The Thermal Impacts of Storm Water on a Cold Water Resource

Kent Johnson and Andy Lamberson
Kiap-TU-Wish Chapter, Trout Unlimited

Luna B. Leopold, c. 1971.

“The health of our waters is the principal measure of how we live on the land.”

-Luna Leopold


WELCOME to RIVER FALLS
1848
"The City on the Kinni"
WHERE LIFE KEEPS GETTING BETTER AND BETTER
LIONS
L
INTERNATIONAL
ROTARY
INTERNATIONAL
K of C
AMERICAN
U.S
LEGION
KINNICKINNIC
RIVER
LAND
TRUST
PROTECT
OUR CHILDREN
O E S

Stormwater Discharge at Division Street

Wet Detention Pond at Division Street

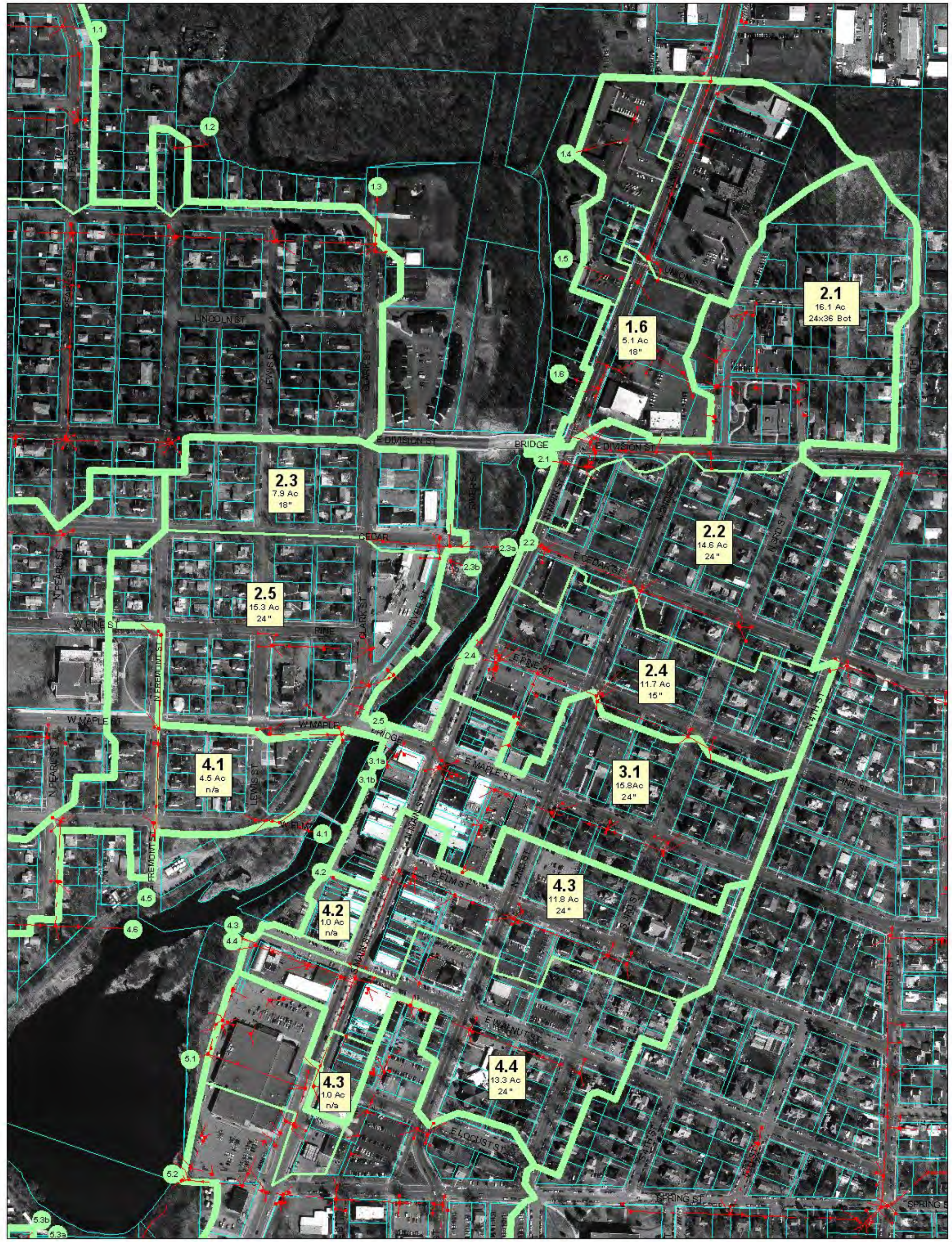
Stormwater Discharge at Maple Street

Stormwater Discharge to South Fork of the Kinni

Stormwater Discharge to South Fork of the Kinni

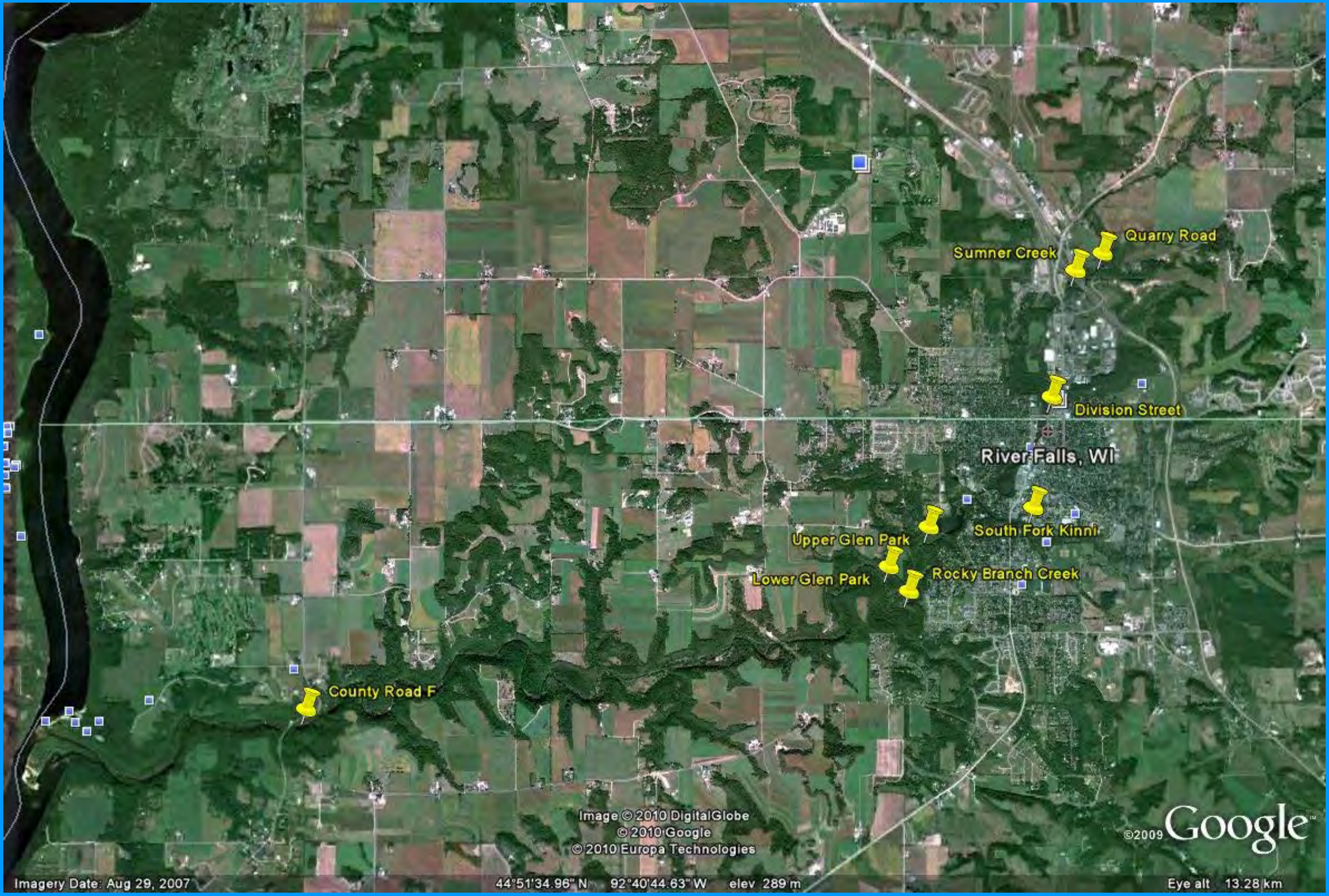
City of River Falls Storm Sewersheds

- Sewersheds comprise 176 acres (85 ac. impervious) discharging through 24 outfalls
- 103 acres (51 ac. impervious) drain to River from east above Lake
- 36 acres (14 ac. impervious) drain to River from west above Lake
- Remainder (36 acres, 20 impervious) drain to Lake George



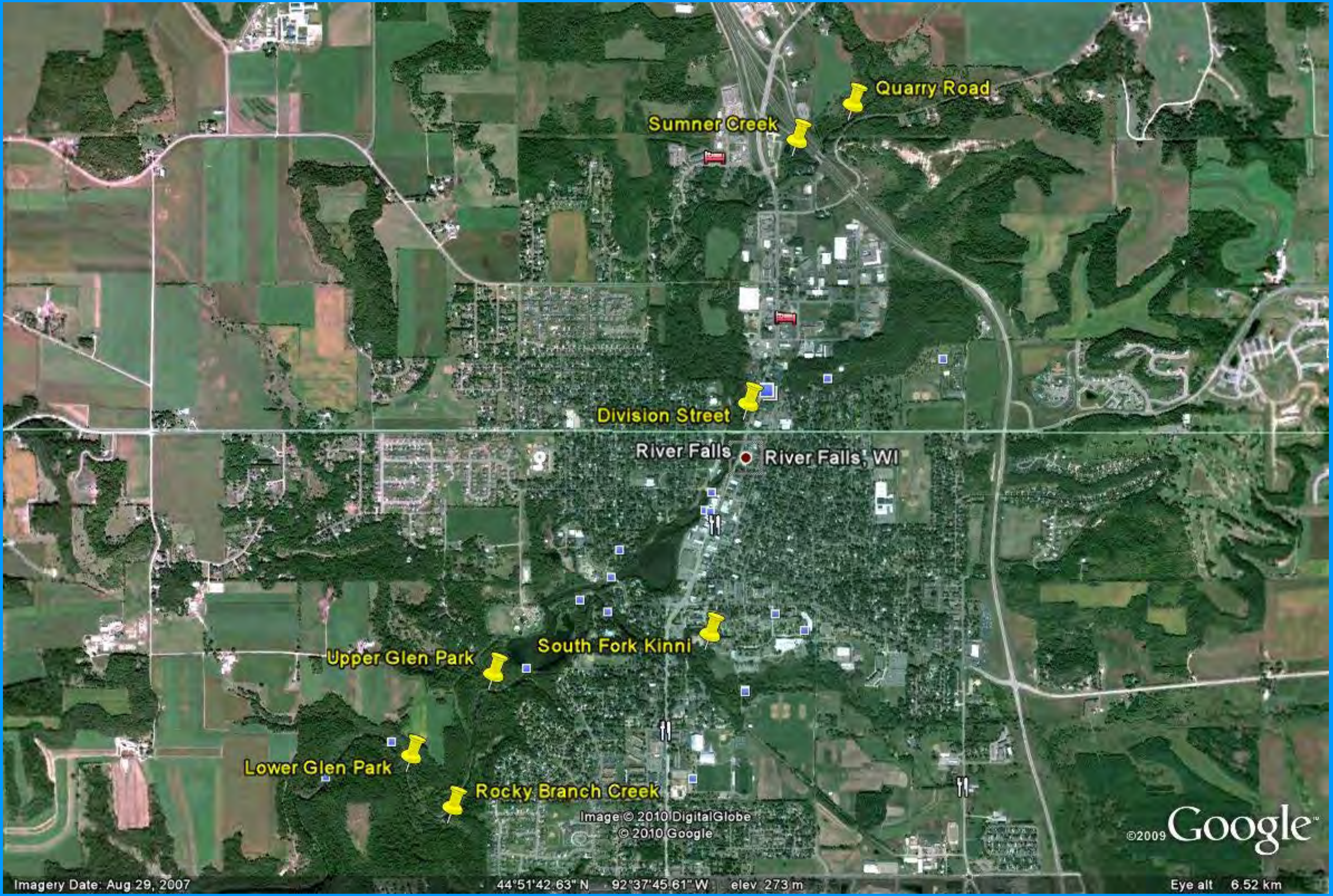
Kinnickinnic River Thermal Monitoring Sites

Kiap-TU-Wish Chapter, Trout Unlimited



Kinnickinnic River Thermal Monitoring Sites

Kiap-TU-Wish Chapter, Trout Unlimited



Thermal Monitoring Instrumentation

Typical Thermal Monitoring Station

Monitoring Station with Camouflage

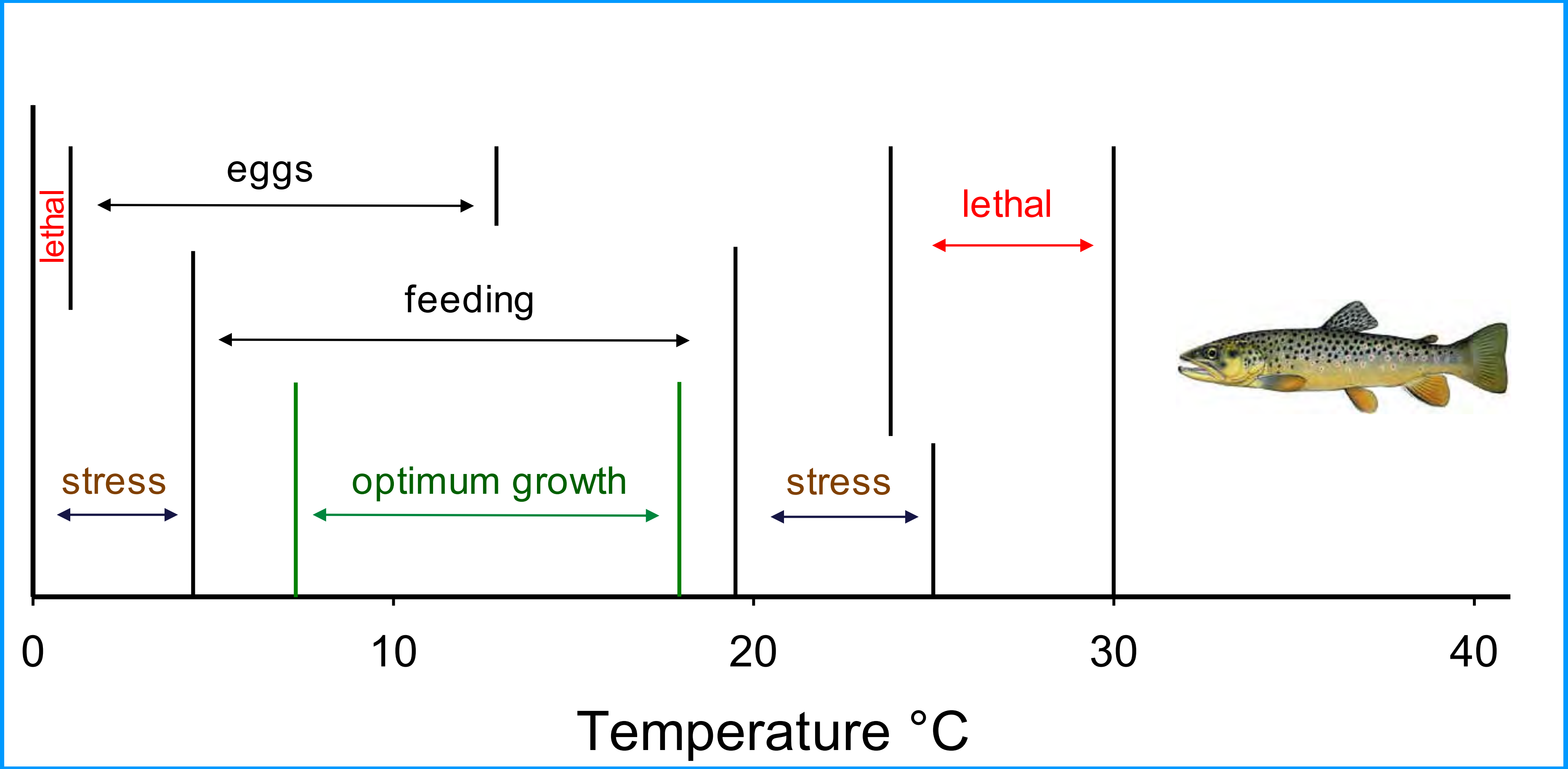
Monitoring Station with Homeland Security

Thermal Preferences of Brown Trout for Survival and Growth

(Armour, 1994)

- Physiological Optimum: 17.0 C (12.0 – 20.0 C)
- Growth Optimum: 16.4 C (7.0 – 19.0 C)
- Zero Net Gain Range: 19.5 – 21.2 C
  (No Growth; Survival = Mortality)
- Visible Thermal Stress: 19 – 30 C
  Lower Value: Avoidance, restlessness, disturbing temperature
  Upper Value: Maximum survival temperature for brief periods
- Upper Ultimate Incipient Lethal Temperature: 25 – 30 C
- Critical Thermal Maximum: 29.8

Thermal Preferences of Brown Trout

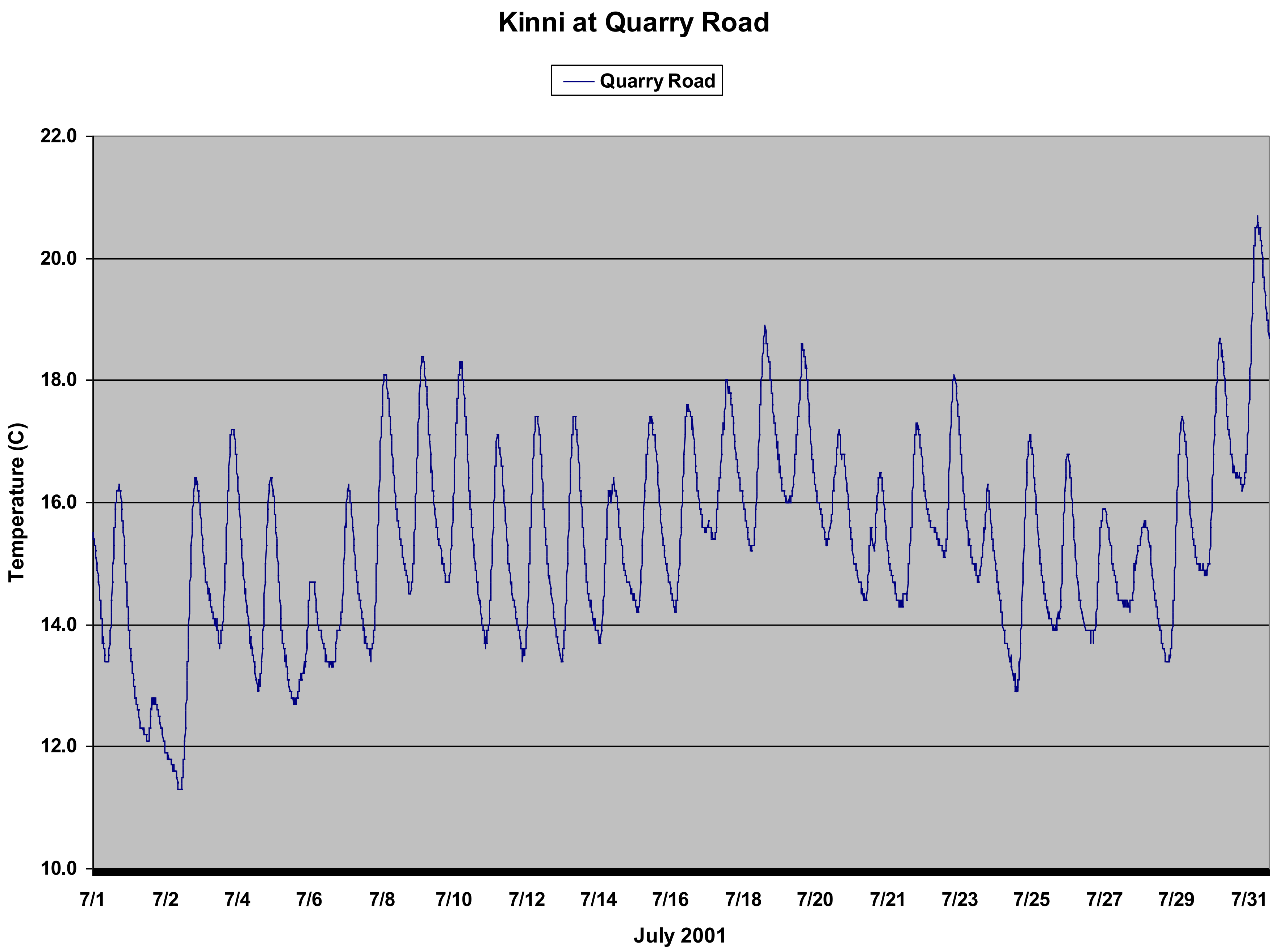


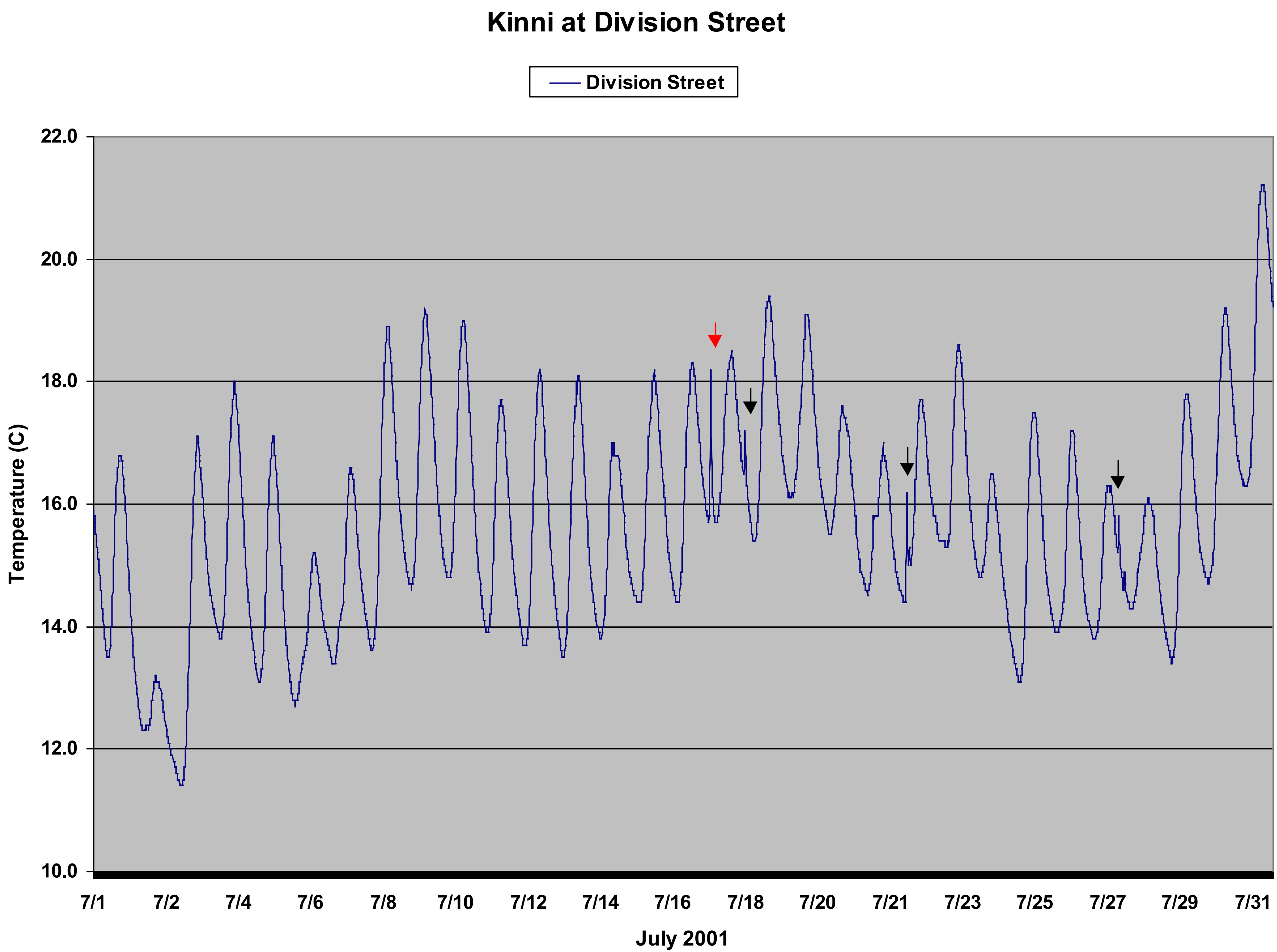
Elliott, J. M. 1994. Quantitative Ecology and the Brown Trout.
Oxford University Press, New York.

