# Climate Change Implications for Lake Environments

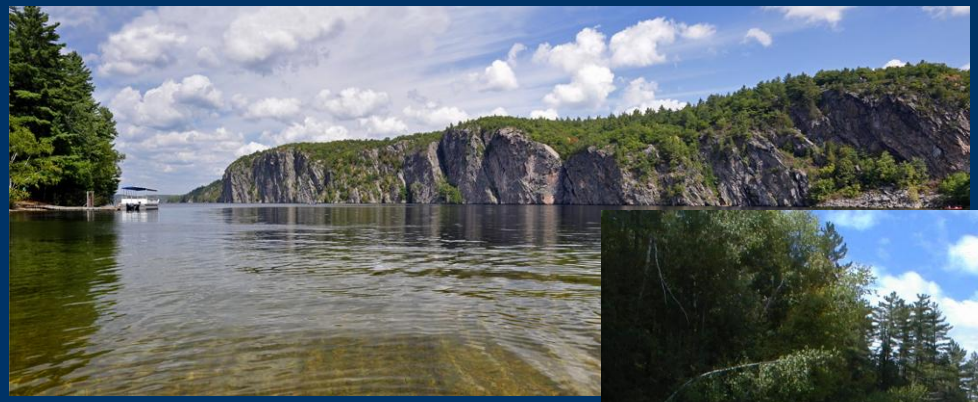
11th Annual lake Links
October 20, 2012
Paul Lehman

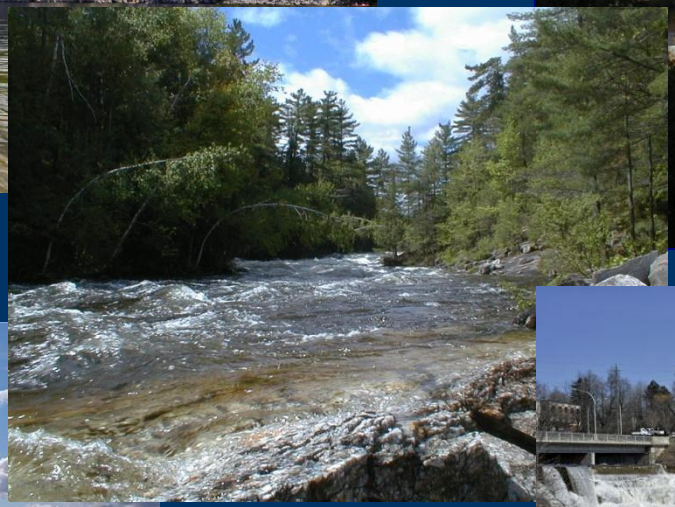
# Overview

- History and description the Mississippi River watershed
- Local impact risk assessment
- Reservoir implications
- Water management implications
- Adaptation options

