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Managing Water in the West

Klamath River Basin Study Update

Klamath Basin Monitoring Program General Membership Meeting, April 30, 2014 Yreka, CA

U.S. Department of the Interior
Bureau of Reclamation

Basin Studies

- **Purpose**
  - Work with state and local partners in 17 Western States to evaluate future water supply and demand imbalances in a changing climate
- **Elements**
  - Projections of future supply and demand, including the impacts of climate change
  - Analysis of how the basin's existing water operations and infrastructure will perform in response to the projections of future water supplies and demands
  - Development of adaptation strategies to reduce any identified imbalances in water supply and demand
  - Trade-off analysis of the options identified, findings, and recommendations as appropriate

Basin Studies

- Appraisal level studies that are intended to build upon existing information
- Basin Study reports are not considered decision documents
- May lead to potential subsequent feasibility-level investigations

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Klamath River Basin Study Area

- Equal 50 percent cost share by Reclamation and non-federal cost-share partners
  - Oregon Water Resources Department
  - California Department of Water Resources

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Phases of the Klamath River Basin Study

Basin Study Elements

Phase 1: Water Supply and Demand Assessment	**Assess current and projected water supply and demand, including the impacts of climate change**
Phase 2: System Reliability Analysis	**Analyze how the basin will respond to water supply and demand projections according to identified metrics**
Phase 3: Development of Adaptation Strategies	**Develop adaptation strategies to reduce any identified imbalances**
Phase 4: Evaluation of Adaptation Strategies	**Evaluate adaptation strategies, findings, and recommendations as appropriate**

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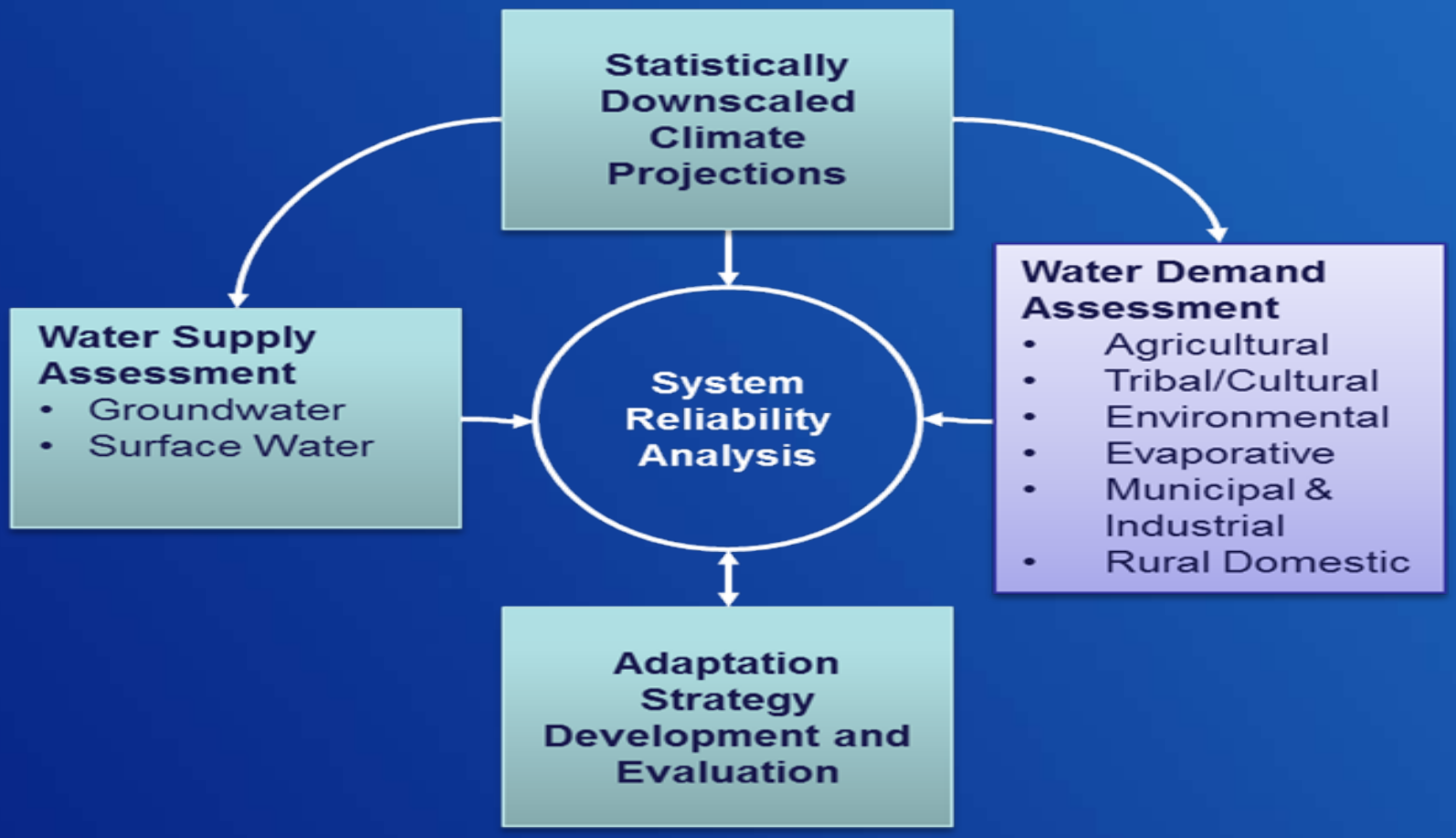
Water Supply and Demand Assessments

