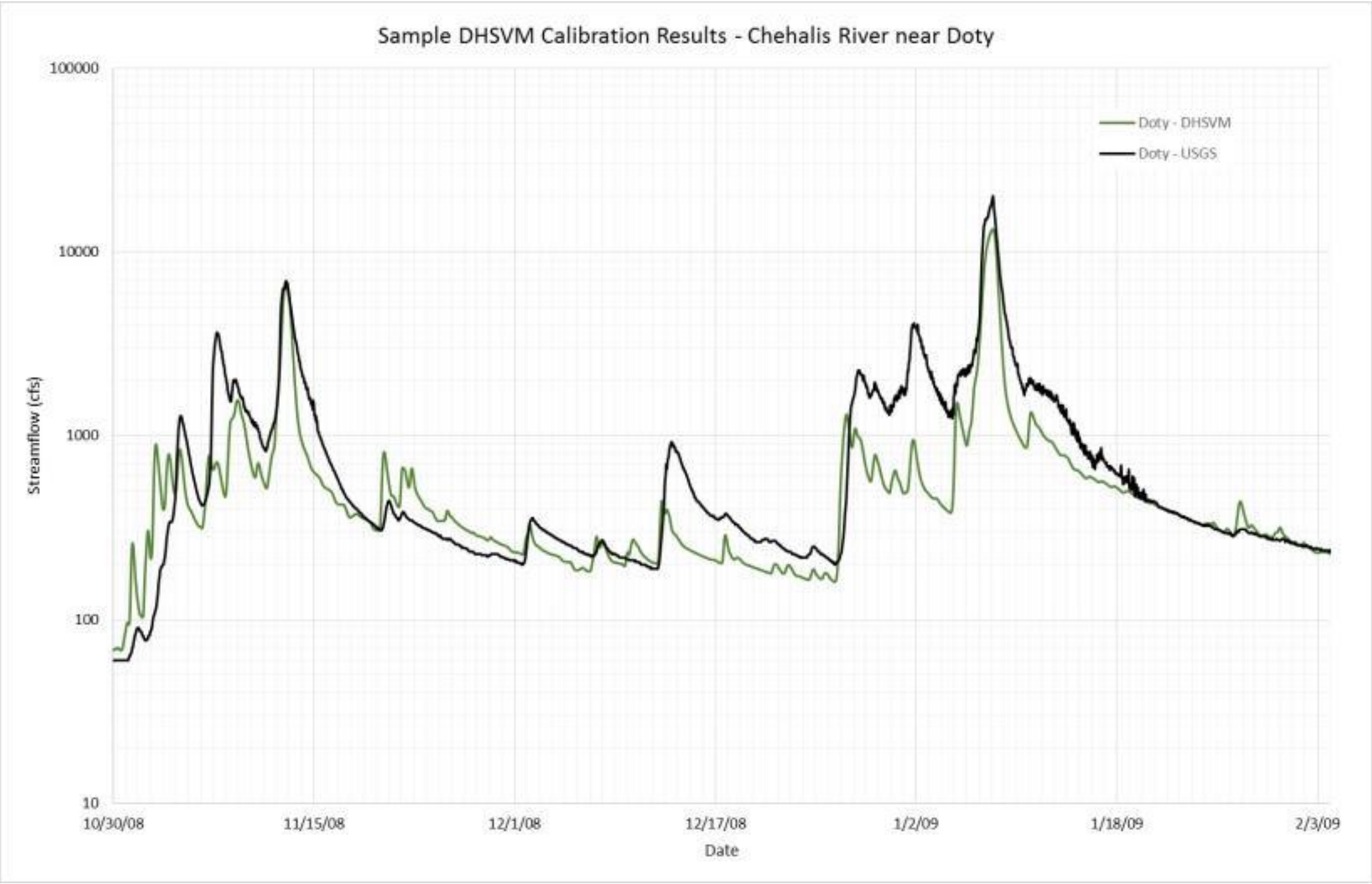
DHSVM Model Calibration



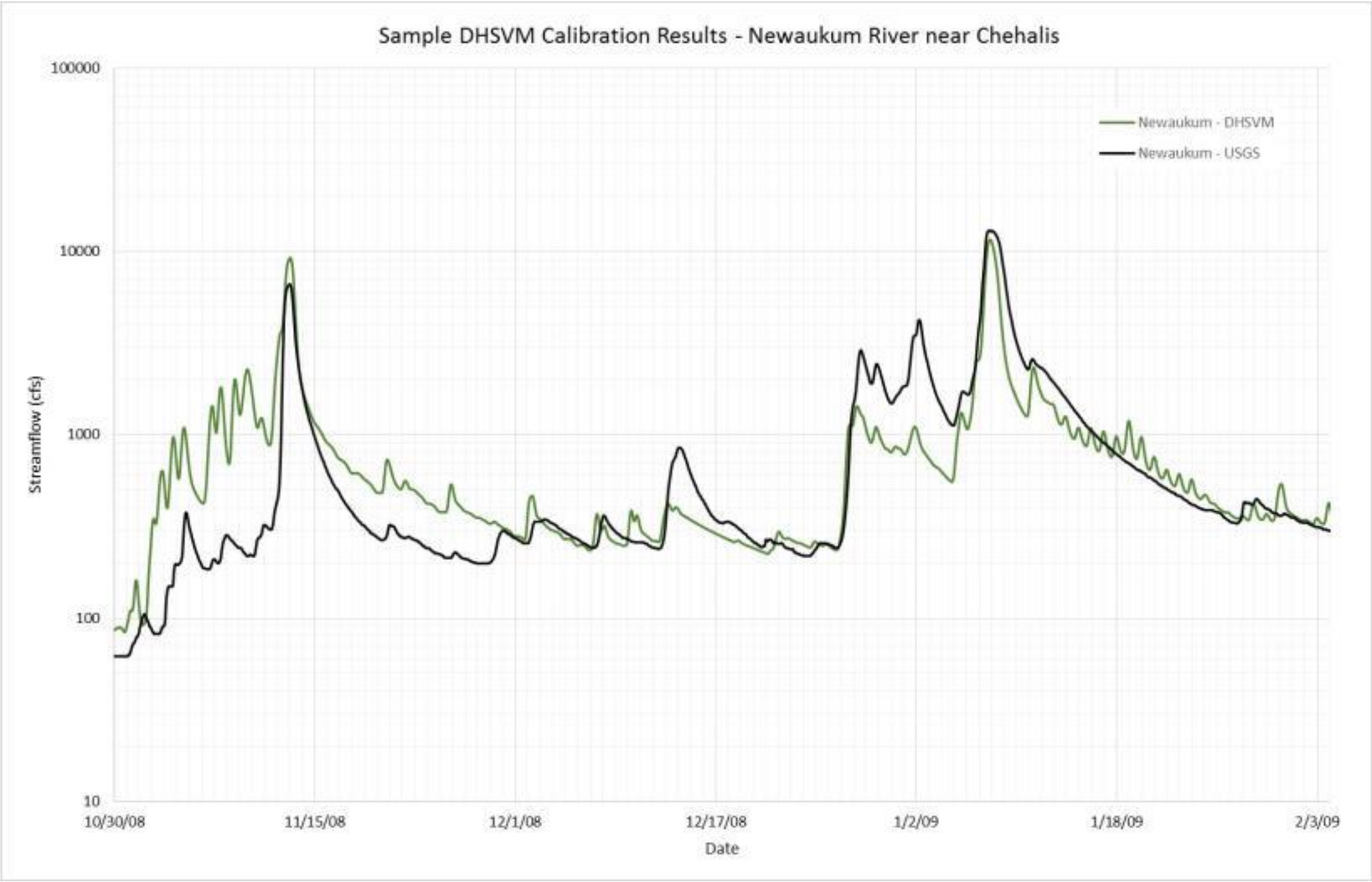
USGS GAGE NAME	GAGE NUMBER	BASIN AREA	PERIOD OF RECORD
Chehalis River near Doty	12020000	113 mi^2	1939-2018
Newaukum River near Chehalis	12025000	155 mi^2	1929-2018
Satsop River near Satsop	12035000	299 mi^2	1929-2018
Chehalis River near Grand Mound	12027500	895 mi^2	1928-2018
Chehalis River at Porter	12031000	1294 mi^2	1952-2018

- Key Parameters
  - Daily Runoff
  - Annual and Seasonal Runoff Volumes
  - Extreme Storm Event Performance (peaks and volumes)
- USGS Gages
  - Chehalis River (Doty, Grand Mound, Porter)
  - Newaukum (near Chehalis)
  - Satsop
- Detailed calibration period (WY 2006 - 2009)
- Extended data set (1980 – 2015) for flow frequency calibration

