1. **Data Set Title**: Willamette Envision Code Version 331 and Related Input Files

2. **Abstract**:
Computer code and related input files developed by the Willamette Water 2100 project, a project that explored how climate change, population growth, and economic growth will alter water availability and use in the Willamette River Basin, USA. The model is based on Envision, a modeling framework developed at Oregon State University (J. Bolte and colleagues; http://envision.bioe.orst.edu/). Willamette Envision is a whole watershed model, i.e. it attempts to represent all the significant processes related to the supply and fate of water in the entire basin. These processes are both natural (e.g. precip, snow dynamics, infiltration, runoff, evapotranspiration) and human (e.g. reservoir operations, irrigation, municipal water use, crop choice). The model takes exogenous projections of climate, population, and income as its drivers. It operates by simulating the processes across the entire basin for one timestep, recording the effects on the landscape, and then advancing to the next timestep. Some processes are modeled at a daily timestep, for example streamflow and evapotranspiration, while others are modeled at an annual timestep, such as population growth and urban expansion. The model code consists of several hundred thousand lines of C++ code and runs as a 64-bit Windows application. Data are stored in ESRI shapefiles representing the stream network and attributed polygons representing landscape characteristics. The code and input files archived here were used to generate WW2100 3.0 model output and is code version 331 from the WW2100svn repository (https://freshwater.ceoas.oregonstate.edu:8443/svn/WW2100svn).

3. **Recommended data citation**:
Willamette Water 2100 Project Team. 2016. Willamette Envision Code Version 331 and Related Input Files. Oregon Hydrologic Information Server.

4. **Data Contact person:**
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5. **Related publications**
http://inr.oregonstate.edu/ww2100/publications

6. **Methods**:
Willamette Envision is a whole watershed model, i.e. it attempts to represent all the significant processes related to the supply and fate of water in the entire basin. These processes are both natural (e.g. precipitation, snow dynamics, infiltration, runoff, evapotranspiration) and human (e.g. reservoir operations, irrigation, municipal water use, crop choice). The model takes exogenous projections of climate, population, and income as its drivers. It operates by simulating the processes across the entire basin for one

timestep, recording the effects on the landscape, and then advancing to the next timestep. Some processes are modeled at a daily timestep, for example streamflow and evapotranspiration, while others are modeled at an annual timestep, such as population growth and urban expansion.

Willamette Envision is made up of sub-models called “plug-ins” that share data with each other via a spatial database as they run. The spatial database stores information about the landscape in map polygons called integrated decision units (IDUs) and a line network representing the river system.

WW2100 executable code consists of one application file (envision.exe) and a collection of dynamically loaded library files which implement subroutines and plug-ins which take two forms: autonomous processes which run at an annual timestep, and global methods which run at a daily timestep. Below is a list of the .dlls and the autonomous processes (APs) and global methods which they implement. Autonomous processes are specified in AltWW2100.xml and global methods are specified in AltHBV_minimum.xml. AP numbers given below are the numbers in the “id” fields in AltWW2100.envx; they are not consecutive, and do not affect the order in which the APs run.

DynamicVeg.dll
- DynamicVeg (AP 0)
- DisturbanceHandler (AP 1)
- TimeInAgeClass (AP 2)

Flow.dll
- Flow (AP 60) (.csv file prefixes “FLOW” from C++ code and “HBV” from .xml specs)
- EvapTrans (global method)
- Urban_Water_Demand (global method)
- ALTWM (global method) (.csv file prefix “ALTWM”)

HBV.dll
- HBV (global method)

Libs.dll (contains many subroutines called from the other .dlls and from envision.exe)

Modeler.dll
- ResetIrrigation (AP 48)
- ResetFireDisturb (AP 10)
- ResetCCdisturb (AP 11)
- ResetHarvestDISTURB (AP 12)
- PVTdisturb (AP 29)

Reporter.dll
- EconAndDisturbanceReport (AP 100) (.csv file prefix “REP”)

SpatialAllocator.dll
- Wildfire (AP 30) (also implements timber harvest)

WW2100AP.dll (.csv file prefix “ECON”)

ColdStart (AP 5)
GetWeather (AP 15)
PopulationGrowth (AP 82)
IrrigationDecision (AP 50)
CropChoice (AP 51)
UrbanWater (AP 52)
UpdateDGVMvegtype (AP 80)
Farmland Rent (AP 81)
LandUseTransitions (AP 49)
UGA expansion (AP 90)
Fish model (AP 95)

Envision code v330 was used to generate model output called WW2100 3.0. This output can be accessed as tabular, shapefile, binary, and graphical datasets at http://inr.oregonstate.edu/ww2100 . Output is for a total of 22 scenarios, 20 representing future conditions (January 1, 2010 - December 31, 2099) and two representing historical conditions (January 1, 1950 - December 31, 2009). Refer to the scenario table (.pdf) and Willamette Water 2100 web page (http://inr.oregonstate.edu/ww2100/model-overview/scenarios) for a description of each scenario. Every modeled year has exactly 365 days. Input daily climate data was resampled for leap years to reduce 366 days to 365 days. The first resampled day represented all of the original January 1 plus 1/365 of the original January 2. The second resampled day represented 364/365 of the original January 2 plus 2/365 of the original January 3, and so on.

