Willamette Water 2100 Modeling Scenarios

Scenario Name	Climate	Population & Income	Forest Disturbance	Urban Develop-ment	Federal Reservoir Operations	Urban Water Demand & Pricing	Crop Choice and Irrigation	Water Claims	Environ-mental Flows
REFERENCE CASE									
Reference Case – MIROC (Ref)	MIROC5 RCP 8.5[1] - middle range climate change; ~4°C (~7.5°F) increase in Willamette River Basin (WRB) annual mean temperatures over century	county population projections to 2050 from OEA (2011) and income to 2040 from Woods & Poole (2011) with linear extrapolations to 2100; pop. in 2010 = 2.41M; 2100 = 5.37M; mean household income in 2010 = $87.9K; 2100 = $242K (in 2005 dollars)	wildfire suppression at historical rates; forest area burned increases from 0.2%/yr in 2010 to 0.6%/yr in 2100; harvest by clear cut at historical rates (8000 ac/yr on public lands + 29000 ac/yr on private lands); no harvest of protected areas; stand age for harvest >= 40 yrs on private land, 40-80 yrs on public lands	all development within UGBs; UGBs expand when 80% developed (72% for Eugene-Springfield); growth of PDX Metro UGB confined to urban reserves through 2060	rule curves implemented as of 2011; reservoir refill begins Feb 1 with target to fill reservoirs by May	increase in water price 2011-2015 (6%/yr) and 2016-2025 (1.5%/yr); actual and anticipated cost increases to cover infrastructure backlogs, seismic upgrades, etc., then prices held constant in real terms for a given city population size; resulting avg per capita municipal use = 88 gal/day in 2100	crop mixes similar to today; crop and energy prices do not rise in real terms; legal limits include max irrigation rate 1/80th cfs/acre and duty 2.5 acre-feet/acre; about 2/3 of acres with water rights irrigated in an average year; result is about 280,000 acres irrigated initially	no new water rights and no new deliveries of stored water from the Willamette Project	includes instream water rights implemented as of 2010 and BiOp recommend-ations as of 2009 except selective withdrawal structure at Cougar; pulse flows in sub-basins not implemented; instream rights cumulative where they overlap in space and time
CLIMATE SCENARIOS – vary only climate inputs									
Low Climate Change – GFDL (LowClim)	GFDL-ESM2M RCP 4.5; ~1°C (2°F) increase in WRB annual mean temps. over century	same as Ref	same as Ref; small decrease in forest area burned per year relative to historical rates	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref
High Climate Change – HadGEM (HighClim)	HadGEM2−ES RCP 8.5; 6°C (~10.5°F) increase in WRB annual mean temps. over century	same as Ref	same as Ref; forest area burned per year increases 9X over historical rates	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref

[1] Climate inputs from selected global climate models downscaled using the Multivariate Adaptive Constructed Analogs (MACA) approach (Abatzoglou & Brown, 2011)

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HUMAN DIMENSIONS SCENARIOS – vary one or more human or policy element									
High Population Growth (HighPop)	same as Ref	pop. growth rates within UGBs doubled relative to Ref; pop. in 2100 = 8.25M	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref
Upland Wildfire Suppression (Fire-Suppress)	same as Ref	same as Ref	fire suppression efforts increase to hold area burned per year to historical rates	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref
Relaxed Urban Expansion (UrbExpand)	same as Ref	same as Ref	same as Ref	UGBs expand when 70% developed; no urban reserves	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref
Late Reservoir Refill (LateRefill)	same as Ref	same as Ref	same as Ref	same as Ref	reservoir refill begins March 1, ramps up to Ref. rule curves between March and May	same as Ref	same as Ref	same as Ref	same as Ref
Limited Irrigation Rates & Duties (LowIrrig)	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref	legal max irrigation rate reduced from 1/80 cfs/acre to 1/100 cfs/acre; duty also reduced from 2.5 to 2.0 acre-feet/acre	same as Ref	same as Ref

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Higher Irrigation Usage (HighIrrig)	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref	avg. fraction of irrigation rights utilized in a given year increased from 2/3rds (Ref case) to 5/6th	same as Ref	same as Ref
New Irrigation Rights (NewIrrig)	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref	new irrigation contracts and related rights introduced 2015-2044; probability of adding new rights reflects their profitability and account for pumping and conveyance costs and contract fees ($9/acre); crop choice as in Ref	new contracts from Willamette Project added to satisfy demand for new irrigation demand	same as Ref
New Instream Flow Rights (New-Instream)	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref	new instream water rights introduced in 2010 (with priority dates as early as 1965) to protect "recom-mended minimum flows for fish life."[2]

[2] See reports including Hutchison, James M., Kenneth E. Thompson, and John D. Fortune Jr. *The fish and wildlife resources of the upper Willamette basin, Oregon, and their water requirements*. Basin Investigations Section, Oregon State Game Commission, 1966; Hutchison, James M., and Warren W. Aney. *The fish and wildlife resources of the Lower Willamette Basin, Oregon, and their water use requirements.* Oregon State Game Commission, 1964; *The fish and wildlife resources of the middle Willamette basin, Oregon, and their water use requirements*. Report to the Oregon State Game Commission, Basin Investigations Section, 1963.