Calibration Results



Calibration Results



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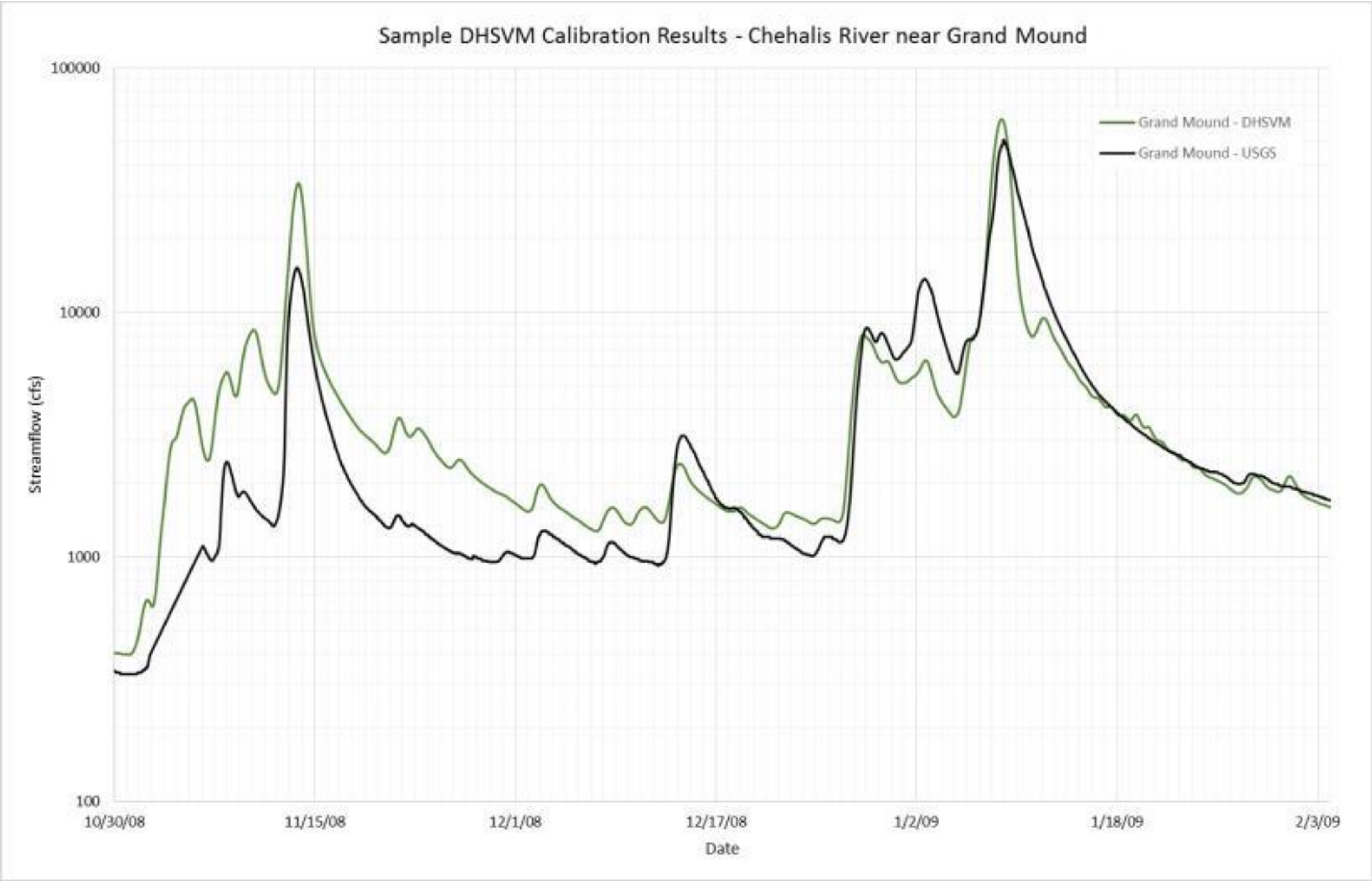

Calibration Summary

- Calibration considered acceptable for comparative analyses (evaluation of climate change and flood reduction projects)
- Many alternative model parameter sets tested but none showed better results
- Precipitation data improvements could improve confidence
- Model calibration summary presented to and accepted by Ecology

Hydrologic Model Application

- Modeling to Evaluate Climate Change Impacts
  - RCP 4.5 (low end)
  - RCP 8.5 (high end)
  - Currently only one GCM run available for each RCP
  - Potential future work could use 3 to 5 additional GCM runs for RCP 8.5 (from ongoing UW work)