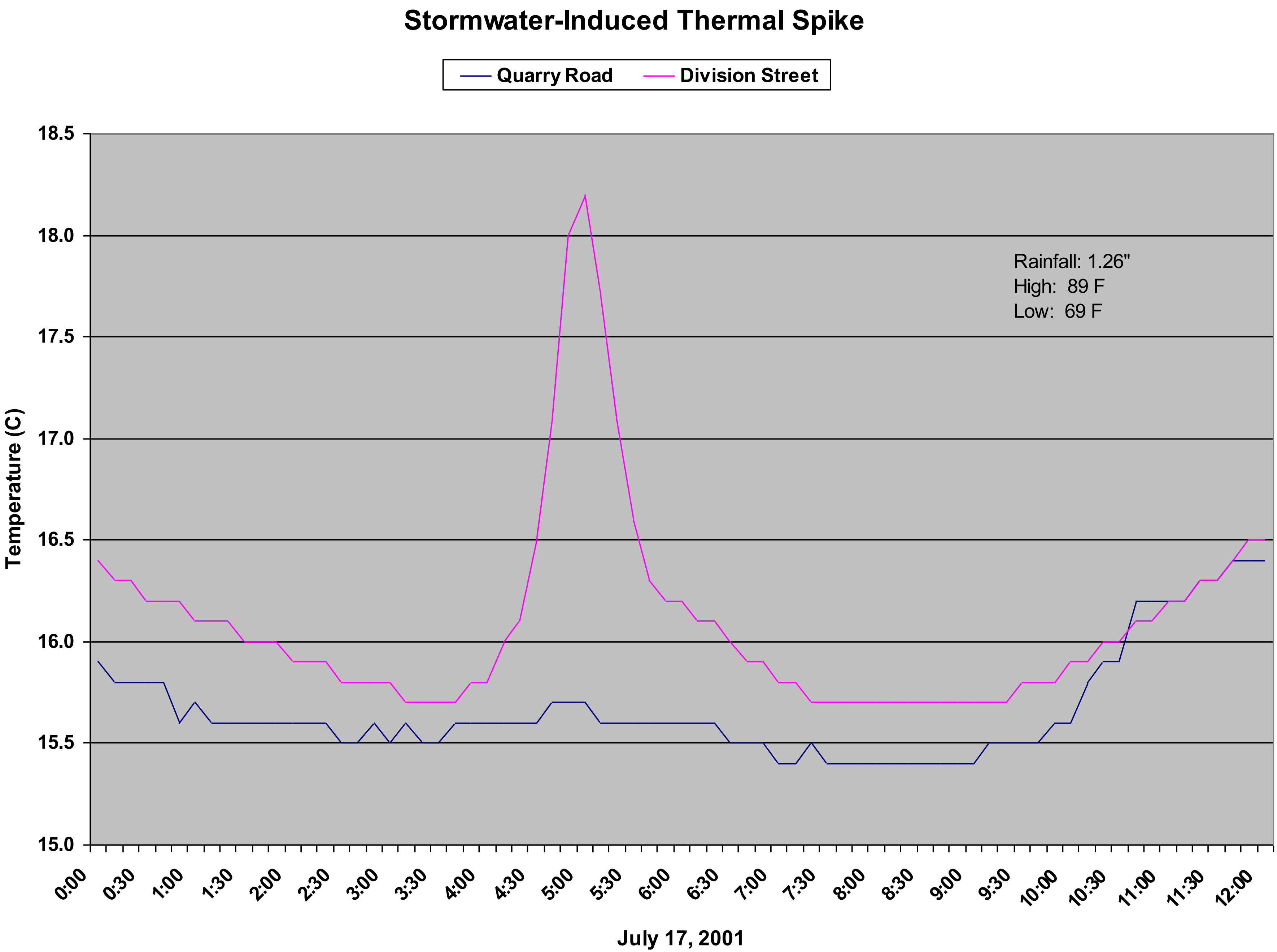
Thermal Preferences of Macroinvertebrates
(Galli, 1990)

Macroinvertebrates serve as a major food source for trout, and are an integral part of the normal energy and organic material processing system in streams

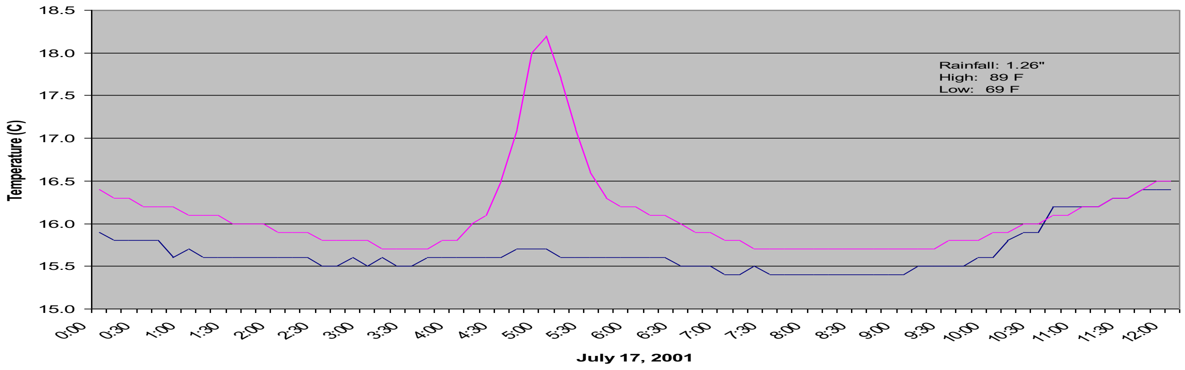
- Many aquatic insects (esp. mayflies) require a fluctuating diurnal temperature regime
- Temperatures > 17 C exceed the optimum for many stoneflies, mayflies, and caddisflies
- Temperatures > 21 C can severely stress most coldwater macro-invertebrates
- Upper Limiting Temperatures:
  - Stoneflies: 13 – 20 C
  - Mayflies: 12 - < 25 C
  - Caddisflies: 20 – 35 C
- Because of temperature regime alteration, temperature-sensitive or thermally-cued macroinvertebrates are often reduced or eliminated below impoundments, leaving only types with broad tolerance ranges


Kinni at Quarry Road
Quarry Road
Temperature (C)
22.0
20.0
18.0
16.0
14.0
12.0
10.0
7/1
7/2
7/4
7/6
7/8
7/10
7/12
7/14
7/16
7/18
7/20
7/21
7/23
7/25
7/27
7/29
7/31
July 2001


Kinni at Division Street
Division Street
Temperature (C)
22.0
20.0
18.0
16.0
14.0
12.0
10.0
7/1
7/2
7/4
7/6
7/8
7/10
7/12
7/14
7/16
7/18
7/20
7/21
7/23
7/25
7/27
7/29
7/31
July 2001


Stormwater-Induced Thermal Spike
Quarry Road
Division Street
Rainfall: 1.26"
High: 89 F
Low: 69 F
Temperature (C)
18.5
18.0
17.5
17.0
16.5
16.0
15.5
15.0
0:00
0:30
1:00
1:30
2:00
2:30
3:00
3:30
4:00
4:30
5:00
5:30
6:00
6:30
7:00
7:30
8:00
8:30
9:00
9:30
10:00
10:30
11:00
11:30
12:00
July 17, 2001

Dynamics of a Thermal Spike



- Antecedent air temperature
- Antecedent pavement temperature
- Timing of rainfall
- Total amount of rainfall
- Intensity of rainfall
- Duration of rainfall

Biological Impacts of a Thermal Spike

Brown Trout (EPA, 1977; Elliot, 1981; Armour, 1994):

- Critical Thermal Maximum: 29.8
- Upper Ultimate Incipient Lethal Temperature: 25 - 30 C
- Maximum temperature for 24-hr. exposure: 24 C
- Maximum temperature for 10-30 min. exposure: 27 - 28 C
- Juvenile fish are far more susceptible to thermal shock
- Temperature changes of less than 0.5 C can be detected; avoidance possible given suitable thermal regime in vicinity

Assessing the Impact of Urban Stormwater Temperature on Brown Trout*

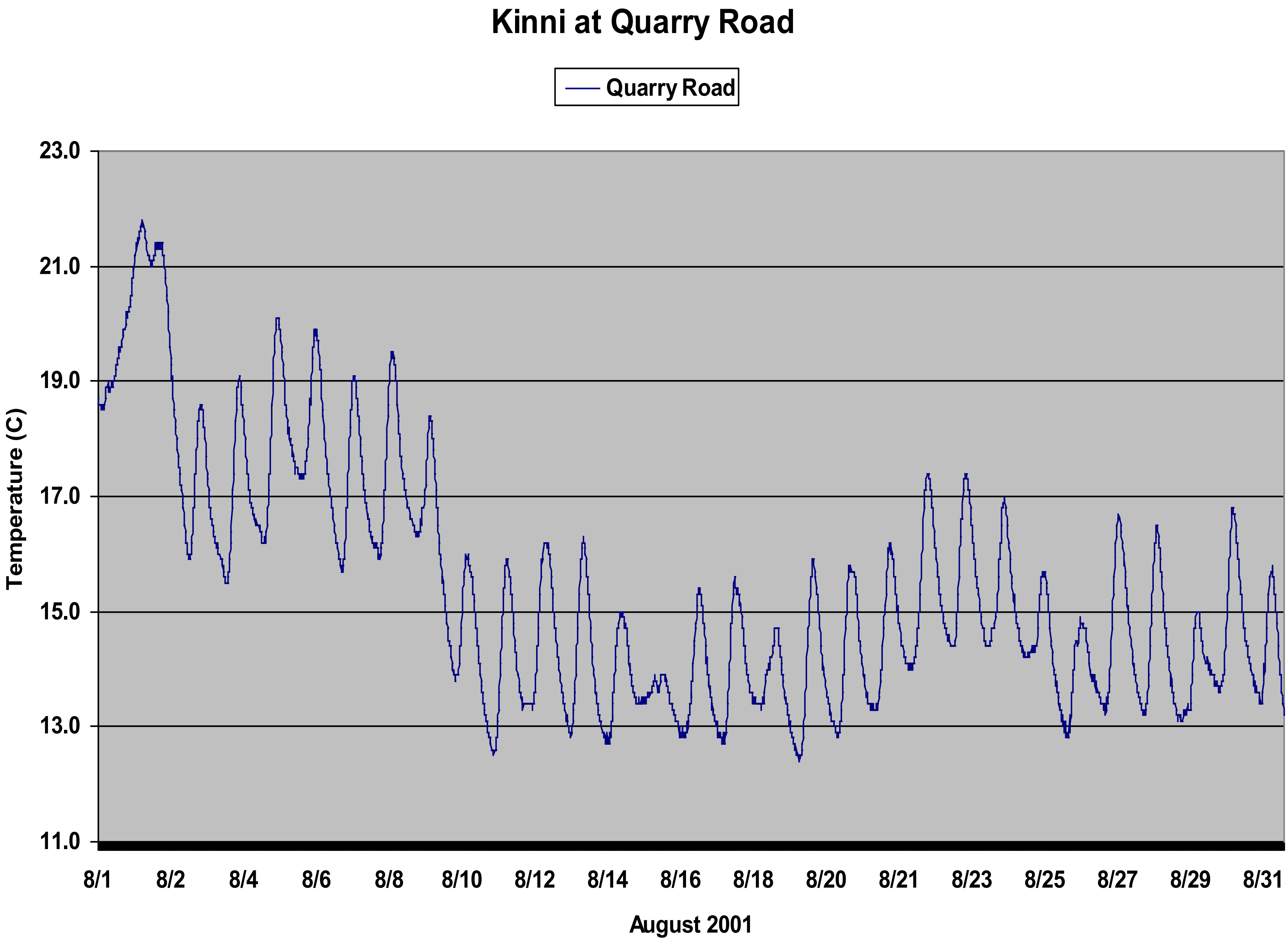
- Maximum daily mean temperatures: ≤ 22 ºC
- Maximum temperature for 1-hour exposure (with a safety margin for 100% survival): 25 ºC
- Rapid temperature change at the beginning of a rain event must not exceed 7 ºC
- Fish-egg development requires daily maximum temperature in winter to be < 12 ºC

*Rossi, L. and R. Hari. 2007. Screening procedure to assess the impact of urban stormwater temperature to populations of Brown Trout in receiving water. Integrated Environmental Assessment and Management 3(3): 383-392.

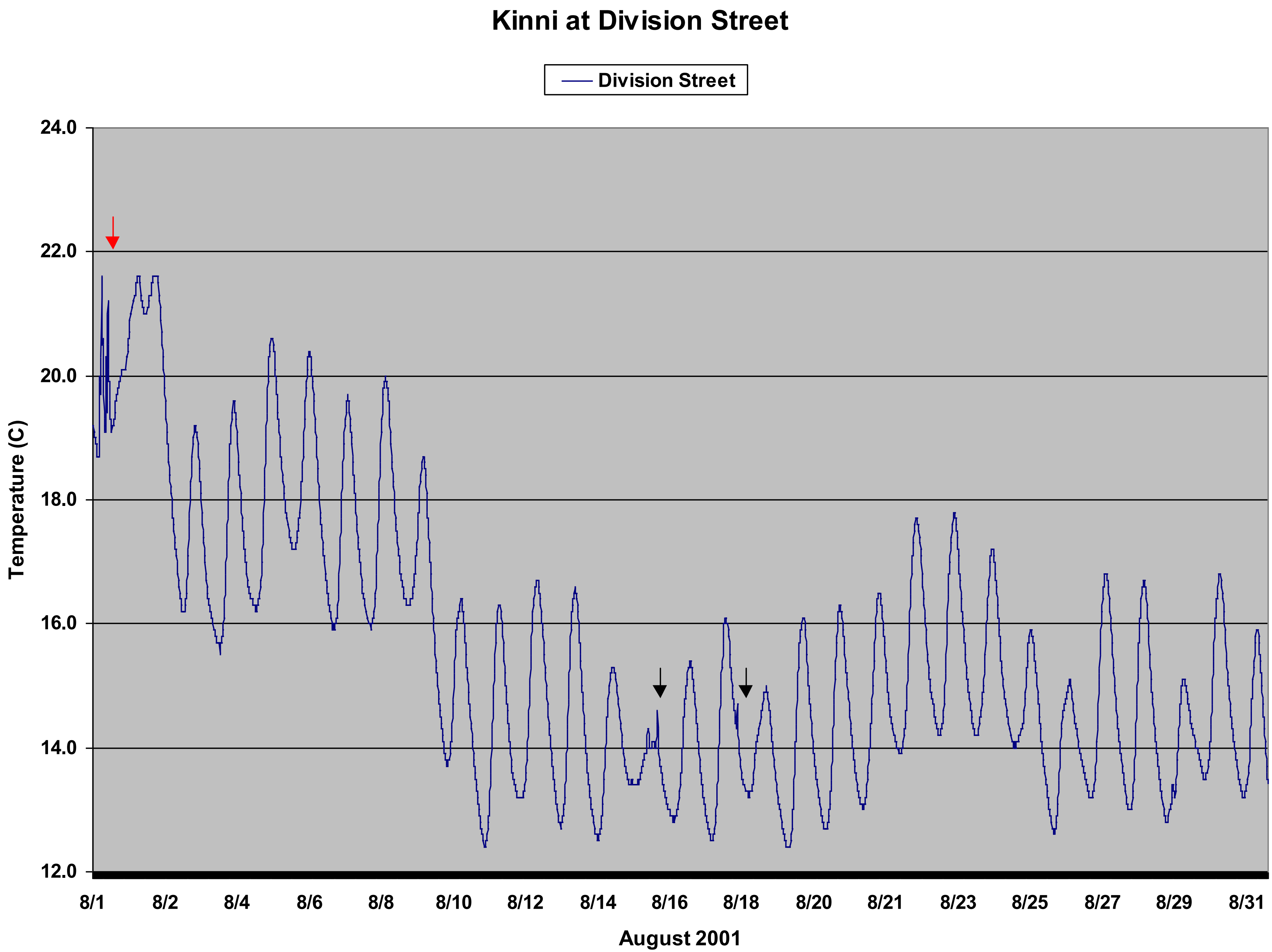
Biological Impacts of a Thermal Spike

Macroinvertebrates (Galli, 1990):

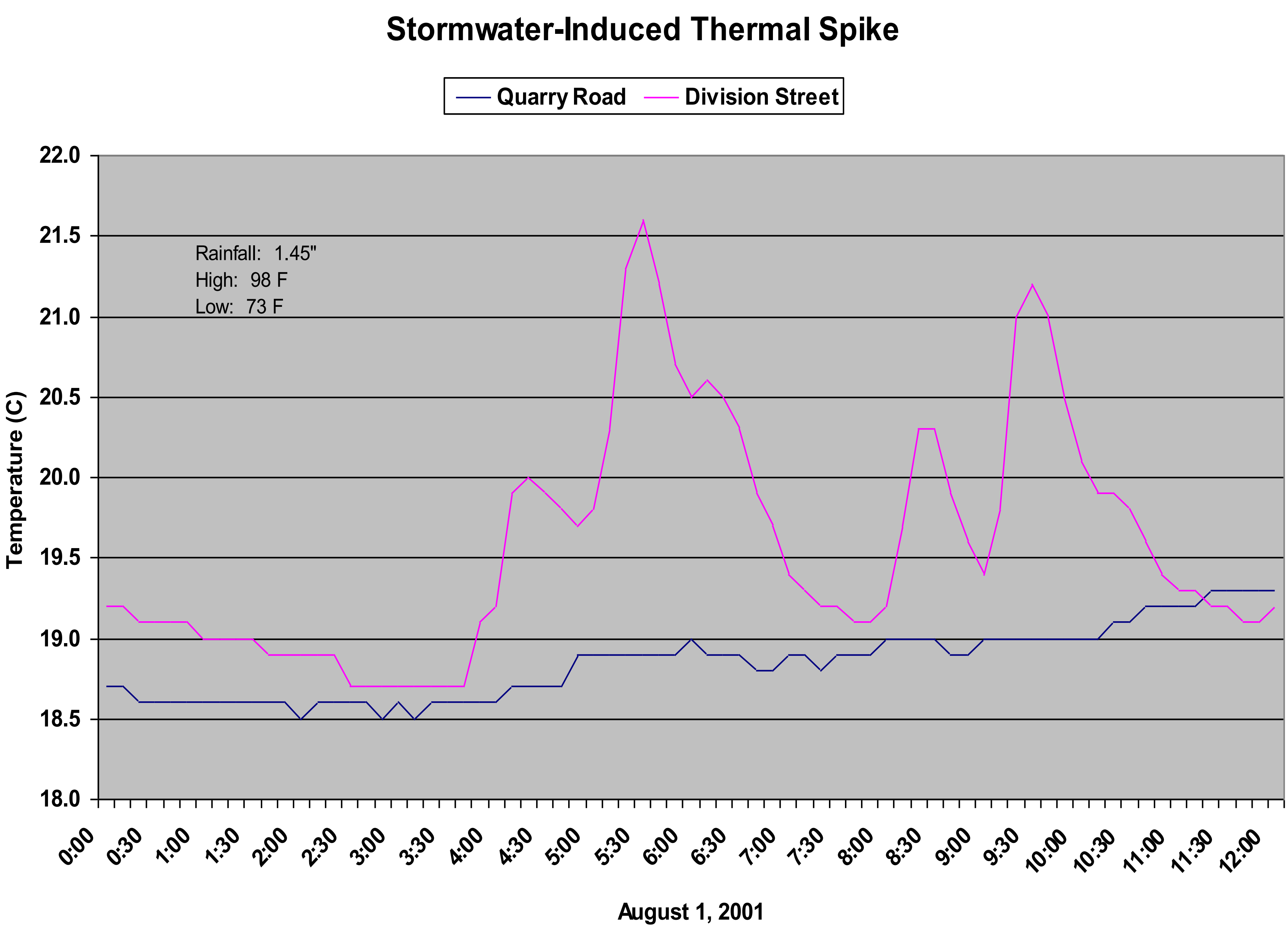
- Demonstrate little ability to acclimate or compensate for temperature changes
- When exposed to a new thermal regime, metabolic response is immediate in the direction of the temperature change
- Small temperature regime changes may have serious implications:
  - Changes of 1-2 C can reduce insect size and fecundity
  - Increases of 2-3 C could eliminate sensitive species
- Insects are adversely affected by exposure to shock temperatures approaching their upper lethal limits
- Thermal shocks may negatively affect insect growth and long-term survivability by interfering with molting