- Assess current and future "natural" water supply
  - Inflow absent human activities
- Assess current and future demands
  - Examples: agricultural, evaporative, environmental, cultural, municipal and industrial
  - Utilize multiple scenarios of climate and demand

System Reliability Analysis



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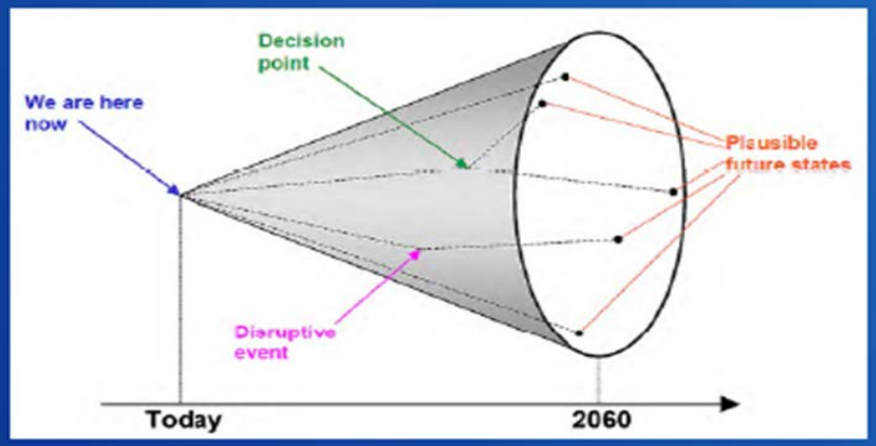
Scenario Planning: Addressing an Uncertain Future

- Future influences on water supply and demand are uncertain
  - Influences include climate, population, land use, etc.
- The Klamath River Basin Study uses a scenario approach to explore the impacts of a range of climate futures and a range of potential adaptation strategies



(adapted from Timpe and Scheepers, 2003)

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Water Supply Assessment – Future Supply

- **Develop future precipitation and temperature scenarios**
  - **Based on West-Wide Climate Risk Assessment**
- **Assess future water supply (SW & GW) under different scenarios**
  - **Ensemble of general circulation model (GCM) projections**
    - Characterize future trends and variability
  - **Paleo-conditioned streamflow**
    - Prehistoric wet/dry states provide context for projected periods of water surplus/drought