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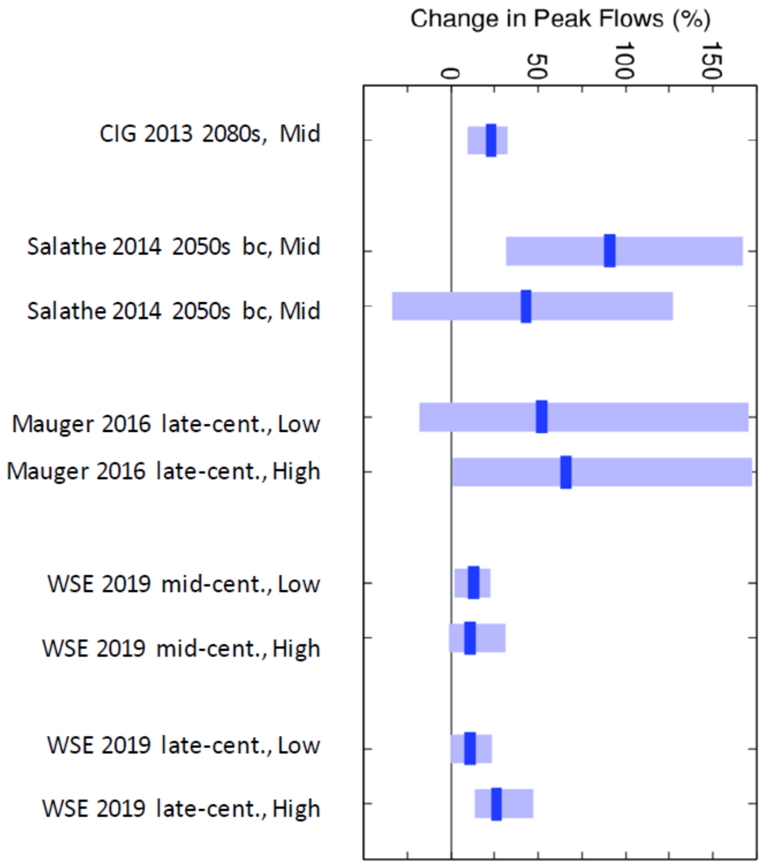
Comparison To Previous Studies



Change in Climate Change Predictions Over Time

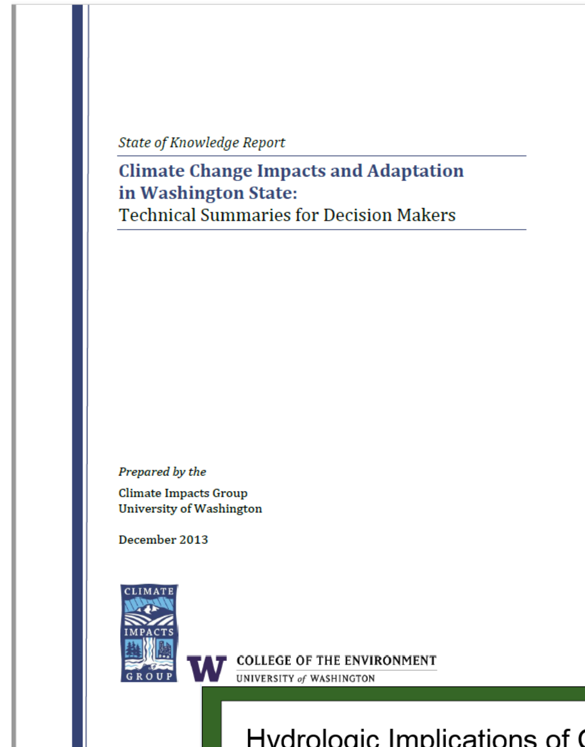
Graphic shows stated estimate (dark line) and range (light area) for estimated increase in peak flows from various studies of the Chehalis River Basin

Previous Study - 2014

Review of Climate Change Literature (WSE, 2014)

Work performed: Reviewed available climate change information related to Chehalis Basin hydrology.

Key Findings: UW CIG region-wide report indicated potential for 18% increase in peak flows. Evolving work at the UW using dynamic downscaling indicated this could be as high as 90% increase.