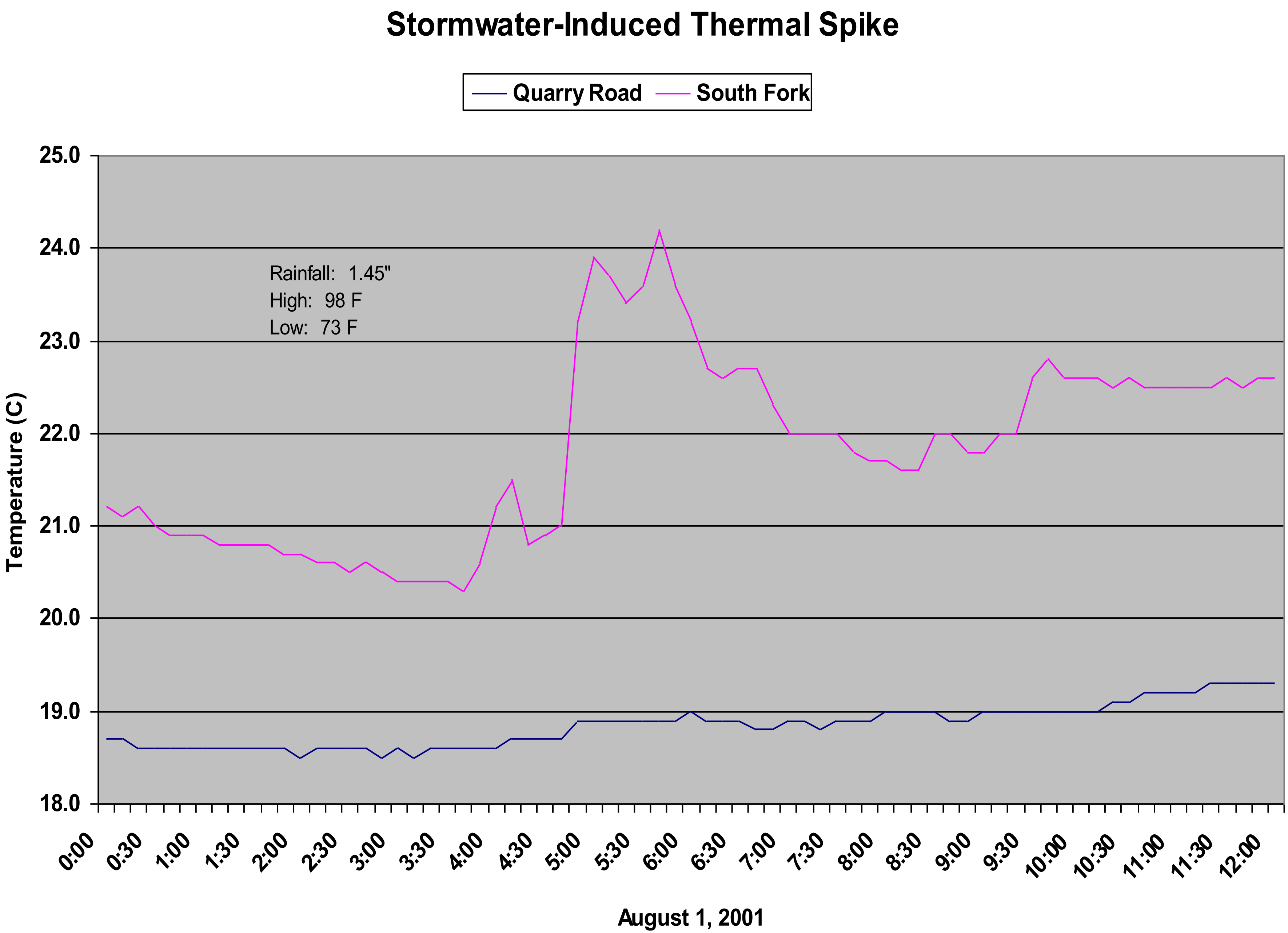
Kinni at Quarry Road
Quarry Road
23.0
21.0
19.0
17.0
15.0
13.0
11.0
Temperature (C)
8/1
8/2
8/4
8/6
8/8
8/10
8/12
8/14
8/16
8/18
8/20
8/21
8/23
8/25
8/27
8/29
8/31
August 2001



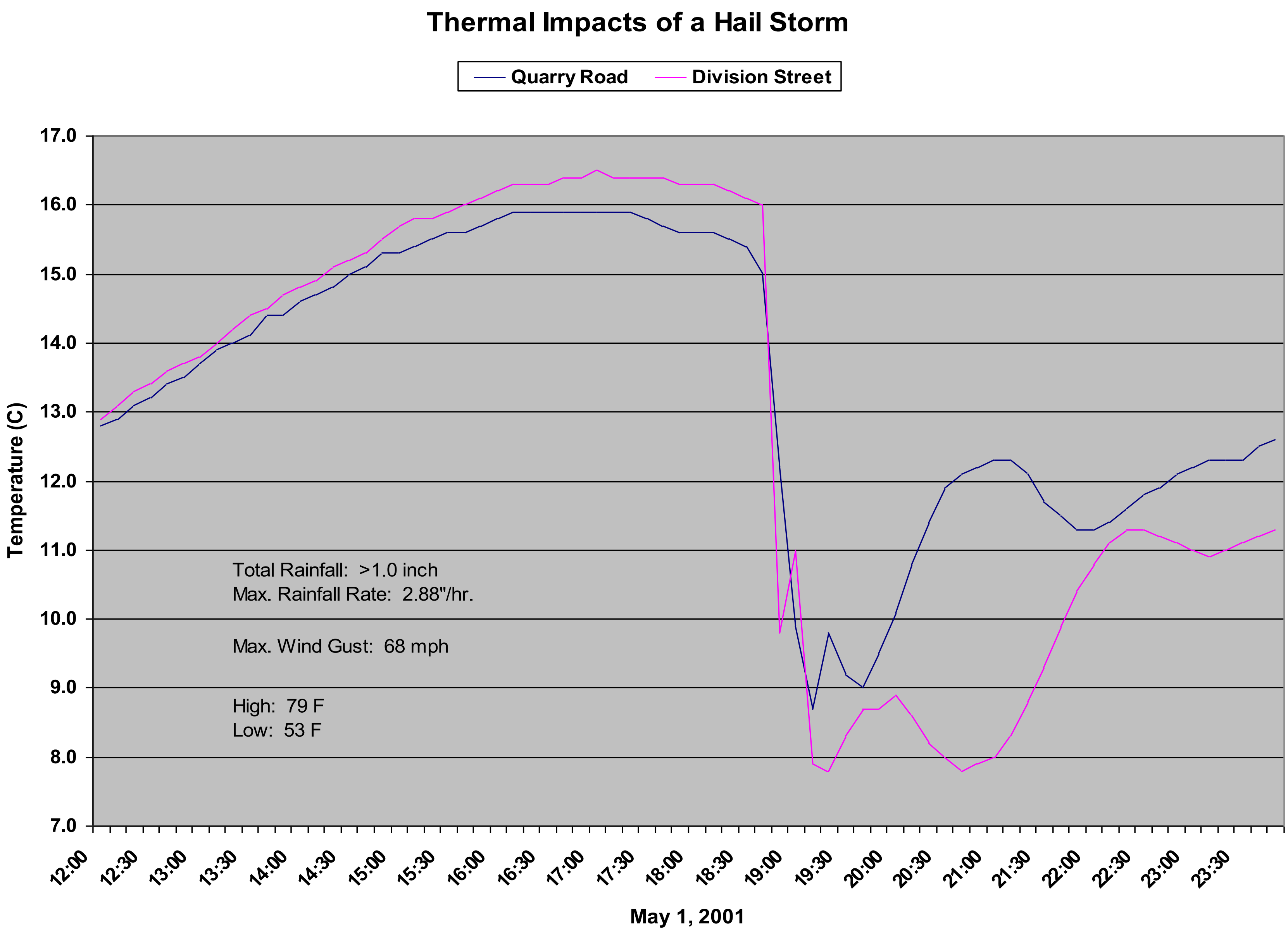
Kinni at Division Street
Division Street
24.0
22.0
20.0
18.0
16.0
14.0
12.0
Temperature (C)
8/1
8/2
8/4
8/6
8/8
8/10
8/12
8/14
8/16
8/18
8/20
8/21
8/23
8/25
8/27
8/29
8/31
August 2001



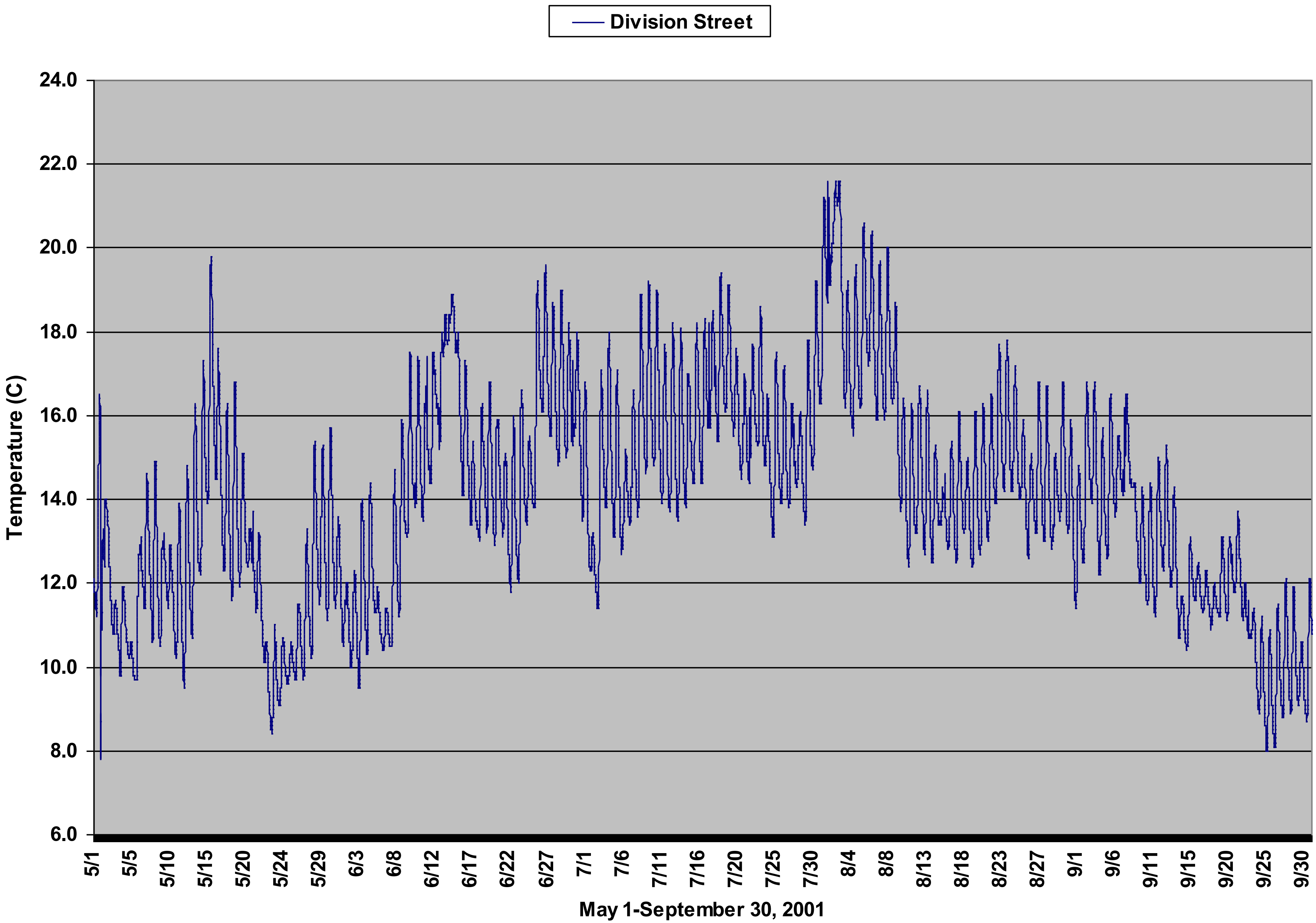
Stormwater-Induced Thermal Spike
Quarry Road
Division Street
Rainfall: 1.45"
High: 98 F
Low: 73 F
Temperature (C)
22.0
21.5
21.0
20.5
20.0
19.5
19.0
18.5
18.0
0:00
0:30
1:00
1:30
2:00
2:30
3:00
3:30
4:00
4:30
5:00
5:30
6:00
6:30
7:00
7:30
8:00
8:30
9:00
9:30
10:00
10:30
11:00
11:30
12:00
August 1, 2001

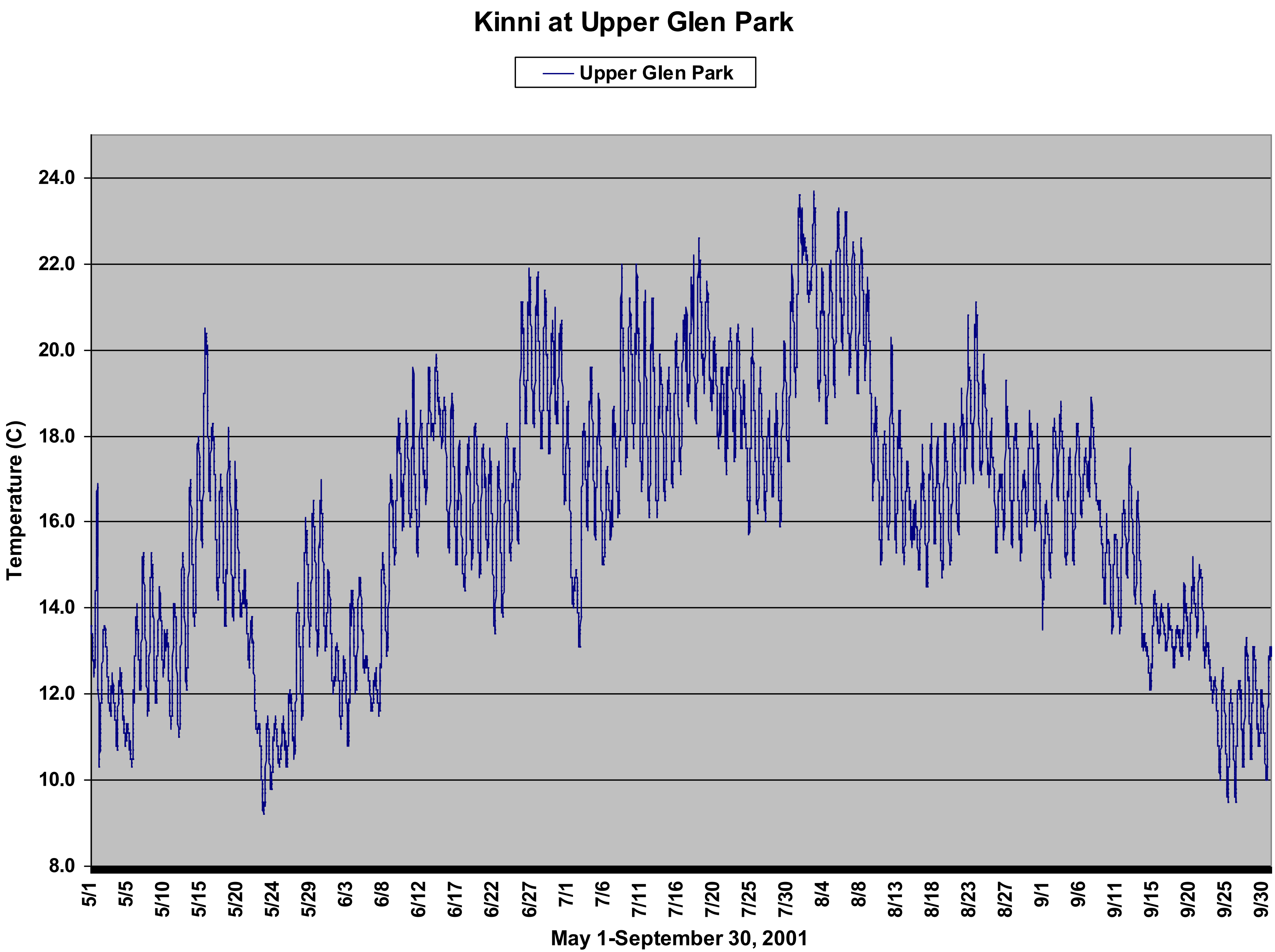


Stormwater-Induced Thermal Spike
Quarry Road
South Fork
Rainfall: 1.45"
High: 98 F
Low: 73 F
Temperature (C)
25.0
24.0
23.0
22.0
21.0
20.0
19.0
18.0
0:00
0:30
1:00
1:30
2:00
2:30
3:00
3:30
4:00
4:30
5:00
5:30
6:00
6:30
7:00
7:30
8:00
8:30
9:00
9:30
10:00
10:30
11:00
11:30
12:00
August 1, 2001

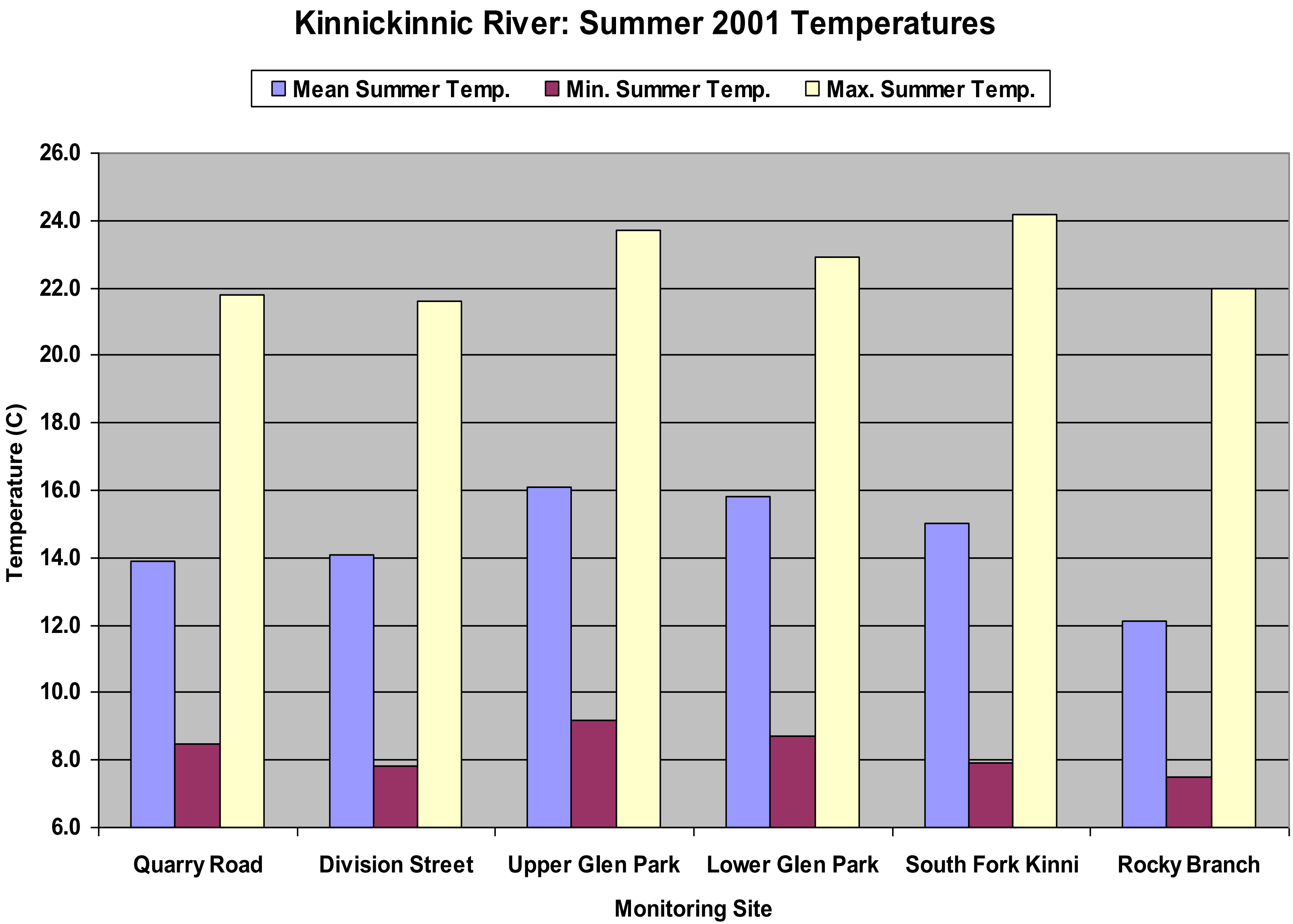

Thermal Impacts of a Hail Storm
Quarry Road
Division Street
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.0
9.0
8.0
7.0
Temperature (C)
Total Rainfall: >1.0 inch
Max. Rainfall Rate: 2.88"/hr.
Max. Wind Gust: 68 mph
High: 79 F
Low: 53 F
12:00
12:30
13:00
13:30
14:00
14:30
15:00
15:30
16:00
16:30
17:00
17:30
18:00
18:30
19:00
19:30
20:00
20:30
21:00
21:30
22:00
22:30
23:00
23:30
May 1, 2001

Kinni at Division Street

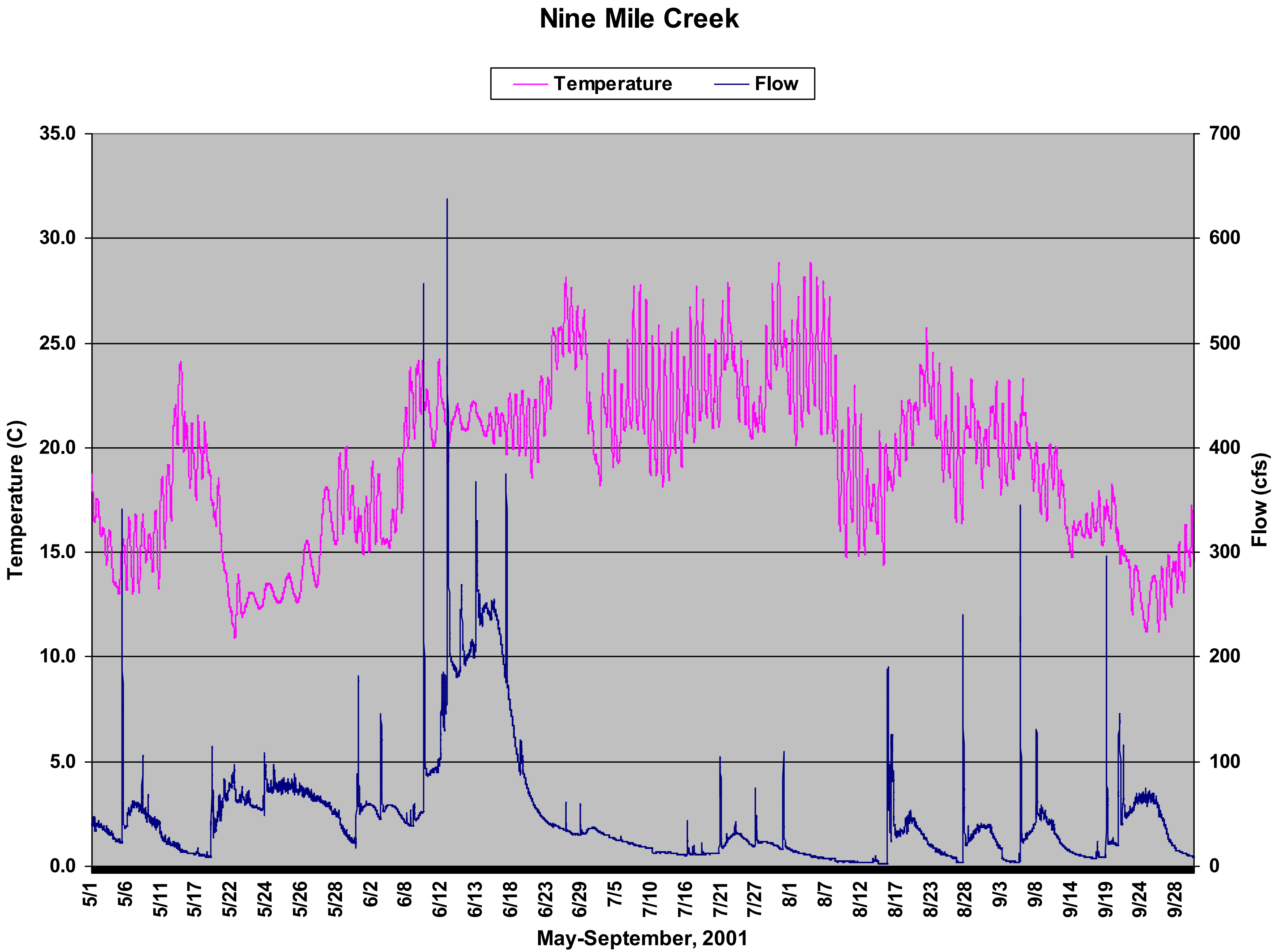




Kinni at Upper Glen Park
Upper Glen Park
24.0
22.0
20.0
18.0
16.0
14.0
12.0
10.0
8.0
Temperature (C)
5/1
5/5
5/10
5/15
5/20
5/24
5/29
6/3
6/8
6/12
6/17
6/22
6/27
7/1
7/6
7/11
7/16
7/20
7/25
7/30
8/4
8/8
8/13
8/18
8/23
8/27
9/1
9/6
9/11
9/15
9/20
9/25
9/30
May 1-September 30, 2001


Kinnickinnic River: Summer 2001 Temperatures
Mean Summer Temp.
Min. Summer Temp.
Max. Summer Temp.
26.0
24.0
22.0
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
Temperature (C)
Quarry Road
Division Street
Upper Glen Park
Lower Glen Park
South Fork Kinni
Rocky Branch
Monitoring Site

Kinnickinnic River and Tributaries: Summer Temperatures, May-September 2001						
	Quarry Road	Division Street	Upper Glen Park	Lower Glen Park	South Fork Kinni	Rocky Branch
Mean Summer Temp.	13.9	14.1	16.1	15.8	15.0	12.1
Min. Summer Temp.	8.5	7.8	9.2	8.7	7.9	7.5
Max. Summer Temp.	21.8	21.6	23.7	22.9	24.2	22.0
No. Temps. > 20C	200	264	2248	1860	1190	42
% Temps. > 20C	0.9	1.2	10.2	8.4	5.4	0.3
May Temps. > 20C	0	0	40	8	29	0
June Temps. > 20C	0	0	331	277	257	0
July Temps. > 20C	31	43	805	601	408	0
August Temps. > 20C	169	221	1072	974	496	42
Sept. Temps. > 20C	0	0	0	0	0	0
No. Temps. > 21C	108	119	1173	771	475	22
No. Temps. > 22C	0	0	429	212	150	0
No. Temps. > 23C	0	0	104	0	28	0
No. Temps. > 24C	0	0	0	0	1	0
Summary statistics are based upon 22,000 10-minute temperature measurements/site during the May 1-September 30, 2001 summer.						



