Impacts of future changes on groundwater recharge and flow in highly-connected river-aquifer systems: A case study of the Spokane Valley-Rathdrum Prairie Aquifer

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Introduction

The Spokane, Washington-Coeur d'Alene, Idaho Corridor is well-known for its Spokane Valley-Rathdrum Prairie (SVRP) Aquifer which is a sole source of drinking water for more than 500,000 people. The aquifer is highly connected to the Spokane River and responds very fast to natural and human perturbations, making it relatively vulnerable to climate and anthropogenic changes in future decades. Recent studies have indicated a decline in minimum daily flow in the Spokane River in the last 100 years, while projecting an increase in cool-season precipitation into the future.

The purpose of this study is to investigate the potential impacts of these projected future climate-driven hydrologic changes on groundwater recharge and flow in the SVRP Aquifer.

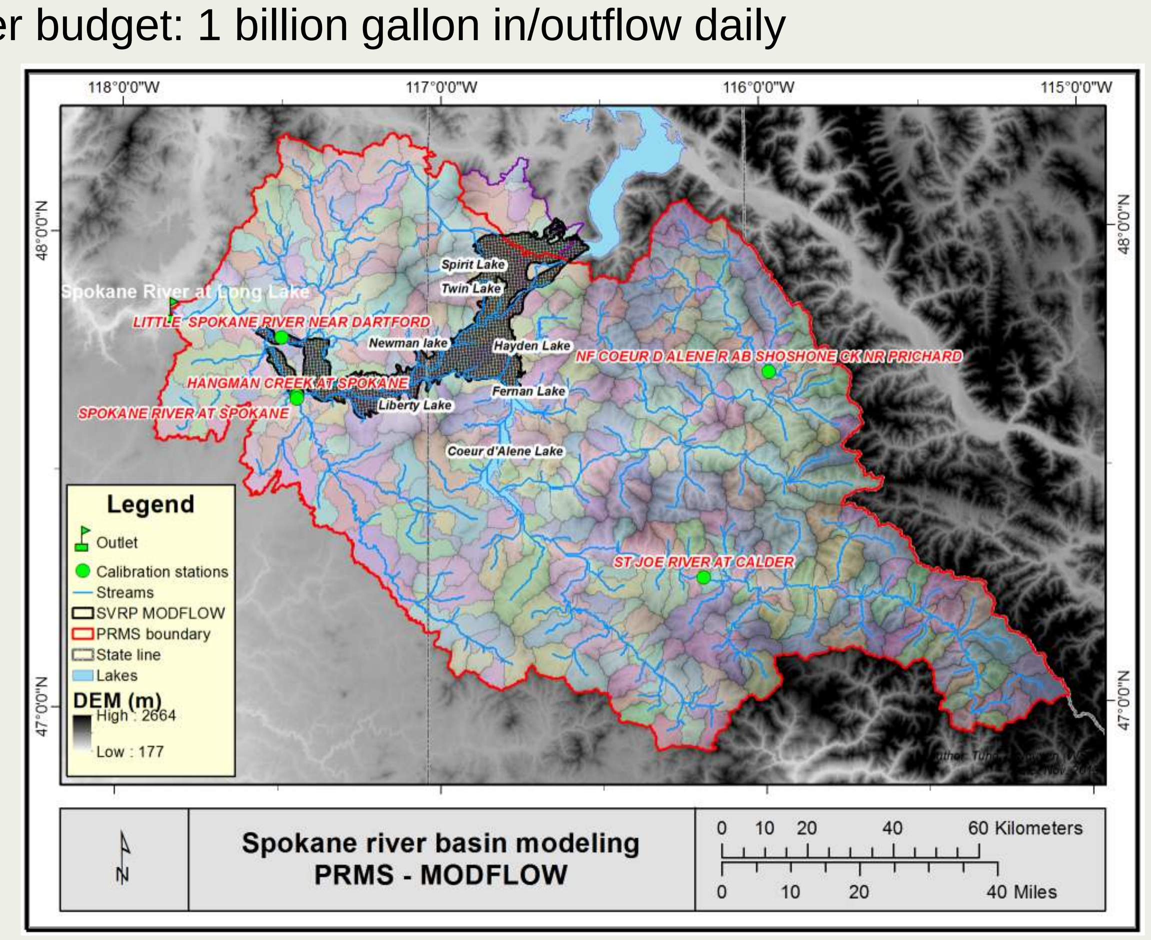
Study area

Spokane River

- Area: 6,020 mi^2 (15,590 km^2)
- Cover: evergreen forest (72.8%), cropland and pasture (18.3%)
- Climate: (P) 35 inches (878 mm) of which 12.6 inches (319mm) is snow (36%), (ET) 35 inches (420 mm)
- Control structures: 7 dams generates hydroelectricity

Spokane Valley-Rathdrum Prairie Aquifer

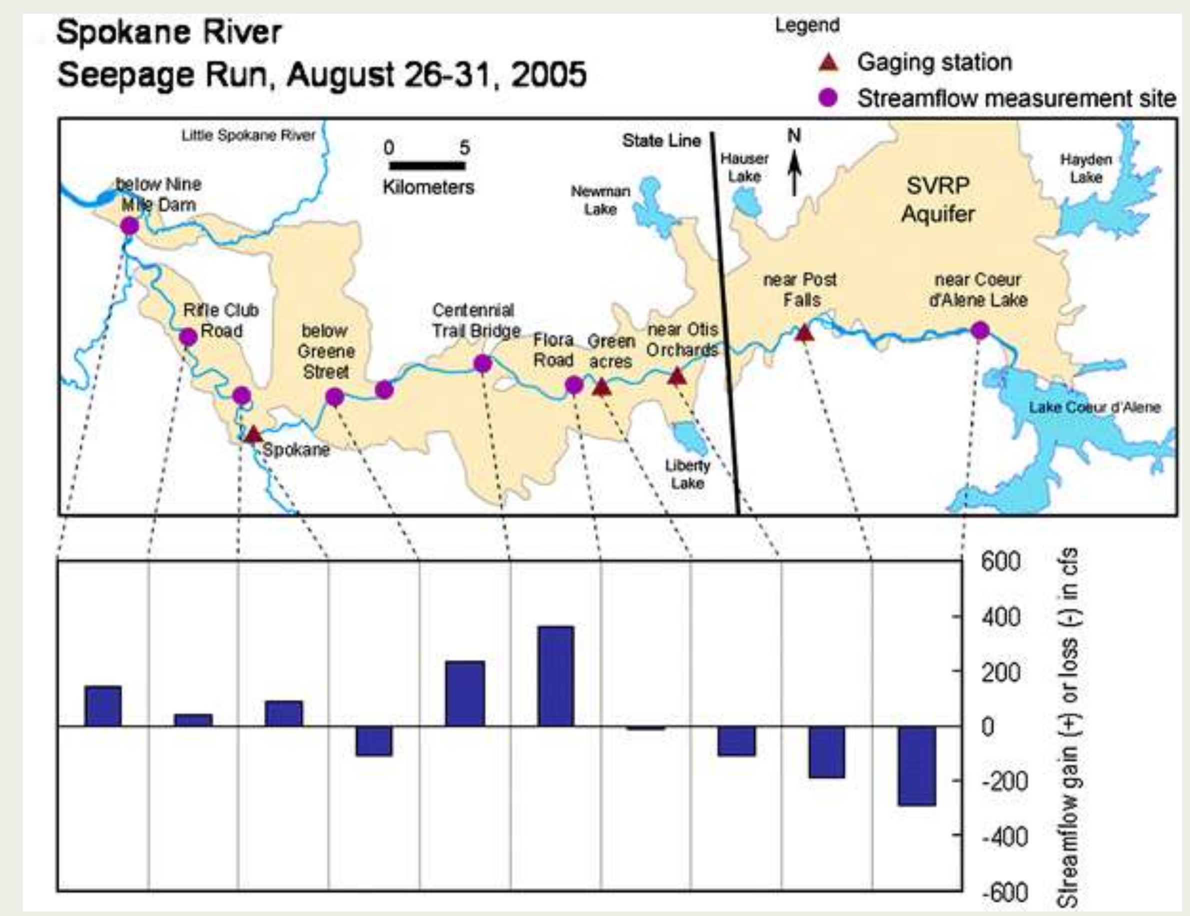
- Area: 370 mi^2 (960 km^2)
- Formation: Unconsolidated coarse-grained sands, gravels, cobbles, and boulders with extremely high hydraulic conductivity (5 ft/d to 22,100 ft/d ~ 1.5 to 6740 m/d)
- Volume: 10 trillion gallons
- Water budget: 1 billion gallon in/outflow daily



