An Exploratory Evaluation of the Effects of Climate Change on the Water Quality of the South Platte River in Denver, Colorado

Jon Novick
Denver Department of Environmental Health
Denver, CO, United States

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Study Purpose

Examine potential effects of climate change on water quality in Denver metro area streams by conducting an assessment of the impacts of drought on water quality

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Study Components

- Evaluate instream flows and classify dates by instream flow condition
- Classify existing instream water quality data by instream flow condition
- Evaluate classified data using graphical and statistical techniques

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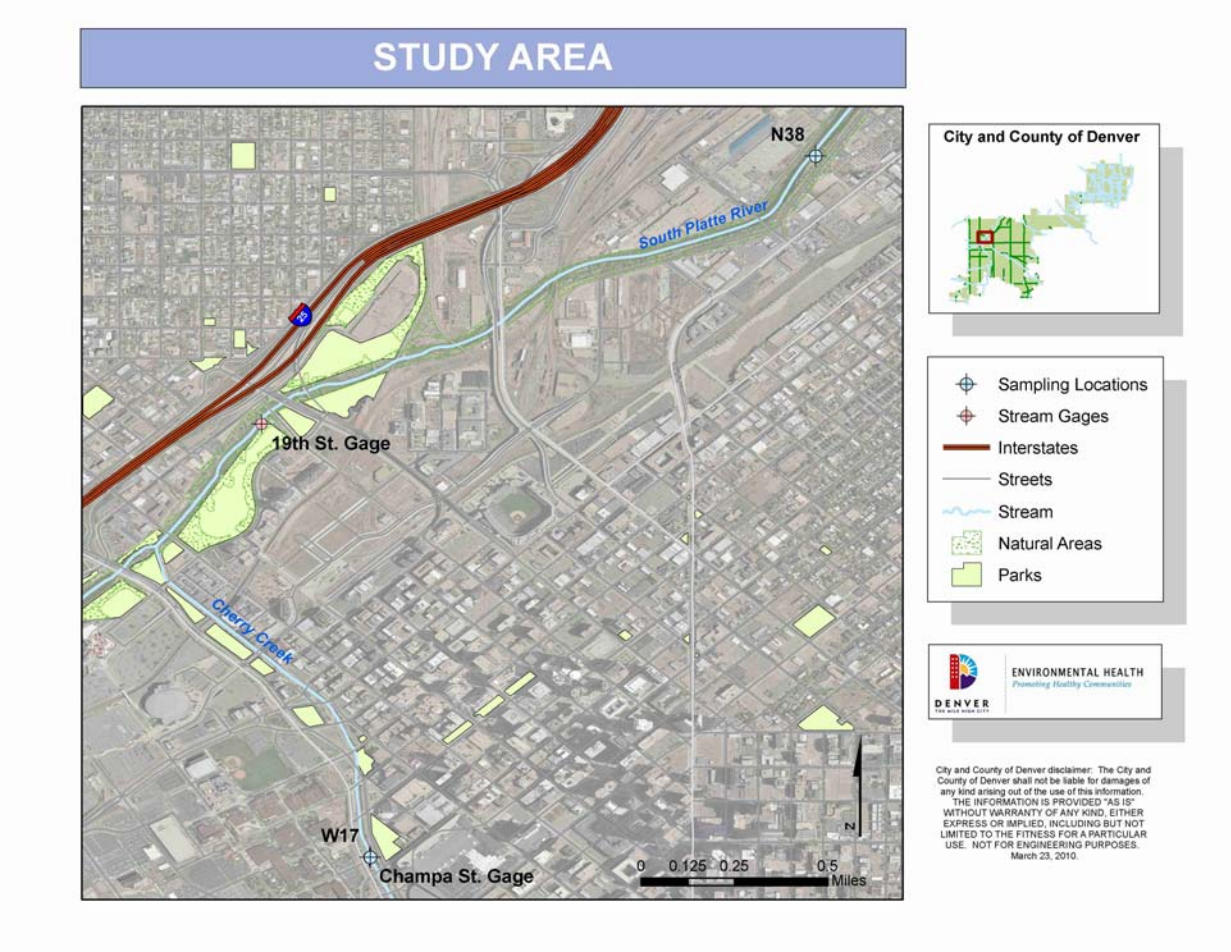
Sampling / Gage Locations



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Instream Flow Evaluation

Instream Flow Evaluation Method

- **Hydrologic drought determination - 7-day daily average instream flows calculated for each date**
  - South Platte data set - January 1976 to December 2009 (construction of Chatfield Reservoir was completed in 1975).
  - Cherry Creek data set – March 1986 to December 2009 (gap in flow data prior to 1986).
- **Rank 7-day average instream flow values by percentile for each date as described by USGS to determine periods of hydrologic drought.**

Data for the evaluation came from the USGS NWISWeb for Colorado website.