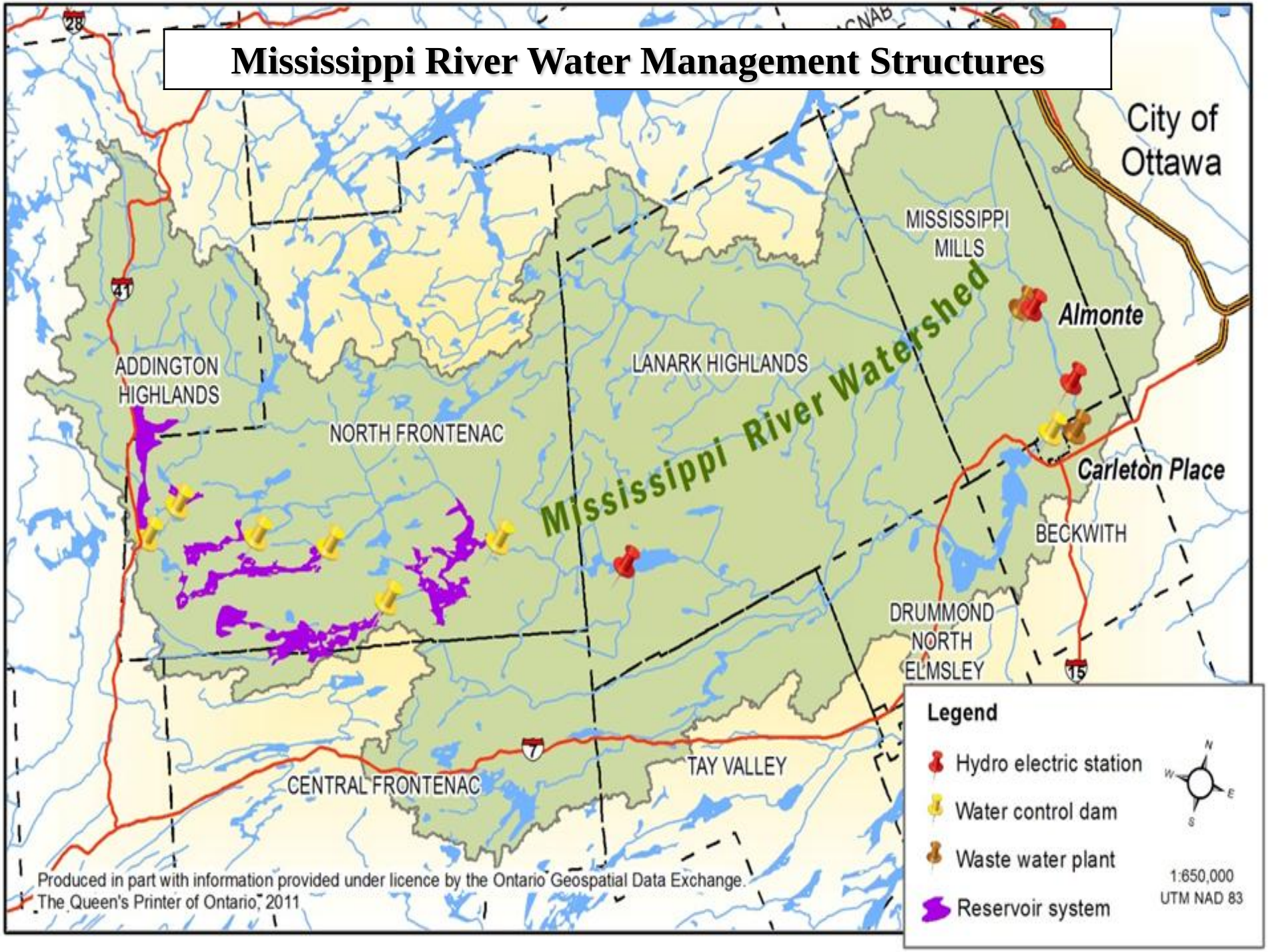
# Mississippi River Watershed

# Mississippi River Watershed



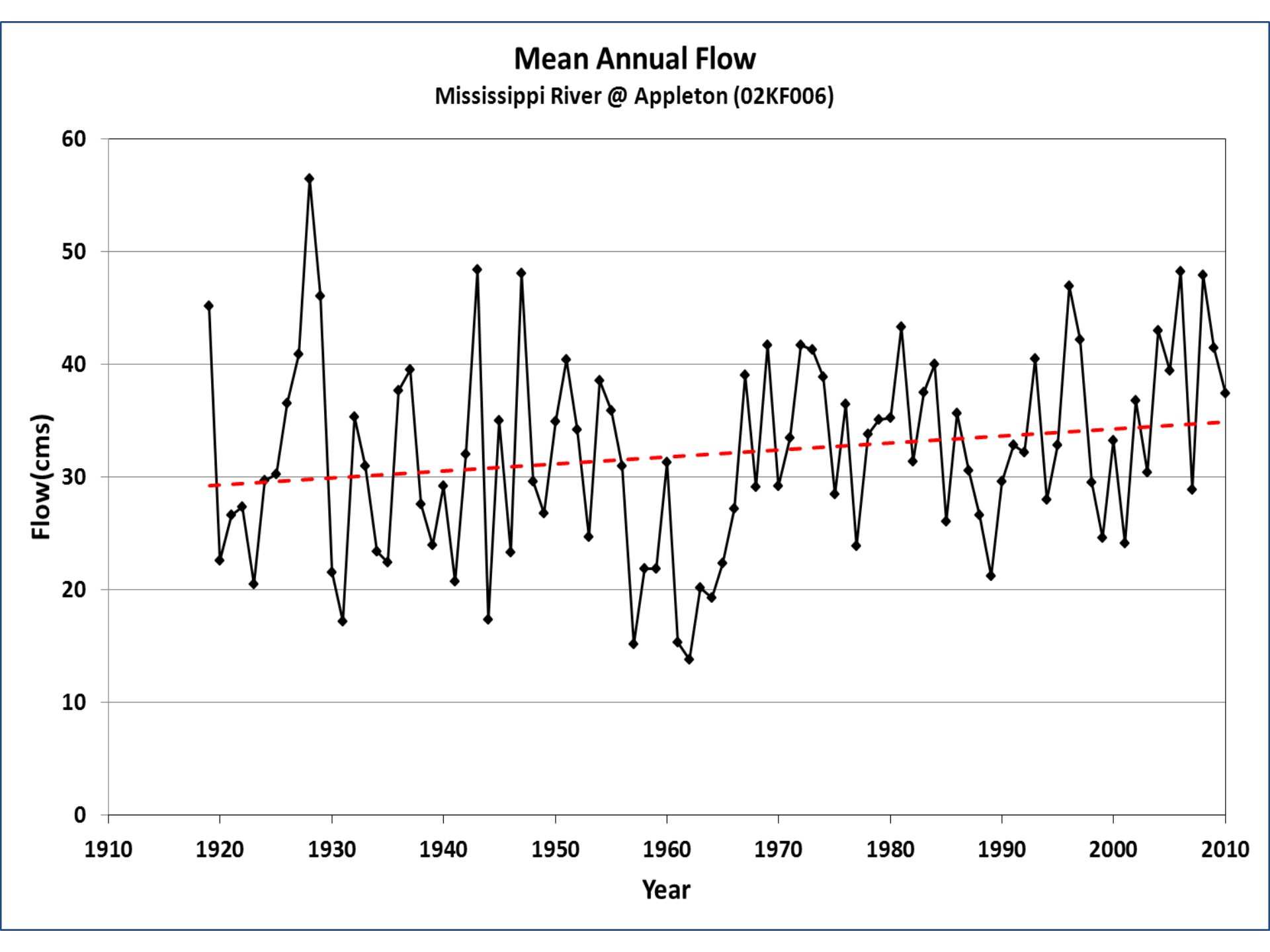


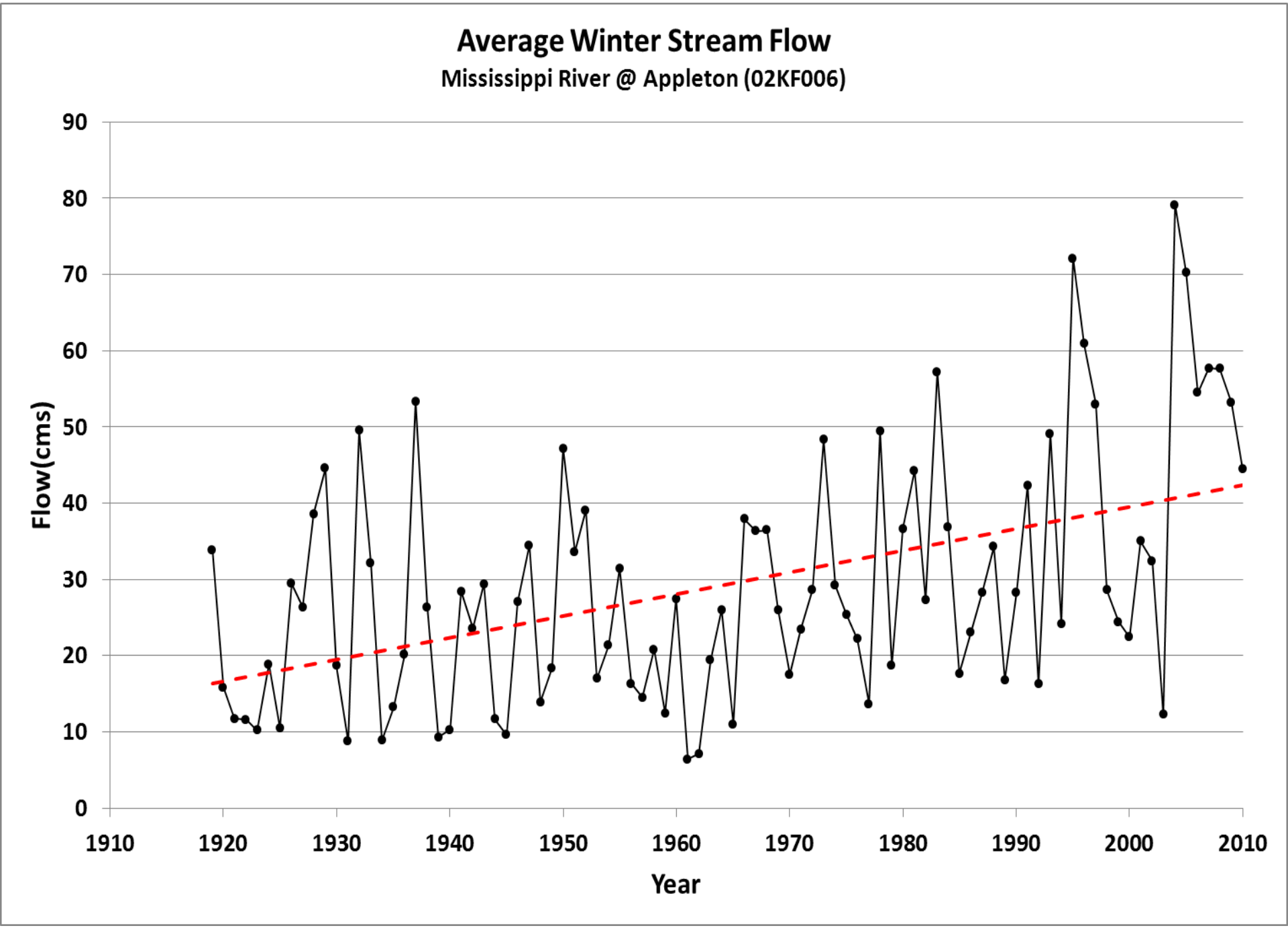
# Mississippi River Water Management Structures