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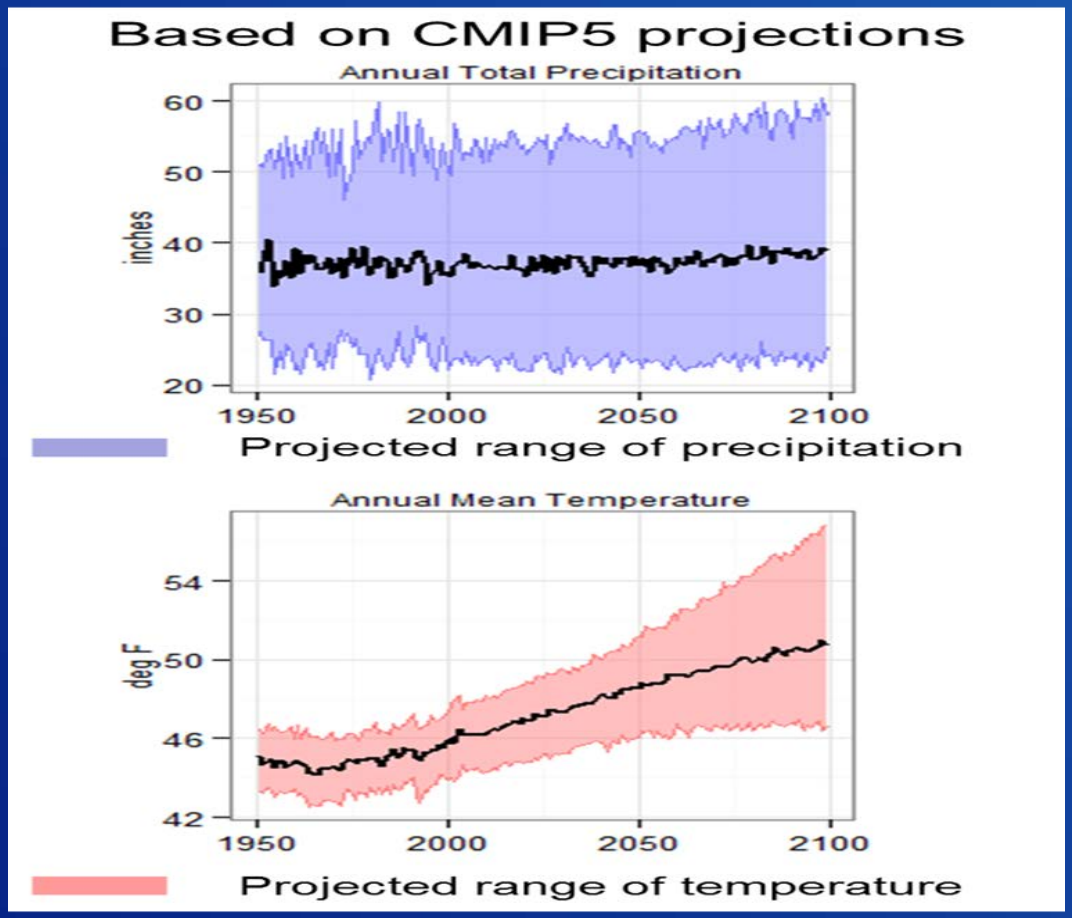
Water Supply Assessment - CMIP5 Projections



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Water Demand Assessment

- Assess current consumptive demands
  - Quantitative approaches
  - Focus on agricultural, evaporative, and municipal and industrial demands
- Assess current non-consumptive demands
  - Mostly qualitative approaches
  - Focus on environmental, cultural, hydropower, and recreational demands
- Assess future demands under different climate scenarios

Water Demand Assessment Conditions

Source: USFWS

Source: US Forest Service

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Agricultural Irrigation Demands