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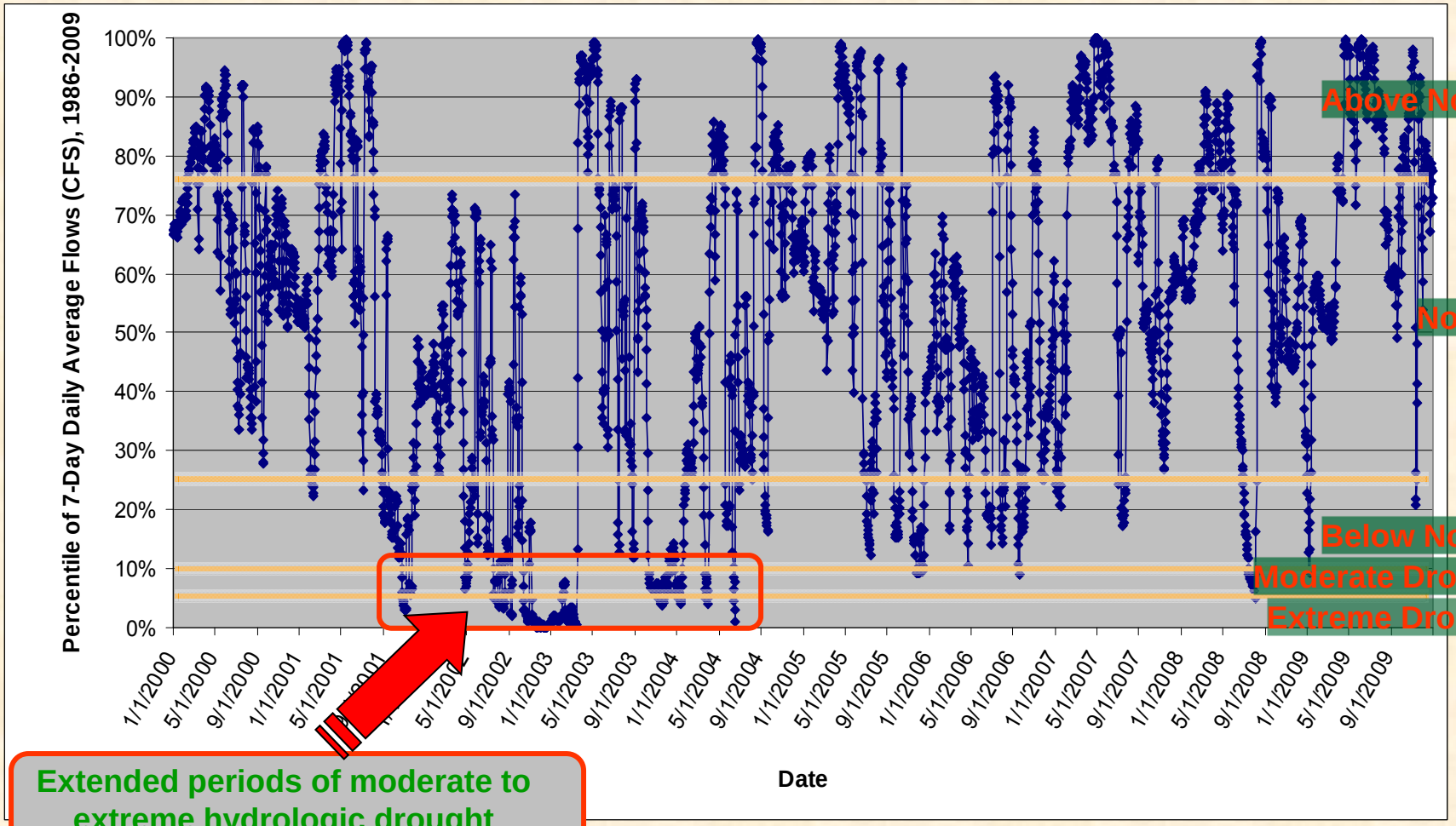
Close up - Cherry Creek, 2000-2009



Extended periods of moderate to extreme hydrologic drought

Note: Drought classification based on categories described by USGS.