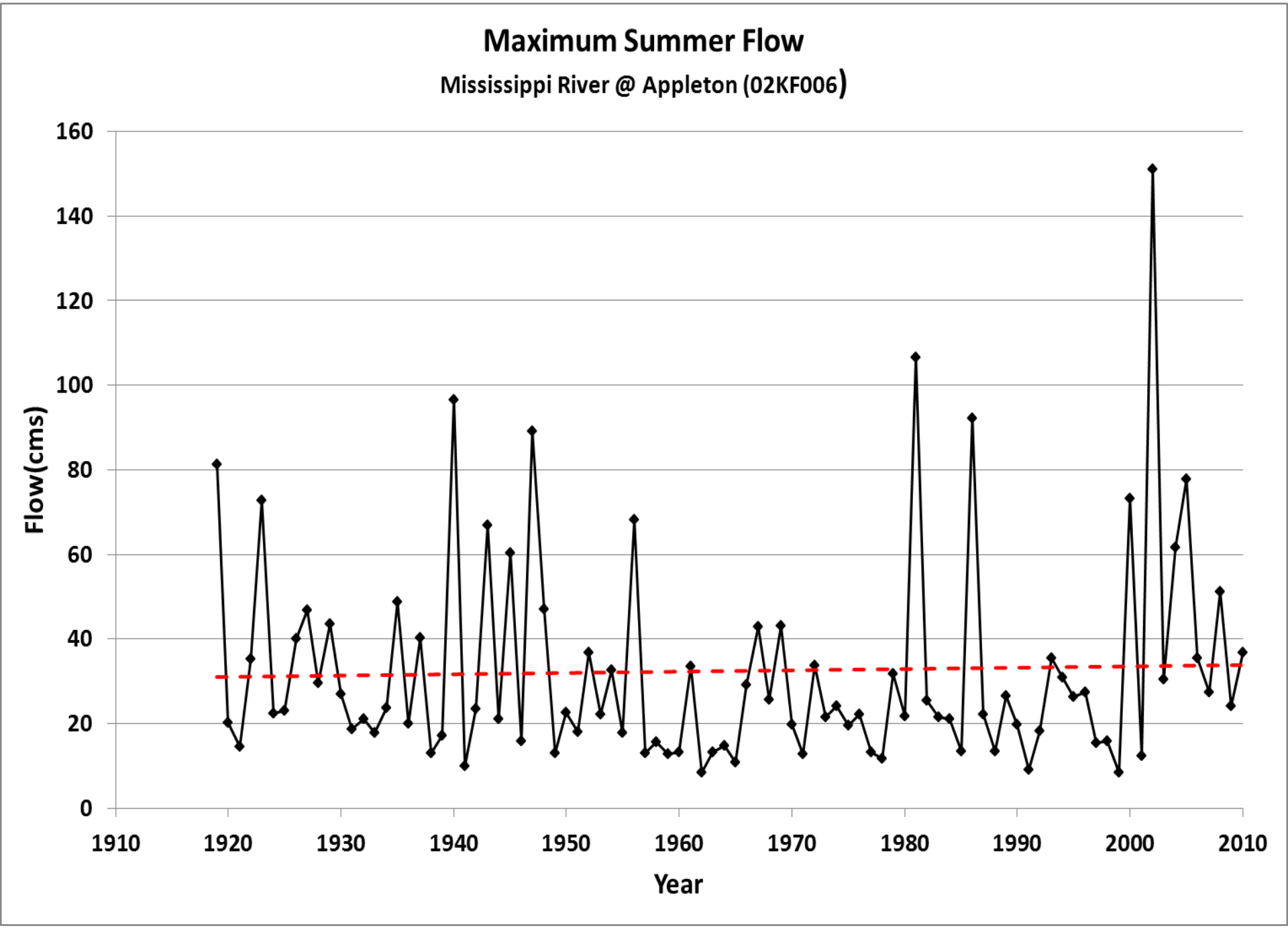


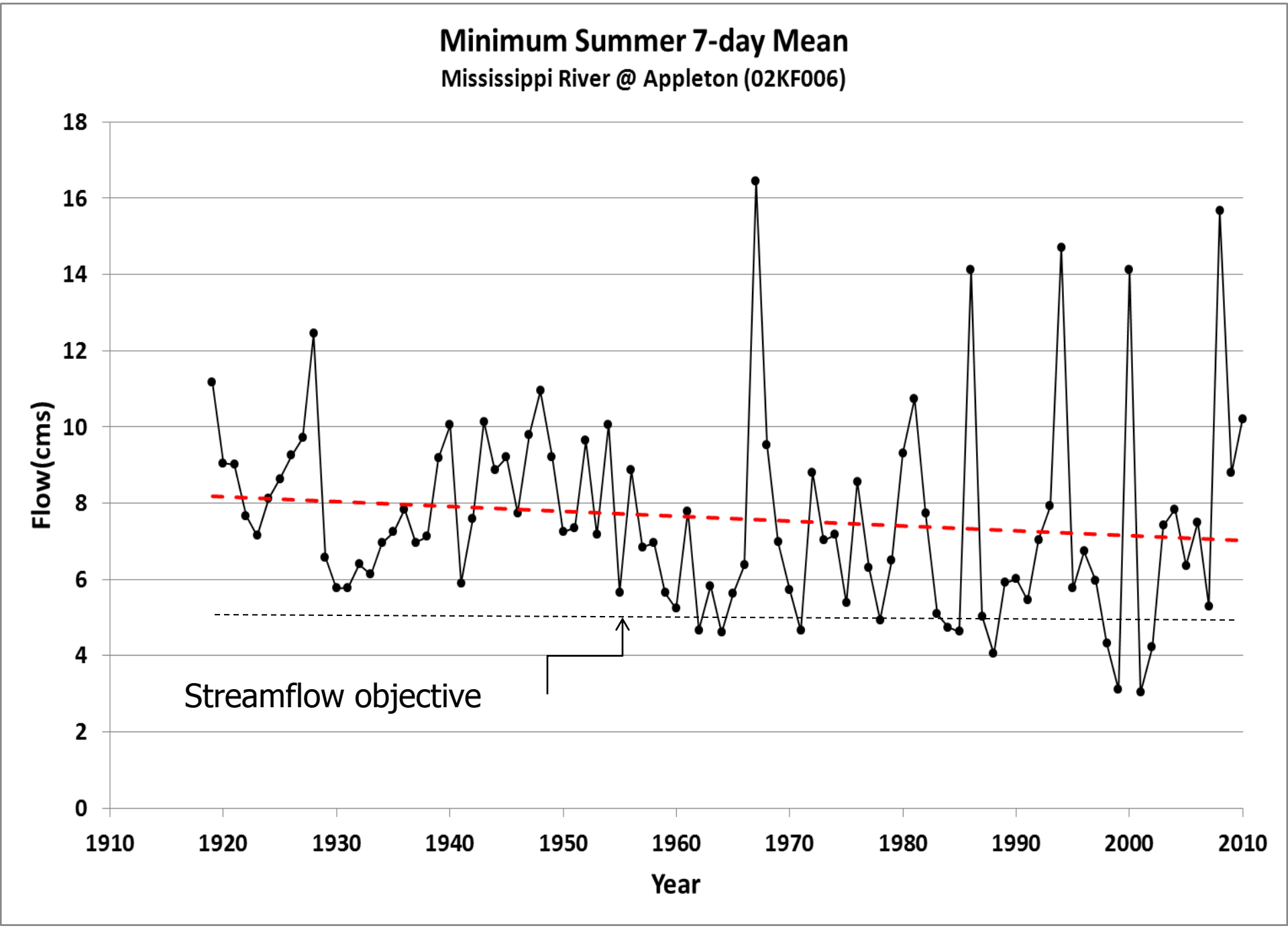
# Climate Change and Vulnerability

- What can we expect?
- How vulnerable will we be?
- How can we adapt?