HDe Climate Scenarios*

CMIP3 & CMIP 5
2030s and 2070s

HW – HD – CT – WW – WD

1950 – 1999 historical baseline

* Same as Water Supply Assessment

ET Demands Model

- Uses ASCE Standardized Penman Monteith Reference ET Equation and FAO-56 Dual Crop Coefficient Method
- Estimates solar radiation and humidity as function of Tmin and Tmax
- Simulates variable growing season lengths (30 day avg T), growing degree days (GDD), and killing frost T, year-round soil moisture balance
- Model outputs include:
  - daily reference evapotranspiration (ET)
  - crop ET
  - net irrigation water requirement (NIWR)
- Current cropping patterns used for future periods
- Future simulations based on T and P scenarios

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NIWR Estimates

- Historical gridded climate data set (Maurer et al. 2002) bias corrected to local weather stations
- ET Demands calibrated to local growing patterns
  - Green-up
  - Harvest
  - Senescence
  - Freeze

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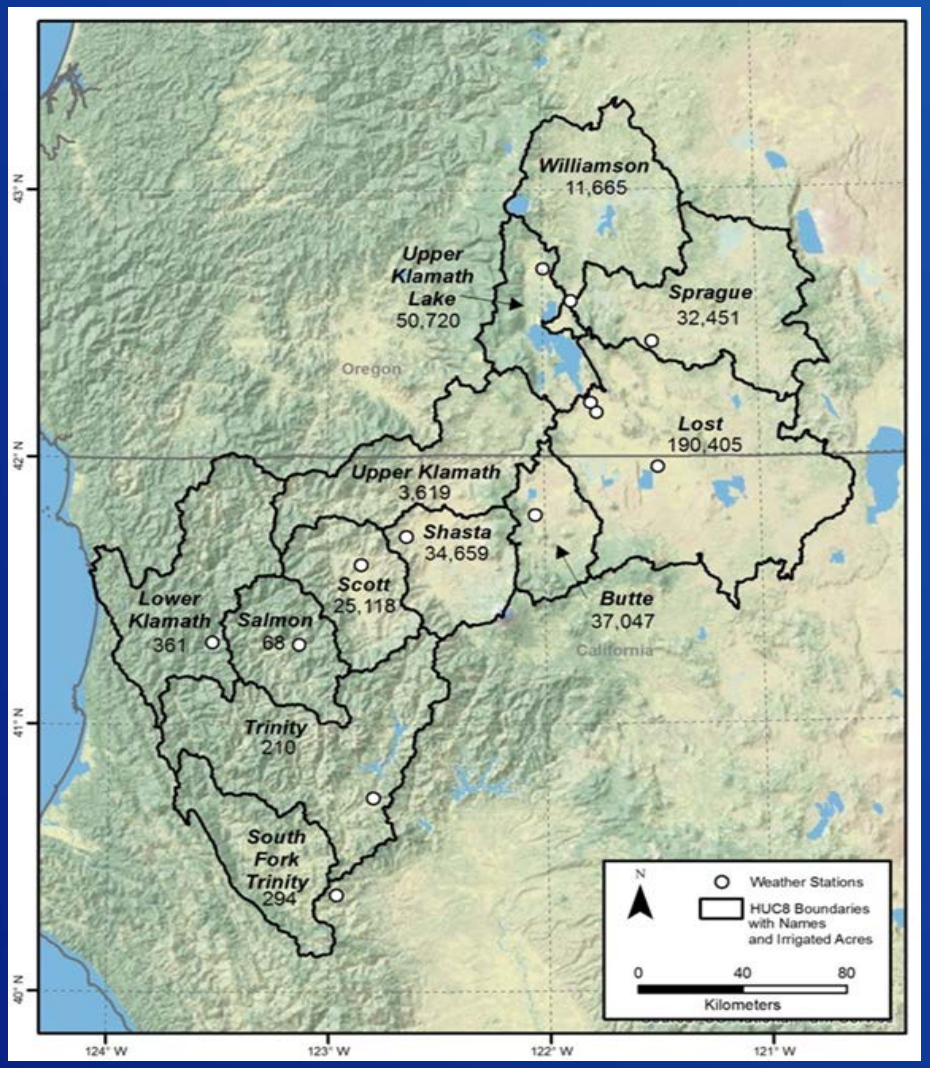
Klamath River Basin Weather Stations