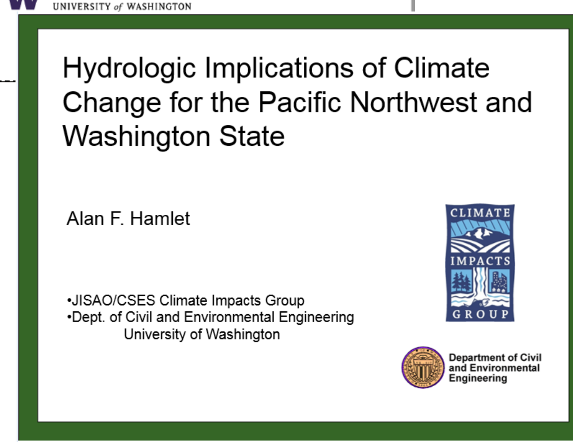


State of Knowledge Report

Climate Change Impacts and Adaptation in Washington State:
Technical Summaries for Decision Makers

Prepared by the
Climate Impacts Group
University of Washington

December 2013



Hydrologic Implications of Climate Change for the Pacific Northwest and Washington State

Alan F. Hamlet

•JISAO/CSES Climate Impacts Group
•Dept. of Civil and Environmental Engineering
University of Washington

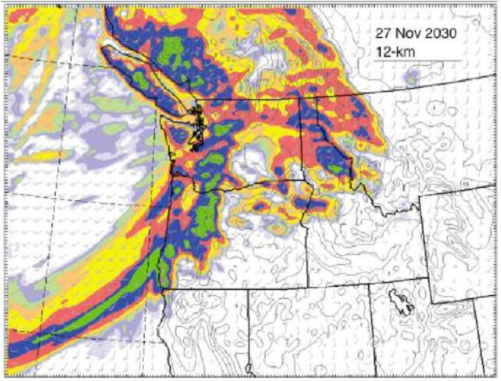
Previous Study - 2016

Climate Change Simulations and Analysis (UW CIG, 2016)

Work performed: Conducted preliminary hydrologic model study (DHSVM and VIC) specific to Chehalis basin.

Key Findings: Found wide range in results depending on Global Climate Model (GCM), downscaling approach, hydrologic model, and representative concentration pathway (RCP). Average increase in 100-year flow 66% from all models, VIC simulations.

Effect of Climate Change on the Hydrology of the Chehalis Basin



Future storm projected by the regional climate model used in this study *(Source: Eric Salathé)*

Prepared by

Guillaume Mauger, Se-Yeun Lee, Christina Bandaragoda, Yolande Serra, and Jason Won.
Climate Impacts Group, University of Washington

July 8, 2016

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Current Study - 2019

DHSVM Modeling including Climate Change Simulations (WSE, 2019)

Work performed: Developed and calibrated hydrologic model for the entire Chehalis River Basin. Evaluated climate change projections for two GCMs/RCPs.

Key Findings: Model difficult to calibrate due to lack of quality rainfall data. Still useful for comparative evaluations. Estimated increase in peak flows due to climate change is 12% to 26%.

MEMORANDUM

Date: February 28, 2019

To: Bob Montgomery, Anchor QEA

From: Larry Karpack, P.E. and Colin Butler, EIT, WSE

Re: Chehalis River Basin Hydrologic Modeling

1.0 Introduction

This technical memorandum summarizes work performed by Watershed Science and Engineering (WSE) to develop and calibrate a hydrologic model of the Chehalis River Basin. The model extends from the headwaters of the Chehalis River upstream of Pe Ell to the mouth of the river at Grays Harbor including all tributaries to the Chehalis River. The model also includes other river basins which drain directly to Grays Harbor, including the Wishkah, Hoquiam, and Humptulips River basins. Together, the area covered by the hydrologic model comprises Water Resource Inventory Areas (WRIAs) 22 and 23 (DOE, 2018). Figure 1 shows the aerial extent of the hydrologic model.