Mean Annual Flow
Mississippi River @ Appleton (02KF006)
Flow(cms)
60
50
40
30
20
10
0
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Year


Average Winter Stream Flow
Mississippi River @ Appleton (02KF006)
Flow(cms)
0
10
20
30
40
50
60
70
80
90
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Year


Maximum Summer Flow
Mississippi River @ Appleton (02KF006)
Flow(cms)
160
140
120
100
80
60
40
20
0
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Year


Minimum Summer 7-day Mean
Mississippi River @ Appleton (02KF006)
Flow(cms)
18
16
14
12
10
8
6
4
2
0
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Year
Streamflow objective

# Risk Assessment

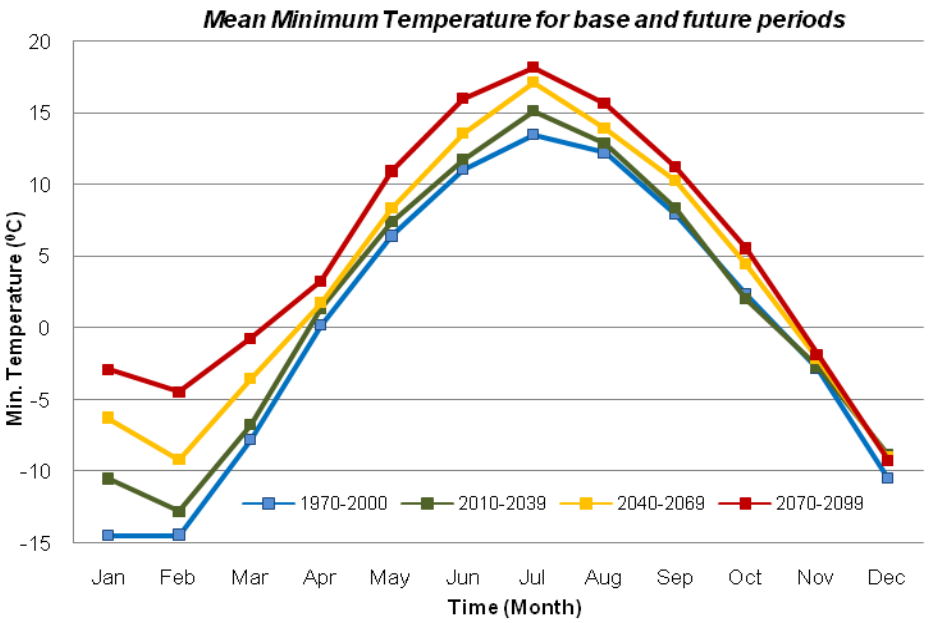
- Preliminary analysis phase
  - Problem definition/scoping
  - Quantify projected changes in precipitation and temperature
  - Model hydrologic response
  - Assess reservoir performance and capacity to satisfying constraints and objectives
  - Assess secondary impacts (fisheries/water quality)

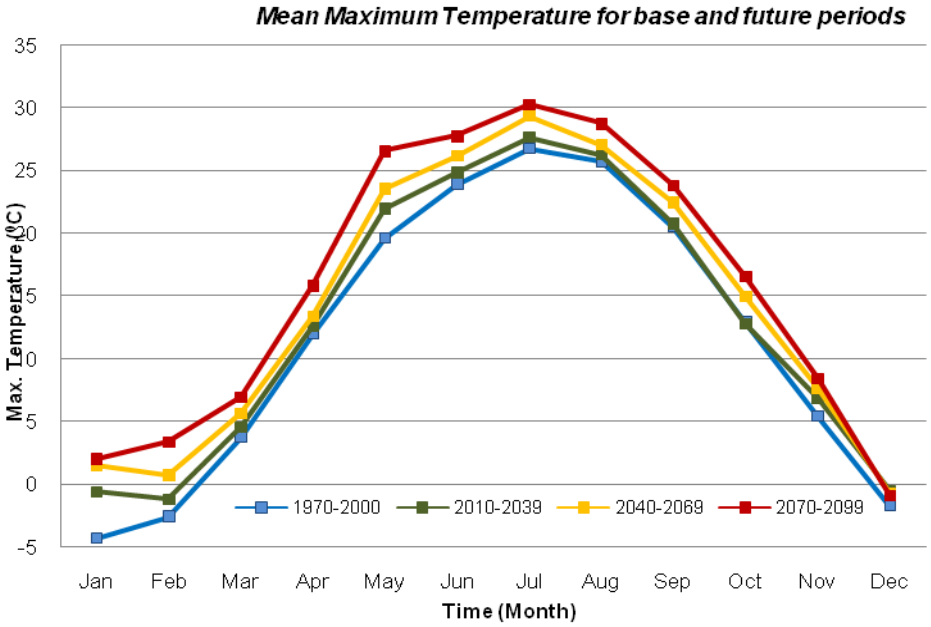
# Methodology

- A2 emissions scenario – CGCM II climate model downscaled to Mississippi R. watershed
  - Temperature
  - Precipitation
- Four periods modeled
  - Base Period 1974 – 2002
  - Future periods (2010 – 2039, 2040 – 2069, 2070 – 2099)
- Mike 11 – NAM calibrated rainfall/runoff model
- MRWM reservoir operation model

