CLIMATE CHANGE IMPACTS AND ADAPTATION PILOT STUDY

HOWARD HANSON DAM

Green River, Washington

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Seattle District

10 September 2014

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US Army Corps of Engineers

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Climate Change & USACE

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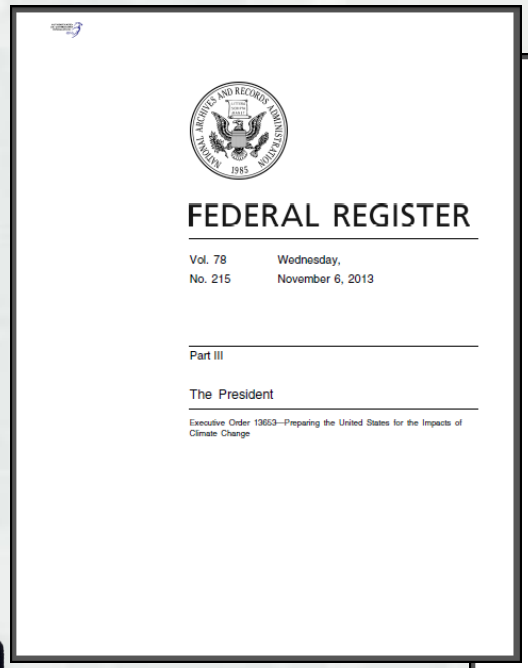

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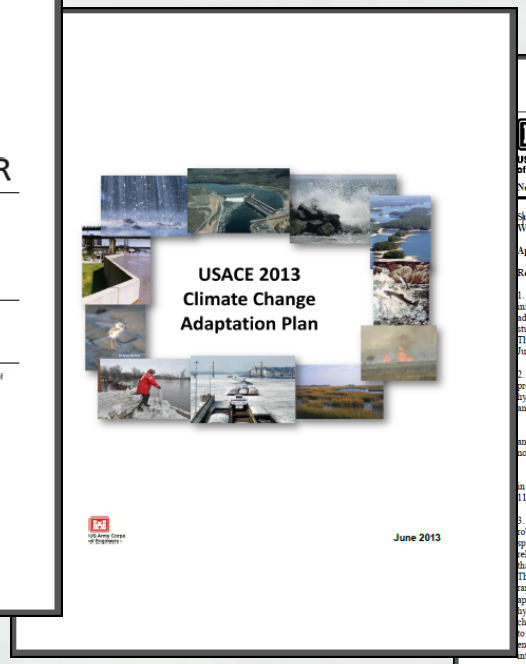
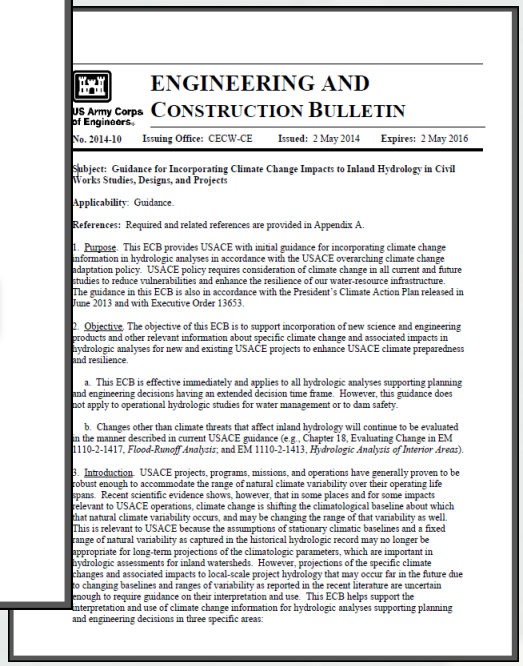
Part III

The President

Executive Order 13653—Preparing the United States for the Impacts of Climate Change





US Army Corps of Engineers

ENGINEERING AND CONSTRUCTION BULLETIN

No. 2014-10 **Issuing Office:** CECW-CE **Issued:** 2 May 2014 **Expires:** 2 May 2016

Subject: Guidance for Incorporating Climate Change Impacts to Inland Hydrology in Civil Works Studies, Designs, and Projects

Applicability: Guidance.

References: Required and related references are provided in Appendix A.

1. Purpose. This ECB provides USACE with initial guidance for incorporating climate change information in hydrologic analyses in accordance with the USACE overarching climate change adaptation policy. USACE policy requires consideration of climate change in all current and future studies to reduce vulnerabilities and enhance the resilience of our water-resource infrastructure. The guidance in this ECB is also in accordance with the President's Climate Action Plan released in June 2013 and with Executive Order 13653.

2. Objective. The objective of this ECB is to support incorporation of new science and engineering products and other relevant information about specific climate change and associated impacts in hydrologic analyses for new and existing USACE projects to enhance USACE climate preparedness and resilience.

a. This ECB is effective immediately and applies to all hydrologic analyses supporting planning and engineering decisions having an extended decision time frame. However, this guidance does not apply to operational hydrologic studies for water management or to dam safety.

b. Changes other than climate threats that affect inland hydrology will continue to be evaluated in the manner described in current USACE guidance (e.g., Chapter 18, Evaluating Change in EM 1110-2-1417, *Flood-Runoff Analysis*; and EM 1110-2-1413, *Hydrologic Analysis of Interior Areas*).

3. Introduction. USACE projects, programs, missions, and operations have generally proven to be robust enough to accommodate the range of natural climate variability over their operating life spans. Recent scientific evidence shows, however, that in some places and for some impacts relevant to USACE operations, climate change is shifting the climatological baseline about which that natural climate variability occurs, and may be changing the range of that variability as well. This is relevant to USACE because the assumptions of stationary climatic baselines and a fixed range of natural variability as captured in the historical hydrologic record may no longer be appropriate for long-term projections of the climatologic parameters, which are important in hydrologic assessments for inland watersheds. However, projections of the specific climate changes and associated impacts to local-scale project hydrology that may occur far in the future due to changing baselines and ranges of variability as reported in the recent literature are uncertain enough to require guidance on their interpretation and use. This ECB helps support the interpretation and use of climate change information for hydrologic analyses supporting planning and engineering decisions in three specific areas:

