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DEPARTMENT OF ENVIRONMENTAL PROTECTION



Office of Water Programs

PA Water Quality Standards Temperature Criteria

ACWA Workshop
April 16-18, 2024

Josh Shapiro, Governor

Jessica Shirley, Interim Acting Secretary



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PA Water Quality Standards

- Implement Sections 5 and 402 of The Clean Streams Law and Section 303 of the Federal Clean Water Act.
- Protected water uses, water quality criteria and an antidegradation policy.
 - 25 Pa. Code Chapter 93
 - 25 Pa. Code Chapter 16



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Temperature Criteria

Protected Use(s):

Aquatic Life

Reason(s) for criteria:

Protect aquatic organisms from the adverse affects associated with excessive or abrupt changes in temperature.



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History of Temperature Criteria in Pennsylvania

- **1962** Sanitary Water Board (SWB) adopts maximums of 58°F for trout streams and 93°F for non-trout streams.



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History of Temperature Criteria in Pennsylvania

- **1973** Department of Environmental Resources (DER) retains the 93°F maximum, revises trout streams to “not more than a 5°F rise above natural temperatures or a maximum of 58°F” and adds similar language for 2 additional criteria with maximums of 86°F and 87°F. New criteria were added for trout stocked streams, which includes a maximum of 74°F from Feb. 15 to July 31.



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History of Temperature Criteria in Pennsylvania

- **1979** DER deletes the 93°F maximum and retains the 87°F criterion for protection of warm water fishes (WWF). The cold water fishes (CWF) and trout stocking (TSF) criteria generally remained unchanged.



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History of Temperature Criteria in Pennsylvania

- **1987** DER adopts Pennsylvania's current temperature criteria to protect the WWF, CWF and TSF uses defined in 25 Pa. Code Chapter 93.



§ 93.3. Protected Water Uses. TABLE 1

Aquatic Life

- CWF** *Cold Water Fishes*—Maintenance or propagation, or both, of fish species including family Salmonidae and additional flora and fauna which are indigenous to a cold water habitat.
- WWF** *Warm Water Fishes*—Maintenance or propagation of fish species and additional flora and fauna which are indigenous to a warm water habitat.
- MF** *Migratory Fishes*—Maintenance or propagation of anadromous and catadromous fishes and other fishes which move to or from flowing waters to complete their life cycle in other waters.
- TSF** *Trout Stocking*—Maintenance of stocked trout from February 15 to July 31 and maintenance and propagation of fish species additional flora and fauna which are indigenous to a warm water habitat.



§ 93.7. Specific water quality criteria. TABLE 3

SYMBOL:

CRITICAL USE:

PERIOD

TEMPERATURE F°

TEMP₁
CWF

TEMP₂
WWF

TEMP₃
TSF

<i>PERIOD</i>	<i>TEMP₁</i> <i>CWF</i>	<i>TEMP₂</i> <i>WWF</i>	<i>TEMP₃</i> <i>TSF</i>
January 1-31	38	40	40
February 1-29	38	40	40
March 1-31	42	46	46
April 1-15	48	52	52
April 16-30	52	58	58
May 1-15	54	64	64
May 16-31	58	72	68
June 1-15	60	80	70
June 16-30	64	84	72
July 1-31	66	87	74
August 1-15	66	87	80
August 16-31	66	87	87
September 1-15	64	84	84
September 16-30	60	78	78
October 1-15	54	72	72
October 16-31	50	66	66
November 1-15	46	58	58
November 16-30	42	50	50
December 1-31	40	42	42

Maximum temperatures in the receiving waterbody resulting from heated waste sources regulated under Chapter 92a, 96 and other sources where temperature limits are necessary to protect designated and existing uses.



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1987 Criteria Development

- Criteria update was initiated due to new publications on thermal impacts to fish and greatly expanded database on thermal regimes in PA streams.
- Newer data revealed ambient stream temperatures periodically exceeded thermal criteria, particularly the CWF maximum of 58°F.
- Criteria values were based on a combination of scientific literature and historical data on thermal regimes in Pennsylvania streams.



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Scientific Literature

- Fish species were selected to be representative of cold and warm water streams in PA.
- Species included: brook trout, brown trout, rainbow trout, northern pike, walleye, muskellunge, northern pike, bluegill, largemouth bass, smallmouth bass, and white crappie.
- 68 publications were included in the development of the criteria.
- Thermal requirements were reviewed for spawning, egg incubation and hatch, growth and survival.