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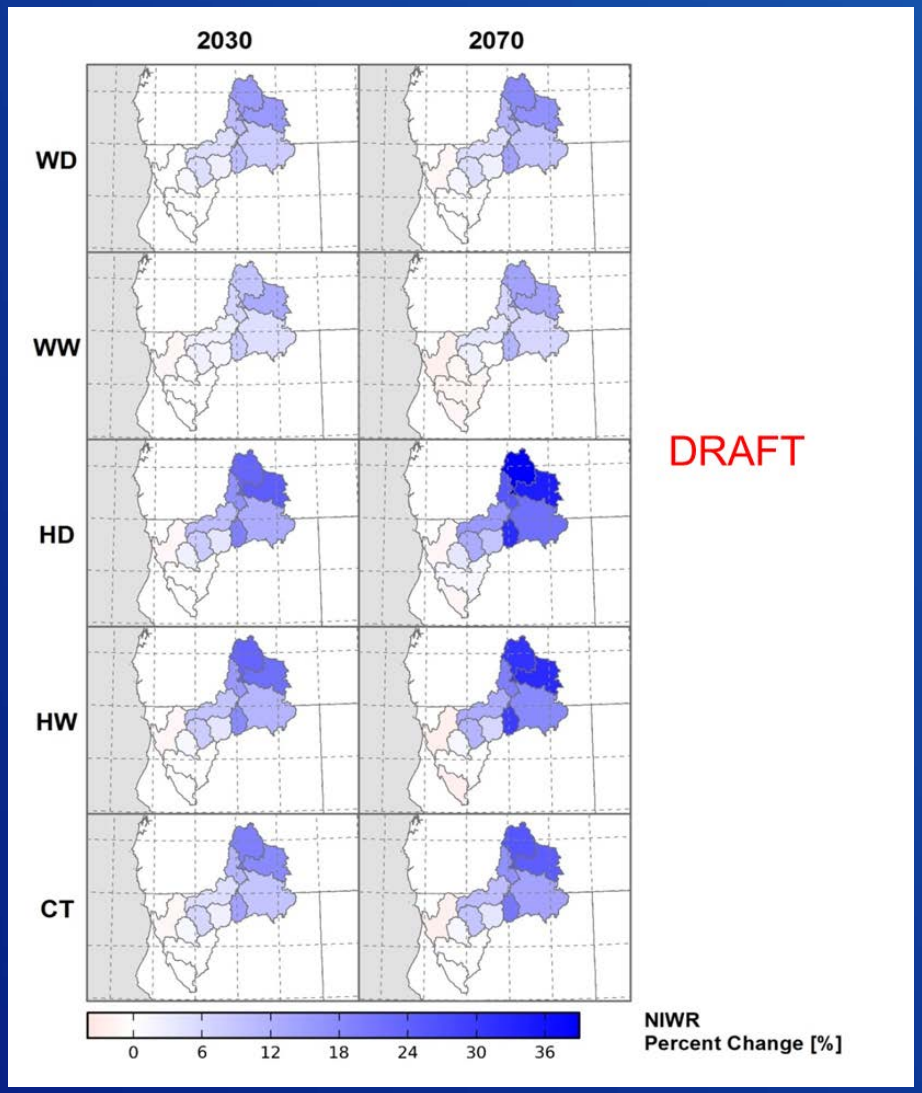
Change in Future NIWR From Historical Baseline (CMIP5)



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Reservoir Evaporation

Transient Simulation period (1950-2099)