Nine Mile Creek
Temperature
Flow
Temperature (C)
Flow (cfs)
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
700
600
500
400
300
200
100
0
5/1
5/6
5/11
5/17
5/22
5/24
5/26
5/28
6/2
6/8
6/12
6/13
6/18
6/23
6/29
7/5
7/10
7/16
7/21
7/27
8/1
8/7
8/12
8/17
8/23
8/28
9/3
9/8
9/14
9/19
9/24
9/28
May-September, 2001

River Falls Storm Water Quality (1992)

Compared to NURP Monitoring Results

Residential Subwatershed

Water Quality Variable (mg/l)	River Falls Median	NURP Median
TSS (Total Suspended Solids)	240.0	101.0
TKN (Total Nitrogen)	2.6	1.90
TP (Total Phosphorus)	0.75	0.38
Cu (Copper)	0.030	0.033
Pb (Lead)	0.015	0.144
Zn (Zinc)	0.110	0.135

River Falls Storm Water Quality (1992)

Compared to NURP Monitoring Results

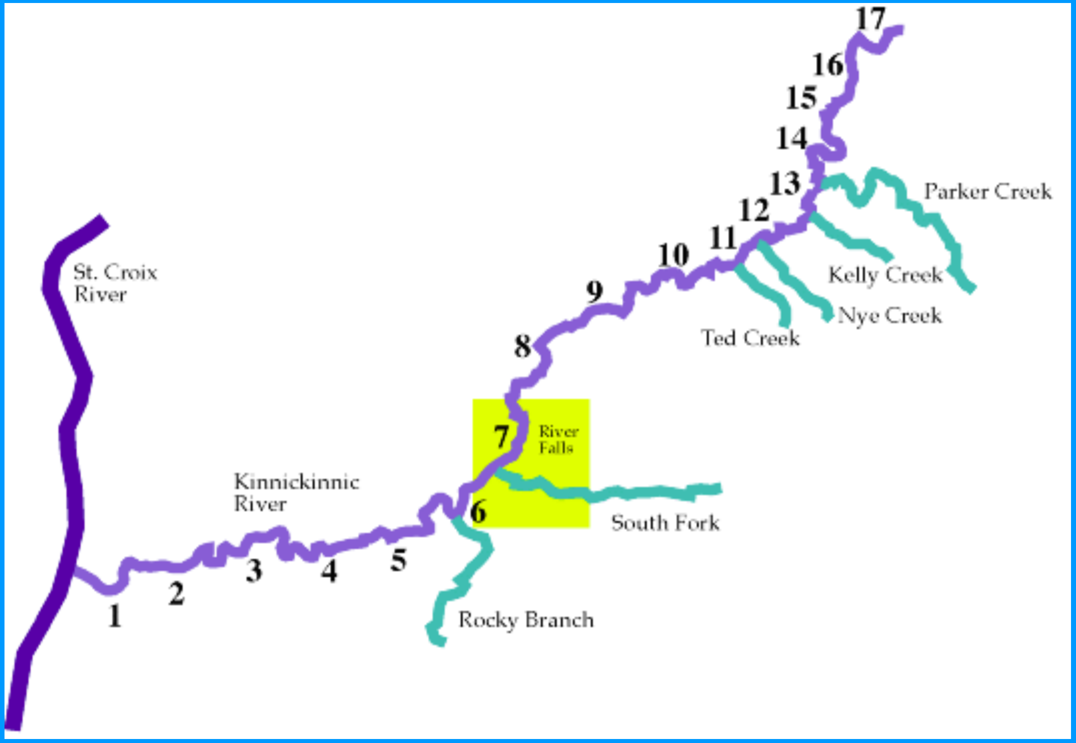
Commercial Subwatershed

Water Quality Variable (mg/l)	River Falls Median	NURP Median
TSS (Total Suspended Solids)	150.0	69.0
TKN (Total Nitrogen)	2.1	1.20
TP (Total Phosphorus)	0.50	0.20
Cu (Copper)	0.030	0.029
Pb (Lead)	0.080	0.104
Zn (Zinc)	0.190	0.226

Monitoring Begets Monitoring: UW-River Falls

Kinnickinnic River
Macroinvertebrate Survey
1999

Figure 1. Macroinvertebrate monitoring sites



Monitoring Begets Monitoring: UW-River Falls

Monitoring Begets Monitoring: City of River Falls

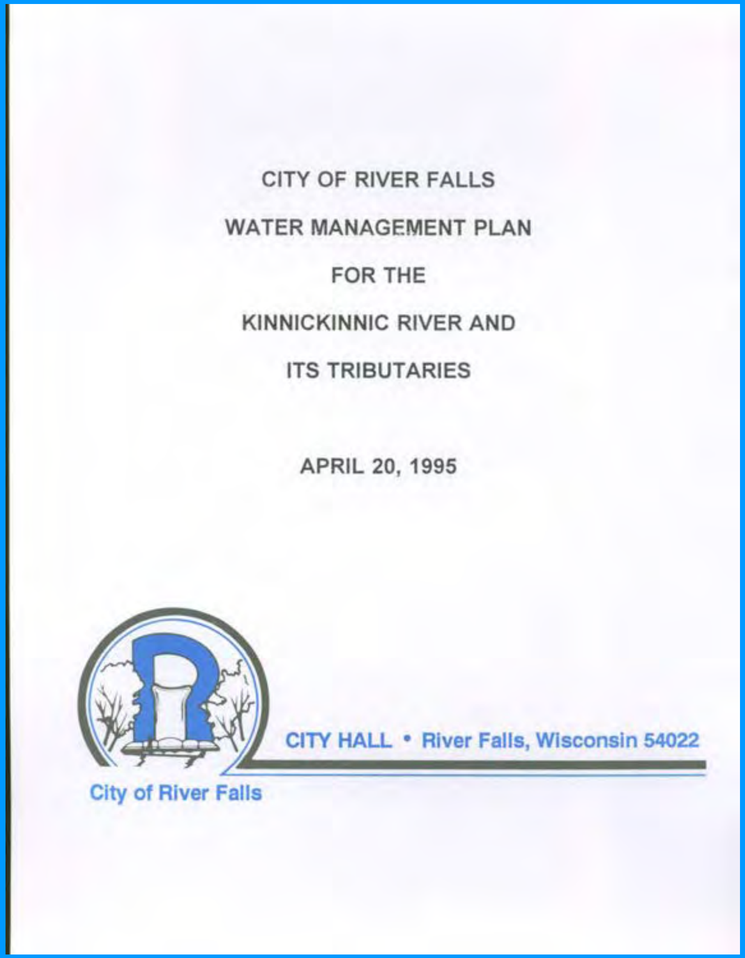
Storm Water Education:
"A Storm on the Horizon"

Storm Water Education:
“A Storm on the Horizon”

- 15-minute video, professionally produced in 1998 by Kiap-TU-Wish and Palisade Productions of Minneapolis, MN
- Target audience: general public, land use planners, and local decision-makers
- The video:
  - Establishes the value of a cold water resource and its importance to the community
  - Demonstrates the impact of storm water on water resources
  - Describes key tools that enable development to occur while protecting water resources
- 3,000 copies of the video have been distributed locally and nationally
- Silver Award, 1999 Chicago International Film Festival

Monitoring Informs Storm Water Management

- City of River Falls Storm Water Management Plan (1994)
- Kinnickinnic River Priority Watershed Program (1995)
- City of River Falls Storm Water Utility (1996)
- City of River Falls Storm Water Ordinance (2002)
- City of River Falls Shoreland Ordinance (2003)


CITY OF RIVER FALLS

WATER MANAGEMENT PLAN

FOR THE

KINNICKINNIC RIVER AND

ITS TRIBUTARIES

APRIL 20, 1995

CITY HALL • River Falls, Wisconsin 54022

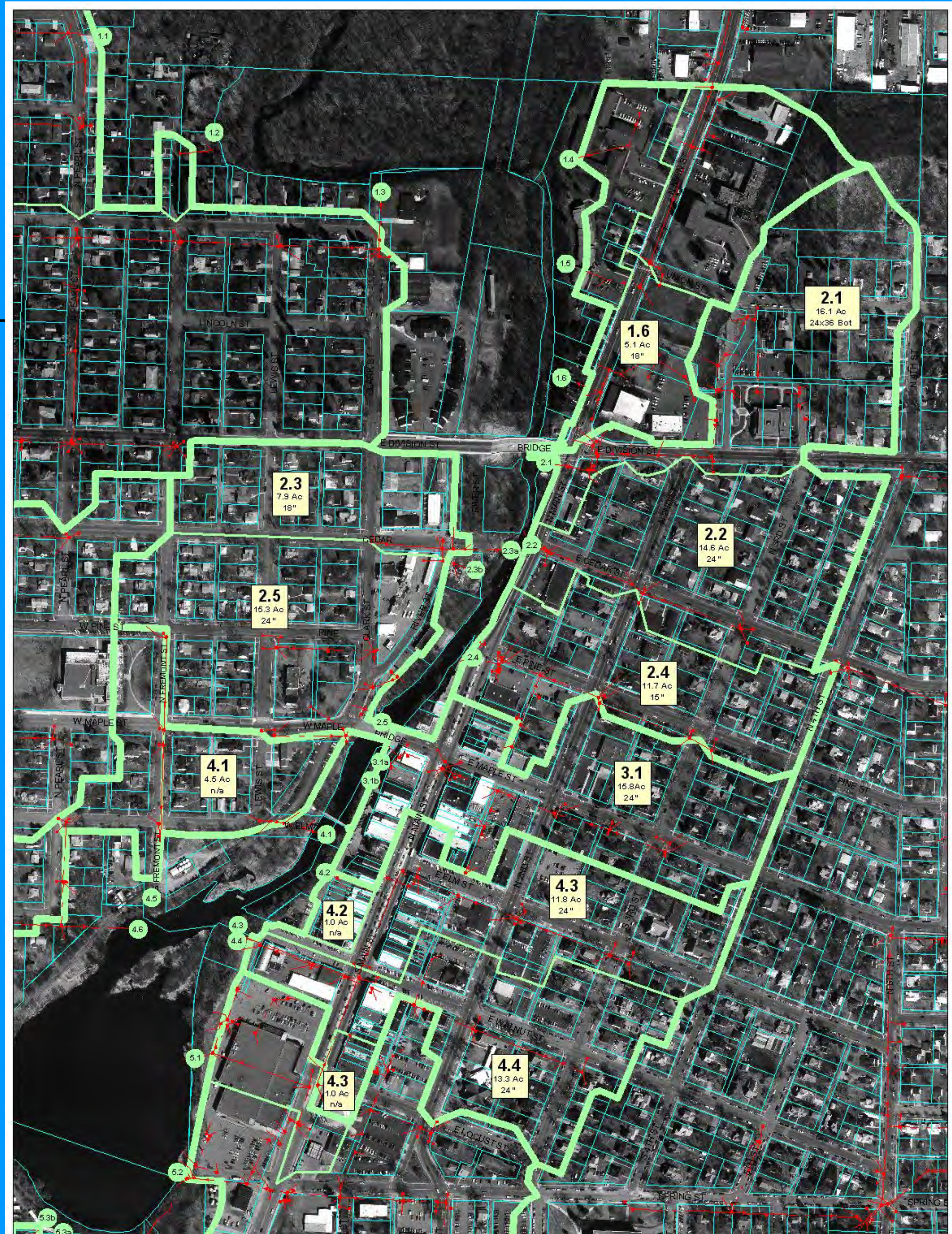
City of River Falls

City of River Falls Storm Water Utility Fees

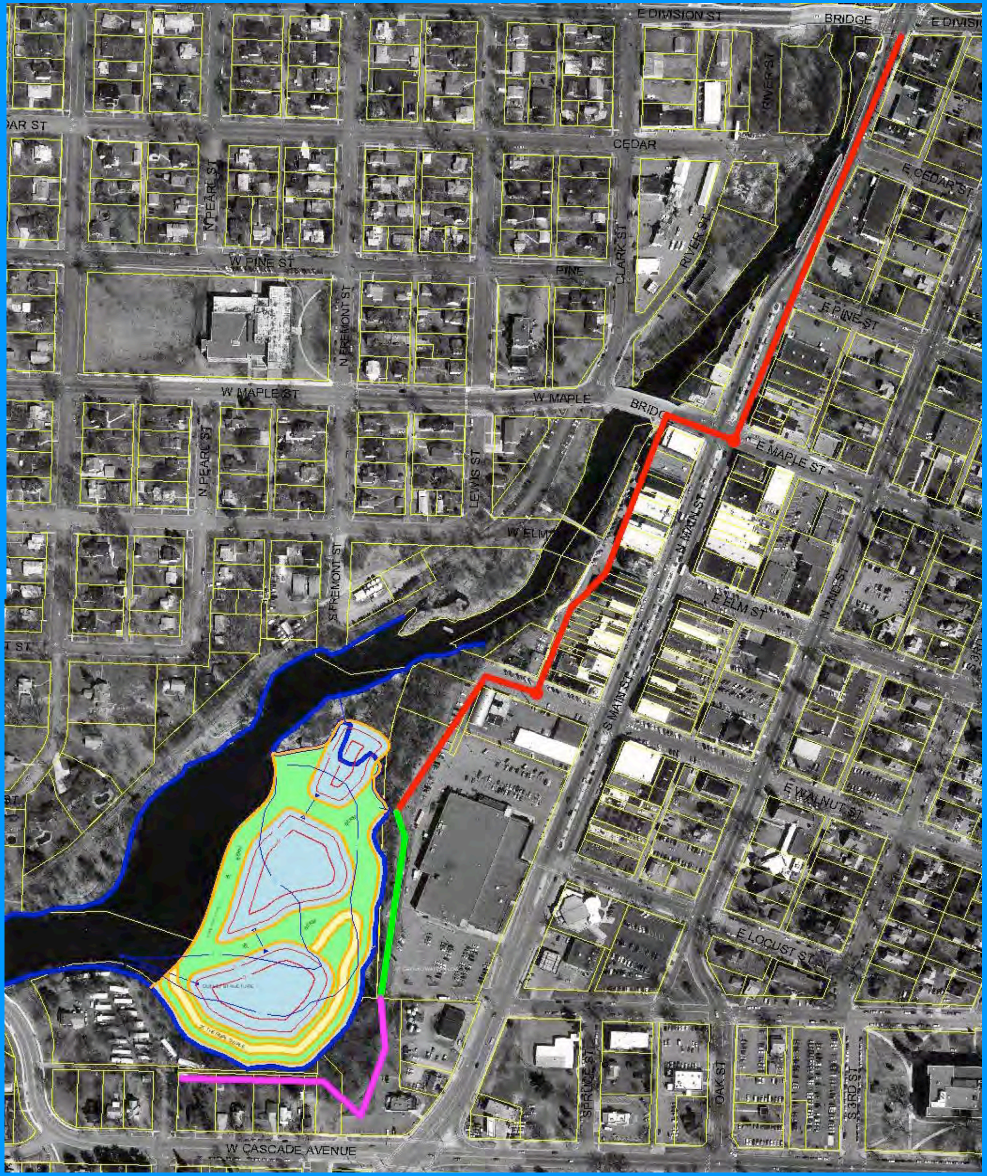
Property Class	Residential Equivalent Factor	Monthly Cost Per Acre	Monthly Cost Per Hshld	Curve No.
Maintained Open Space		$ 2.64		61
Residential	1	15.54	3.14	72
Medium Density Residential	1.3	20.24		75
Public/Quasi-Public (University)	2.22	34.45		82
City Property, Developed	2.72	42.22		85
Industrial	3.3	51.28		88
Office/Service/Churches	3.74	58.11		90
Commercial	4.23	65.71		92
Parks/Open Spaces	exempt	0		
Agriculture	exempt	0		
Roads, Lakes and Rivers	exempt	0		

City of River Falls Storm Sewersheds

- Sewersheds comprise 176 acres (85 ac. impervious) discharging through 24 outfalls
- 103 acres (51 ac. impervious) drain to River from east above Lake
- 36 acres (14 ac. impervious) drain to River from west above Lake
- Remainder (36 acres, 20 impervious) drain to Lake section



Lake George Area Storm Water Treatment Concept Plan:



Lake George Area Storm Water Treatment Concept Plan:

- TSS Reduction Benefit: 60-70%

- Thermal Benefit:

  Baseflow: Up to 1^{o} C

  Runoff Events: <0.5^{o} C w/o watershed improvements
  0.5^{o} – 1^{o}C with watershed improvements

- Cost:

  Lake Re-Configuration: $515,000 – 1,012,000

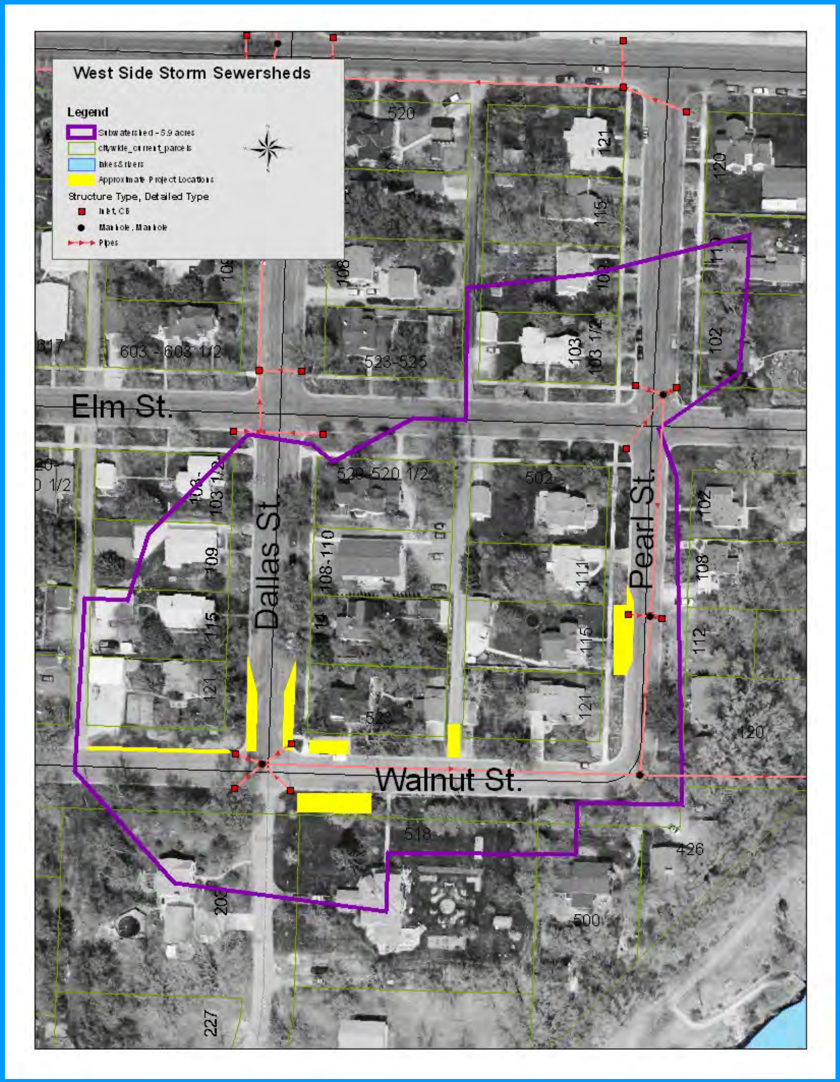
  North Interceptor: $944,000 - $1,200,000

  East Interceptor: $184,000 - $247,000

  South Interceptor: $212,000 - $289,000

  Total = $1,855,000 - $2,748,000

River Falls West Side Storm Water Retrofit Project:



“Our vision was to retrofit an older area of River Falls that was constructed before storm water management practices were installed.”

River Falls West Side Storm Water Retrofit Project:

Practices Installed

Curb Bump Outs

The curb line of the street was bumped out into the existing parking lane of the street, and a curb cut provided in the gutter allows water into the practice.

The bump out area is slightly depressed to allow water to pond and soak into the ground before overflowing to the existing curb storm sewer inlet.

Bump outs were installed on Dallas Street and were planted with native, long-rooted grasses. The rain garden on Pearl Street also has a small bump out area to increase the size of the rain garden.

River Falls West Side Storm Water Retrofit Project:

Practices Installed

Pervious Pavers

These pavers are similar to regular pavers, however they have bumps on the edges to create larger void spaces between the pavers. These spaces are then filled with a granular rock material which allows water to flow through it into a storage layer below and eventually infiltrate into the ground.

These are being installed at the end of the alley to capture the runoff from the alley and the garages along it.

River Falls West Side Storm Water Retrofit Project:

Practices Installed

Permeable Concrete

This looks very similar to regular concrete, but it allows water to pass through. Many describe it looking similar to a Rice Krispy bar. This is the first permeable concrete installed in this part of Wisconsin!

A section of existing curb and gutter was removed on Walnut St. and replaced with a solid concrete curb and a permeable concrete gutter section.

River Falls West Side Storm Water Retrofit Project:

Practices Installed

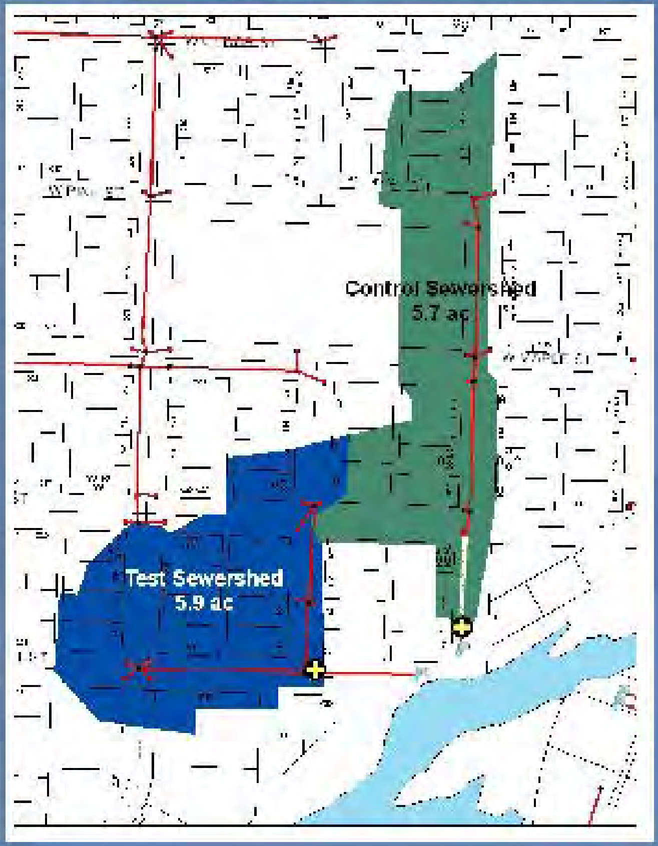
Rain Gardens

Rain gardens are shallow depressions planted with flowers, grasses, or shrubs. The gardens collect storm water and allow it to soak into the ground. These gardens are taking street runoff through curb cuts.

