

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

Bureau of Clean Water

Triennial Review of Water Quality Standards TR17 Updates to Chloride Criteria

Water Resources Advisory Committee
March 24, 2016

Tom Wolf, Governor

John Quigley, Secretary

Current Chloride Criterion

Pennsylvania's existing chloride criterion was developed primarily for the protection of potable water supplies (PWS use).

The chloride criterion is not applied in all waters of this Commonwealth. It is applied only at the point of water supply intake.

A maximum level of 250 milligrams of chloride per liter of water.

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

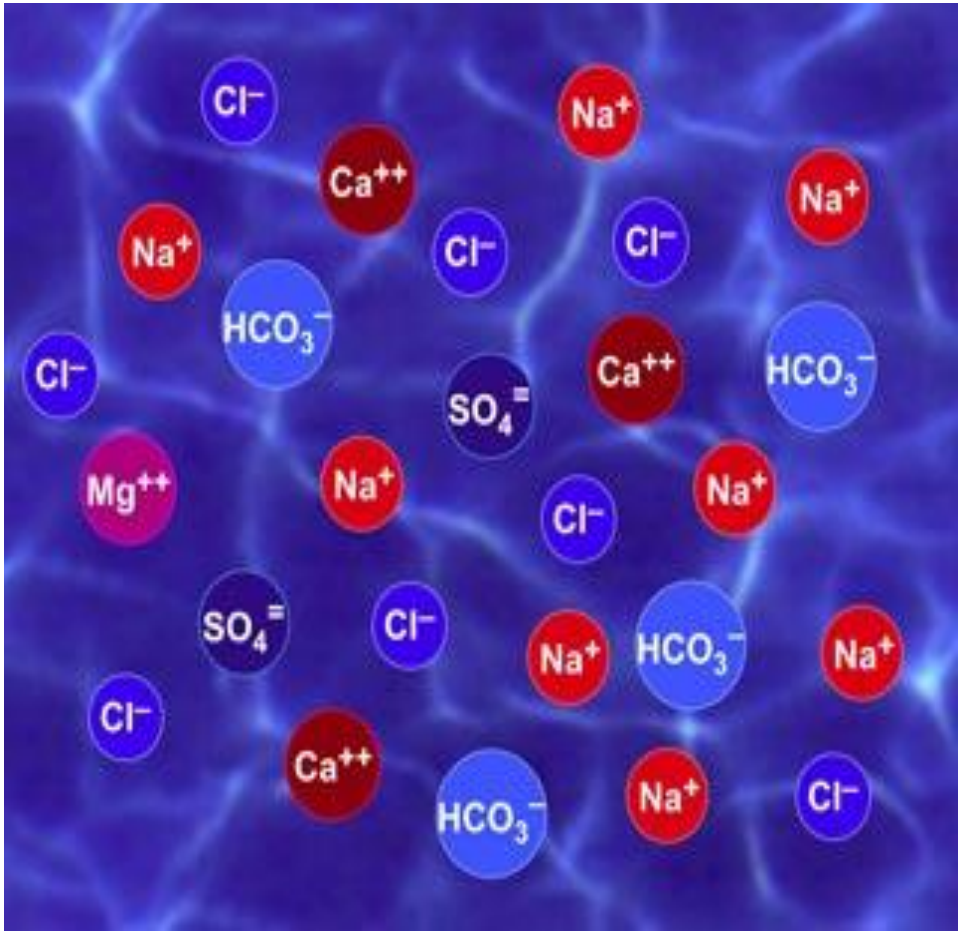
Need for Aquatic Life Use Protection

Numerous toxicity tests show aquatic organisms found in Commonwealth waters are being negatively impacted by current chloride concentrations.

Aquatic life protection must be applied statewide to all waters, in order to protect sensitive organisms.