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Scientific Literature

Trout/salmonids:

- Alabaster and Welcomme (1962)
- Bishai (1960)
- Carl (1938)
- Coutant (1970)
- Frost (1967)
- Fry (1946)
- Hokanson et al. (1976)
- Hokanson et al. (1973)
- Leitritz and Lewis (1980)
- McAfee (1966)
- McCormick et al. (1972)
- Rayner (1942)
- Spaas (1960)
- Staley (1966)
- Stuart (1961)
- Vojno (1973)



Scientific Literature

Largemouth and smallmouth bass:

- Coutant (1983)
- Horning and Pearson (1973)
- Kramer and Smith (1962)
- Lee (1969)
- Markus (1932)
- McCormick (1981)
- Peek (1965)
- Strawn (1961)
- Surber (1943)
- Wren (1980)

Muskellunge/pike:

- Fabricus and Gustafson (1958)
- Hokanson et al. (1973)
- Scott (1964)
- Threinen et al. (1966)
- Toner and Lawler (1969)

Crappie:

- Goodson (1966)
- Kleiner and Hokanson (unpublished, EPA)
- Siefert (1968)



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Scientific Literature

Bluegill:

- Anderson (1959)
- Banner and Van Armon (1972)
- Beitinger and Magnuson (1976)
- Emig (1966)
- Lemke (1977)
- Maloney (1949)
- Snow et al. (1966)

Walleye:

- Grimstead (1971)
- Hokanson (1986)
- Kelso (1972)
- Koenst and Smith (1976)
- Niemuth and Churchill (1959)
- Regier et al. (1969)
- Wren and Forsythe (1978)



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Scientific Literature

General Studies:

- Brungs and Jones (1977)
- Carlander (1969)
- Cherry (1977)
- Clugnston (1966)
- Eddy et al. (1943)
- Eddy and Underhill (1974)
- Hart (1952)
- Hokanson (1977)
- Johnson (1971)
- Mantelman (1958)
- Nat'l Academy of Sciences (1972)
- Nat'l Technical Advisory Committee (1968)
- O'Donnell and Churchill (1969)
- Scott and Crossman (1973)
- Smith and Koenst (1975)
- Spigarelli (1975)
- Vernidub (1974)



FISH TEMPERATURE DATA (°F)

SPECIES	PRIMARY SPAWNING MONTHS	SPAWNING RANGE	SPAWNING OPTIMUM	INCUBATION RANGE	OPTIMUM GROWTH RANGE	UPPER LETHAL
<u>CWF</u>						
Brook Trout	Oct-Nov	37-56	<48	?-55	50-66	77
Brown Trout	Oct-Nov	34-56	45-48	41-59	45-66	79
Rainbow Trout	Apr-June	41-63	48	41-55	63-66	81
<u>WWF</u>						
White Crappie	April-May	57-73	61-68	57-73	?	91
Small Mouth Bass	April-May	55-73	63-64	55-72	73-88	95
Large Mouth Bass	April-June	61-81	70	55-79	73-88	95
Bluegill	May-July	66-90	77	72-93	72-93	99
Walleye	Feb-April	39-63	43-48	48-59	61-82	93
Muskellunge	March-April	48-59	55	52-63	?	91
Northern Pike	Feb-April	39-64	54	45-66	?	91



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Historical Pennsylvania Stream Data

- Pennsylvania Water Quality Network (WQN) station data.
<http://www.depgis.state.pa.us/WQN/>
- 280 = # of total stations in the 1980's
- 50 = # of stations included in the criteria development
 - 30 = # of stations on warm water streams
 - 20 = # of stations on cold water streams



LIST OF STREAMS INCLUDED IN ANALYSIS OF HISTORICAL DATA

CWF:

WWF:

NAME	WQN #	NAME	WQN#	NAME	WQN #
Schuylkill River	114	Delaware River	101	Allegheny River	804
Little Schuylkill River	119	Brandywine Creek	105	Little Conemaugh River	816
W. Br. Schuylkill River	120	Schuylkill River	113	Crooked Creek	818
Saucon Creek	127	Maiden Creek	118	Conewango Creek	832
Cacoosing Creek	144	Neshaminy Creek	121	French Creek	847
Yellow Breeches Creek	212	Lehigh River	123	Tunungwant Creek	858
Little Juniata River	217	Little Neshaminy Creek	169	Ohio River	902
Wapwallopen Creek	310	Conodoguinet Creek	213	Shenango River	909
Spring Creek	415	Conestoga Creek	231	Mahoning River	915
Little Pine Creek	429	Susquehanna River	306	Connoquenessing Creek	917
Pine Creek	431	Cowanesque River	320		
Chest Creek	436	Tioga River	324		
Marsh Creek	442	W. Br. Susquehanna River	401		
E. Br. Antietam Creek	504	Bald Eagle Creek	412		
Allegheny River	807	Chillisquaqua Creek	425		
W. Br. Clarion River	824	Conococheague Creek	501		
E. Br. Clarion River	825	Rock Creek	503		
Clarion River	833	Sewickley Creek	715		
Oil Creek	852	Ten Mile Creek	717		
N. Fork Little Beaver Creek	923	Jacobs Creek	721		



**EXCEEDENCES OF THE TEMP₁ CRITERION BY
AMBIENT TEMPERATURES IN CWF STREAMS
(1976-1985)***

MONTH	TOTAL # OF TEMPERATURE READINGS ON RECORD	# OF READINGS EXCEEDING 58°F	% OF READINGS EXCEEDING 58°F
January	159	0	0
February	175	0	0
March	186	0	0
April	185	24	13
May	178	70	39
June	181	153	85
July	189	180	95
August	194	185	95
September	184	142	77
October	195	28	14
November	190	3	2
December	183	0	0

*Based on WQN records for the 20 CWF streams listed in Table 1



**EXCEEDENCES OF THE TEMP₂ CRITERION BY
AMBIENT TEMPERATURES IN WWF STREAMS
(1976-1985)***

MONTH	TOTAL # OF TEMPERATURE READINGS ON RECORD	# OF READINGS EXCEEDING 87°F	% OF READINGS EXCEEDING 87°F
January	226	0	0
February	243	0	0
March	254	0	0
April	243	0	0
May	259	0	0
June	243	0	0
July	251	2	<1
August	262	2	<1
September	249	0	0
October	259	0	0
November	257	0	0
December	243	0	0

*Based on WQN records for the 30 WWF streams listed in Table 1



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**MEAN MONTHLY ΔT 'S
FOR SELECTED WARM WATER STREAMS (°F)**

NAME	D-J	J-F	F-M	M-A	A-M	M-J	J-J	J-A	A-S	S-O	O-N	N-D
Delaware River	-5	+5	+4	+7	+10	+10	+6	+1	-8	-11	-11	-8
Brandywine Creek	-5	-1	+7	+7	+9	+5	+10	-1	-7	-9	-8	-7
Schuylkill River	-3	+4	+1	+7	+14	+7	+6	-2	-4	-13	-10	-7
Maiden Creek	-4	0	+4	+8	+12	+7	+3	+1	-5	-9	-9	-8
Neshaminy Creek	-4	+4	+6	+7	+13	+6	+2	+1	-5	-12	-11	-7
Lehigh River	-4	+2	+4	+8	+10	+12	+3	-3	-6	-11	-10	-5
Little Neshaminy Creek	-4	+3	+8	+5	+13	+7	+4	-1	-7	-10	-9	-9
Conodoguinet Creek	0	+1	+9	+8	+8	+6	+2	+4	-9	-9	-10	-10
Conestoga Creek	-5	+3	+9	+9	+7	+10	+4	0	-10	-10	-9	-8
Susquehanna River	-5	+2	+5	+10	+10	+11	+3	0	-6	-12	-6	-6
Cowanesque River	-3	0	+2	+14	+11	+12	0	+2	-10	-15	-7	-6
Tioga River	-3	+3	+2	+11	+10	+10	+2	0	-6	-16	-5	-8
W. Br. Susquehanna R.	-3	+2	+6	+6	+12	+8	+6	0	-8	-11	-14	-4
Bald Eagle Creek	-2	+1	+5	+7	+8	+7	+9	-4	-5	-9	-8	-9
Ilisquaqua Creek	-1	+3	+2	+10	+10	+10	+2	+2	-9	-11	-4	-14
Conococheague Creek	-3	+3	+4	+9	+10	+6	+4	+4	-9	-14	-7	-7
Rock Creek	-4	+3	+7	+9	+11	+3	+8	-1	-7	-14	-5	-10
Sewickley Creek	-6	+2	+5	+6	+8	+4	+4	+4	-8	-10	-4	-5
Ten Mile Creek	-4	+2	+8	+7	+10	+9	+1	+5	-6	-17	-11	-4
Jacobs Creek	-7	+2	+7	+11	+8	+2	+3	+2	-5	-15	-3	-5
Allegheny River	-4	0	+4	+9	+8	+10	+6	-1	-6	-9	-10	-7
Little Conemaugh River	+2	-1	+3	+4	+8	+12	+2	+4	-1	-13	-8	-11
Crooked Creek	-6	+1	+3	+8	+13	+5	+4	+1	-5	-13	-7	-6
Conewango Creek	-4	+2	+3	+10	+11	+8	+6	-1	-6	-16	-7	-6
French Creek	-4	-1	+5	+6	+14	+11	+4	-1	-10	-8	-8	-8
Tunungwant Creek	-1	+1	+3	+11	+7	+6	+10	-5	-5	-9	-13	-5
Ohio River	-5	+1	+5	+7	+7	+13	+6	+4	-11	-8	-6	-13
Shenango River	-2	-1	+8	+8	+10	+11	+5	-1	-5	-13	-9	-11
Mahoning River	-3	+1	+6	+7	+13	+9	+3	0	-4	-13	-7	-12
Conoquenessing Creek	+4	-5	+4	+7	+10	+6	+9	-1	-5	-9	-14	-6
Average Mean	-3.2	+1.4	+5.0	+8.1	+10.2	+8.0	+4.6	+0.4	-6.6	-11.6	-8.3	-7.7
Standard Deviation	2.3	2.0	2.2	2.1	2.1	2.8	2.6	2.5	2.2	2.6	2.8	2.6