Rain gardens were installed on Walnut Street and Pearl Street. Due to the time of year that construction occurred, planting of the rain gardens occurred in the spring of 2008.

Monitoring Approach

- Flow meters installed in the outfall pipes of two storm sewersheds.
  - Greyline Instruments - Stingray Flowmeters
  - 18" RCP Pipes
- 2006 & 2007 pre-construction data
- Practices installed October 2007
- 2008 post construction data



Monitoring – What we Saw

- Inspected during rain events
  - Pavers taking water well

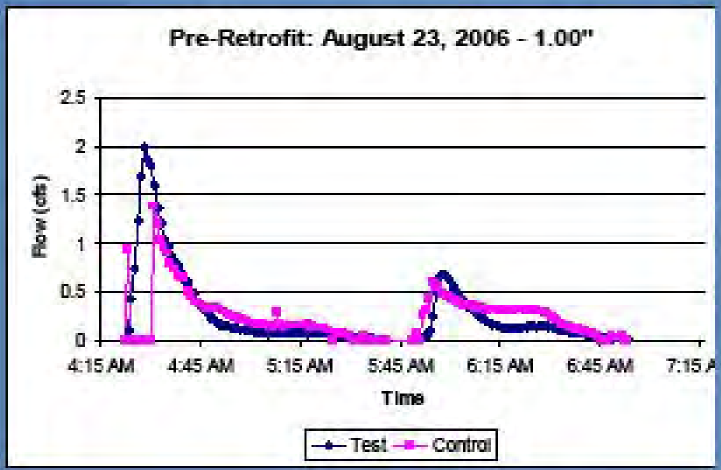
Monitoring – What we Saw

- Inspected during rain events
  - Pavers taking water well
  - Porous concrete not taking much water

Monitoring – What we Saw

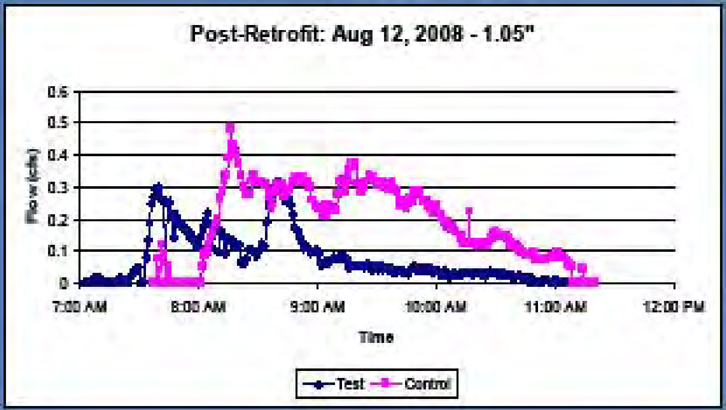
- Inspected during rain events
  - Pavers taking water well
  - Porous concrete not taking much water
  - Rain gardens filled and drained in 4-5 hours

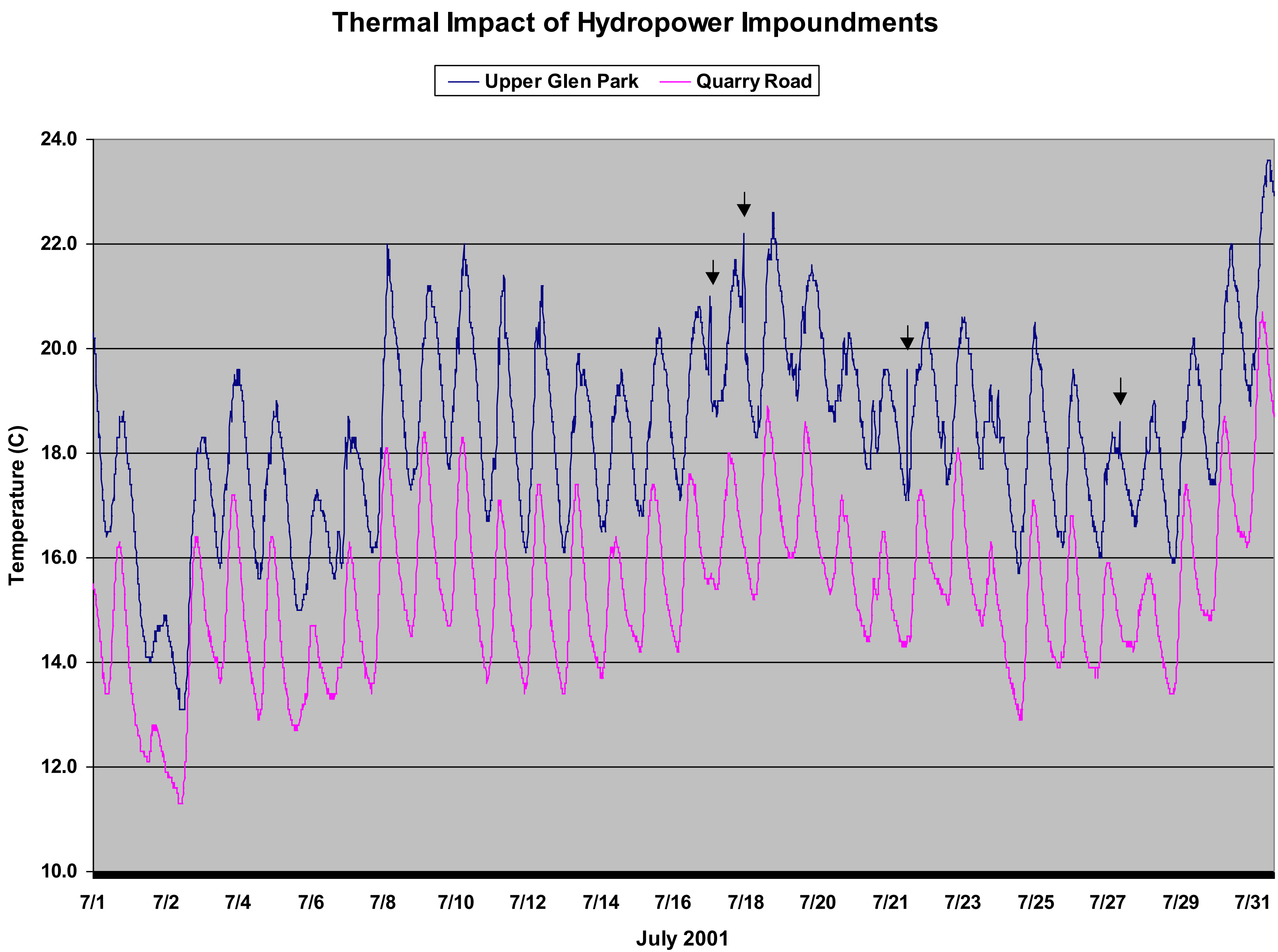
Monitoring – What we Saw



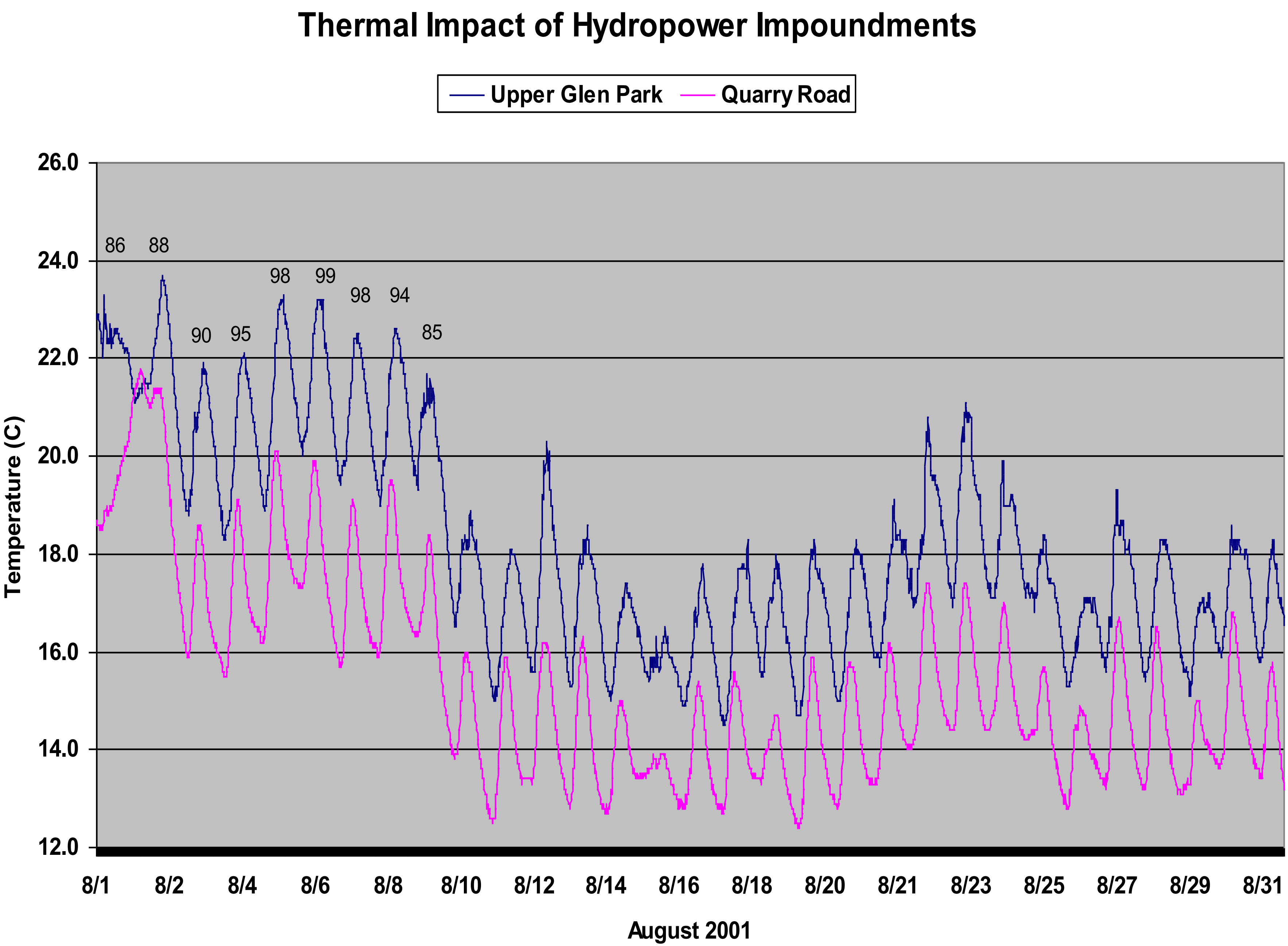
- 1″ Events
- August, AM rain
- 3 hours of rain/4hrs rain
- ¼″ rain 6 days prior

	Volume (cf)	Rc
Pre-Retrofit Control	2519	0.12
Pre-Retrofit Test	2301	0.11
Post-Retrofit Control	2485	0.12
Post-Retrofit Test	1145	0.05



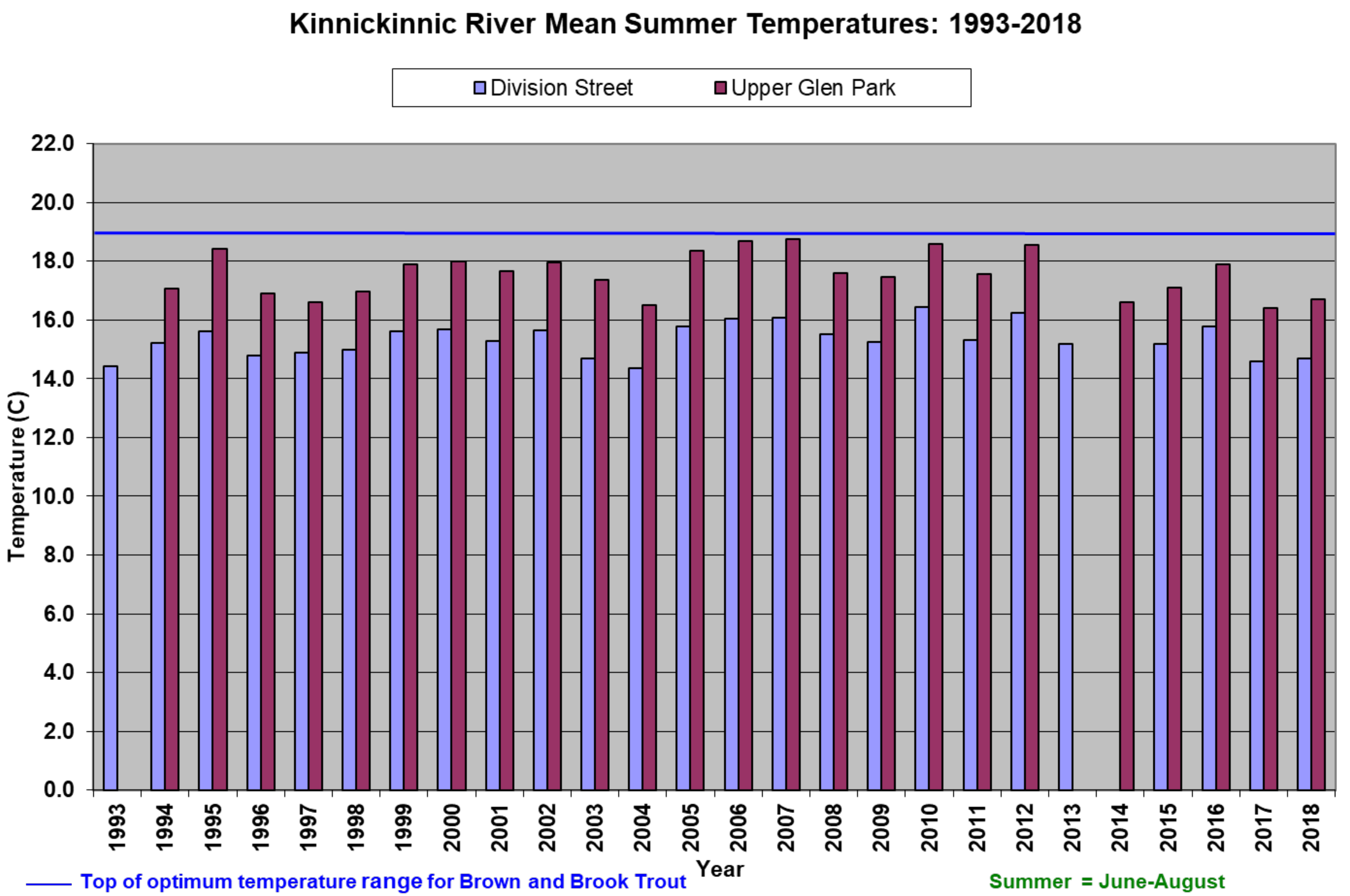


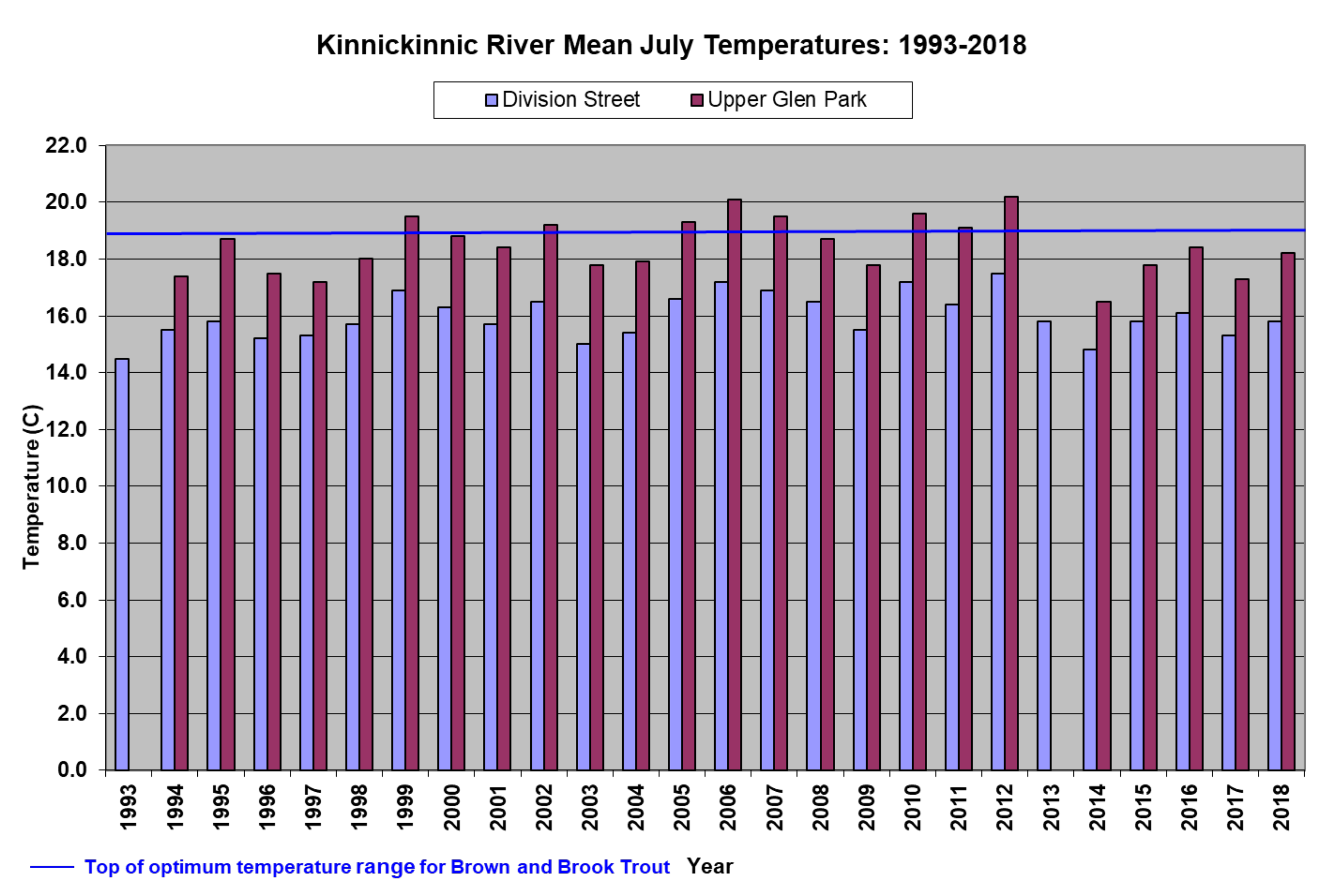
Thermal Impact of Hydropower Impoundments
Upper Glen Park
Quarry Road
24.0
22.0
20.0
18.0
16.0
14.0
12.0
10.0
Temperature (C)
7/1
7/2
7/4
7/6
7/8
7/10
7/12
7/14
7/16
7/18
7/20
7/21
7/23
7/25
7/27
7/29
7/31
July 2001

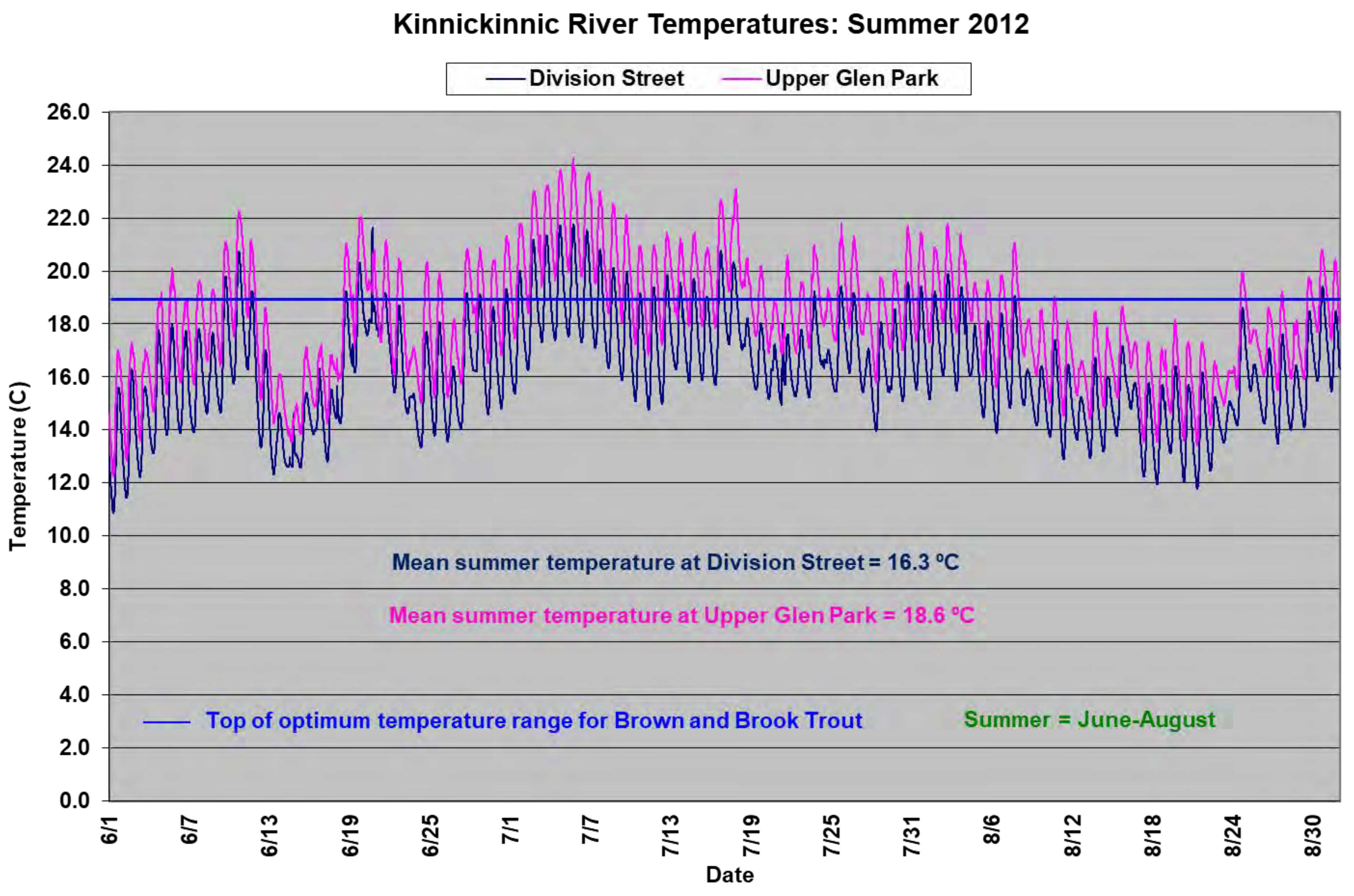

Thermal Impact of Hydropower Impoundments
Upper Glen Park
Quarry Road
Temperature (C)
26.0
24.0
22.0
20.0
18.0
16.0
14.0
12.0
86
88
90
95
98
99
98
94
85
8/1
8/2
8/4
8/6
8/8
8/10
8/12
8/14
8/16
8/18
8/20
8/21
8/23
8/25
8/27
8/29
8/31
August 2001