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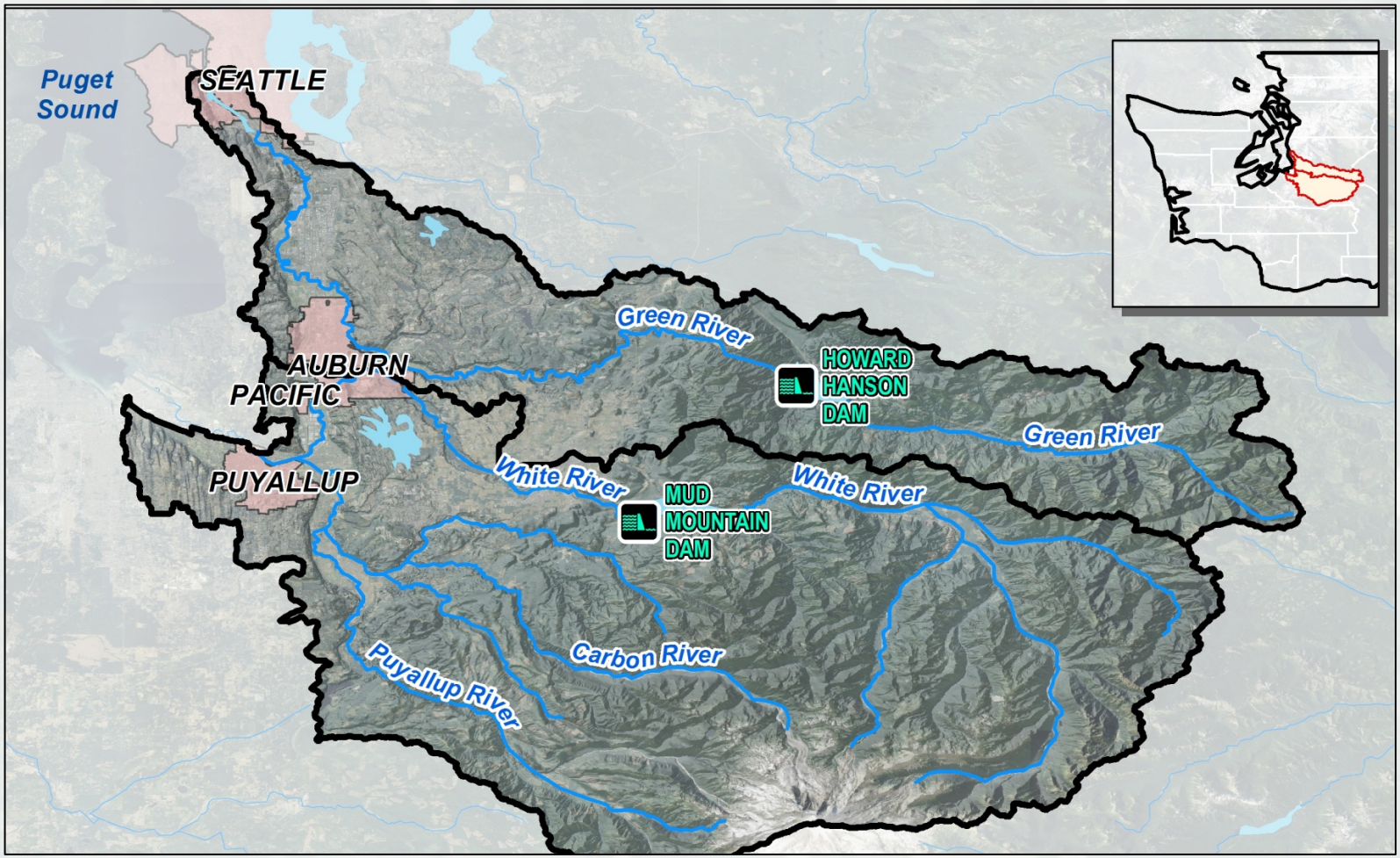

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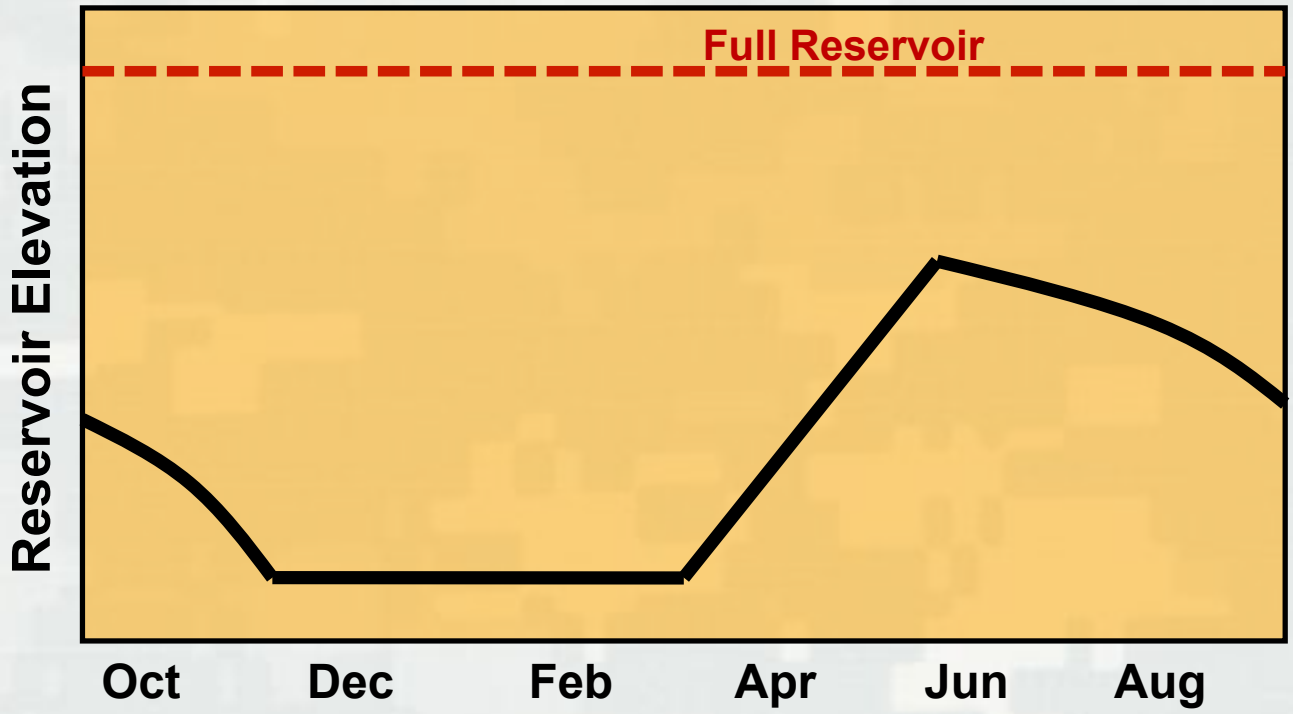
Authorized Purposes

1. Flood Risk Management (October – February)
2. Fisheries Conservation (July – October)
3. Water Supply for City of Tacoma (July – October)



Flooding Mechanisms in W. WA

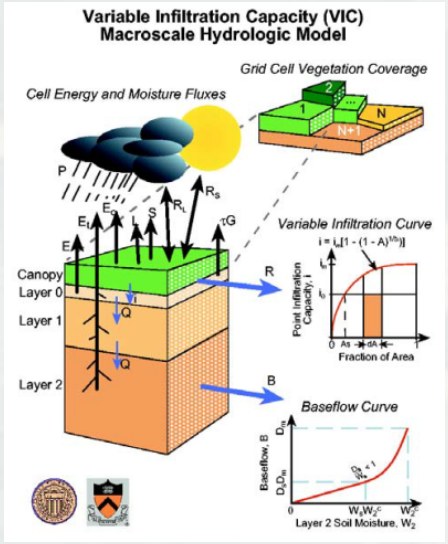
- Virtually all major flooding caused by atmospheric rivers
- Storm orientation is key
- No significant spring snowmelt flooding

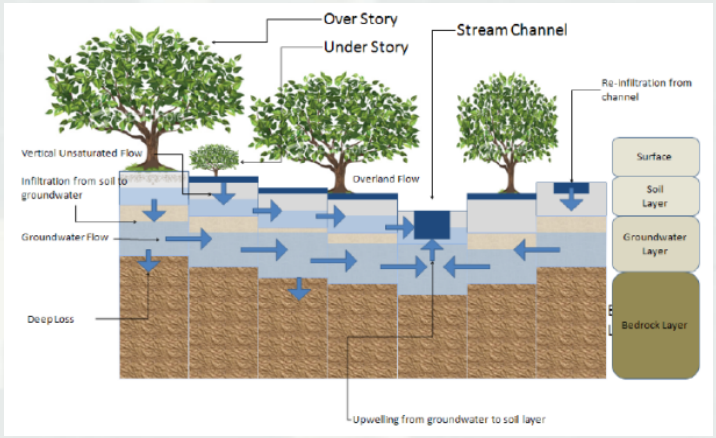
November 1959, Green River *(King County Archives)*

Neiman, P.J., L.J. Schick, F.M. Ralph, M. Hughes, G. A. Wick, 2011, Flooding in western Washington: The connection to atmospheric rivers, *Journal of Hydrometeorology*, 12, 1337-1358.