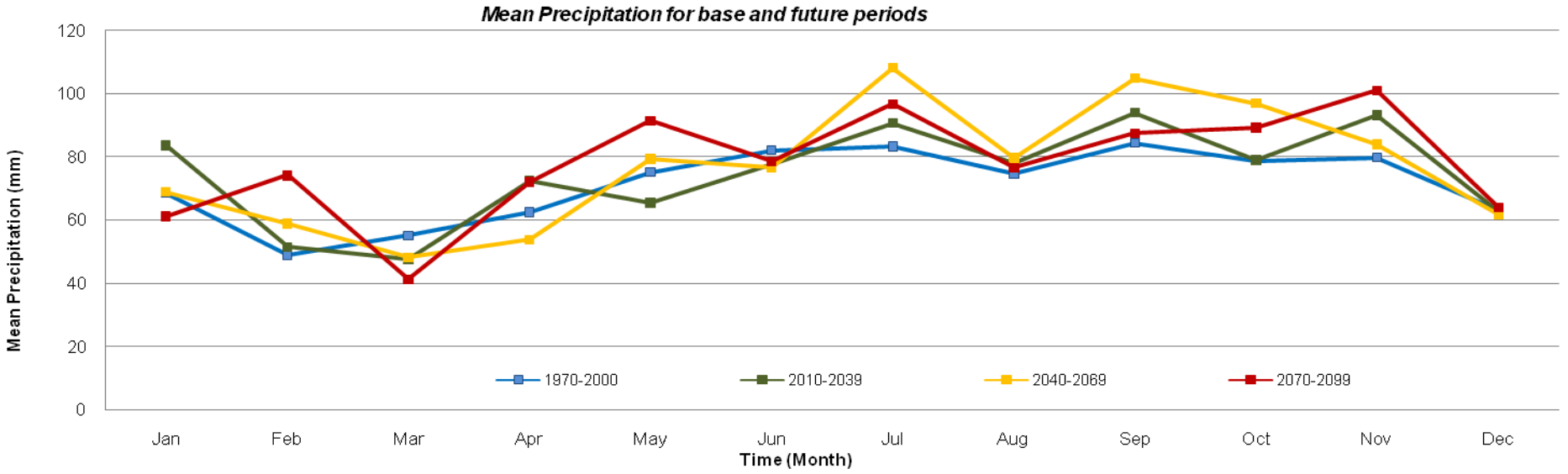
# RESULTS

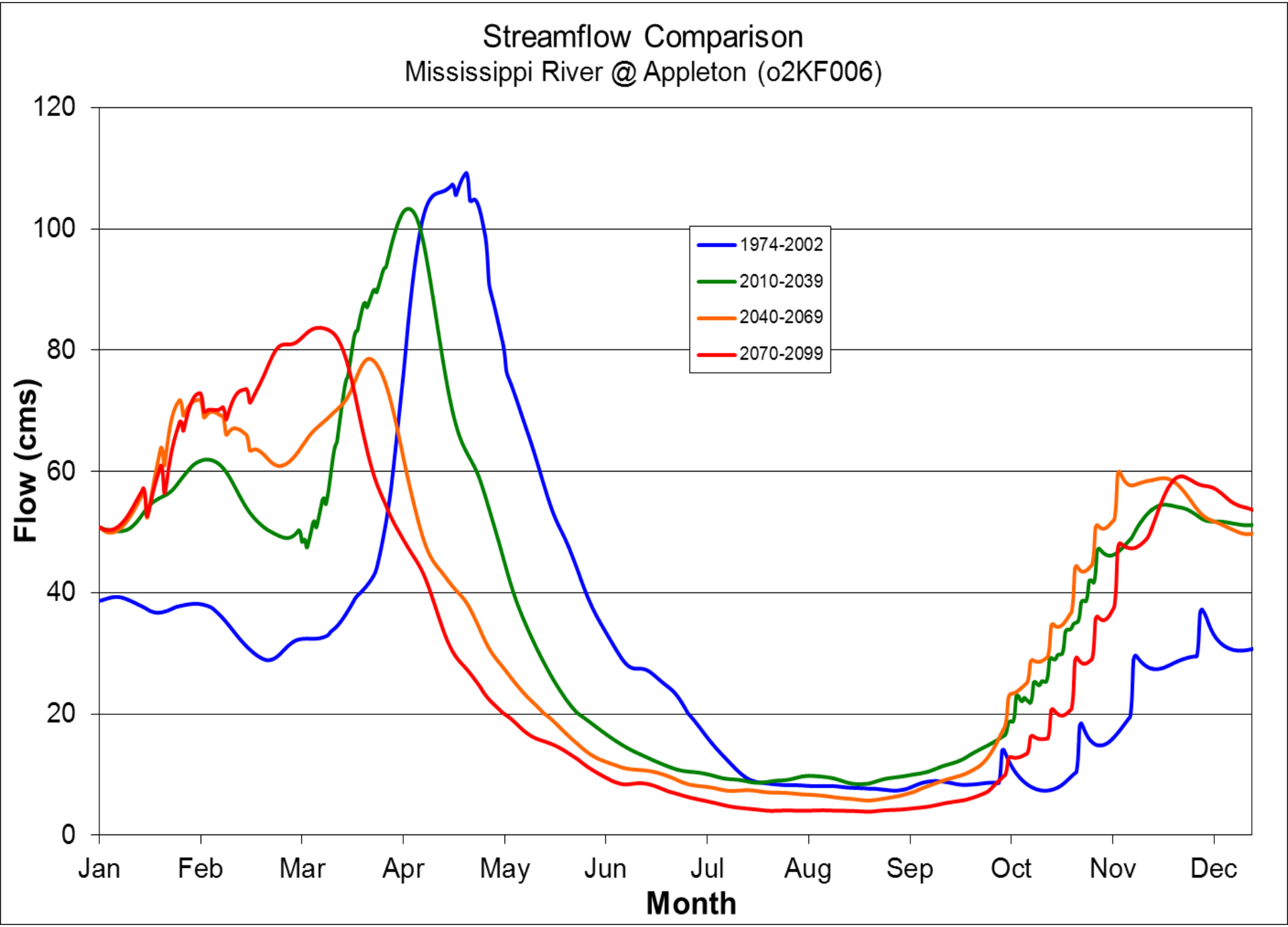
## Minimum and Maximum Temperature - Base and Future Projections