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Instream Flow Evaluation Results

Periods of moderate to extreme hydrologic drought were observed between spring of 2002 and summer of 2004 based on 7-day average daily flows between 1976 and 2009.

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Evaluation of Water Quality Data

- Sampling dates were classified by USGS defined drought regimes and the resulting datasets were compared using box and whisker plots.

- Kruskal-Wallis tests were conducted to determine the significance of the relationships between the drought-defined datasets for each analyte.

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Parameters Evaluated

- **Field Parameters**
  - pH, Temperature, Dissolved Oxygen, Specific Conductivity
- **General Chemistry**
  - Alkalinity, Hardness, Chloride, Sulfate, Calcium, Magnesium
- **Solids**
  - Total Suspended Solids, Total Dissolved Solids
- **Nutrients**
  - Total Ammonia, Nitrite, Nitrate, Total Kjeldahl Nitrogen, Phosphorous
- **Organic Carbon**
  - Total Organic Carbon, Dissolved Organic Carbon
- **Bacteria**
  - *Escherichia coli*, Fecal coliform
- **Dissolved Metals**
  - Copper, Manganese, Selenium

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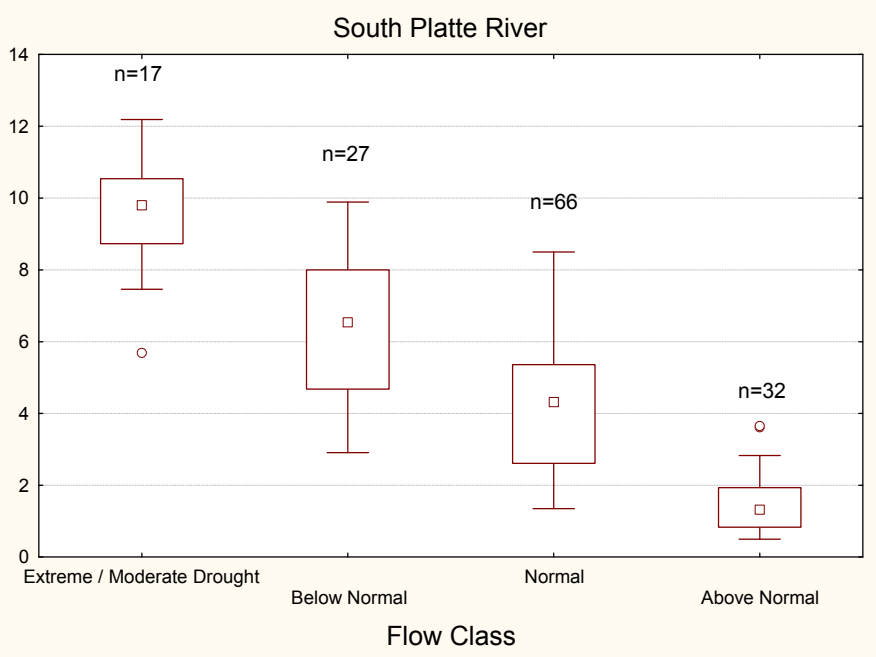
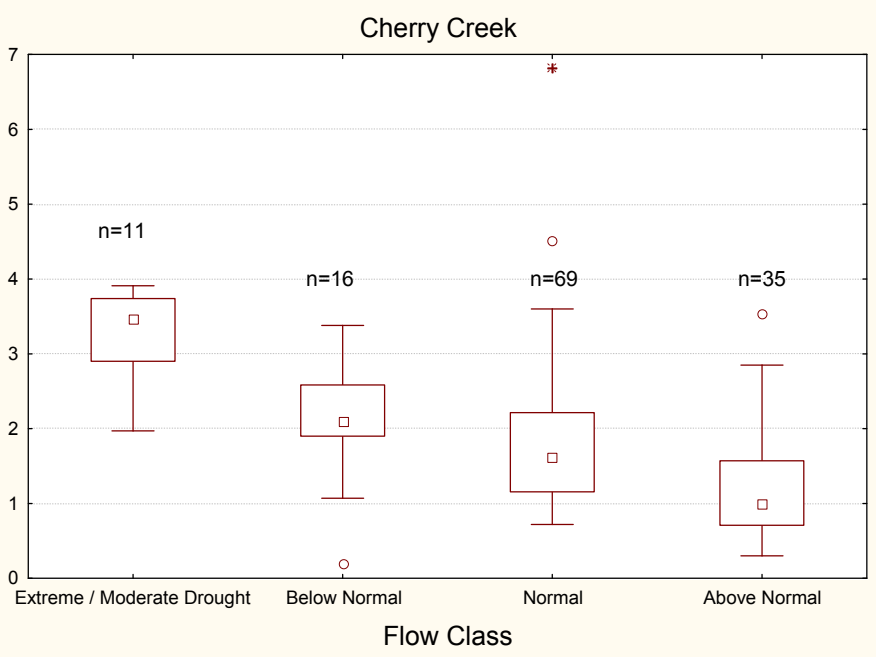
Nitrate in mg/L