Hydrologic Modeling

- ECHAM5 A1B GCM dynamically downscaled using the WRF model
- Hydrologic modeling with both the VIC model (macro scale) and the DHSVM (fine-scale)



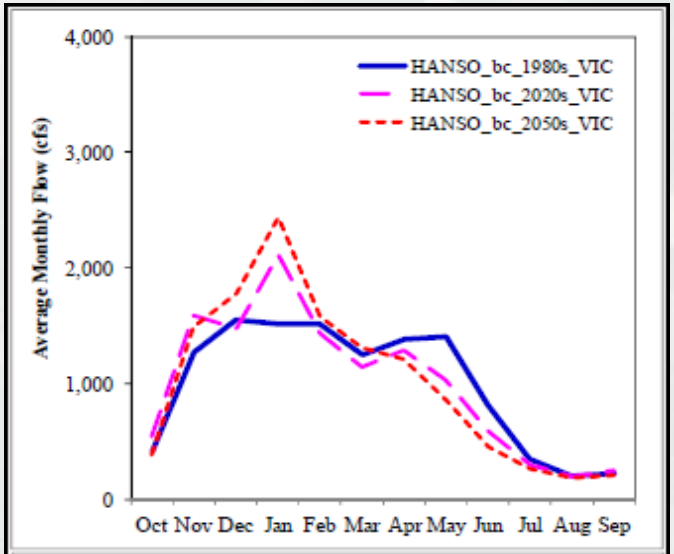


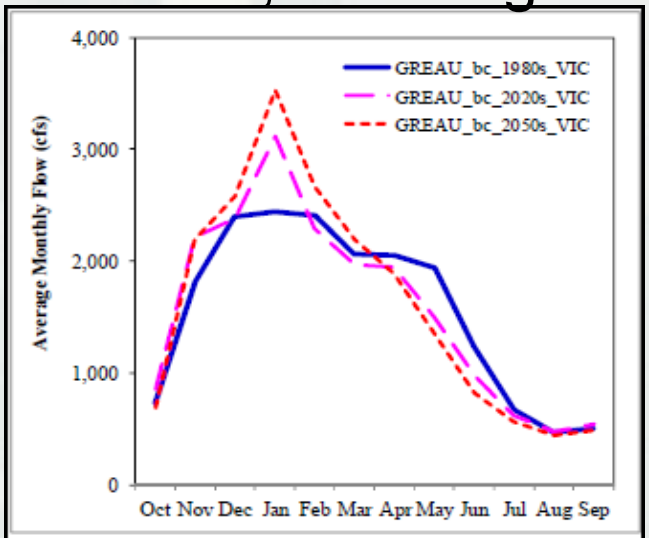
Unregulated Hydrology

Howard Hanson Dam

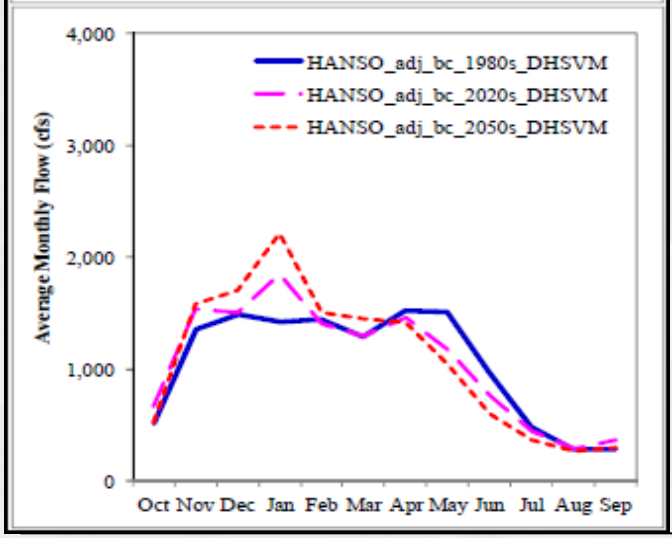
Auburn, Washington

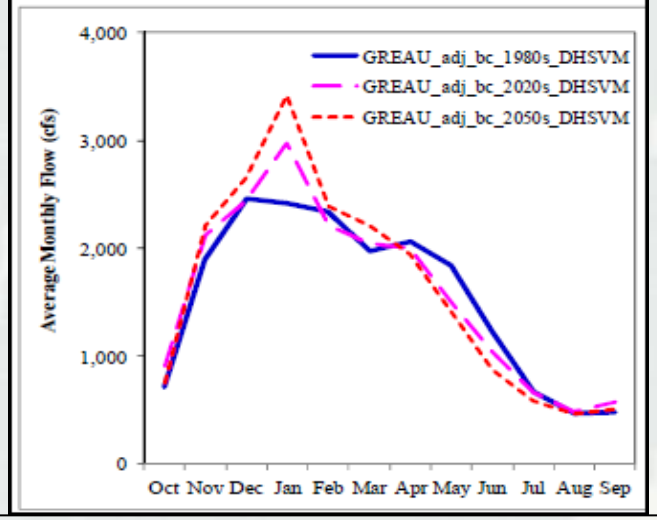
VIC





DHSVM





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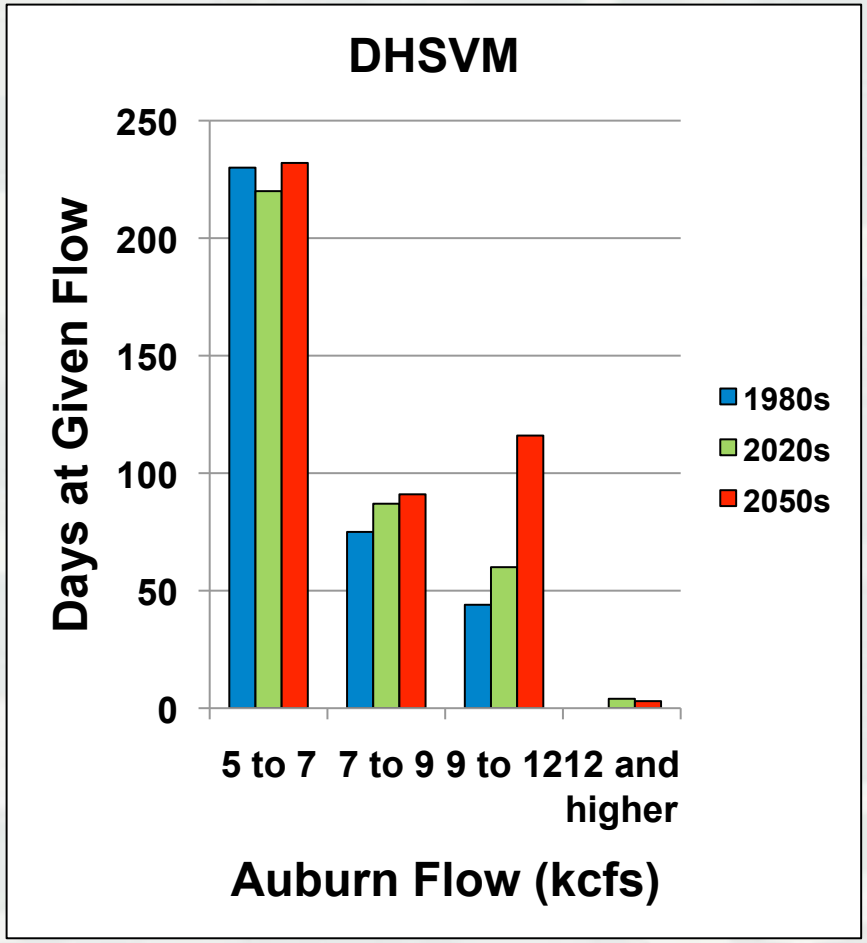
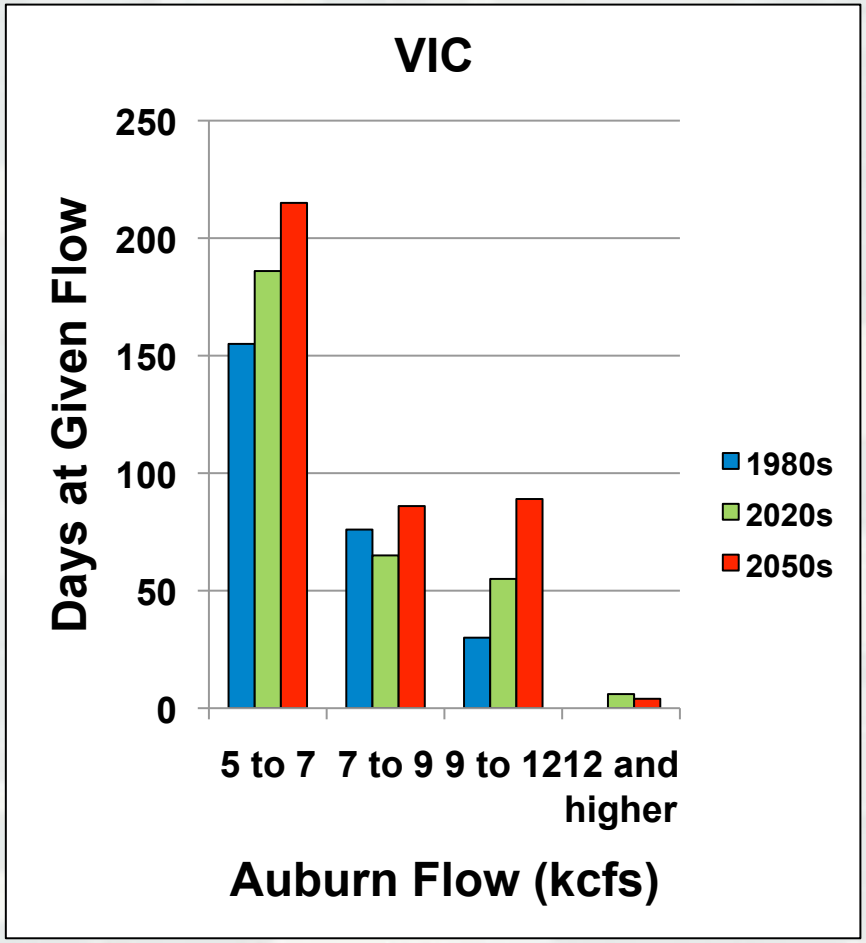
Flooding - Magnitude