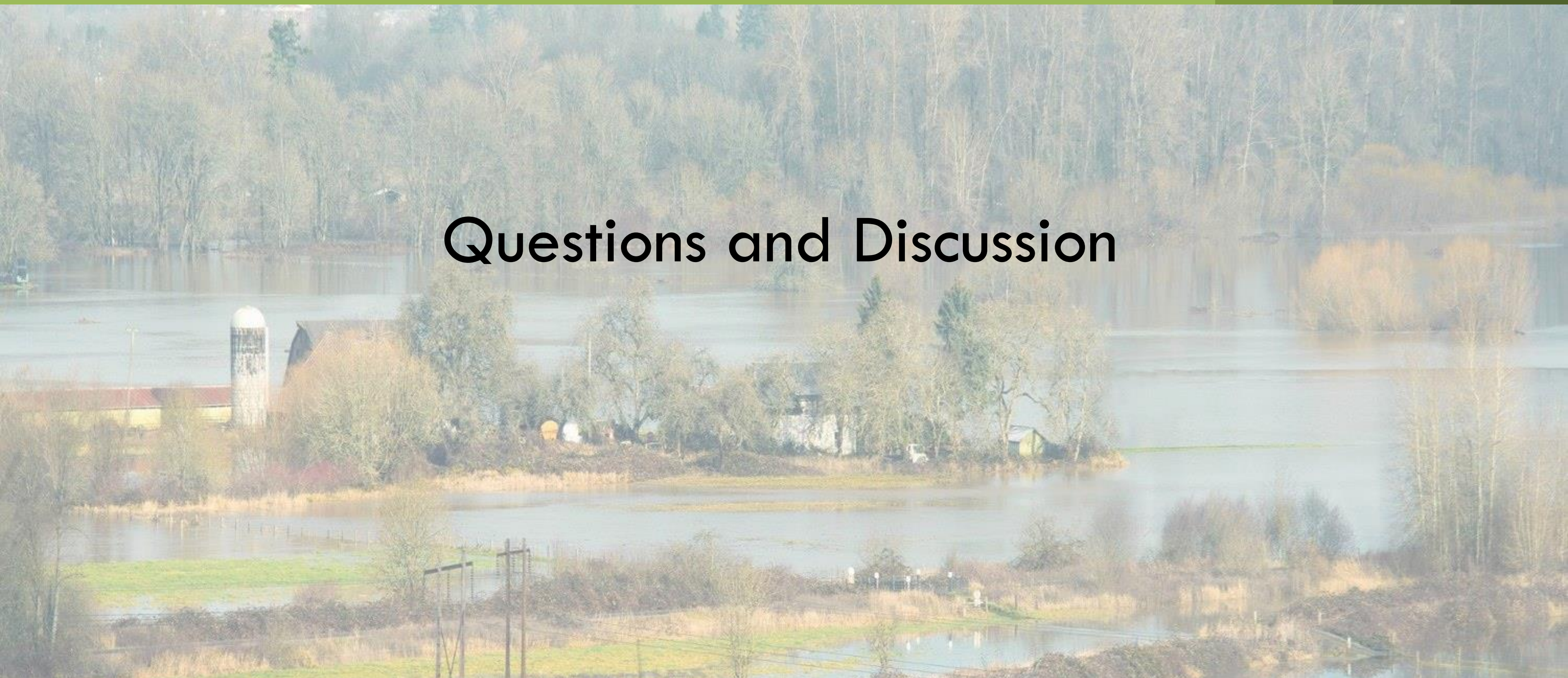
The Chehalis River Basin hydrologic model was configured using the Distributed Hydrologic Soil Vegetation Model (DHSVM) software (Wigmosta et al, 1994). DHSVM is a gridded, physically based, distributed parameter model that provides an integrated representation of watershed processes at a user defined spatial resolution. Key data inputs to the DHSVM model include topographic, soils, land cover, and meteorological data. Development of the DHSVM model is described below in Section 3.

Meteorological inputs for the hydrologic model were provided by the University of Washington's Climate Impacts Group (CIG) and include a physically based historical data set spanning January 1981 through December 2015, as well as two long term historical/future data sets based on Global Climate Model (GCM) predictions. The meteorological data sets used in this study are described in Section 4.

The hydrologic model was calibrated and verified by comparing simulated flows against data from five USGS stream gaging stations in the basin, depicted in Figure 1 and listed in Table 1. Collectively these gages cover approximately 70% of the model domain. Preliminary calibration was conducted using an automated model parameter optimization routine to best match daily observed flows at these gaging stations for October 2006 through September 2009. Long term runs of the model were then completed and peak annual flow data for 1981 through 2015 were extracted and compared to USGS observed peak flows. Additional adjustments to model inputs were made to best match observed flows at each of the gage locations. The model calibration process and results are fully described in Section 5. The calibrated DHSVM model was then run using long term meteorological data sets to provide data for evaluation of potential climate change impacts on Chehalis River basin hydrology. This evaluation is described in Section 6.

Chehalis Basin Strategy: Reducing Flood Damage and Restoring Aquatic Species Habitat 1

Questions and Discussion



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