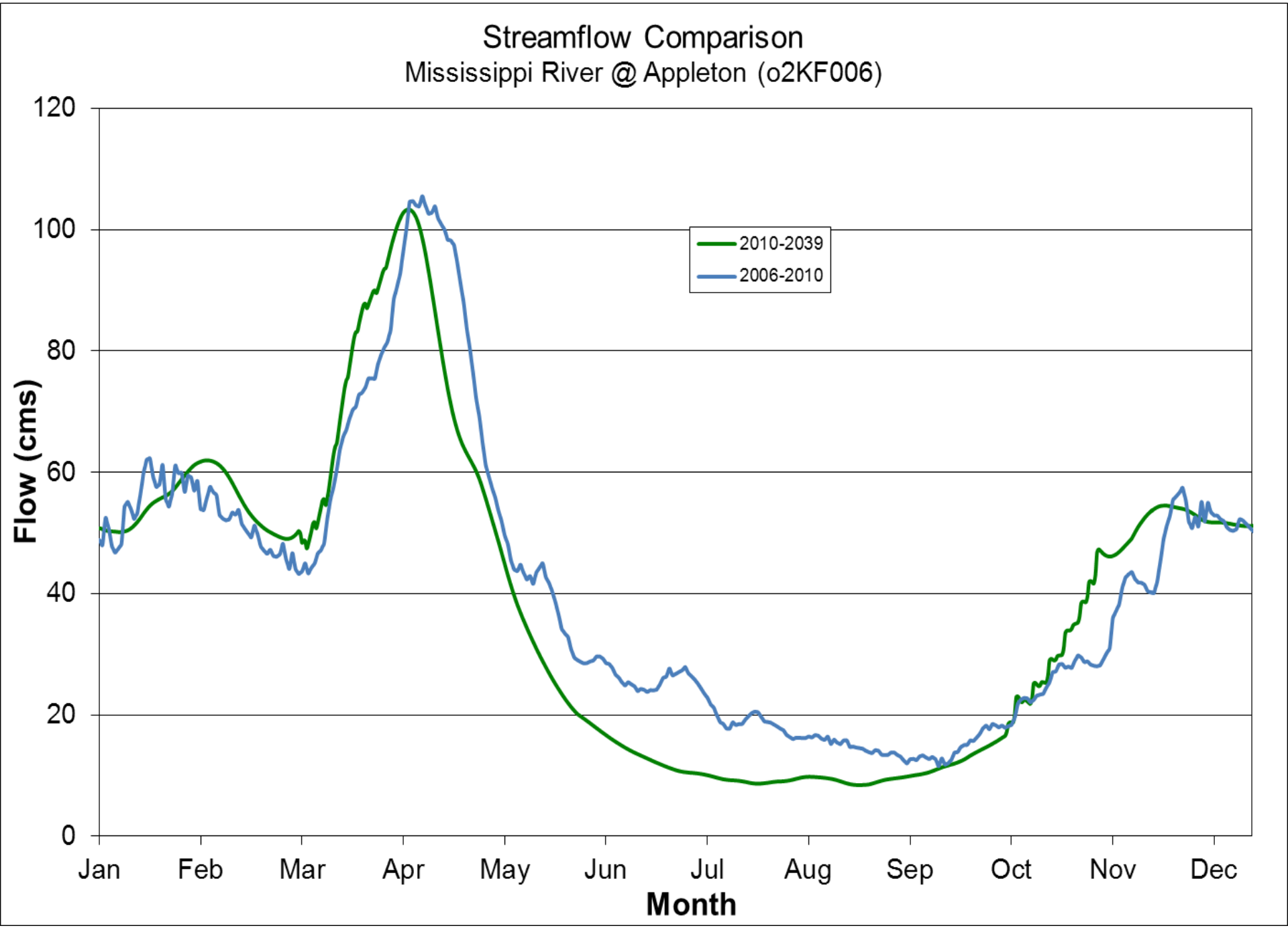


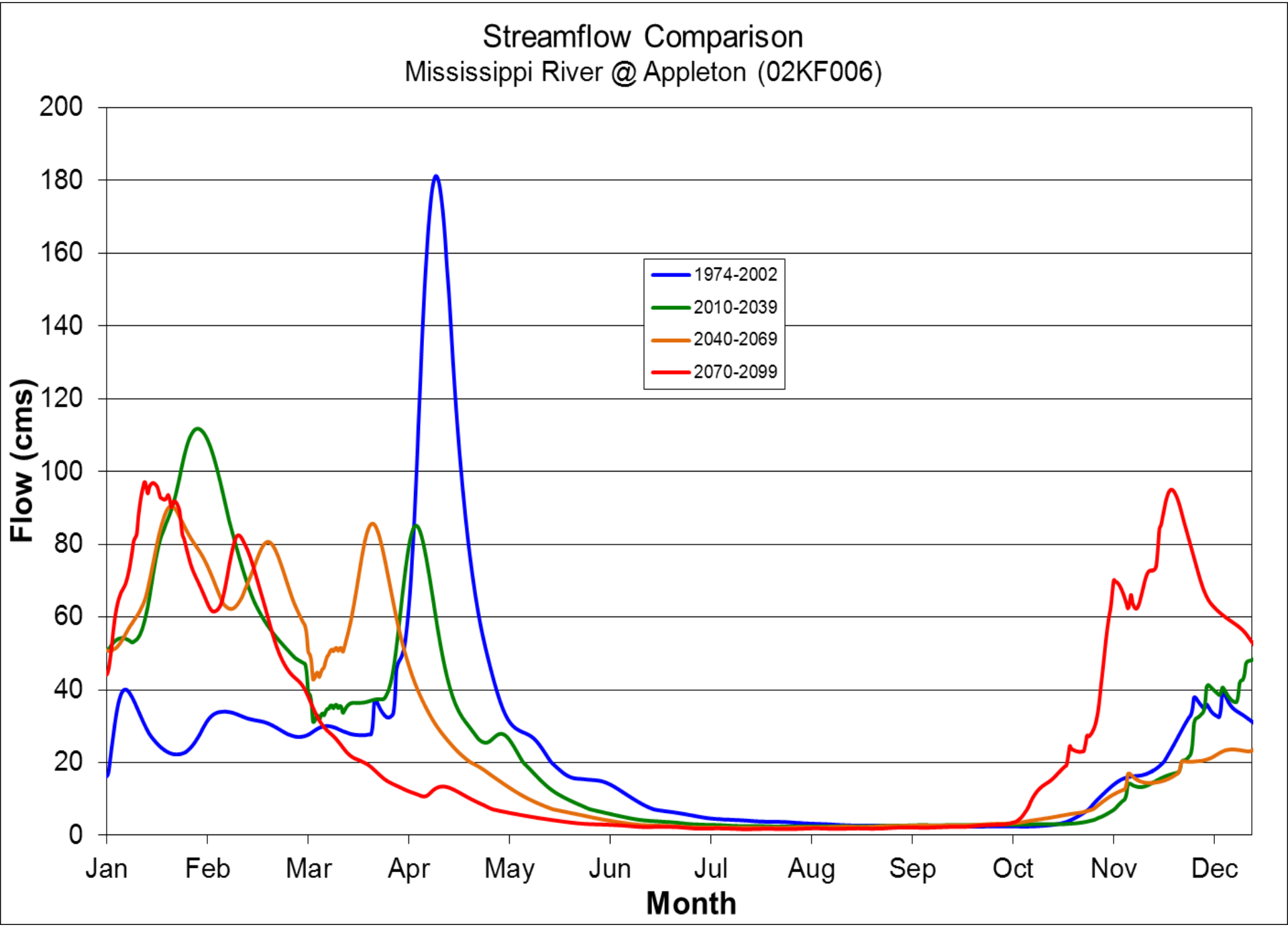




## Mean Precipitation - Base and Future Projections



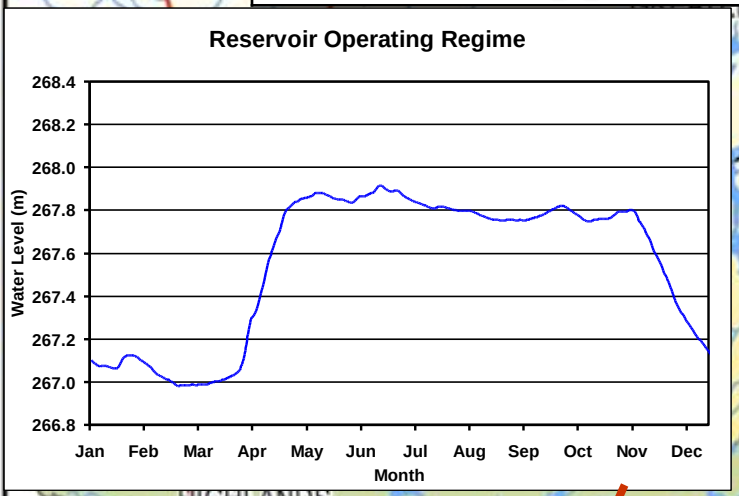

Streamflow Comparison
Mississippi River @ Appleton (o2KF006)
120
100
80
60
40
20
0
Flow (cms)
1974-2002
2010-2039
2040-2069
2070-2099
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month


Streamflow Comparison
Mississippi River @ Appleton (o2KF006)
120
100
80
60
40
20
0
Flow (cms)
2010-2039
2006-2010
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month


Streamflow Comparison
Mississippi River @ Appleton (02KF006)
1974-2002
2010-2039
2040-2069
2070-2099
Flow (cms)
0
20
40
60
80
100
120
140
160
180
200
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