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Worst Case Scenario (Econ-Extreme)	same as Ref	Same as HighPop; pop. growth rates within UGBs doubled relative to Ref; pop. in 2100 = 8.25M	Same as FireSuppress; fire suppression efforts increase to hold area burned per year to historical rates	same as Ref	same as Ref	same as Ref	Combination of HighIrrig and NewIrrig; avg. fraction of irrigation rights utilized in a given year increased from 2/3rds (Ref case) to 5/6th; new irrigation contracts and related rights introduced 2015-2044; probability of adding new rights reflects their profitability and account for pumping and conveyance costs which are assumed to be half of those estimated for NewIrrig scenario; contract fees set to zero; crop choice as in Ref	new contracts from Willamette Project added to satisfy demand for new irrigation demand	Same as NewInstream; new instream water rights introduced as of 2010 (but with original priority dates as early as 1965) to protect "recom-mended minimum flows for fish life."[2]

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STAKEHOLDER DEFINED SCENARIOS – recombine multiple climate and human elements									
Extreme extreme changes in climate and population combined with policies that emphasize resource use over conser-vation; assumes all sectors 'share the pain' in water deficit years	same as High Climate Change (Hadley) - 6°C (~10.5°F) increase in WRB annual mean temps. over century	same as HighPop; pop. growth rates within UGBs doubled relative to Ref; pop. in 2100 = 8.25M	increase in wildfire suppression so that forest area burned per year increases from 0.2%/yr in 2010 to 0.8%/yr in 2100; harvest by clear cut at historical rates (8,000 ac/yr on public lands + 29,000 ac/yr on private lands); no harvest of protected areas; stand age for harvest >= 40 yrs on private and public lands	same as UrbExpand; UGBs expand when 70% developed; no urban reserves	reservoir refill begins March 1, ramps up to existing rule curves between March and May; 1% chance each year for one of the five biggest reservoirs to go offline for one calendar year; reservoir treated as "Run of the River" when offline	sssumes the non-residential sector of the economy grows between 2015-2030 to the highest levels (relative to personal income) observed in any location in the WB in recent years; this assumption raises municipal water demand by increasing the ratio of non-residential to residential water demand; all other urban water assumptions as in Reg	new irrigation contracts and related rights introduced 2015-2044, similar to NewIrrig scenario; conveyance costs are assumed to be half of those estimated for NewIrrig scenario; contract fees set to zero; crop choice as in Ref	new claims of stored water (May-October) Up to 233,060 acre-feet/yr for municipal uses Up to 550,000 acre-feet for agricultural irrigation[3]	same as Ref

[3] Maximum claims based on Willamette Basin Reservoir Study Interim Report (USACE, 2000) and 1994 Application for Reservation (ODA, 1994 and League of Oregon Cities and Special Districts Association of Oregon, 1994)

Scenario Name	Climate	Population & Income	Forest Disturbance	Urban Develop-ment	Reservoir Ops	Urban Water Demand & Pricing	Crop Choice and Irrigation	Water Claims	Environ-mental Flows
Managed mid-range changes in climate and population with a continuation of recent trends in resource use and manage-ment; assumes all sectors 'share the pain' in water deficit years	same as Ref; middle range climate (MIROC); ~4°C (~7.5°F) increase in WRB annual mean temperatures over century	same as Ref; pop. in 2010 = 2.41M; 2100 = 5.37M	differential increase in wildfire suppression on private and public lands; resulting increase in forest area burned on private lands from 0.2%/yr in 2010 to 0.3%/yr in 2100 and on public lands from 0.2%/yr in 2010 to 0.8%/yr in 2100; harvest by clear cut at historical rates (8000 ac/yr on public lands + 29,000 ac/yr on private lands); no harvest of protected areas; stand age for harvest >= 40 years on private and 40-80 years on public lands	same as Ref	same as Ref	municipal use declines to 100 gal/day/ capita then holds at that rate to 2100	same as Ref	new deliveries of stored water (May-October) Up to 133,060 acre-feet/yr for municipal uses Up to 385,000 acre-feet for agriculture	same as Ref

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COUNTER-FACTUAL SCENARIOS – hold one element constant or absent to determine model sensitivity									
Stationary Climate (Stationary-Clim)	21st century climate inputs based on random water years drawn from simulated historical MIROC5 1950-2009	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref
Zero Population and Income Growth (NoGrow)	same as Ref	population and household income remain at 2011 levels throughout century	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref
Zero Population Growth (NoPop-Growth)	same as Ref	population remains at 2011 levels throughout century; income rises as in Ref	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref
Zero Income Growth (NoInc-Growth)	same as Ref	income remains at 2011 levels throughout century; population rises as in Ref	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref
Run of the River (No-Reservoirs)	same as Ref	same as Ref	same as Ref	same as Ref	modeled without federal reservoirs	same as Ref	same as Ref	same as Ref	same as Ref
All Fallow (AllFallow)	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref	same as Ref	crop choice set to "fallow" for all agricultural lands (including trees and orchards); no irrigation	same as Ref	same as Ref

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HISTORICAL SCENARIOS – simulation period 1950-2009 – allow comparison of modeled future to modeled past									
Historic Mid-Range Climate (HistoricRef)	simulated historical climate based on MIROC5 global climate model	not modeled; landcover held constant with 2010 conditions	not modeled; landcover held constant with 2010 conditions	not modeled; landcover held constant with 2010 conditions	same as Ref	not modeled; landcover held constant with 2010 conditions	not modeled; landcover held constant with 2010 conditions	not modeled	same as Ref
Historic High Climate (Historic-HadGEM)	simulated historical climate based on HadGEM2-ES global climate model	not modeled; landcover held constant with 2010 conditions	not modeled; landcover held constant with 2010 conditions	not modeled; landcover held constant with 2010 conditions	same as Ref	not modeled; landcover held constant with 2010 conditions	not modeled; landcover held constant with 2010 conditions	not modeled	same as Ref