Flood Flow = 12 kcfs

Flooding - Timing

Spring

- DHSVM: more March floods
- VIC: no shift

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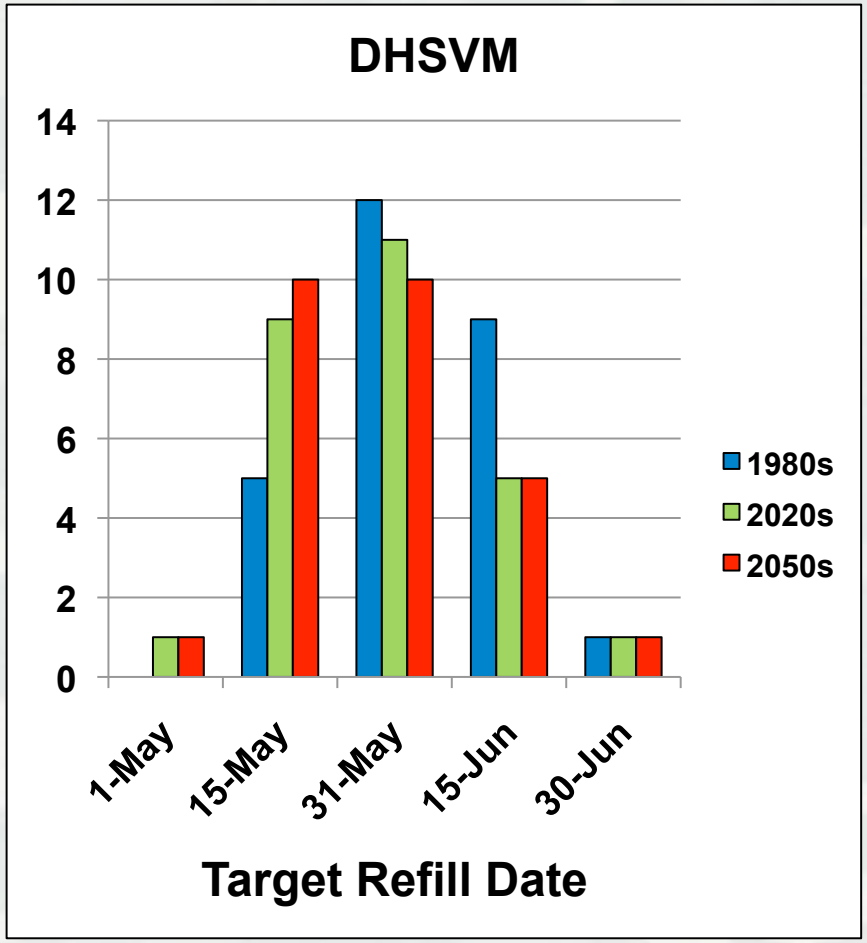
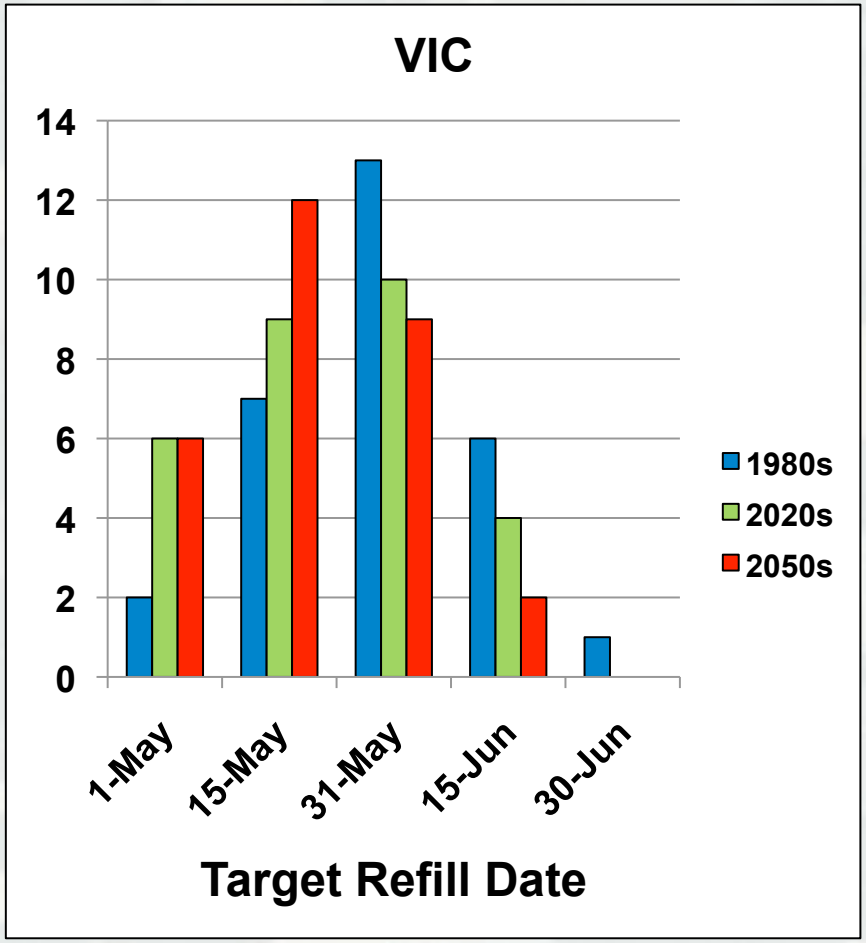
Fall