**AVERAGE MEAN MONTHLY ΔT 's CALCULATED
FOR COLD AND WARM WATER STREAMS ($^{\circ}F$)**

<u>Period</u>	<u>Cold Water Streams</u>	<u>Warm Water Streams</u>
December - January	-3.5	-3.2
January - February	+2.1	+1.4
February - March	+3.4	+5.0
March - April	+8.1	+8.1
April - May	+6.9	+10.2
May - June	+6.9	+8.0
June - July	+4.4	+4.6
July - August	-0.9	+0.4
August - September	-4.4	-6.6
September - October	-9.8	-11.6
October - November	-7.3	-8.3
November - December	-4.9	-7.7



**STATISTICAL EVALUATION OF THE SEASONAL TEMPERATURE CYCLES
CALCULATED FOR COLD AND WARM WATER STREAMS IN PENNSYLVANIA**

PERIOD	AVERAGE MEAN ΔT OF SAMPLE		STANDARD DEVIATION OF SAMPLE MEAN		95% CONFIDENCE INTERVAL FOR AVERAGE MEAN ΔT OF POPULATION ($^{\circ}F$)*	
	CWF	WWF	CWF	WWF	CWF	WWF
December-January	-3.5	-3.2	1.4	2.3	-2.8 to -4.2	-2.3 to -4.1
January-February	+ 2.1	+ 1.4	1.6	2.0	+ 1.4 to + 2.8	-0.7 to + 2.1
February-March	+ 3.4	+ 5.0	1.4	2.2	+ 2.7 to + 4.1	+ 4.2 to + 5.8
March-April	+ 8.1	+ 8.1	2.1	2.1	+ 7.1 to + 9.1	+ 7.3 to + 8.9
April-May	+ 6.9	+ 10.2	2.5	2.1	+ 5.7 to + 8.1	+ 9.4 to + 11.0
May-June	+ 6.9	+ 8.0	2.0	2.8	+ 6.0 to + 7.8	+ 7.0 to + 9.0
June-July	+ 4.4	+ 4.6	2.4	2.6	+ 3.3 to + 5.5	+ 3.6 to + 5.6
July-August	+ 0.9	+ 0.4	2.9	2.5	+ 0.2 to + 2.3	-0.5 to + 1.3
August-September	-4.4	-6.6	2.4	2.2	-3.3 to -5.5	-5.8 to -7.4
September-October	-9.8	-11.6	2.9	2.6	-8.4 to -11.2	-10.6 to -12.6
October-November	-7.3	-8.3	2.7	2.8	-6.0 to 8.6	-7.3 to -9.3
November-December	-4.9	-7.7	2.2	2.6	-3.9 to -5.9	-6.7 to -8.7