# Reservoir Implications

# Mississippi River Water Management Structures




City of Ottawa

MISSISSIPPI MILLS

Almonte

Mississippi River Watershed

LANARK HIGHLANDS

NORTH FRONTENAC

Carleton Place

BECKWITH

DRUMMOND NORTH ELMSLEY

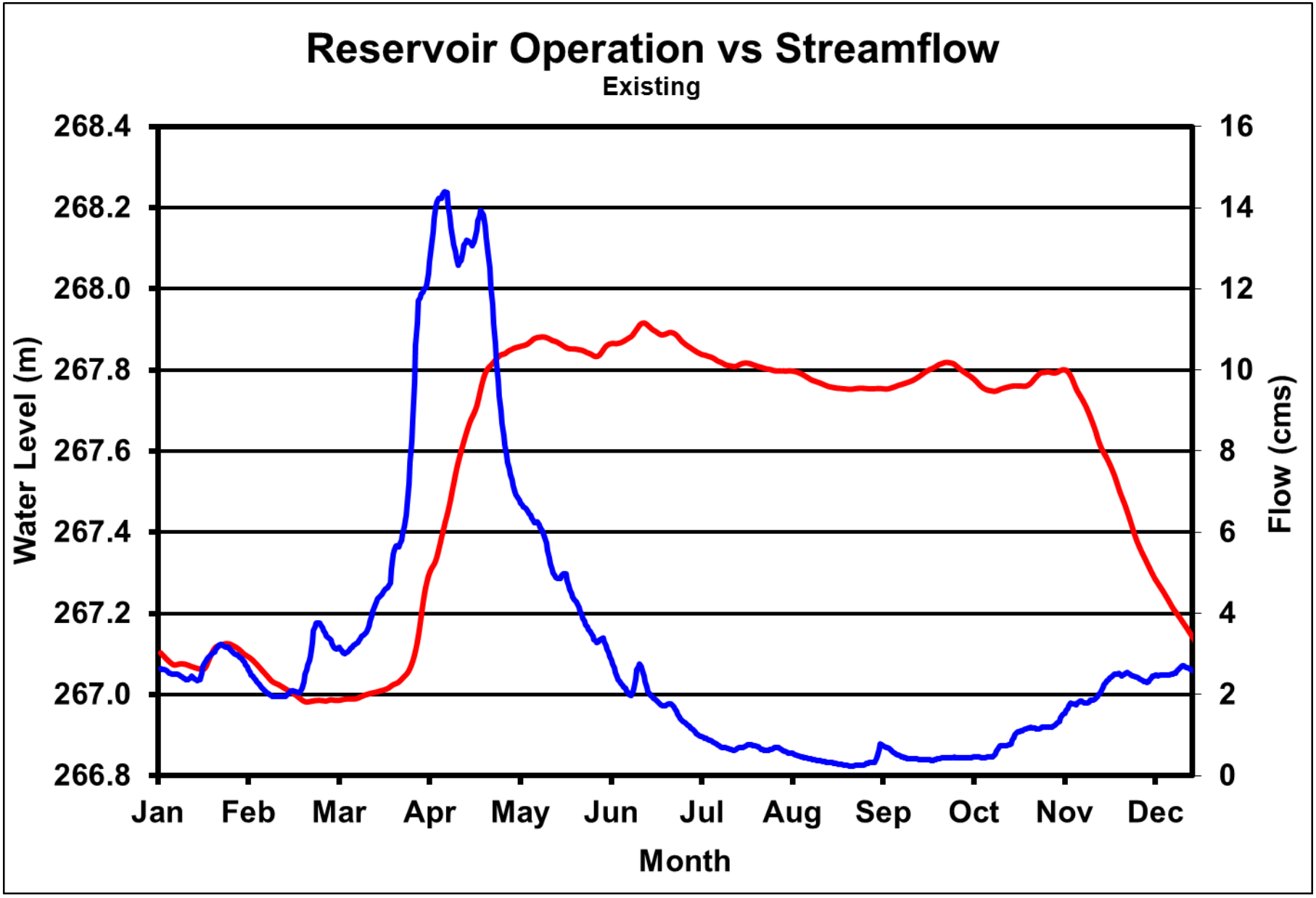
TAY VALLEY

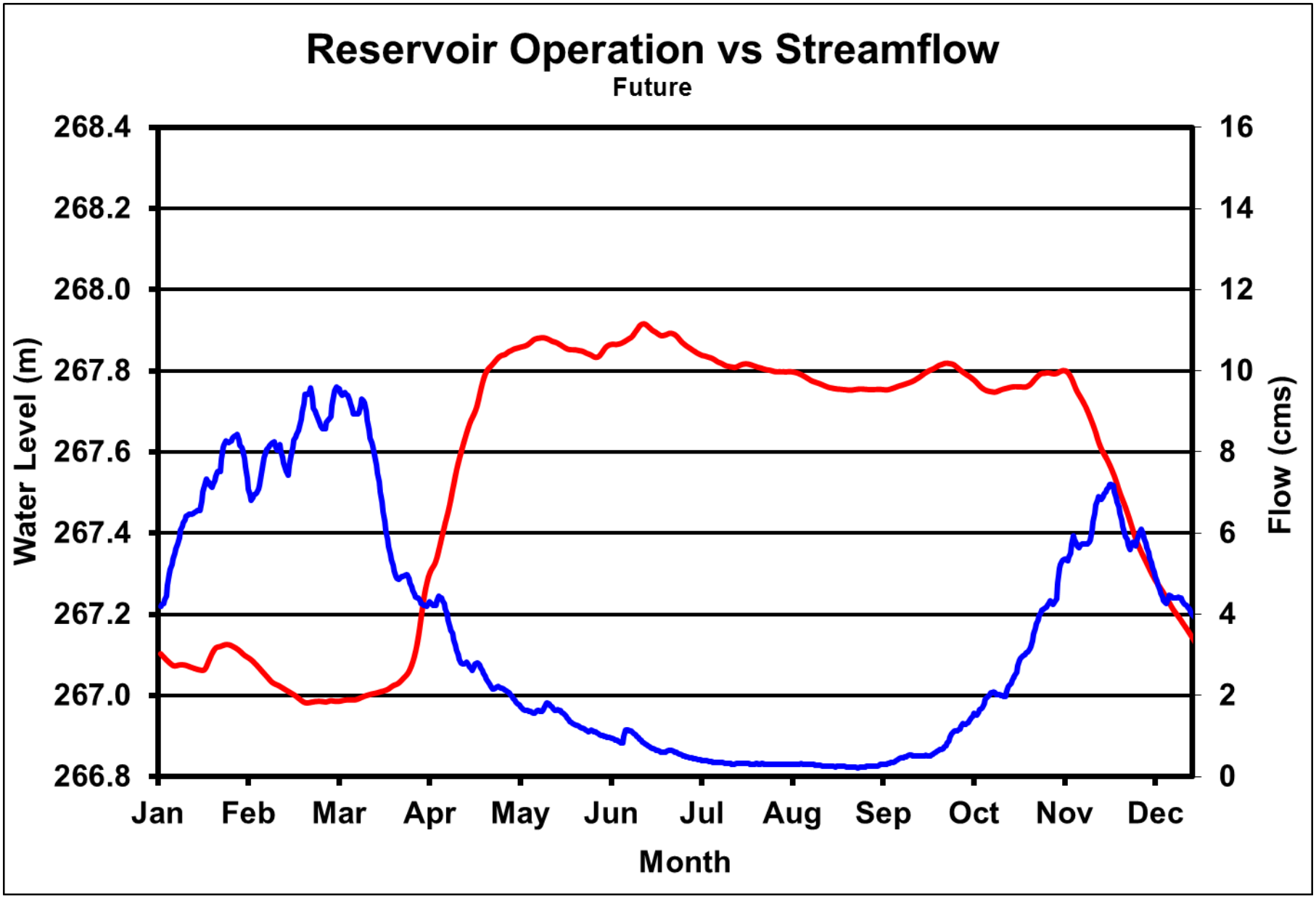
CENTRAL FRONTENAC

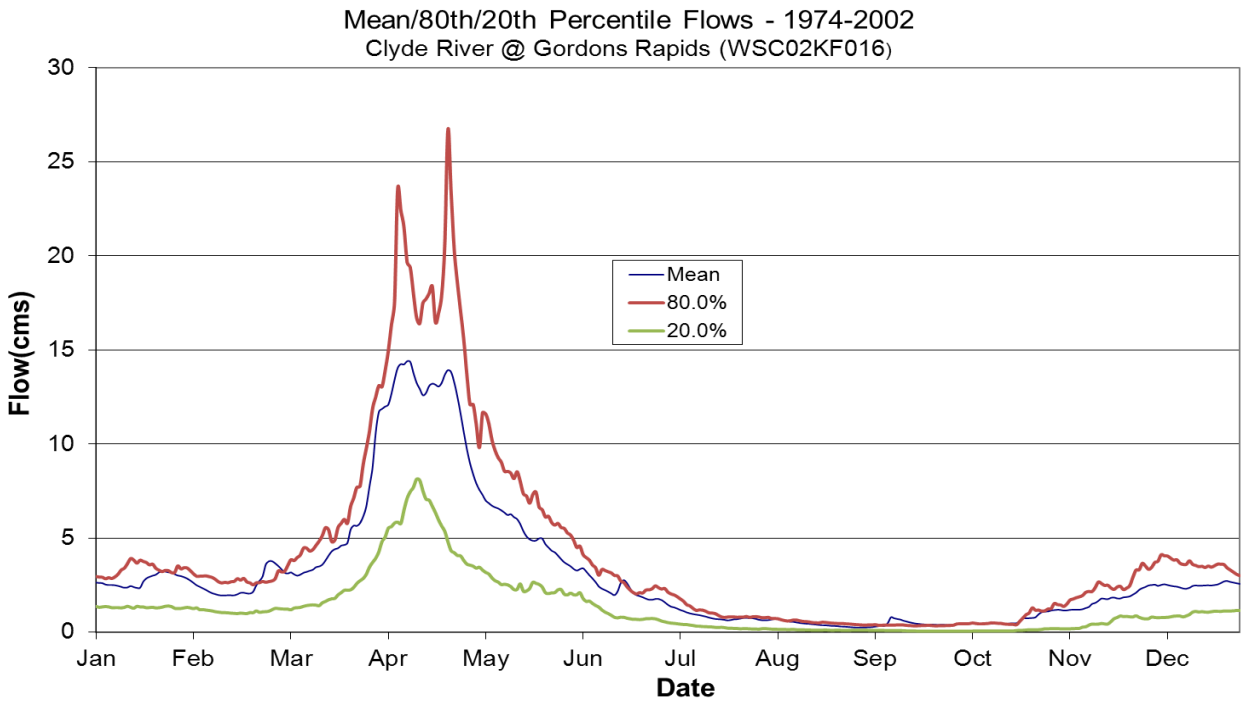
**Legend**

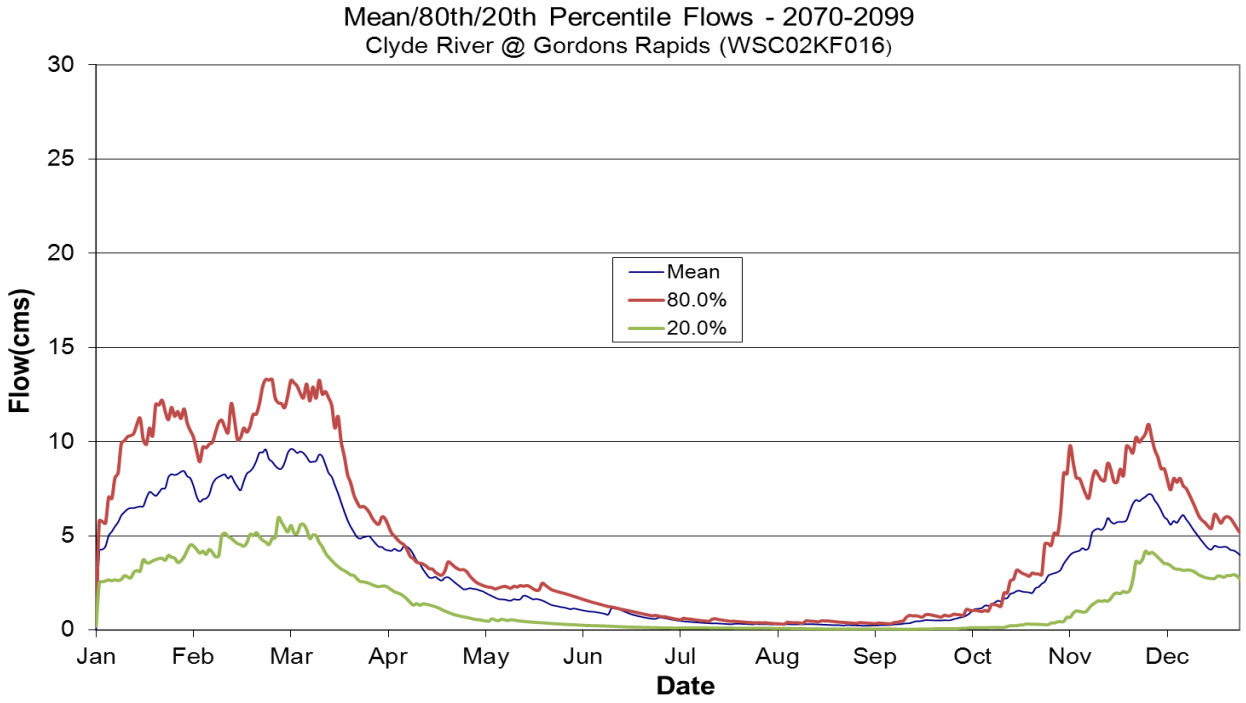
- Hydro electric station
- Water control dam
- Waste water plant
- Reservoir system

1:650,000
UTM NAD 83


Reservoir Operation vs Streamflow
Existing
268.4
268.2
268.0
267.8
267.6
267.4
267.2
267.0
266.8
Water Level (m)
16
14
12
10
8
6
4
2
0
Flow (cms)
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month


Reservoir Operation vs Streamflow
Future
268.4
268.2
268.0
267.8
267.6
267.4
267.2
267.0
266.8
Water Level (m)
16
14
12
10
8
6
4
2
0
Flow (cms)
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month




# Implications

- Highly variable flows over fall/winter
- Potential risks:
  - achieving summer recreation targets
  - water supply targets
  - shoreline damage
  - unsafe ice conditions

# Water Management Implications (Primary)

- Stream Flows
  - Freshets 28% lower/6-7 weeks earlier
  - Minimum summer flows
    - 44% lower
    - Persist 28% longer
  - Fall/winter flows 70% higher
- Greater flood risk in fall and winter
- Increased shoreline erosion
- Increased frazil ice generation
- Greater variability in summer water levels

# Water Management Implications (Secondary)

- Higher evapo-transporation rates
  - 10% increase in precipitation
  - 16% increase in evapo-transpiration
  - 26% reduction in annual streamflow
  - Greater water demands
- Higher surface water temperatures
- Lower flushing rates/degraded water quality
  - Waste water discharge criteria

# Adaptation Options

- Maintain/increase reservoir capacity
  - Mississippi River (25%)
  - Employ risk based management strategies
- Minimize nutrient loading
- Improve capacity for watershed monitoring and assessment
  - Flood warning
  - Low water response
  - Reservoir response
- Adapt shoreline structures
  - Floating docks

# Thank you

- Mississippi Valley Conservation
  - http://www.mvc.on.ca/
  - plehman@mvc.on.ca