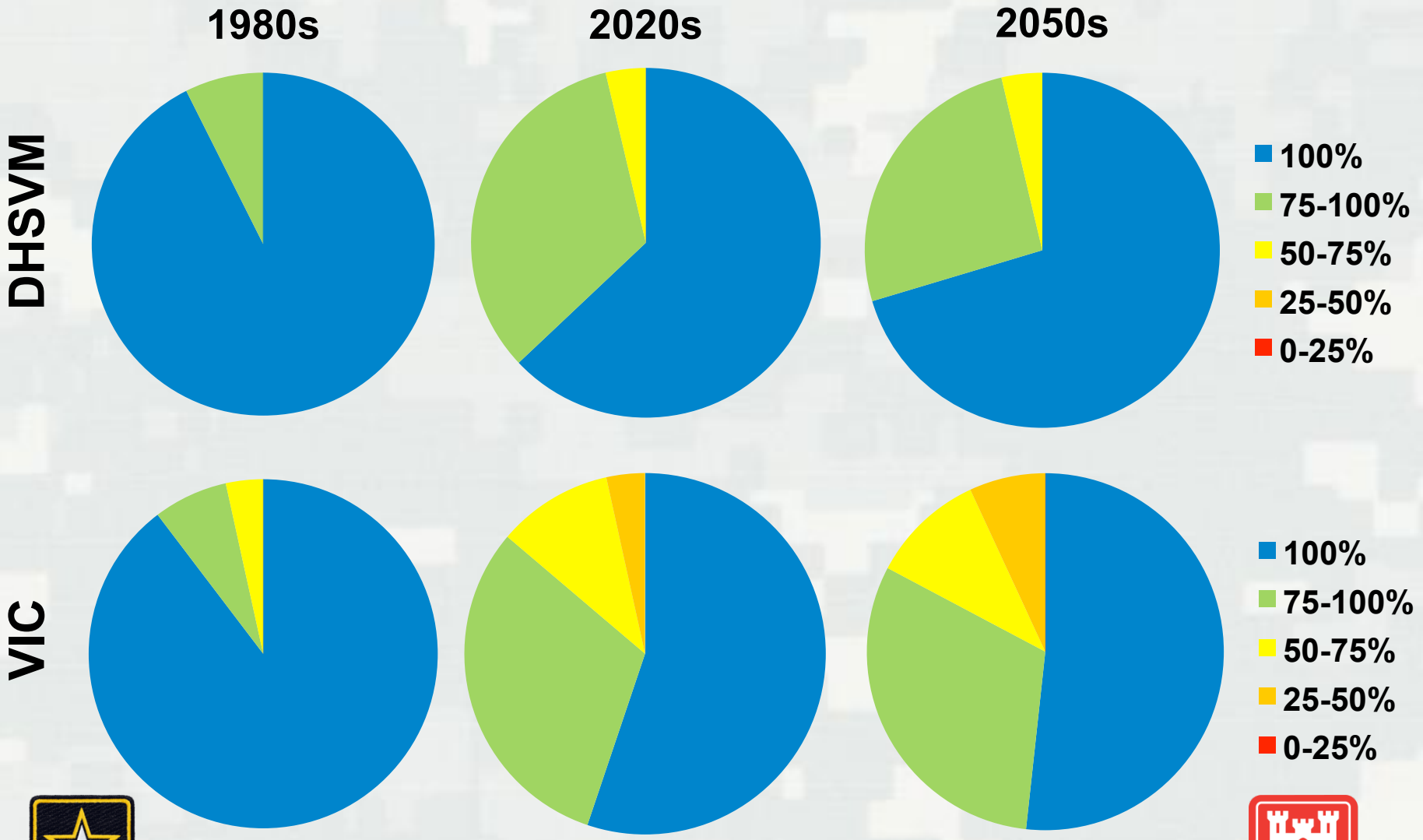
- DHSVM: earlier fall floods
- VIC: more October floods

Refill - Conservation





Refill – M&I



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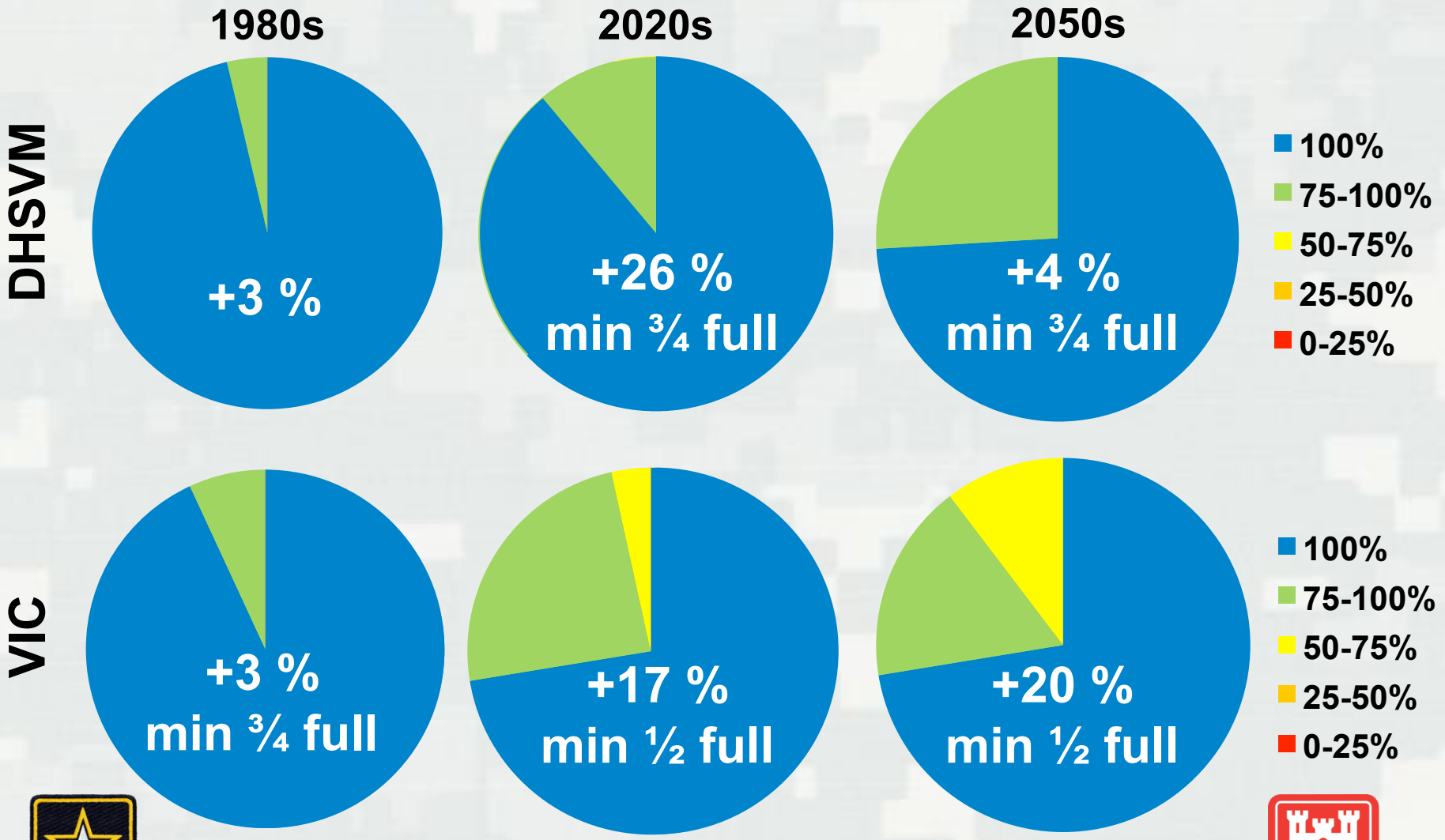
Adapted Refill – M&I



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Summary & Conclusions

- Higher winter flow, lower spring flow
- Resilient, but still wondering about AR changes
- Refill season compressed
- Potential adaptations for further study

Questions?