Ionic Composition

Freshwater sources are dominated by the cations Ca^{2+}, Mg^{2+}, K^{+} and Na^{+} and the anions $HCO3^{-}$, SO_4^{2-} and Cl^{-}. (Wetzel, 1983)



pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

Test Compound Determination

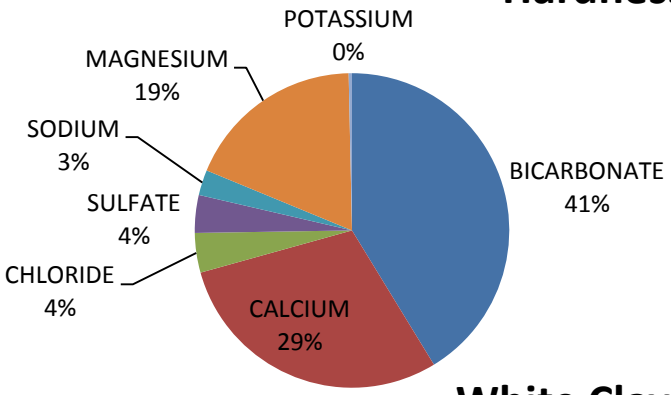
Data obtained from stream surveys of Pennsylvania waters confirmed the ionic composition is: >40% $HCO3^-$/ Ca^{2+}, followed by SO_4^{2-}, Mg^{2+}, Na^+, K^+ and Cl^-.

Pennsylvania waters are calcium/bicarbonate dominant.

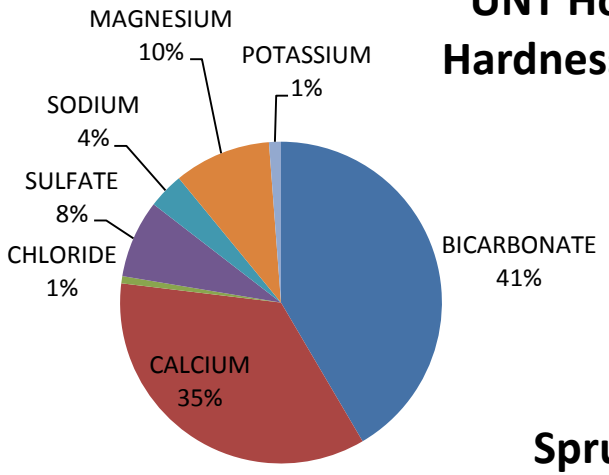
pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

PA Water Ionic Composition

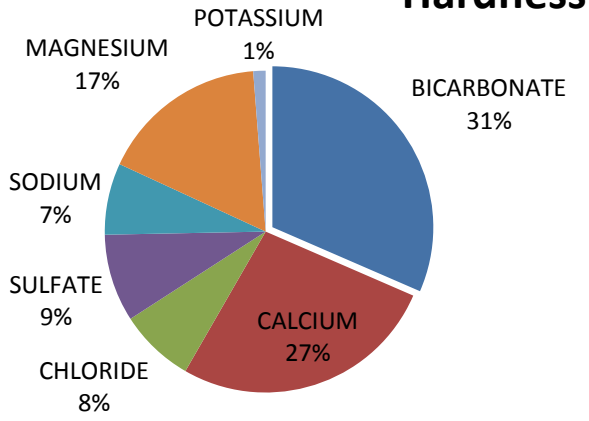
Cedar Run
Hardness = 212



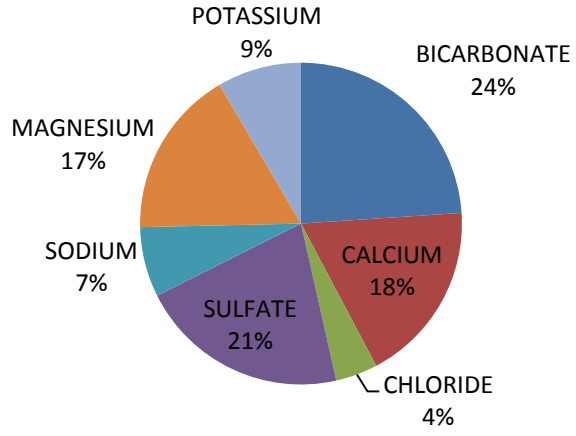
UNT House
Hardness = 94



White Clay Creek
Hardness = 89



Spruce Run
Hardness = 6



pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

Acceptable Test Product

- The order of chloride salt toxicity to freshwater organisms is KCl > $MgCl_2$ > $CaCl_2$ > NaCl. (Mount et al 1997)
- NaCl is the least toxic to aquatic organisms.
- Therefore, chloride toxicity to freshwater organisms was evaluated using NaCl as the test compound. Using NaCl ensures that the effect concentrations were derived from test where the effects are based on the chloride anion, not the associated cations.