WW2100 3.0 output also includes two historical scenarios that were generated with Willamette Envision code v331. This code differs from v330 in one way: it uses landscape conditions at the end of the first year of the Reference Case scenario (idu_2011.dbf). In the historic scenarios, these processes are turned off:

Population Growth
Update DGVMvegtype
LandUseTransitions
UGA expansion

Turning off those processes has the effect that:

- population doesn't change from year to year
- potential vegetation type doesn't change from year to year in the upland forests; forests will regenerate after a disturbance in accordance with the potential vegetation type in 2010
- land use stays the same as at the end of 2010; modeling polygons (called IDUs) don't transition from agriculture to developed, etc.
- Urban Growth Area boundaries stay the same as at the end of 2010

All the other processes remain turned on: crop choice, irrigation decision, wildfire, forest growth and so on. The result is that most landscape conditions stay the same from year to year in the historical scenarios, but not all.

Other versions of Willamette Envision code can be accessed from an online repository located at: https://freshwater.ceoas.oregonstate.edu:8443/svn/WW2100svn.

7. **Location:**
   Hydrologic Unit Code: 170900

8. **File format**:
   Many different file formats are included in this set of files. The source code itself is principally in .cpp and .h files. The model code is organized as a Microsoft Visual Studios "solution", described in the .sln file format used by Visual Studios. Many of the input data files are in .xml format. The .envx format is itself a specially structured form of the .xml format. Text output files are formatted as comma-separated values (.csv files). Binary output files created by Flow plug-in use the suffix ".flw". Spatial data layers are in shapefile format (.shp, etc.). Document and analysis files use .txt, .docx, .pdf, and .xlsx file formats. Executable files use .exe suffixes, and dynamically loaded libraries use .dll suffixes.

9. **Related Documentation**:
   IDU_description.pdf
   IDU_DataDictionary.xlsx - includes data dictionary and lookup table
   idu.xml
   Streams_description.pdf
   Streams_DataDictionary.xlsx
   WW2100_ScenarioTable.pdf
   Notes.pdf - notes on how this version of code differs from previous versions
   Scenario_Comparison.xlsx - comparison of how model output differs from output from earlier code versions

10. **Attribution:**
    Willamette Envision is based on Envision, a modeling framework developed at Oregon State University (J. Bolte and colleagues; http://envision.bioe.orst.edu/).The following individuals contributed to the design and coding of modeling components within Willamette Envision:

    Overall framework -
    John Bolte, Oregon State University
    David Conklin, Oregon Freshwater Simulations

    Hydrologic model and FLOW framework -

Kellie Vaché, Oregon State University
John Bolte, Oregon State University
Anne Nolin, Oregon State University
Cynthia Schwartz, Oregon State University
James Sulzman, Oregon State University

Willamette project reservoir modeling -
Kellie Vaché, Oregon State University
Desiree Tullos, Oregon State University
Matt Cox, Oregon State University

Hydrologic model calibration -
Heejun Chang, Portland State University
Eric Watson, Portland State University
Anne Nolin, Oregon State University
David Conklin, Oregon Freshwater Simulations
John Dalrymple, Oregon Freshwater Simulations

Upland forest modeling -
John Bolte, Oregon State University
David Turner, Oregon State University
David Conklin, Oregon Freshwater Simulations
James Sulzman, Oregon State University

Water rights modeling -
John Bolte, Oregon State University
James Sulzman, Oregon State University
Adell Amos, University of Oregon
William Jaeger, Oregon State University
David Conklin, Oregon Freshwater Simulations
Andrea Laliberte, Earthmetrics

Lowland land use change modeling -
Andrew Plantinga, University of California, Santa Barbara
Daniel Bigelow, Oregon State University
David Conklin, Oregon Freshwater Simulations

Agricultural land and water use modeling -
William Jaeger, Oregon State University
Dan Bigelow, Oregon State University
Cynthia Schwartz, Oregon State University
David Conklin, Oregon Freshwater Simulations

Urban and rural residential water demand modeling -
Christian Langpap, Oregon State University
William Jaeger, Oregon State University
David Conklin, Oregon Freshwater Simulations

11. **Sponsorship**:
Generation of this code was supported by the National Science Foundation under grants No. 1039192 (OSU), 1038925 (PSU), and 1038899 (UO).

12. **Overview of project and disclaimer**:
The Willamette Water 2100 project was a six year collaborative research effort by Oregon State University, Portland State University and the University of Oregon to evaluate how climate change, population growth, and economic growth will alter the availability and the use of water in the Willamette River Basin on a decadal to centennial timescale. The project team developed a computer model, called Willamette Envision, that integrates aspects of hydrology, ecology, and human systems, and allows scientists and stakeholders to explore the interaction between land and water management policies, economics, climate, and ecology. The project was supported by grants from the National Science Foundation and was carried out between 2010 and 2016. Any opinions, findings, and conclusions or recommendations expressed by this work are those of the authors and do not necessarily reflect the views of the National Science Foundation.

13. **Keywords**:
Envision, Water Sustainability and Climate, water scarcity, Willamette River Basin

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