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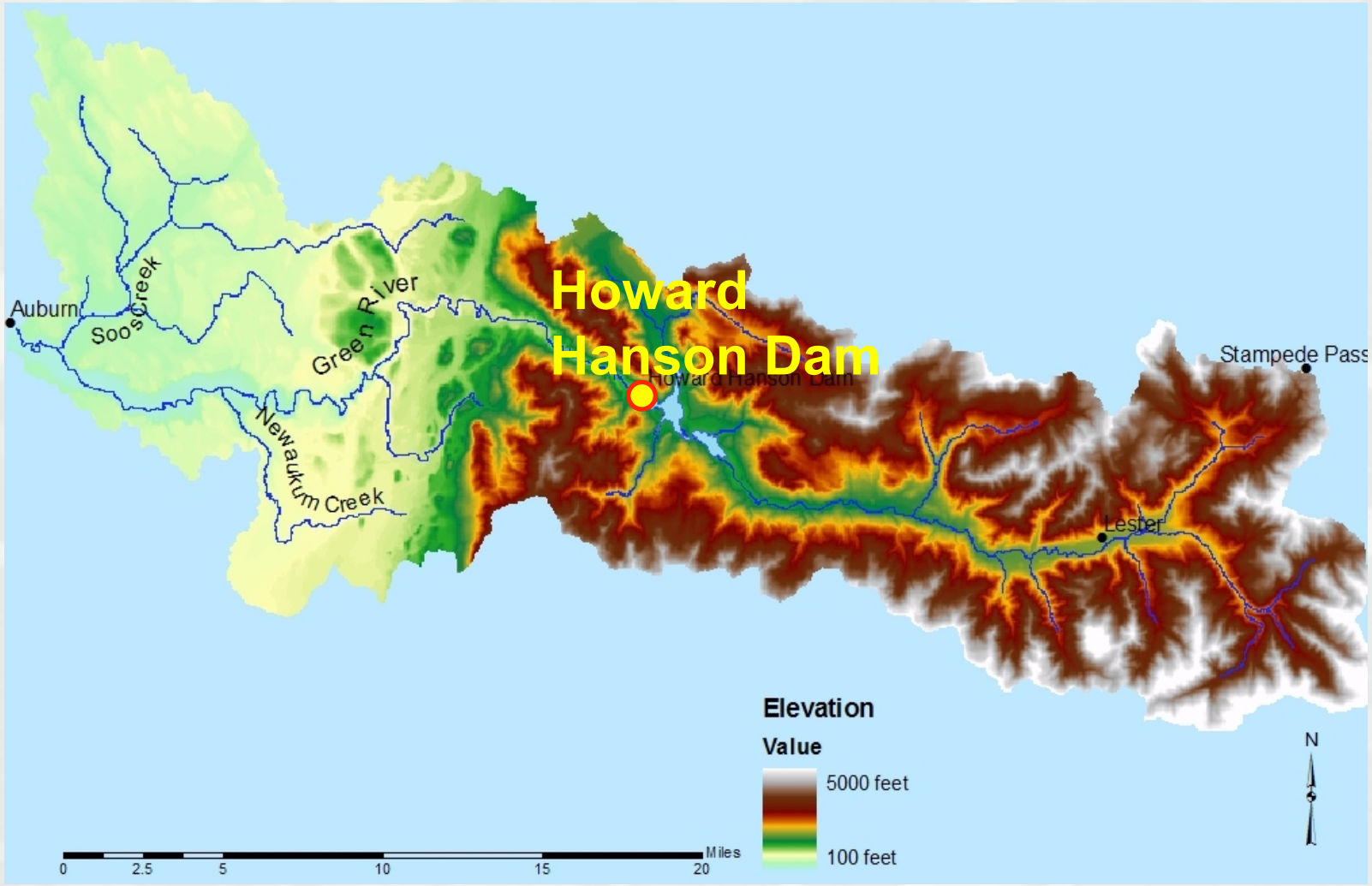
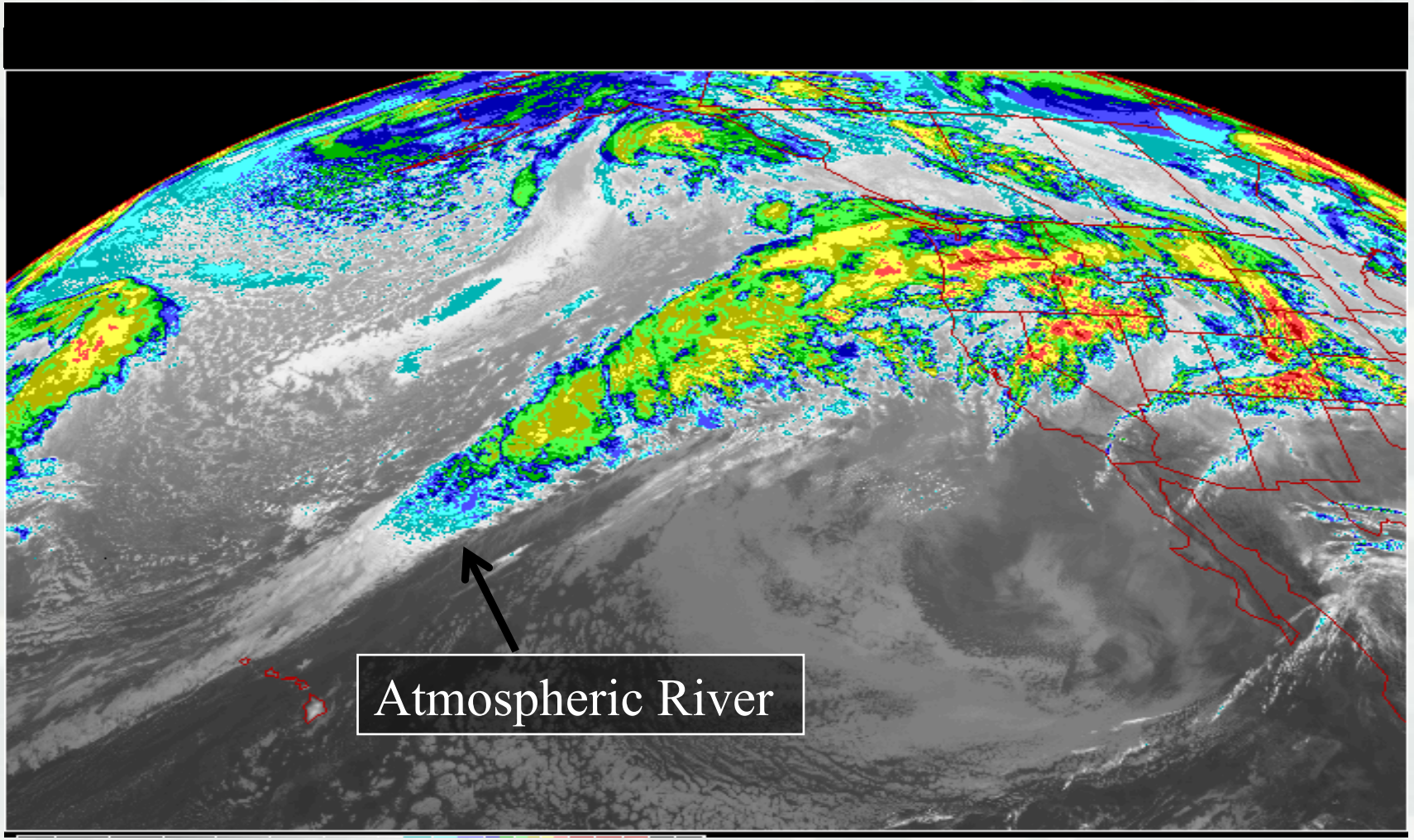
Green River Watershed