Use both CMIP3 & CMIP 5 climate projections

Complementary Relationship Lake Evaporation (CRLE) Model

- Relies on commonly measured and estimated climate observations (air temp, solar radiation, dewpoint depression)
- Accounts for heat storage leading to potential shift in seasonal evaporation
- Evaporation and net evaporation (E minus P) estimates developed for 9 reservoirs
- Average monthly historical reservoir conditions (storage volume and surface area) calculated and assumed constant for analysis period
- Relatively insensitive to the contrasts between the open water and land environments

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CRLE DRAFT Results – Net Evap (in)

Scenario	Period	BCSD Projection	Upper Klamath Lake	Clear Lake	Gerber Reservoir	Tule Lake	Lower Klamath Lake	JC Boyle Reservoir	Copco Reservoir	Iron Gate Reservoir	Clair Engle Lake
Historical	Historical	-	21.1	32.0	24.1	33.3	33.0	22.5	20.8	27.2	-26.0
Warm Dry	2030	CMIP-3	21.9	33.0	25.0	34.2	34.0	23.5	22.0	28.3	-22.5
Warm Dry	2030	CMIP-5	22.8	33.6	25.8	34.9	34.6	24.3	22.8	29.0	-22.2
Warm Wet	2030	CMIP-3	19.4	31.1	22.8	32.8	32.4	20.9	18.7	25.8	-35.3
Warm Wet	2030	CMIP-5	19.8	31.7	23.1	33.2	32.8	21.3	19.2	26.2	-33.5
Hot Dry	2030	CMIP-3	24.1	35.0	27.2	36.1	35.8	25.6	24.1	30.3	-20.6
Hot Dry	2030	CMIP-5	24.2	34.5	26.9	35.9	35.6	25.5	23.9	30.1	-20.4
Hot Wet	2030	CMIP-3	20.5	32.8	23.9	34.1	33.7	22.1	20.2	27.2	-32.9
Hot Wet	2030	CMIP-5	20.9	33.0	24.2	34.4	34.0	22.5	20.5	27.5	-33.5
Central Tendency	2030	CMIP-3	21.6	33.0	24.9	34.4	34.1	23.2	21.3	28.0	-26.8
Central Tendency	2030	CMIP-5	21.1	32.9	24.3	34.3	33.9	22.7	21.0	27.8	-27.0
Warm Dry	2070	CMIP-3	23.7	34.7	26.6	35.9	35.6	25.2	23.7	29.9	-19.6
Warm Dry	2070	CMIP-5	22.8	33.5	25.6	34.9	34.7	24.3	22.7	29.1	-21.9
Warm Wet	2070	CMIP-3	19.3	32.0	22.8	33.5	33.1	21.0	19.0	26.3	-37.3
Warm Wet	2070	CMIP-5	19.2	31.3	22.5	32.9	32.6	20.8	18.7	26.0	-34.5
Hot Dry	2070	CMIP-3	26.1	37.3	29.3	38.2	37.8	27.7	26.3	32.4	-15.6
Hot Dry	2070	CMIP-5	26.1	37.1	29.1	38.3	38.0	27.7	26.2	32.5	-17.7
Hot Wet	2070	CMIP-3	21.0	33.7	24.4	35.1	34.7	22.8	20.9	28.2	-31.7
Hot Wet	2070	CMIP-5	21.5	34.1	24.2	35.7	35.4	23.3	21.4	29.0	-33.6
Central Tendency	2070	CMIP-3	21.9	34.0	25.3	35.3	34.9	23.6	21.7	28.6	-27.6
Central Tendency	2070	CMIP-5	22.2	34.0	25.4	35.4	35.0	23.7	21.9	28.7	-28.3

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M&I and Rural Domestic Demands

- M&I
  - Current M&I demand estimates based on:
    - previous studies of large systems
    - reported data by small systems
    - USGS Water Use Program data
  - All future demand estimates are a function of population growth and climate change
  - Growth rate and per capita demand from planning studies and state sources
  - Assumed that 30% of demand is for landscape irrigation to adjust for climate change
- Rural Domestic
  - Demand estimates based on USGS Water Use Program 2005 data; county population growth rates from state sources
  - Per capita demands calculated from USGS Water Use Program data