Thermal Impacts of Hydropower Impoundments

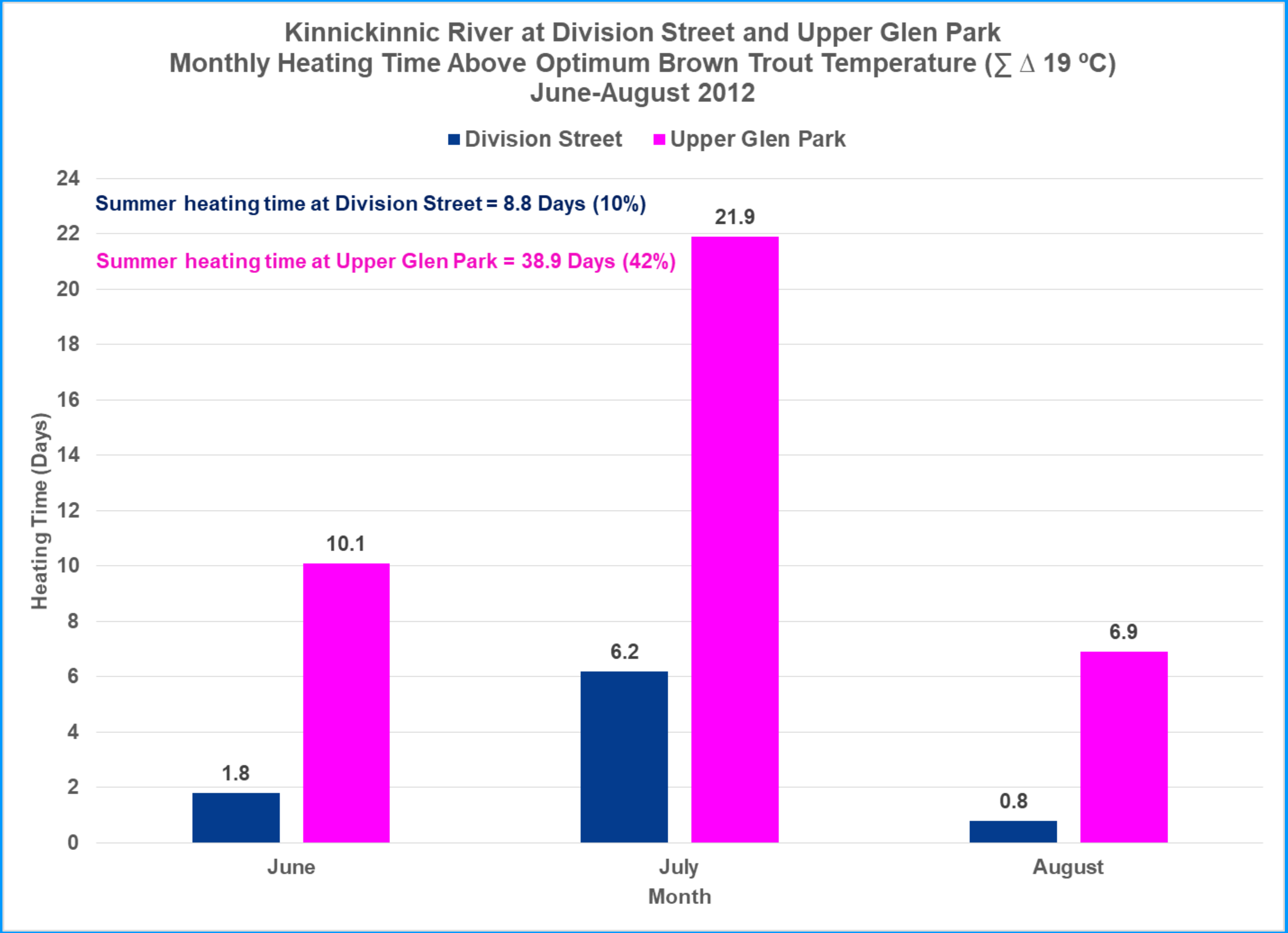
- On average during the 1993-2018 period of record, downstream summer average temperatures at Upper and Lower Glen Park are 2.1-2.4º C (3.8-4.2° F) warmer than the upstream summer average temperatures at Quarry Road and Division Street.
- This temperature differential is even greater in July (the warmest summer month), with downstream temperatures 2.3-2.7º C (4.2-4.7° F) higher than upstream temperatures.
- Throughout the summer period, the downstream temperatures at Upper and Lower Glen Park more frequently exceed the critical temperature thresholds that support healthy coldwater macroinvertebrate and brown trout communities in the Kinnickinnic River.
- During the summer of 2012, the temperature threshold of 19º C was exceeded for a cumulative total of 8.8 days (10% of the summer period) at Division Street. In comparison, this threshold was exceeded for a cumulative total of 38.9 days (42% of the summer period) at Upper Glen Park, thereby posing a much greater thermal risk to the downstream coldwater community.


Kinnickinnic River Mean Summer Temperatures: 1993-2018
Division Street
Upper Glen Park
Temperature (C)
22.0
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Year
Top of optimum temperature range for Brown and Brook Trout
Summer = June-August


Kinnickinnic River Mean July Temperatures: 1993-2018
Division Street
Upper Glen Park
22.0
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Temperature (C)
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Top of optimum temperature range for Brown and Brook Trout
Year

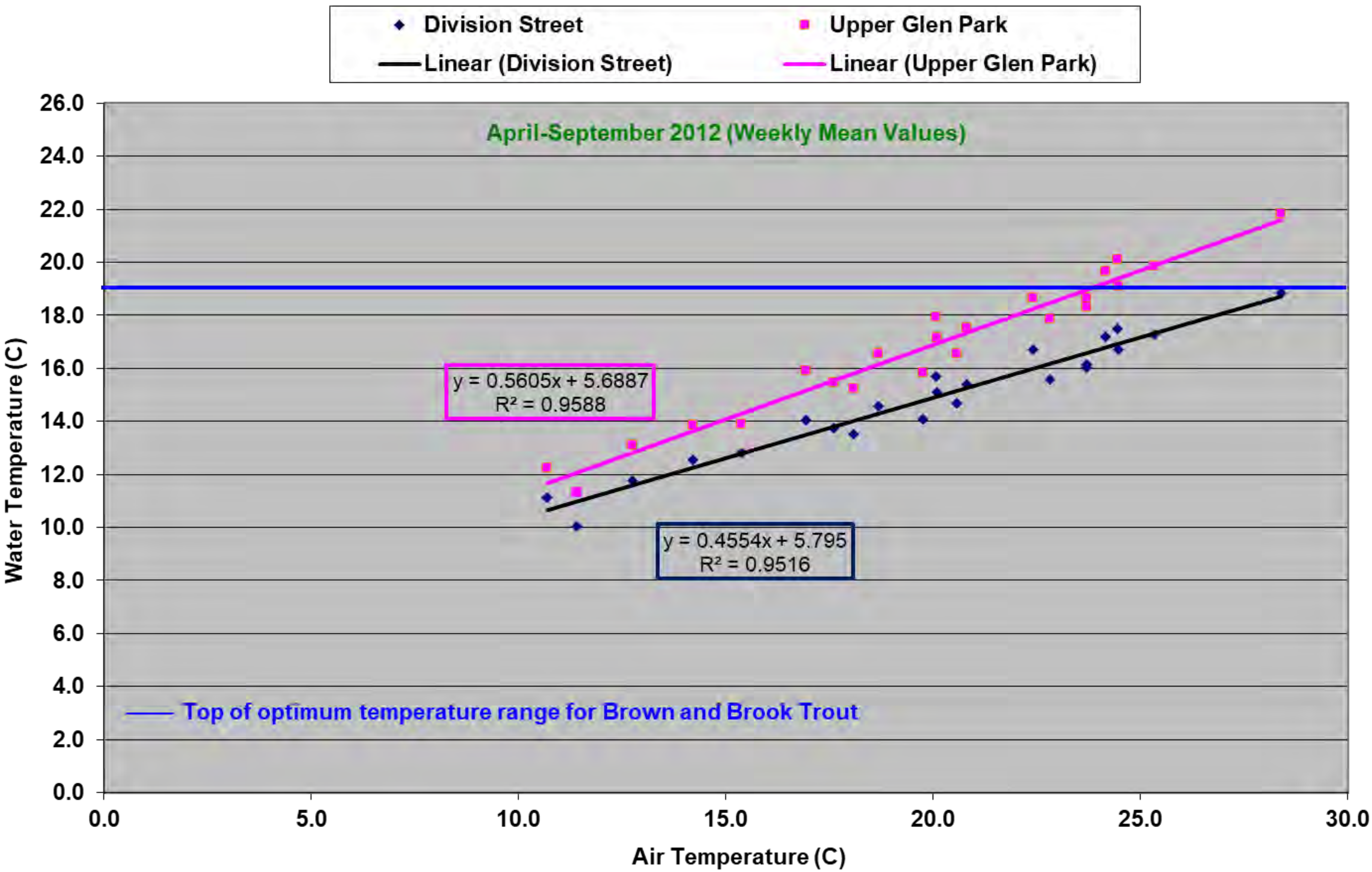


Kinnickinnic River Temperatures: Summer 2012
Division Street
Upper Glen Park
26.0
24.0
22.0
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Temperature (C)
Mean summer temperature at Division Street = 16.3 °C
Mean summer temperature at Upper Glen Park = 18.6 °C
Top of optimum temperature range for Brown and Brook Trout
Summer = June-August
6/1
6/7
6/13
6/19
6/25
7/1
7/7
7/13
7/19
7/25
7/31
8/6
8/12
8/18
8/24
8/30
Date



Kinnickinnic River at Division Street and Upper Glen Park
Monthly Heating Time Above Optimum Brown Trout Temperature (∑ ∆ 19 ºC)
June-August 2012
Division Street
Upper Glen Park
Summer heating time at Division Street = 8.8 Days (10%)
Summer heating time at Upper Glen Park = 38.9 Days (42%)
Heating Time (Days)
24
22
20
18
16
14
12
10
8
6
4
2
0
1.8
10.1
6.2
21.9
0.8
6.9
June
July
August
Month

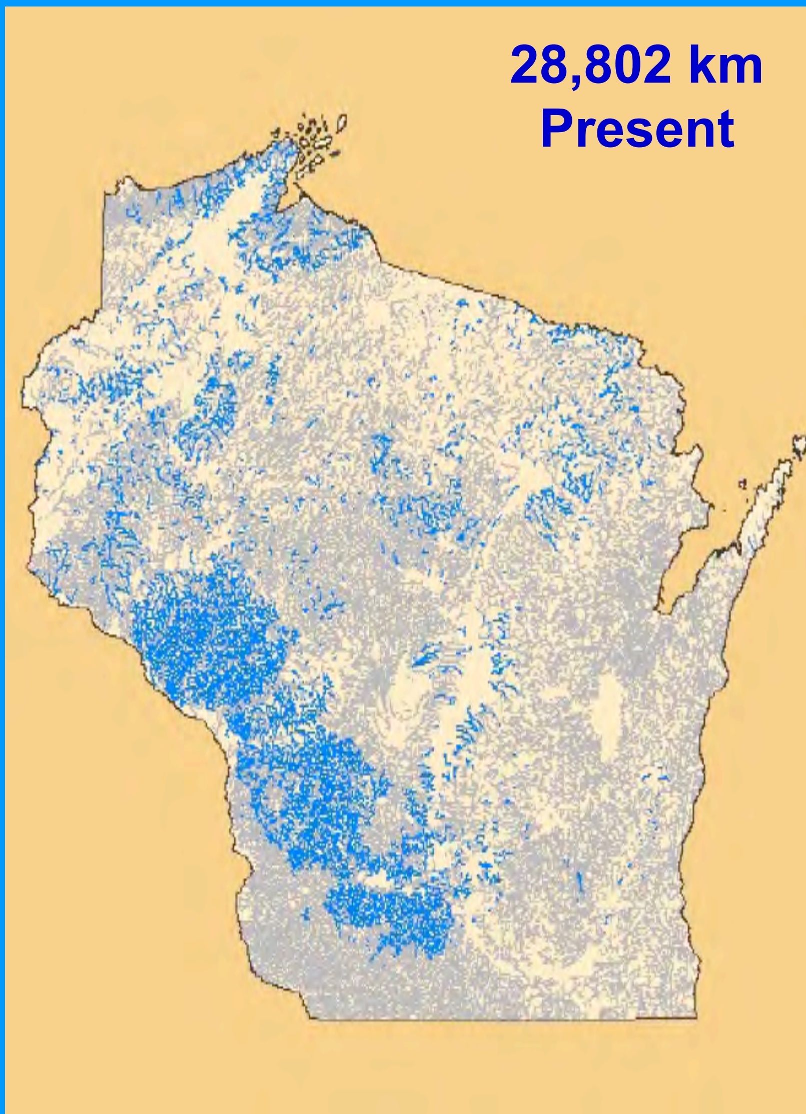
Kinnickinnic River Air Temperature vs Water Temperature at Division Street and Upper Glen Park

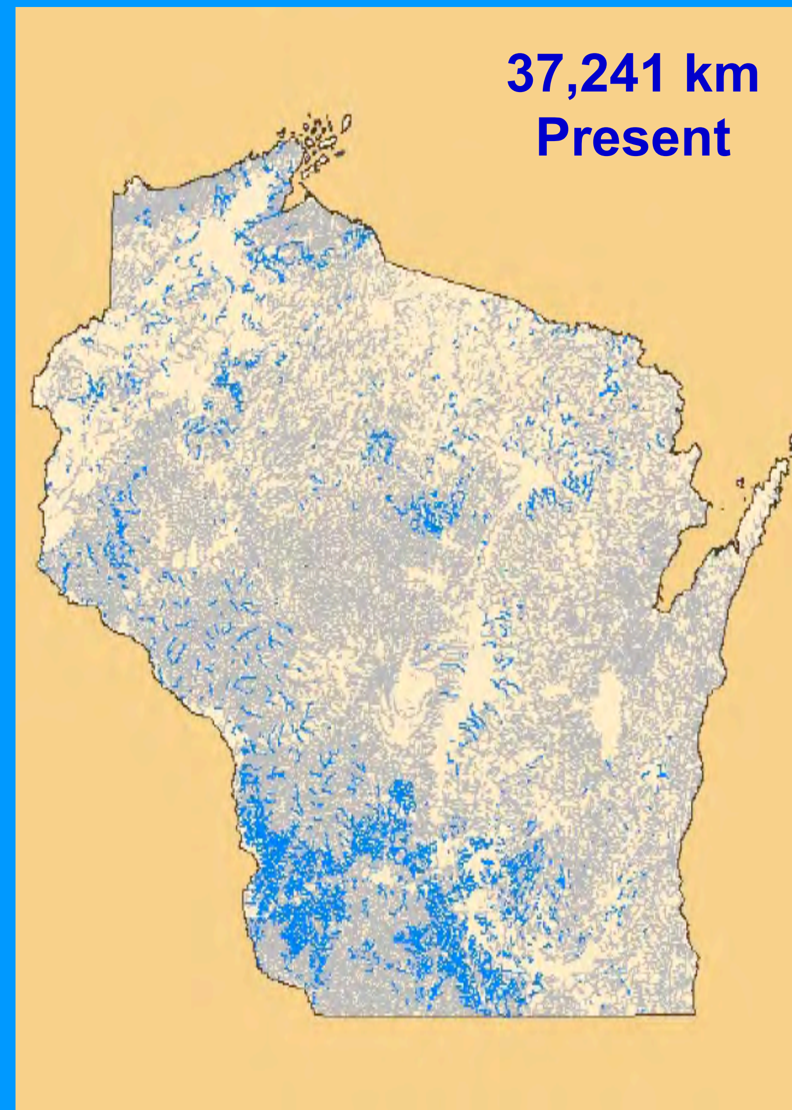


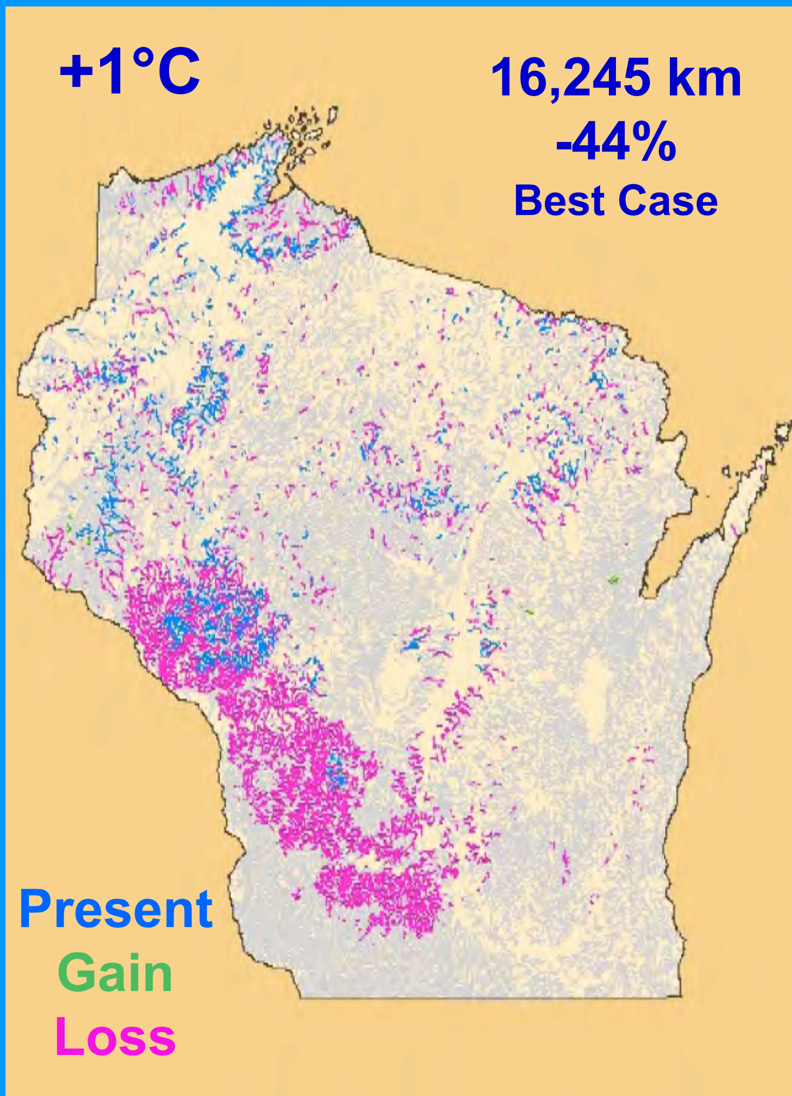
Mitro, Lyons, and Stewart (2007)

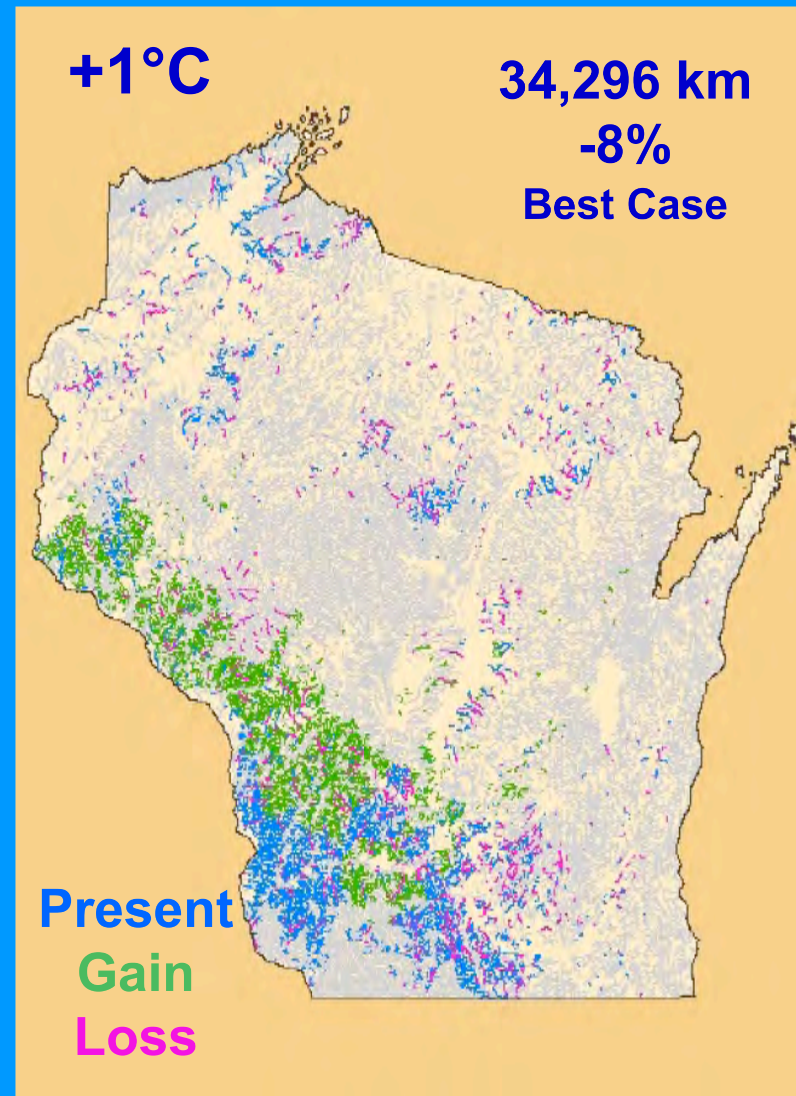
Climate Change, Trout Ecology and the Future of Inland Trout Management in Wisconsin

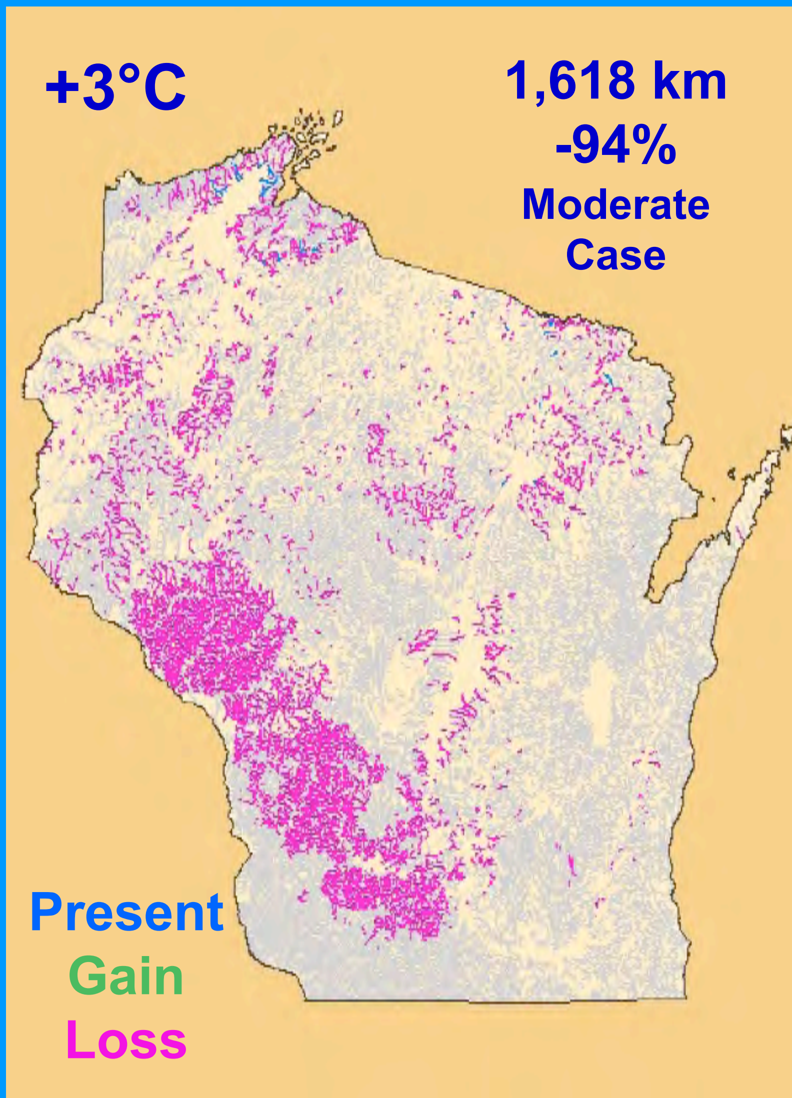
- Stream temperature is the most important factor that determines where trout can live and cannot live
- A warming climate will affect the distribution of trout
- Extreme precipitation events associated with climate change may limit trout recruitment
- Drought conditions associated with climate change will limit stream flows and fish habitat