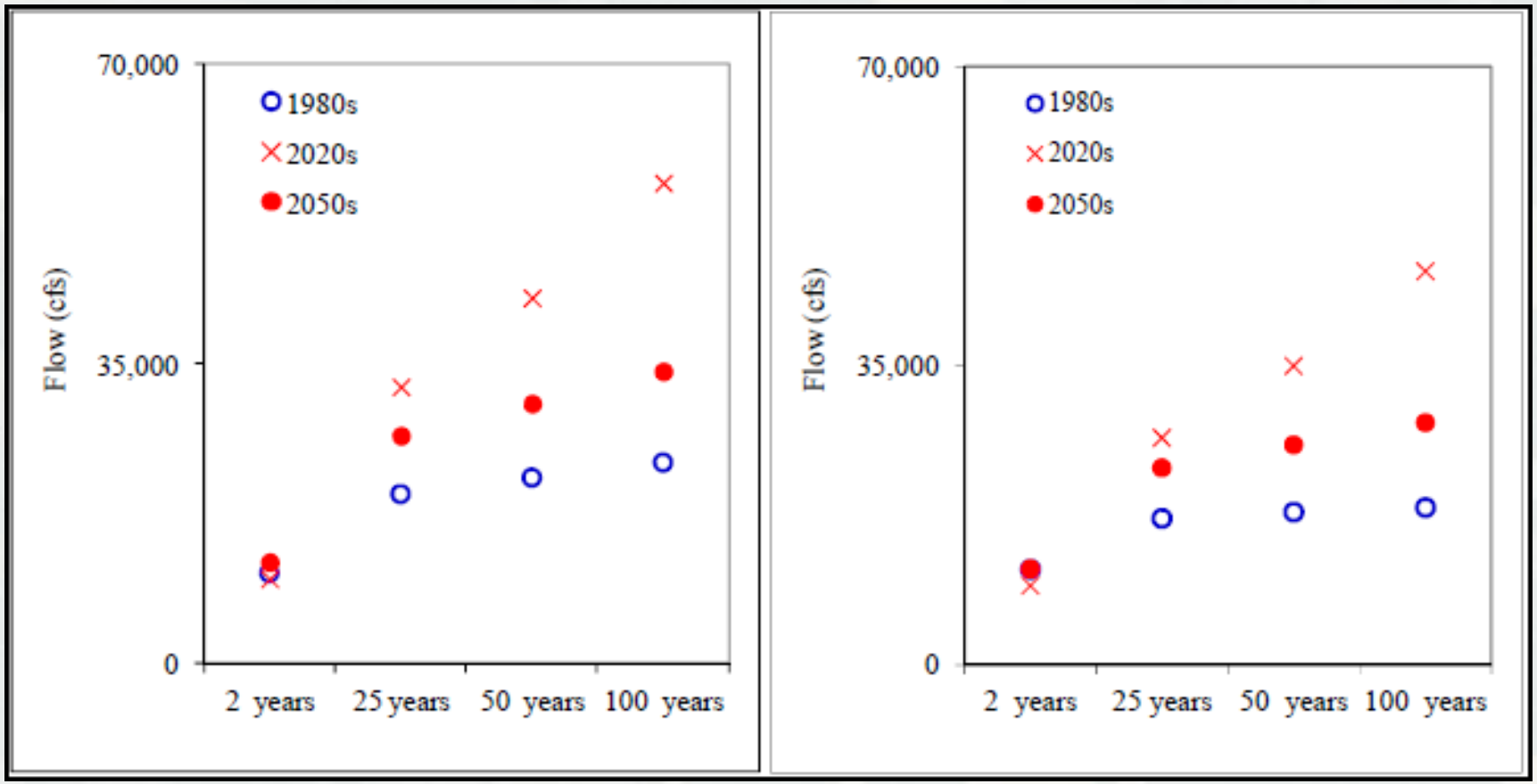


February 1996



Hydrologic Modeling

Flood statistics for Howard Hanson Dam inflow



VIC **DHSVM**

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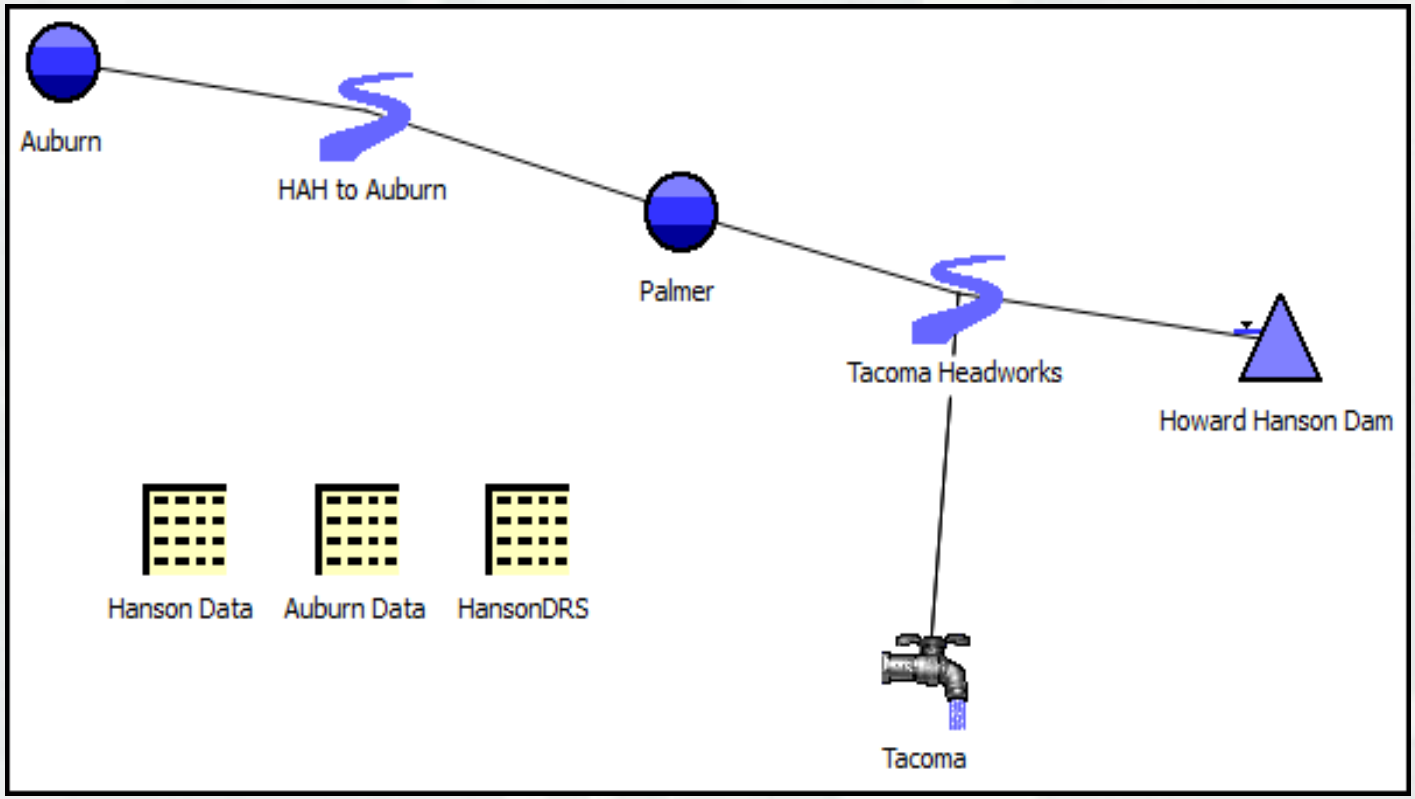
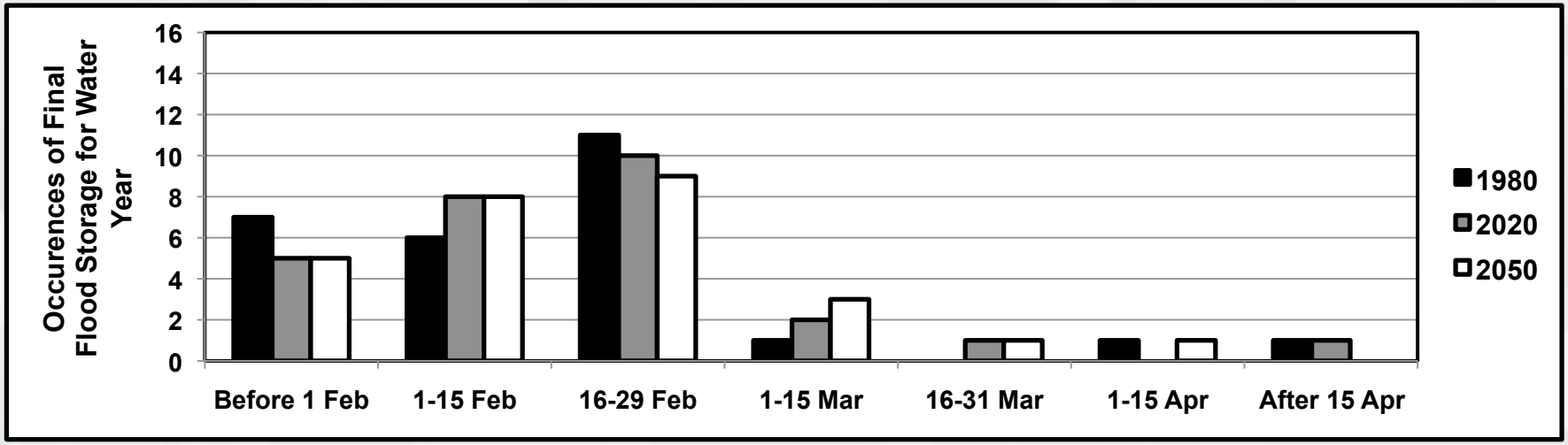
Reservoir Modeling