Detection limit = 0.2 mg/L

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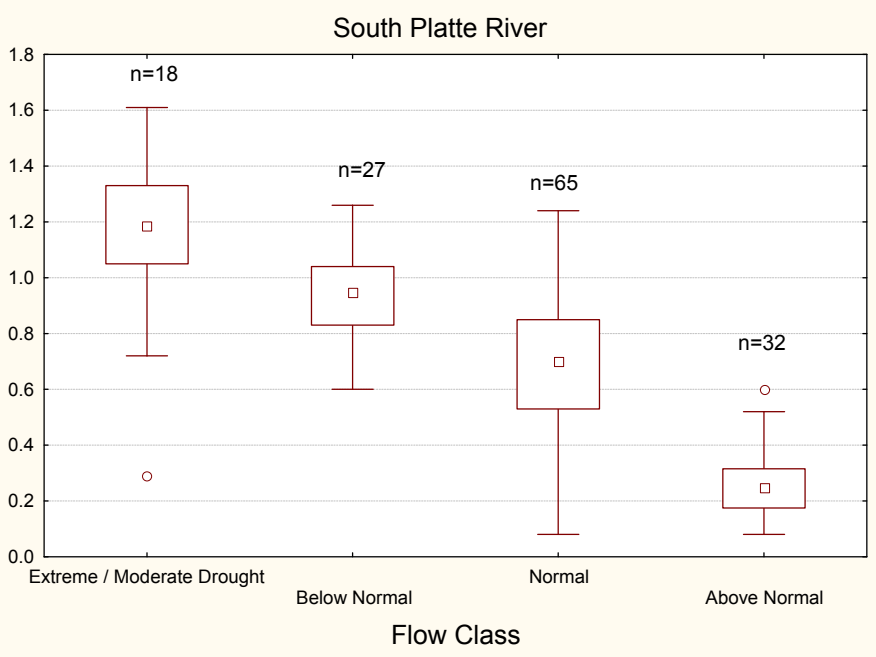
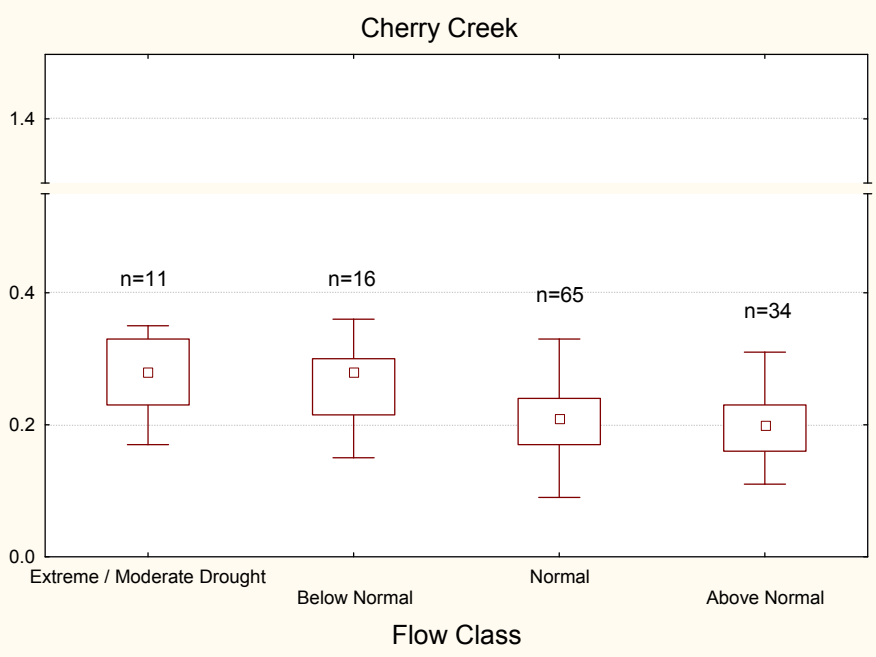
Total Phosphorous in mg/L