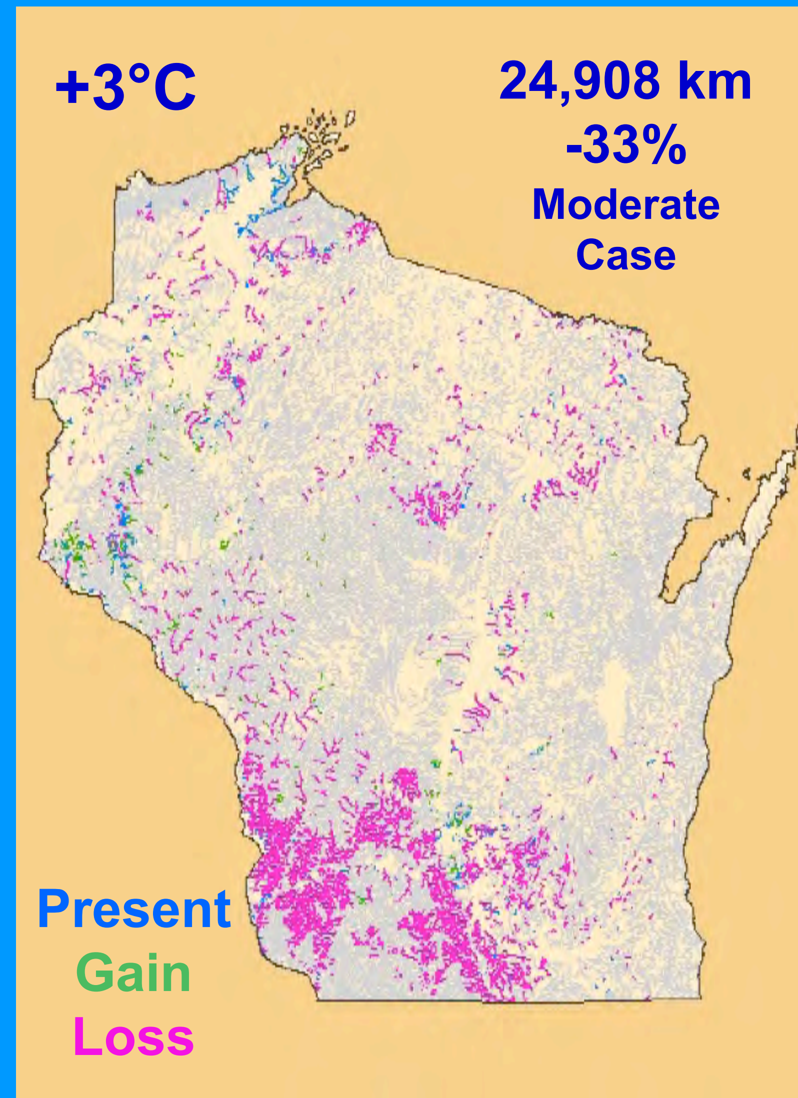

28,802 km
Present

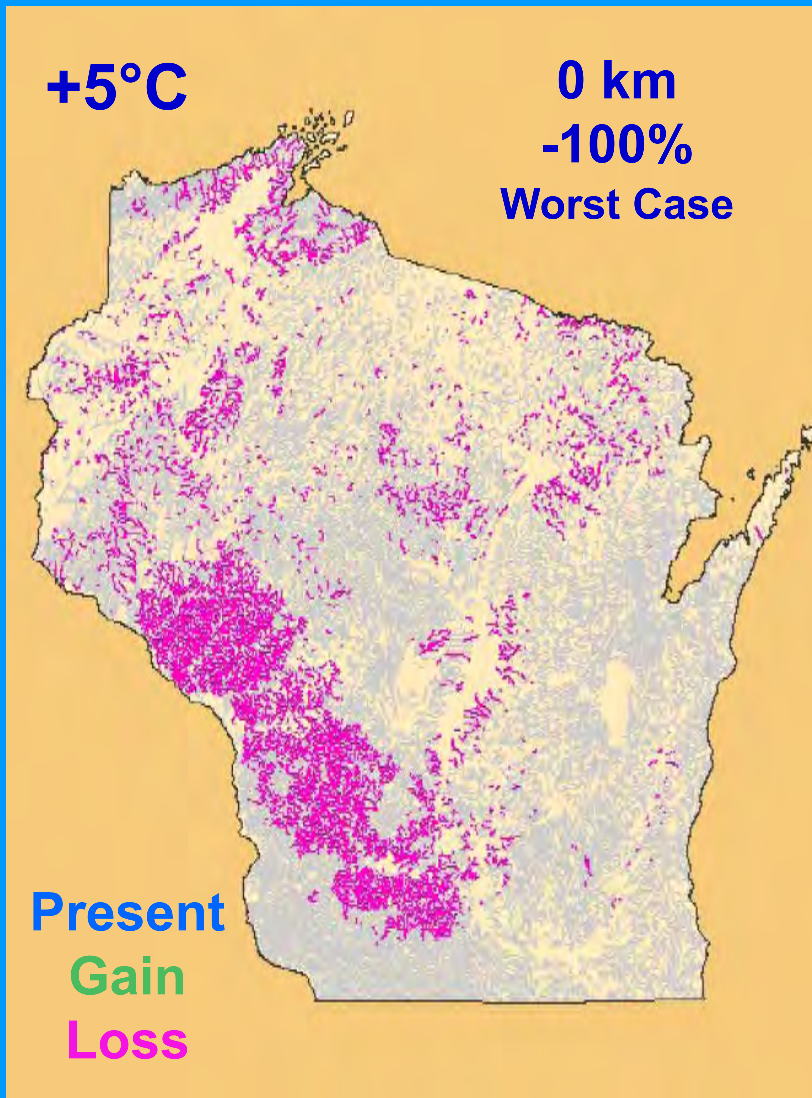

37,241 km
Present

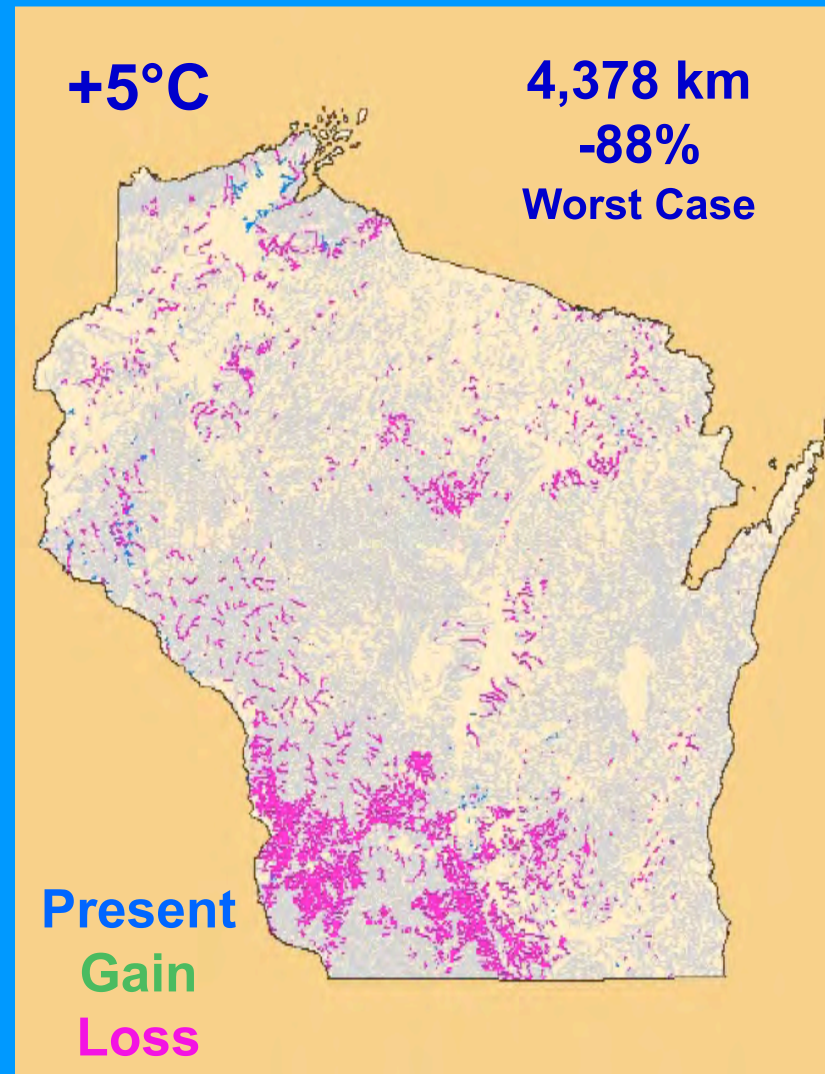

+1°C
16,245 km
-44%
Best Case
Present
Gain
Loss


+1°C
34,296 km
-8%
Best Case
Present
Gain
Loss


+3°C
1,618 km
-94%
Moderate
Case
Present
Gain
Loss

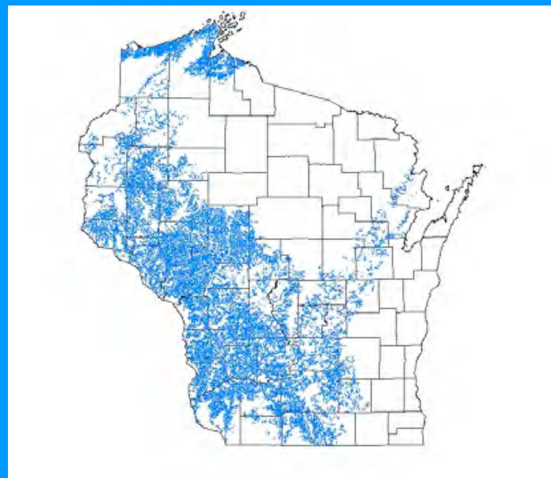

+3°C
24,908 km
-33%
Moderate
Case
Present
Gain
Loss


+5°C
0 km
-100%
Worst Case
Present
Gain
Loss

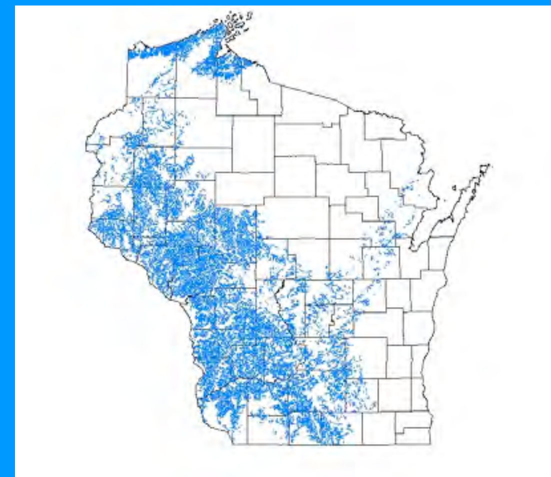

+5°C
4,378 km
-88%
Worst Case
Present
Gain
Loss

Brown Trout

Current climate



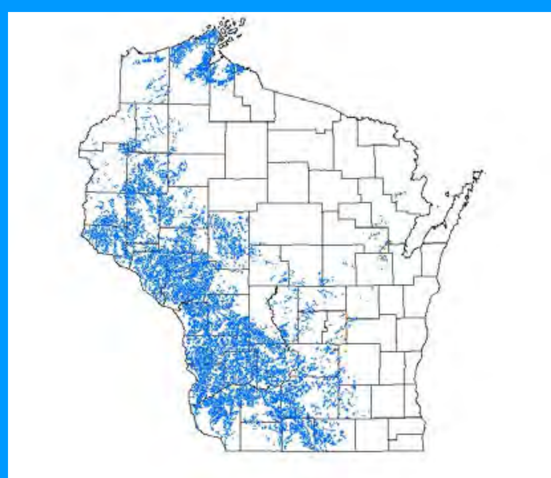
Best case (-7.9%)



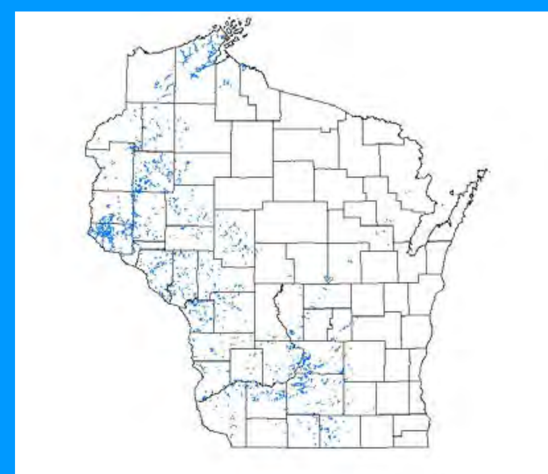
1.0 C (0.8 C)

Moderate case (-33.1%)

3.0 C (2.4 C)



Worst case (-88.2%)

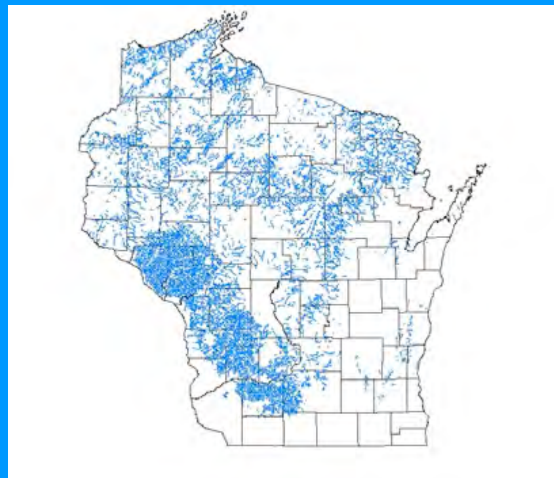


5.0 C (4.0 C)

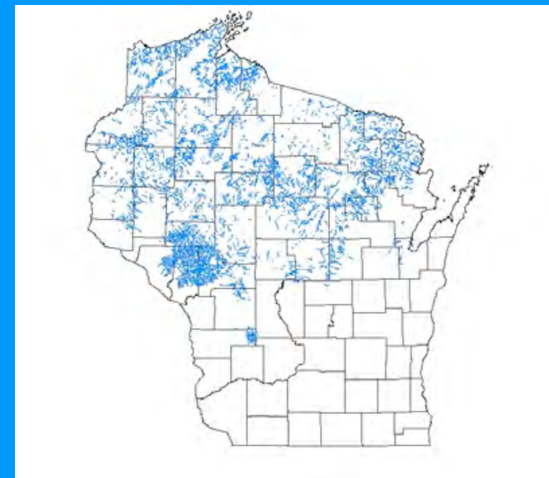
Mitro, M., J. Lyons, and S. Sharma. 2011. Wisconsin Initiative on Climate Change Impacts: Coldwater Fish and Fisheries Working Group Report. 31 p

Brook Trout

Current climate



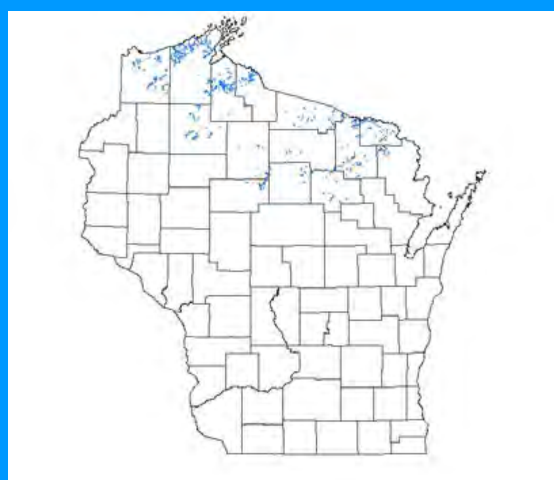
Best case (-43.6%)



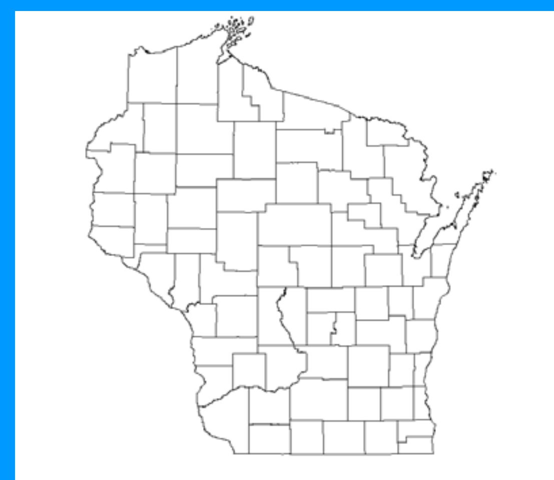
1.0 C (0.8 C)

Moderate case (-94.4%)

3.0 C (2.4 C)



Worst case (-100%)

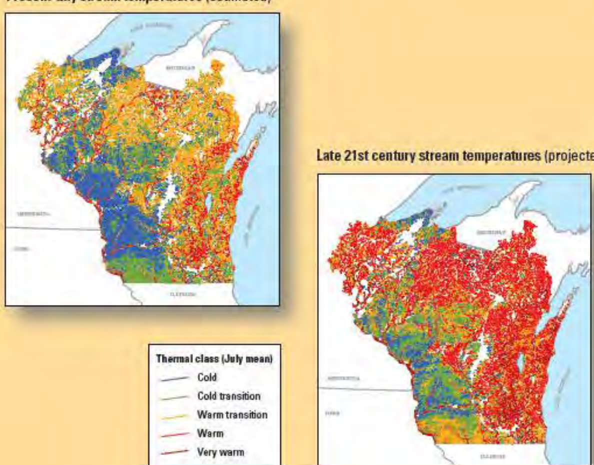


5.0 C (4.0 C)

Mitro, M., J. Lyons, and S. Sharma. 2011. Wisconsin Initiative on Climate Change Impacts: Coldwater Fish and Fisheries Working Group Report. 31 p

Prepared in cooperation with the Wisconsin Department of Natural Resources

A Model for Evaluating Stream Temperature Response to Climate Change in Wisconsin



Scientific Investigations Report 2014–5186

U.S. Department of the Interior
U.S. Geological Survey

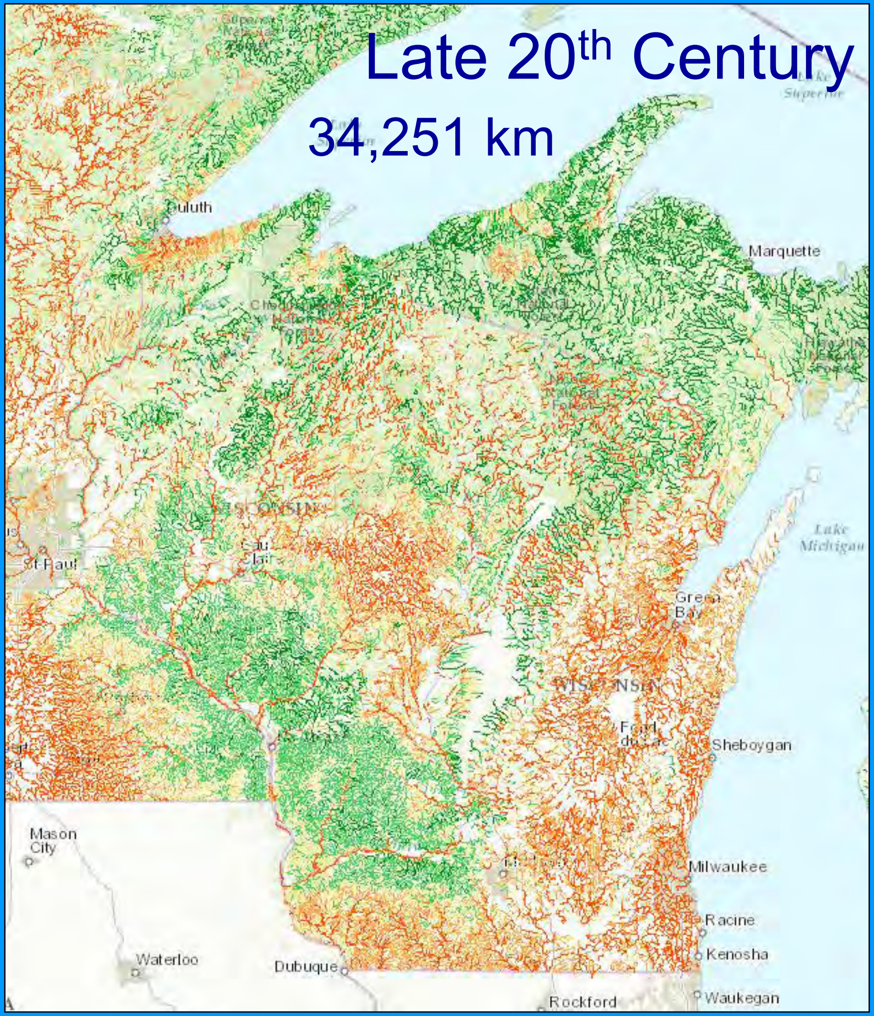
Prepared in cooperation with Michigan State University, Michigan Department of Natural Resources Institute of Fisheries Research, and the Wisconsin Department of Natural Resources

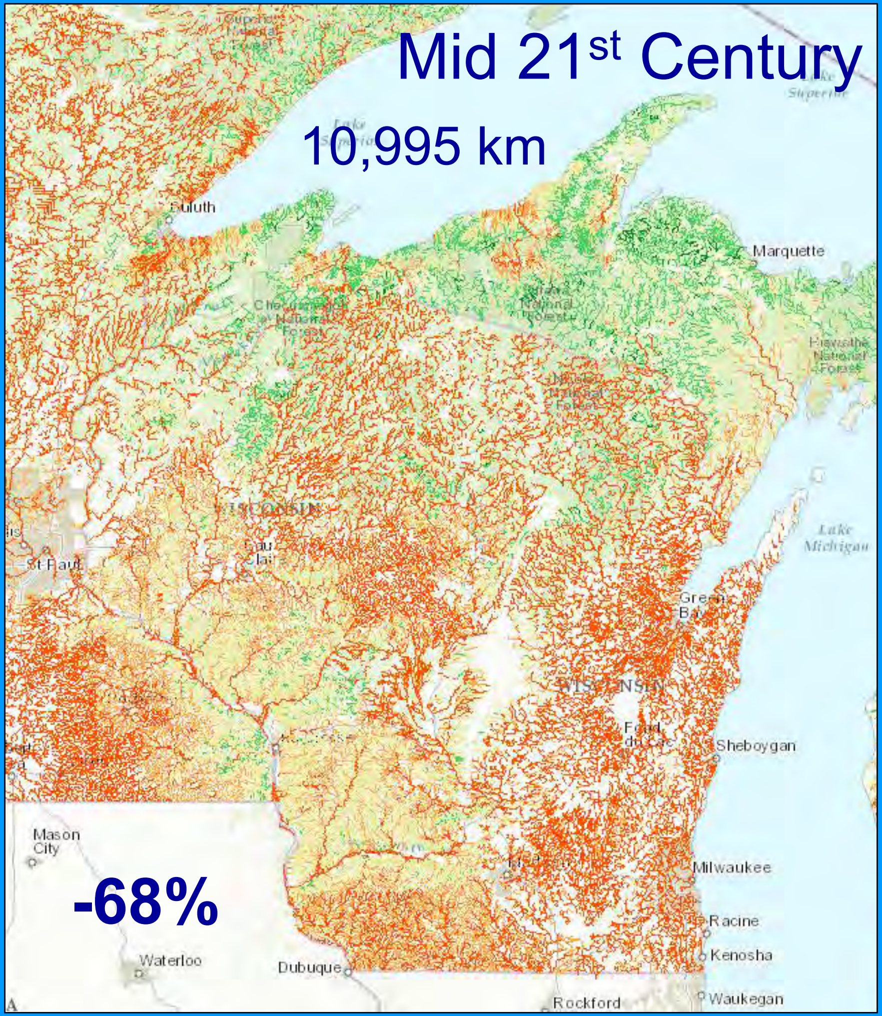
FishVis, A Regional Decision Support Tool for Identifying Vulnerabilities of Riverine Habitat and Fishes to Climate Change in the Great Lakes Region