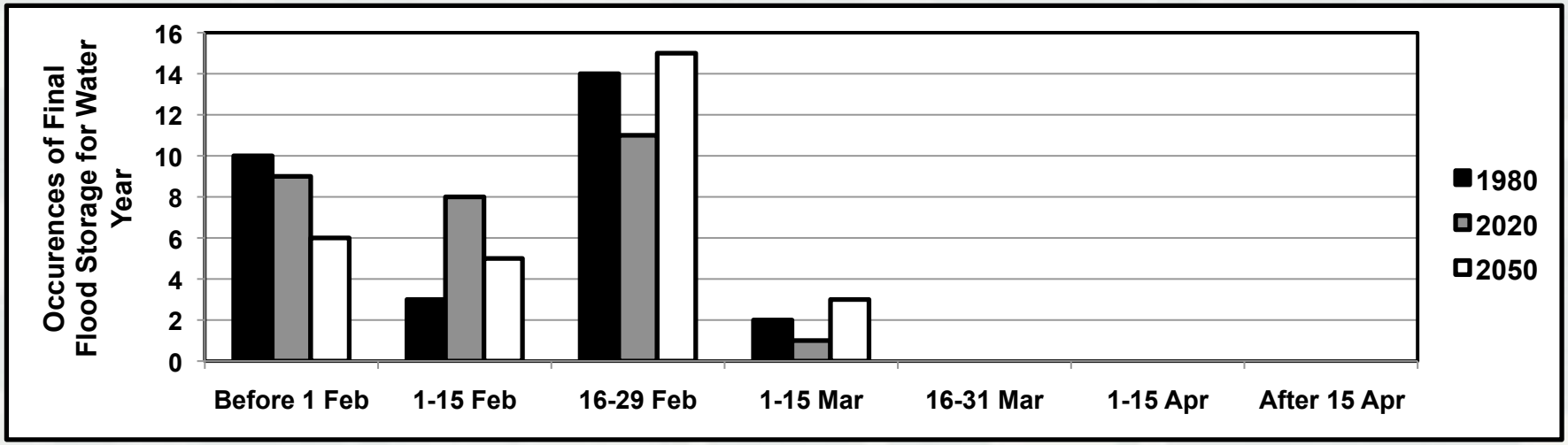
Three analysis categories: flooding, refill, and low flow

Flooding – Spring Timing

DHSVM



VIC



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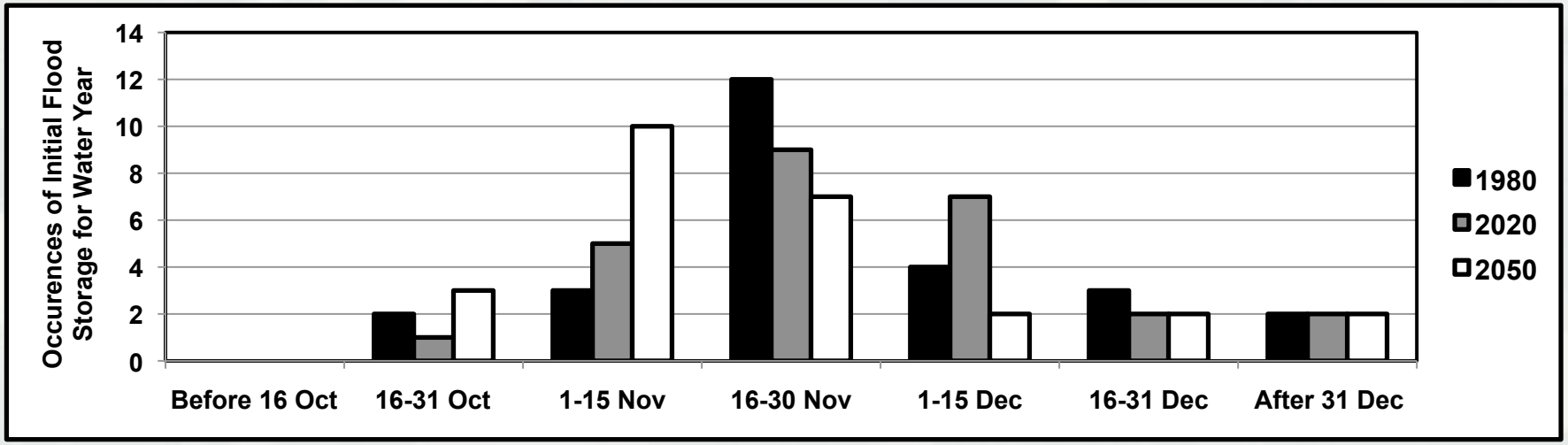
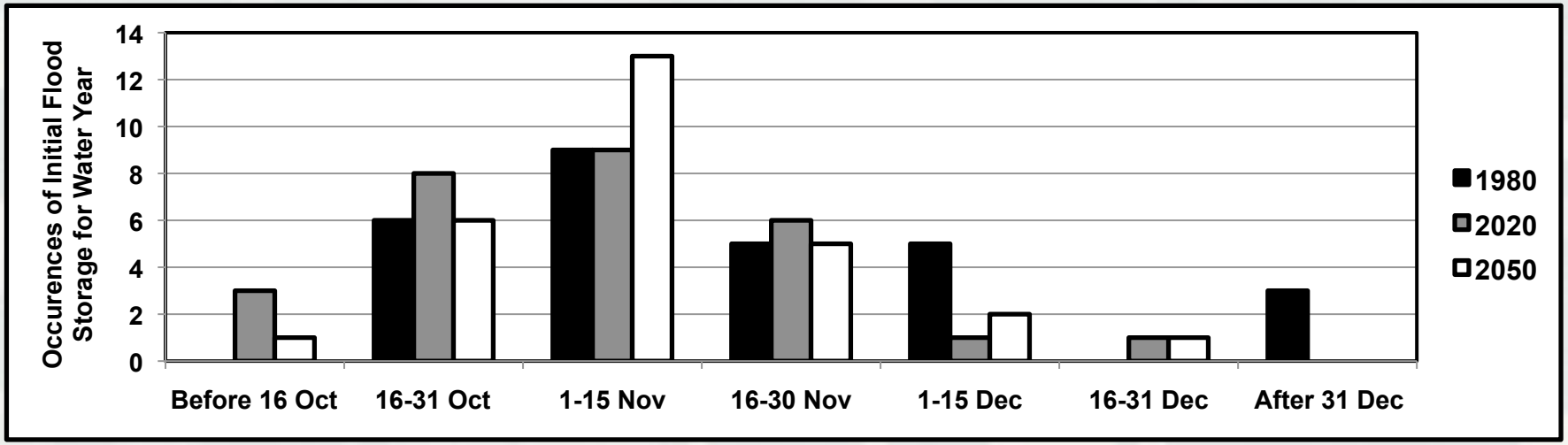
Flooding – Fall Timing

DHSVM



VIC



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Low Flow

- Models struggled with low flow calibration
- Two hydrologic models showed opposite trends:
  - ▶ VIC showed decrease in 7q10 flows
  - ▶ DHSVM showed increase
- In both simulations, the future time periods exhibited an increase in the number of days at minimum flow