Detection limit = 0.08 mg/L

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A Closer Look at the Statistics

NO3

	Extreme / Moderate Drought	*Below Normal*	*Normal*	*Above Normal*
W17				
Ext. / Mod. Drought		↔	▲▲	▲▲
Below Normal	↔		↔	▲▲
Normal	▲▲	↔		▲▲
Above Normal	▲▲	▲▲	▲▲	
N38				
Ext. / Mod. Drought		↔	▲▲	▲▲
Below Normal	↔		▲▲	▲▲
Normal	▲▲	▲▲		▲▲
Above Normal	▲▲	▲▲	▲▲	

Total Phosphorous

	Extreme / Moderate Drought	*Below Normal*	*Normal*	*Above Normal*
W17				
Ext. / Mod. Drought		↔	▲	▲▲
Below Normal	↔		↔	▲
Normal	▲	↔		↔
Above Normal	▲▲	▲	↔	
N38				
Ext. / Mod. Drought		↔	▲▲	▲▲
Below Normal	↔		▲▲	▲▲
Normal	▲▲	▲▲		▲▲
Above Normal	▲▲	▲▲	▲▲	

▲▲ Difference in means is strongly significant, $p \leq 0.01$

▲ Difference in means is significant, $p \leq 0.05$

↔ Difference in means is not significant, $p > 0.05$

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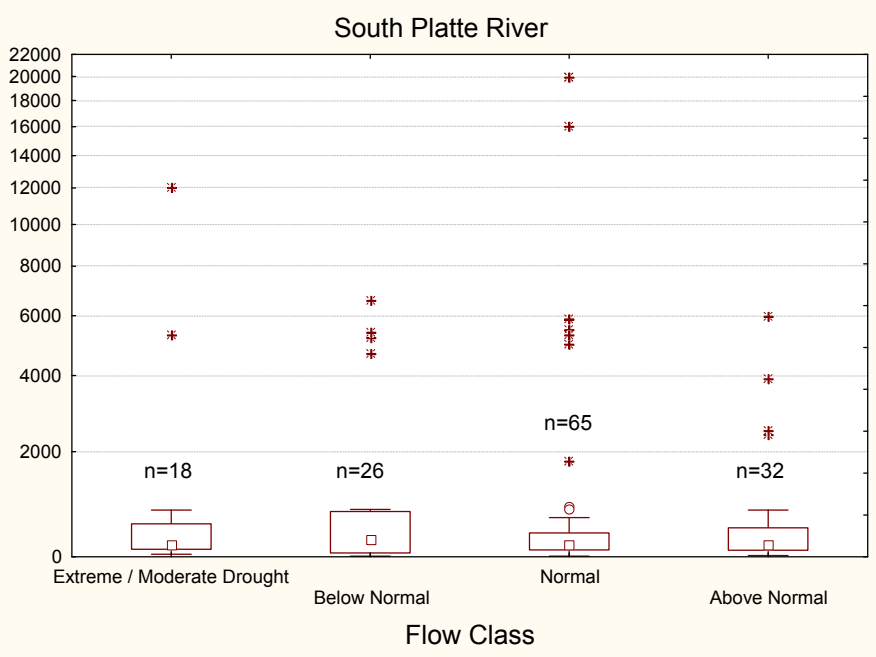
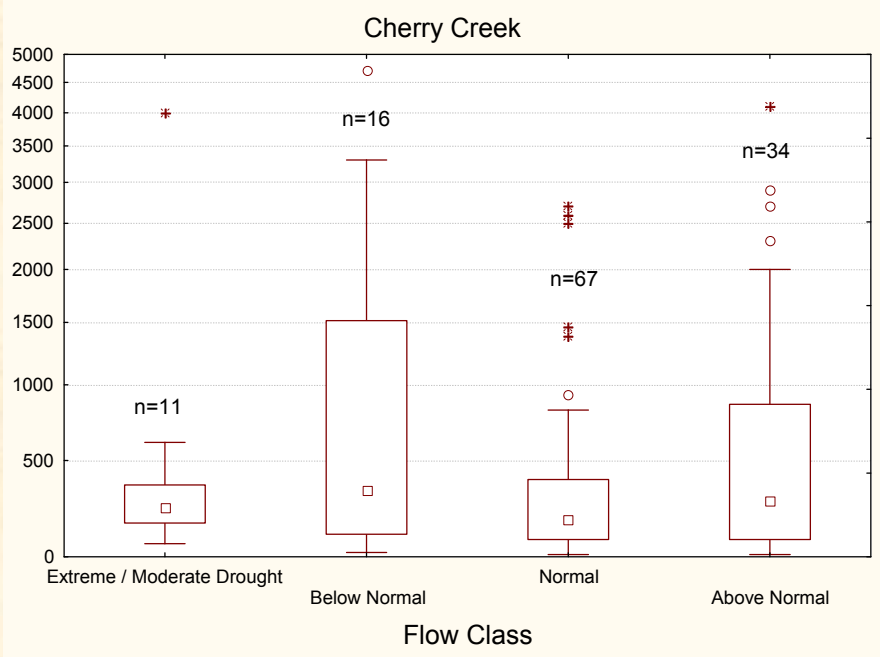
E. coli in CFU / 100 mL