River – Aquifer interaction

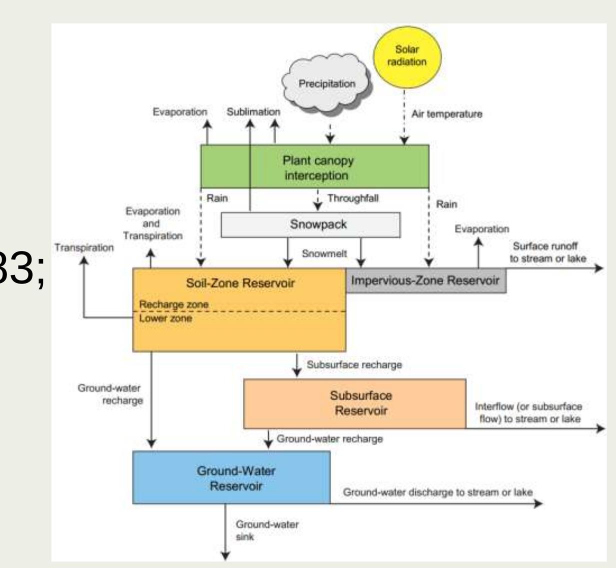
Significant levels of interaction between the SVRP and the Spokane River

- Inflow to SVRP: 49% from Spokane river
- Outflow from SVRP: 58% to Spokane river; 16% to Little Spokane river and 22% human usage



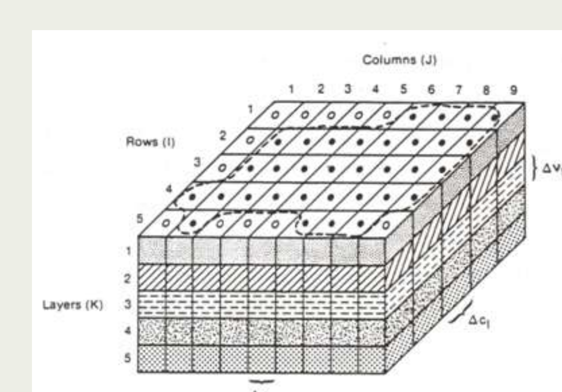
Methodology

Precipitation-Runoff Modeling System (PRMS)



- Deterministic, distributed-parameter, physical-process-based hydrologic modeling system (Leavesley et al., 1983; Markstrom et al., 2008)
- Simulate land-surface hydrologic processes and hydrologic water budgets at the watershed scale with temporal scales ranging from days to centuries

MODFLOW



- Three-dimensional finite-difference groundwater model (McDonald and Harbaugh, 1984)
- Able to simulate various types of groundwater systems and becomes worldwide standard groundwater model

Surface-Water Routing (SWR1) Process

- Taking into account management of surface water using control structures
- Account for backwater effects

Expected results

A coupled version of the PRMS model and MODLFOW which is capable of represent the dynamics of the highly-connected Spoken River – SVRP aquifer. The model is calibrated and validated at a daily time-step using 16 years of both observed streamflow and observed well data (1990 – 2005)

Projected change of groundwater recharge and flow in the SVRP groundwater using statistically downscaled climate projections of temperature and precipitation between 2010 and 2050 from four general circulation models

The relative sensitivities of groundwater recharge and flow with respect to changes in climate and land cover are also examined. These results can be used as good references for long term water resources management and planning in the region

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