Scientific Investigations Report 2016–5124

U.S. Department of the Interior
U.S. Geological Survey

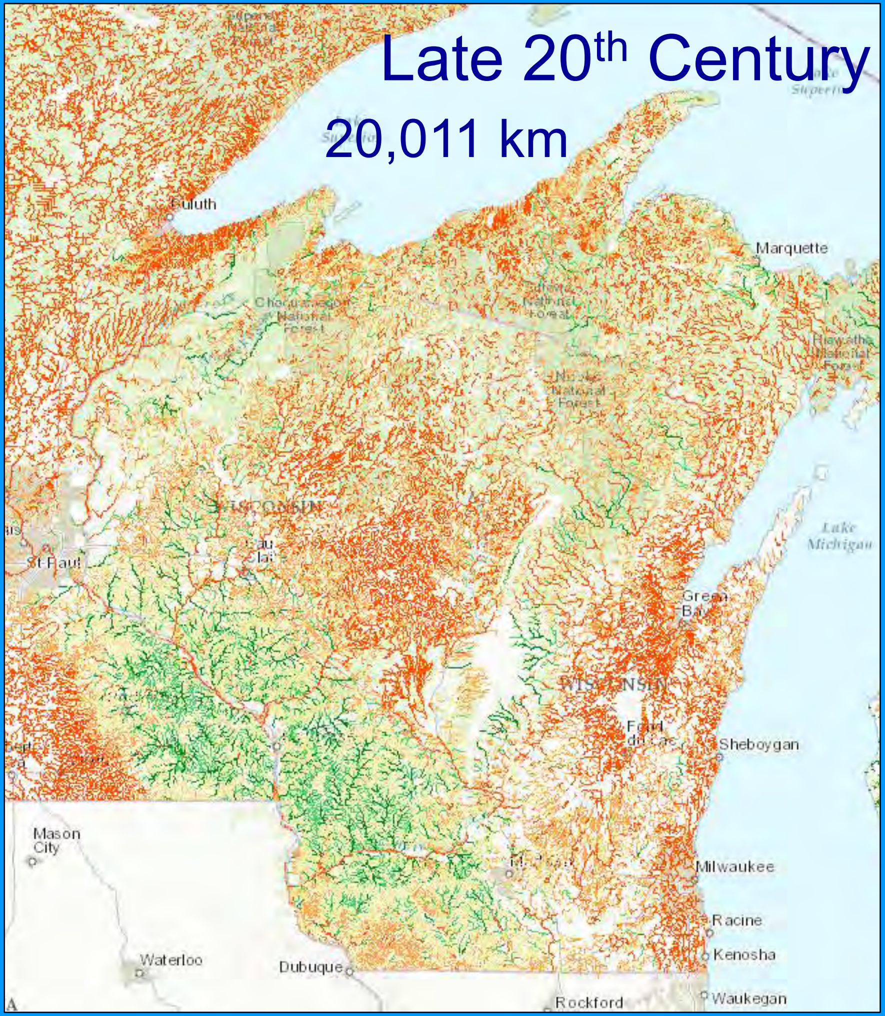
Brook Trout

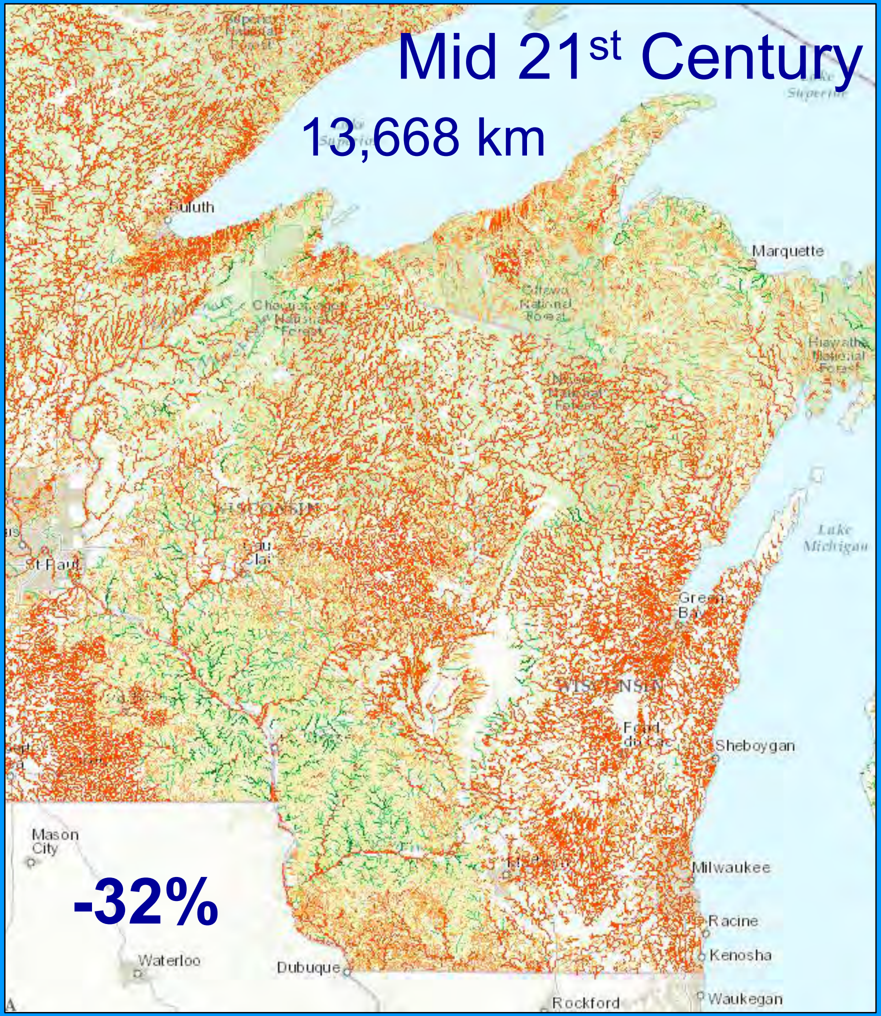




Mitro et al., 2019. Projected changes in Brook Trout and Brown Trout distribution in Wisconsin streams in the mid-twenty-first century in response to climate change. Hydrobiologia 840: 215-226.

Brown Trout





Mitro et al., 2019. Projected changes in Brook Trout and Brown Trout distribution in Wisconsin streams in the mid-twenty-first century in response to climate change. Hydrobiologia 840: 215-226.

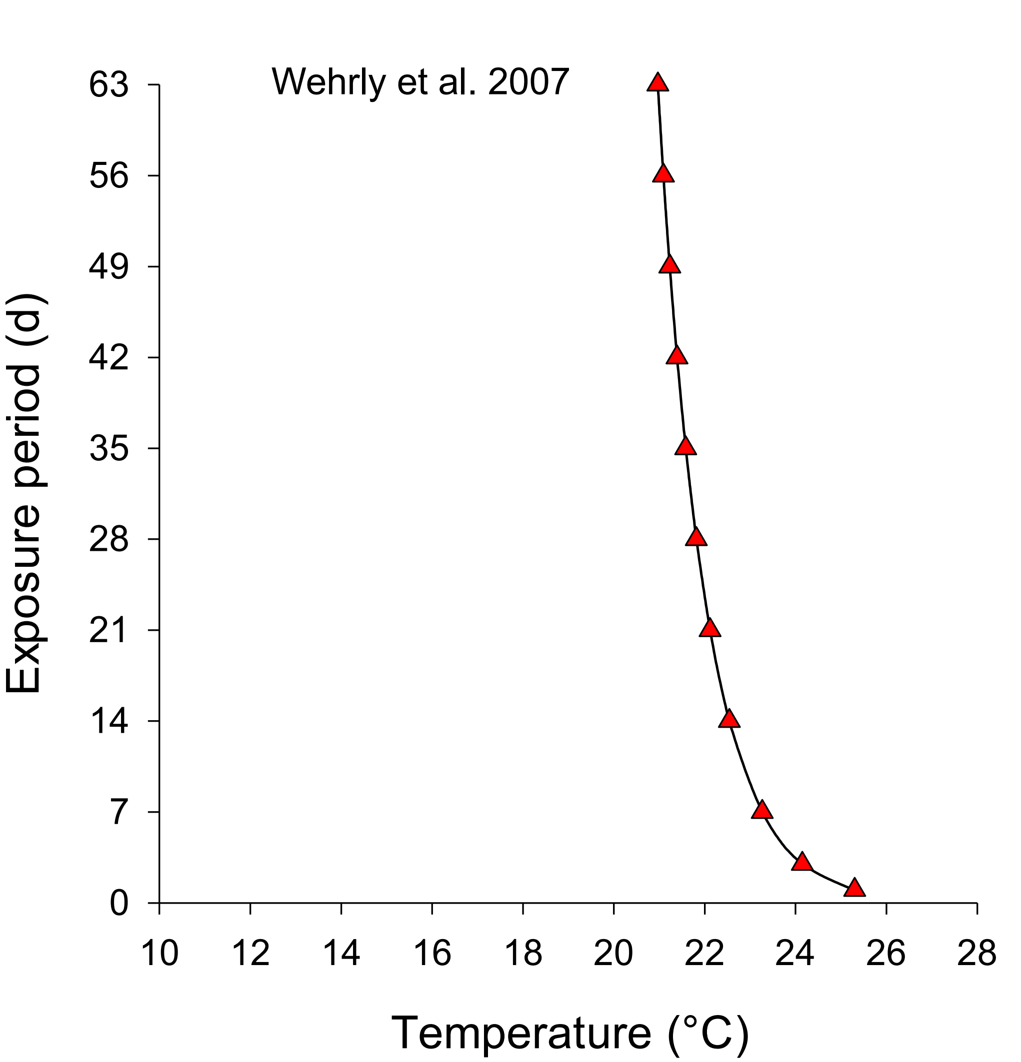
Nations Approve Landmark Climate Accord in Paris*
December 12, 2015

195 nations reached a landmark accord that will, for the first time, commit nearly every country to lowering planet-warming greenhouse gas emissions to help stave off the most drastic effects of climate change.

The new deal will not, on its own, solve global warming. At best, scientists who have analyzed it say, it will cut global greenhouse gas emissions by about half enough as is necessary to stave off an increase in atmospheric temperatures of 2 degrees Celsius or 3.6 degrees Fahrenheit (above pre-industrial levels). That is the point at which, scientific studies have concluded, the world will be locked into a future of devastating consequences, including rising sea levels, severe droughts and flooding, widespread food and water shortages and more destructive storms.

***New York Times, December 12, 2015**

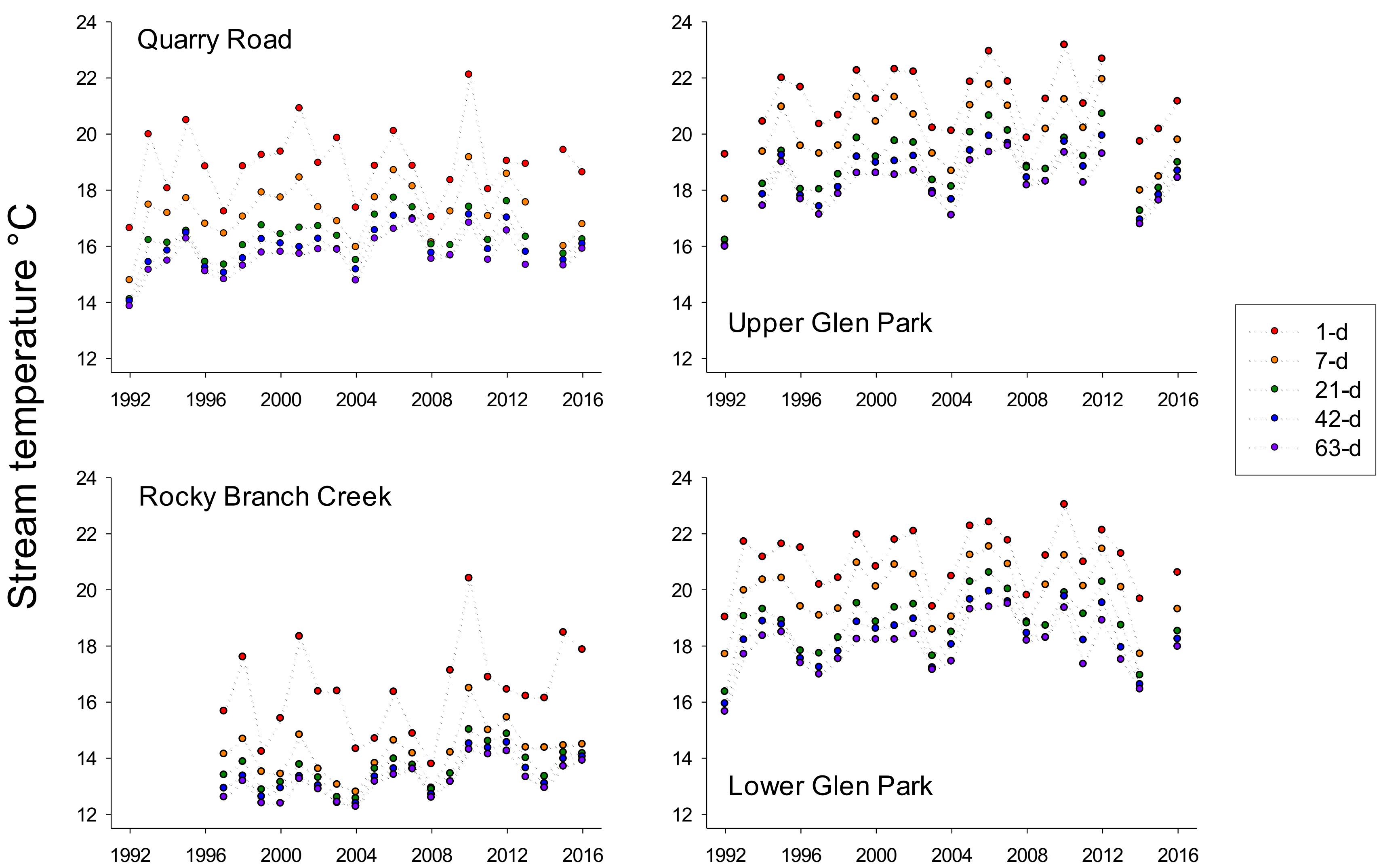
Brook Trout and Brown Trout Thermal Tolerance Limits
Maximum *n*-day mean temperature



Mitro, M. 2017. Effects of changing environmental conditions on Driftless fishes. WDNR, Madison, WI. Presented at 2017 Driftless Area Symposium, La Crosse, WI.

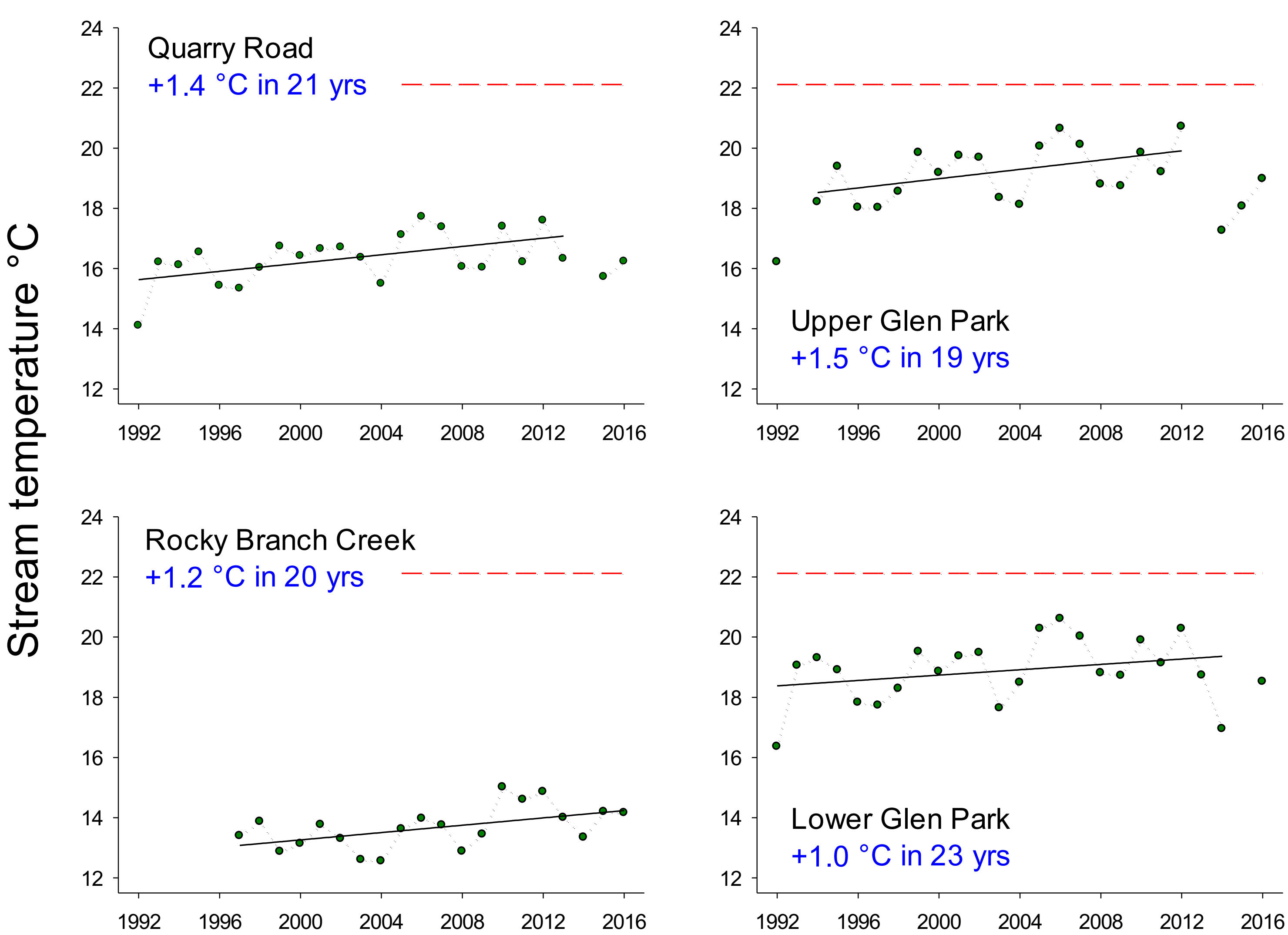
Kinnickinnic River, Wisconsin

Maximum *n*-day mean temperature

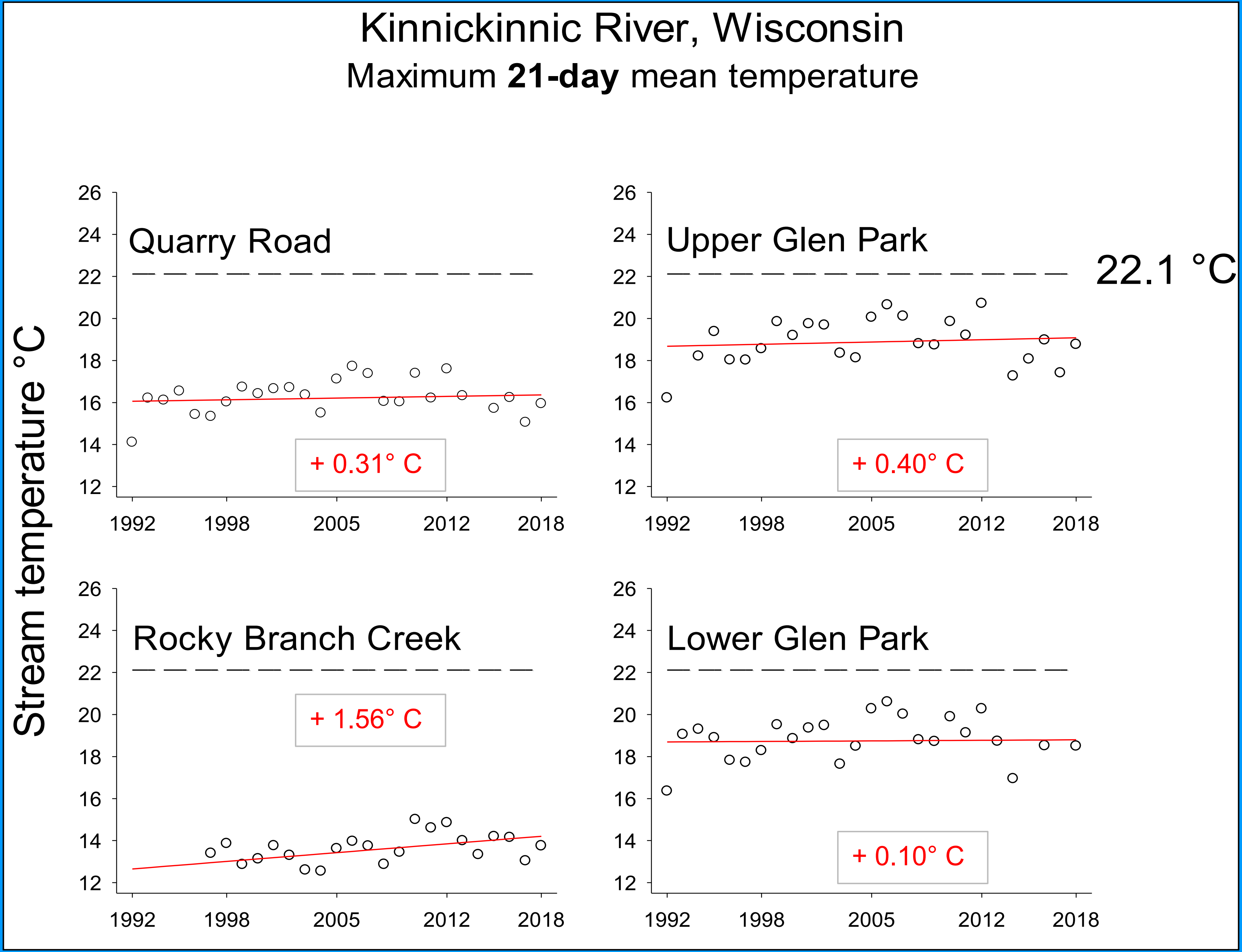


Mitro, M. 2017. Effects of changing environmental conditions on Driftless fishes. WDNR, Madison, WI. Presented at 2017 Driftless Area Symposium, La Crosse, WI.

Kinnickinnic River, Wisconsin
Maximum 21-day mean temperature



Mitro, M. 2017. Effects of changing environmental conditions on Driftless fishes. WDNR, Madison, WI. Presented at 2017 Driftless Area Symposium, La Crosse, WI.



Analysis by Matt Mitro, WDNR Coldwater Fisheries Research Scientist (2019)

For More Information:

Visit the Kiap-TU-Wish Website at:

www.kiaptuwish.org/


Questions?
d.kent.Johnson@gmail.com