Detection limit = 10 CFU / 100 mL

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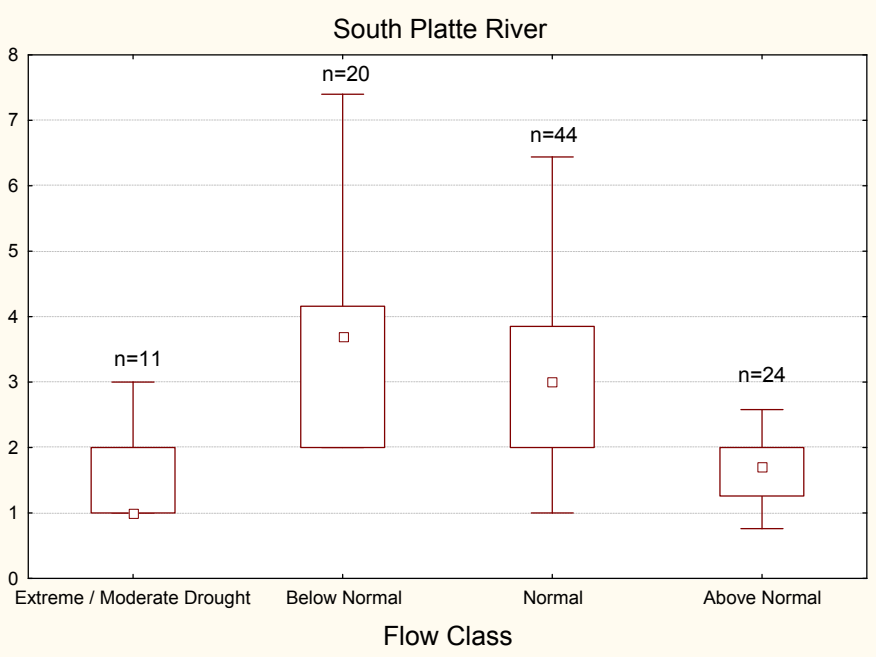
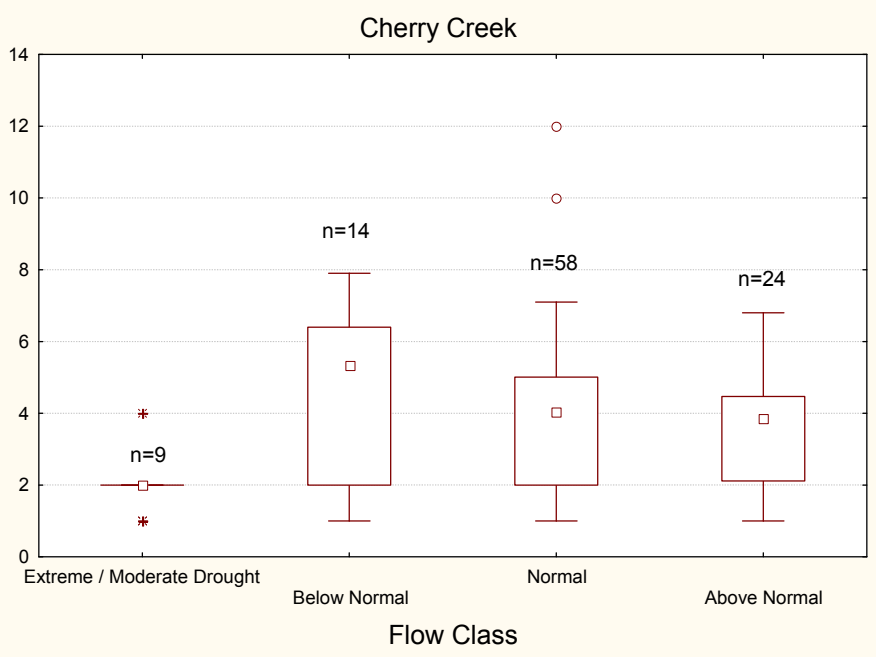
Dissolved Selenium in ug/L