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Future M&I and Rural Domestic Demand DRAFT Estimates

Future Period and Scenario	M&I (AFY)	RD (AFY)
2005 USGS Estimates	18,204	11255
2030 Base Demand	24,017	12,345
2030 Warm-Dry CMIP3	24,153	12,415
2030 Warm-Dry CMIP5	24,216	12,448
2030 Warm-Wet CMIP3	24,144	12,411
2030 Warm-Wet CMIP5	24,184	12,431
2030 Hot-Dry CMIP3	24,345	12,515
2030 Hot-Dry CMIP5	24,382	12,534
2030 Hot-Wet CMIP3	24,298	12,490
2030 Hot-Wet CMIP5	24,378	12,532
2030 Central CMIP3	24,242	12,461
2030 Central CMIP5	24,278	12,480
2070 Base Demand	26,638	13,631
2070 Warm-Dry CMIP3	27,005	13,821
2070 Warm-Dry CMIP5	26,942	13,781
2070 Warm-Wet CMIP3	26,976	13,806
2070 Warm-Wet CMIP5	26,930	13,775
2070 Hot-Dry CMIP3	27,273	13,960
2070 Hot-Dry CMIP5	27,439	14,040
2070 Hot-Wet CMIP3	27,199	13,921
2070 Hot-Wet CMIP5	27,488	14,064
2070 Central CMIP3	27,077	13,858
2070 Central CMIP5	27,139	13,884

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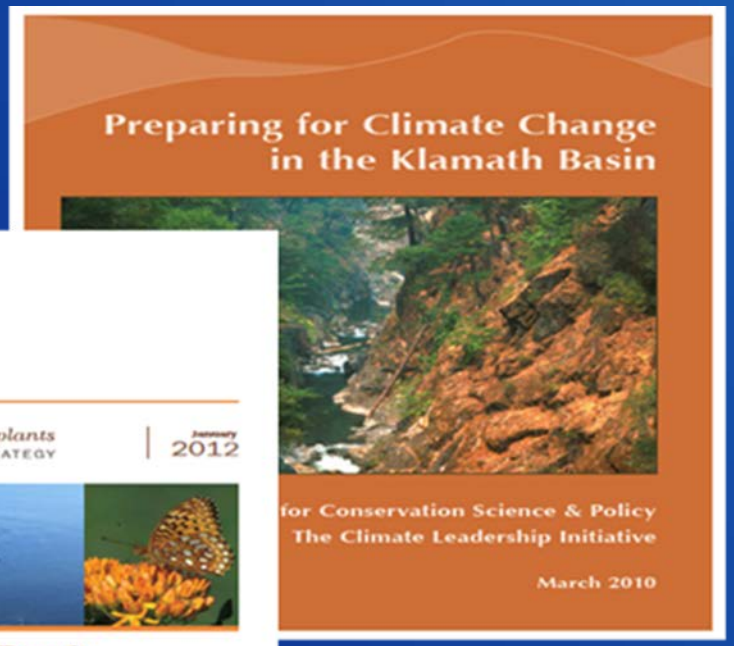
System Reliability Analysis

- Identify reliability metrics
  - Metrics = Evaluation criteria that are used to determine baseline and future system reliability
  - Metrics can be measured for a particular resource to quantify the reliability
- Determine baseline system reliability
  - Develop an analytical framework for evaluating reliability
  - Analytical framework to include representation of hydropower use, large scale water management, water quality (in terms of water temperature)
- Project future system reliability with and without adaptation strategies in place to identify plausible strategies for mitigation of climate change risks

Example Literature



Examples of existing literature that identifies potential adaptation strategies

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Study Information

- Reclamation's Basin Study Website
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- Klamath River Basin Study Website
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- Questions or comments
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