*as calculated with the students T test,

Where : \bar{x} = mean of sample
 S_x = standard deviation of sample mean
 N = number of elements in sample
 T = t score for 95% certainty



RATIONALE FOR PROPOSED TEMP₁ MAXIMUMS

PERIOD	MAXIMUM (°F)	PRIMARY BASIS FOR MAXIMUM*	BIOLOGICAL FUNCTIONS PROTECTED BY MAXIMUM **				
			GONADAL MATURATION	SPAWNING	EGG INCUBATION AND HATCH	GROWTH	SURVIVAL
January 1-31	38	ΔT	-	-	X	X	X
February 1-29	38	ΔT	-	-	X	X	X
March 1-31	42	ΔT	-	-	X	X	X
April 1-15	48	ΔT	-	-	X	X	X
April 16-30	52	ΔT	-	-	X	X	X
May 1-15	54	ΔT	-	-	-	X	X
May 16-31	58	ΔT	-	-	-	X	X
June 1-15	60	ΔT	-	-	-	X	X
June 16-30	64	ΔT	-	-	-	X	X
July 1-31	66	BR	X	-	-	X	X
August 1-31	66	BR	X	-	-	X	X
September 1-15	64	ΔT	X	-	-	X	X
September 16-30	60	ΔT	X	-	-	X	X
October 1-15	54	ΔT	X	X	X	X	X
October 16-31	50	ΔT	-	X	X	X	X
November 1-15	46	ΔT	-	X	X	X	X
November 16-30	42	ΔT	-	X	X	X	X
December 1-31	40	ΔT	-	-	X	X	X

* BR = biological requirements, ΔT = average mean monthly temperature transition, see text for further explanation.

** Based on the requirements of representative cold water species (- = not applicable, X = function protected)



RATIONALE FOR PROPOSED TEMP₂ MAXIMUMS

PERIOD	MAXIMUM (°F)	PRIMARY BASIS FOR MAXIMUM*	BIOLOGICAL FUNCTIONS PROTECTED BY MAXIMUM **					
			GONADAL MATURATION	SPAWNING	EGG INCUBATION AND HATCH	GROWTH	SURVIVAL	
January	1-31	40	BR	X	-	-	X	X
February	1-29	40	BR	X	X	X	X	X
March	1-31	46	BR	X	X	X	X	X
April	1-15	52	BR	-	X	X	X	X
April	16-30	58	BR	-	X	X	X	X
May	1-15	64	BR	-	X	X	X	X
May	16-31	72	BR	-	X	X	X	X
June	1-15	80	ΔT	-	X	X	X	X
June	16-30	84	ΔT	-	X	X	X	X
July	1-31	87	BR	-	X	X	X	X
August	1-31	87	BR	-	-	-	X	X
September	1-15	84	ΔT	-	-	-	X	X
September	16-30	78	ΔT	-	-	-	X	X
October	1-15	72	ΔT	-	-	-	X	X
October	16-31	66	ΔT	-	-	-	X	X
November	1-15	58	ΔT	-	-	-	X	X
November	16-30	50	BR	X	-	-	X	X
December	1-31	42	BR	X	-	-	X	X

* BR = biological requirements, ΔT = average mean monthly temperature transition, see text for further explanation.

** Based on the requirements of representative cold water species (- = not applicable, X = function protected)



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Temperature Criteria Implementation

Approximately 222 active NPDES permits with temperature effluent limitations.

- 44 permits with numeric effluent limits based on criteria
- 53 permits with M/R requirements
- 123 permits with IMAX of 110°F
- Approximately 15 permits with approved CWA Section 316(a) thermal variances.



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Temperature Criteria Implementation

Implementation guidance and permit tools

- Thermal Limits Spreadsheet (Go to www.dep.pa.gov and search “PA DEP water quality models and tools”)



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Temperature Criteria Implementation

- Assessments
 - Approximately 60 miles of streams and rivers are currently impaired for thermal modifications.
- TMDLs
 - PA currently has one TMDL and one 4B restoration plan that addresses impairments due to thermal modifications.



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