Detection limit = 0.20 ug/L

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A Closer Look at the Statistics

E. coli

	Extreme / Moderate Drought	Below Normal	Normal	Above Normal
W17				
Ext. / Mod. Drought		↔	↔	↔
Below Normal	↔		↔	↔
Normal	↔	↔		↔
Above Normal	↔	↔	↔	
N38				
Ext. / Mod. Drought		↔	↔	↔
Below Normal	↔		↔	↔
Normal	↔	↔		↔
Above Normal	↔	↔	↔	

Dissolved Selenium

	Extreme / Moderate Drought	Below Normal	Normal	Above Normal
W17				
Ext. / Mod. Drought		▲▲	▲	↔
Below Normal	▲▲		↔	↔
Normal	▲	↔		↔
Above Normal	↔	↔	↔	
N38				
Ext. / Mod. Drought		▲▲	▲▲	↔
Below Normal	▲▲		↔	▲▲
Normal	▲▲	↔		▲▲
Above Normal	↔	▲▲	▲▲	

▲▲ Difference in means is strongly significant, $p \leq 0.01$

▲ Difference in means is significant, $p \leq 0.05$

↔ Difference in means is not significant, $p > 0.05$

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Summary of Observations

- Cherry Creek
  - Trend Observed
    - Increase with increased flow: TSS, dissolved selenium
    - Decrease with increased flow: DO, specific conductivity, alkalinity, hardness, TDS, sulfate, nitrite, nitrate, tot. P, calcium, dissolved copper
  - No trend observed
    - pH, temperature, chloride, total ammonia, TKN, TOC, DOC, *E. coli*, fecal coliform, dissolved manganese
- South Platte River
  - Trend Observed
    - Increase with increased flow: pH, temperature, TSS
    - Decrease with increased flow: DO, specific conductivity, alkalinity, hardness, TDS, chloride, sulfate, total ammonia, nitrite, nitrate, TKN, tot. P, DOC, calcium, dissolved copper, magnesium, dissolved manganese, dissolved selenium
  - No trend observed
    - *E. coli*, fecal coliform, TOC

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Conclusions

- Degradation of water quality was observed during periods of moderate to extreme low instream flows.
- If climate change results in more frequent periods of moderate to low instream flows, it is reasonable to expect that water quality in the South Platte River and Cherry Creek will be negatively impacted.
- Observed differences between the South Platte River and Cherry Creek suggest that the impact of climate change on water quality is likely to be different in different watersheds.

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Questions?

Jon Novick
Denver Dept. of Environmental Health
Environmental Quality Division
(720) 865-5468
jon.novick@denvergov.org

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