Climate Impacts Water

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Topics

- Planning Before Now
- Current Drought
- Future Hydroclimatology
 - Temperature & Evaporation
 - Hydrology
 - Seasonality
 - Droughts
 - Rain Event Timing
- Sea Level Rise
- Conclusion

What Was Done Before

• Santa Cruz City Water Supply EIR: *"1976-1977 event has been established as the most severe drought [...], the City uses this as a benchmark for assessing system reliability"*

	Probability Of:		
	0-5% Peak-Season Shortage	5-15% Peak- Season Shortage	15-25% Peak- Season Shortage
NOP (2010)	7% of years	1% of years	N/A
Long-term (2030)	5% of years	11% of years	1% of years

EIR Table 8.3-1. Baseline of Water Supply Reliability



Adapt Water Supply Planning to Climate Change

- Need More Details than:
 - "very likely a redistribution with intense precipitation periods alternated with very dry years"

Sierra Nevada Research Institute (UC Merced)

• Need Quantities and Time Periods like:

 "A water shortage worse than the one during the 1977 drought could occur in 1 out of every 6 to 8 years by mid century and 1 out of every 3 to 4 years at the end of the century"

Calif Dept. Water Resources



Current vs. Past Droughts



* 9 Droughts 1890-2000 (110 yrs) 33 years were dry = <u>30 %</u>

Last 15 years, 11 dry = <u>73%</u>

* April 1st 2015 Snow Survey 5% of Normal NEW RECORD Past record **1977** & **2014**

* January 2015 Precipitation ZERO = NEW RECORD Past record **2014**

* Winter 2015 Temperature Warmest = NEW RECORD Past record **2014**



Current Drought

 Cause = High Pressure Ridge in NE Pacific Blocked Storms past 2 years



Drought Cause?

Declining Arctic Sea Ice Cover Effects [Sewall 2005]



• Climate Change -> "Three Times More Likely" [Swain et al. 2014]

What Does It Mean?

Random Natural Variability?

Or

Consequence of Climate Change?

"highly accurate prediction or one heck of a coincidence"!



Future Hydroclimatology

- Climate Change Study of Santa Cruz County
 - 'Simulation of Climate Change in San Francisco Bay Basins, California: Case Studies in the Russian River Valley and Santa Cruz Mountains'
 - U.S. Geological Survey
 - Scientific Investigations Report 2012–5132
 - Lorraine E. Flint and Alan L. Flint
 - Sponsored and Funded by Santa Cruz County, Department of Environmental Health Services



Temperature

• "Maximum air temperature in the Bay Area has steadily risen over the last century by 1 degree Celsius (°C), and all model and scenario projections indicate it will continue to rise." [USGS Flint 2012]

• "Increases in air temperature dominate the effects of climate change on the landscape, regardless of future changes in precipitation or water supply in the Santa Cruz Mountains." [USGS Flint 2012]



Temperature -> Evaporation

<u>Physics</u>: +1 °F Temperature \rightarrow +4% Evaporation



Evaporation Impact

- PAST (Soquel-Aptos Basin)
 - Rain = 32.3"
 - Evaporation = 21.2"
 - 66% Lost
 - <u>34% Usable</u>



Evaporation Impact

- PAST (Soquel-Aptos Basin)
 - Rain = 32.3"
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 - 66% Lost
 - <u>34% Usable</u>
- FUTURE??
 - Rain = 32.3"
 - Evaporation = **130%** * 21.2" = 27.6"
 - 85% Lost



- <u>15% Usable</u>

Hydrology

 "Declines in runoff and recharge for the GFDL model [...] along the coast in the mountains near Santa Cruz [...] of nearly 250 mm/year" (10"/year or -30%) [USGS Flint 2012]

 "Even the PCM model, which projected a general increase in precipitation, shows declines in recharge up to 200 mm/year in the Santa Cruz area" (8"/year or -25%)



Your Hydrology







• "less precipitation in the fall (November–December) and spring (March–April)" [USGS Flint 2012]



UCSC research [Snyder et al. 2004]

Rain Season

Four months \rightarrow Two monthsDec - Mar \rightarrow Jan & Feb

Dry Season

Six months \rightarrow Eight months May - Oct \rightarrow Apr - Nov



Future Drought

 "Future projections include more than one drought every decade, with a multi-decadal drought for {global climate model} GFDL-A2 at the end of the 21st century." [USGS Flint 2012]

Drought 12 years long!



Future Drought



[USGS Flint 2012]

Future Drought Risks

Greater than "80% chance of a multi-decadal drought during 2050–2099"

"Exceptionally high risk of a multi-decadal megadrought occurring over the {Southwest} during the late 21st century"



Precipitation Event Timing

• What if Total Precipitation = no change and Temperature = no change?

- Study 120 Yrs of Santa Cruz & Watsonville Daily Climate Observations
- Rain Events
 - Intensity = -2.9% per decade
 - Duration = +2.2% per decade
- Pauses between Events
 - Lull = +1.7% per decade

- "get weaker" "last longer"
- "gap bigger"



Event Timing -> Hydrology

- Soquel-Aptos Basin Model (also Live Oak)
- Next 30 Years (2045)
- Rain Event Timing as Model Input
- No Temperature or Total Precipitation Changes
- Evaporation +4.4%
- Recharge
- Baseflow
- Streamflow

-6.7%

- -5.7%
- -3.0%

Hydrology Impacts



Sea Level Rise





[California Climate Action Team 2010]

Seawater Intrusion

- EIR: "because the City's wells are located closest to the shoreline, they would be among the first impacted by seawater intrusion."
- EIR: "the City may need to further reduce pumping from the Live Oak wells due to lowered groundwater levels and the threat of seawater intrusion."



City Seawater Intrusion



Conclusions

- Santa Cruz is in a New Climate!
- Reasonable Water Target Required
 Water needed to protect till when
- Expect Conditions to Get Worse
- No Added Supply is Too Much
 - Any excess will be needed & soon