Toxicological Study - Chloride

- EPA and Chapter 93 criteria development methodologies were used to derive acute and chronic chloride criteria.

- Data used was from:
  - approved U.S. EPA chloride toxicity dataset
  - results of the Stroud mayfly toxicity tests

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

Toxicological Study – Acute Chloride

- Acute values were used from all acceptable data.

- This resulted in 219 acute toxicity results for aquatic species (51 genera).

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

Acute Chloride Data Set

Genus	Genus	Genus
Epioblasma	*Physa*	*Aciperser*
Sphaerium	*Rana*	*Cyprinella*
Neocloeon	*Pseudacris*	*Lepidostoma*
Lampsilis	*Lirceus*	*Lepomis*
Anafroptilum	*Macaffertium*	*Carassius*
Ambystoma	*Planorbella*	*Gambusia*
Ceriodaphnia	*Ephemerella*	*Oncorhynchus*
Elliptio	*Limnodrilus*	*Libellulidae*
Procloeon	*Bufo*	*Fundulus*
Megalonaisas	*Caecidotea*	*Gasterosteus*
Lasmigona	*Lumbriculus*	*Cambarus*
Margaritifera	*Nephelopsis*	*Anguilla*
Brachionus	*Erpobdella*	*Agria*
Daphnia	*Ameriurus*	
Isonychia	*Pimephales*	
Musculium	*Tubifex*	
Villosa	*Chironomus*	
Gyraulus	*Leptophlebia*	
Diaptomus	*Lithobates*	

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

Toxicological Study – Acute Chloride

Based on the lethal or effect concentrations (LC50 or EC50), the four genera most sensitive to acute testing were:

Rank	Genus/ Species	GMAV mg/L
4	*Lampsilis* (wavy-rayed lamp mussel)	991
3	*Neocloeon* (mayfly)	959
2	*Sphaerium* (fingernail clam)	785
1	*Epioblasma* (mussel)	698

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

Toxicological Study - Chloride

The genus mean acute value (GMAV), 698 mg/L chloride includes the most sensitive organism (*Northern Riffleshell*).

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

Chronic Chloride Data Set

The chronic toxicity data set included 10 aquatic species.

Species
Pimephales promelas (Fathead minnow)
Oncorhynchus mykiss (Rainbow trout)
Daphnia ambigua (water flea)
Daphnia magna (water flea)
Daphnia pulex (water flea)
Ceriodaphnia dubia (water flea)
Lumbriculus variegatus (worm)
Neocloeon triangulifer (mayfly)
Anafroptilum semirufum (mayfly)
Procloeon fragile (mayfly)

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

Chronic Chloride Data Set

The four species most sensitive to the chronic testing are:

Rank	Species	SMCV mg/L
4	*Daphnia ambigua* (water flea)	259
3	*Procloeon fragile* (mayfly)	239
2	*Anafroptilum semirufum* (mayfly)	160
1	*Neocloeon triangulifer* (mayfly)	153

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

Toxicological Study - Chronic Chloride

The species mean chronic value (SMCV) for the most sensitive organism (*Neocloeon triangulifer*) is 153 mg/L chloride.

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

Calculation Definitions

Genus Mean Acute Values (GMAV) – is the geometric mean of the SMAV's.

Final Acute Value (FAV) – is calculated based on the GMAV's of the 4 organisms with a cumulative probability closest to 0.05.

- If the FAV is calculated to be larger than the lowest GMAV, the lowest GMAV is used.

Criteria Maximum Concentration (CMC) – is equal to one half the FAV

Acute/Chronic Ratio (ACR) - the calculated geometric mean of the available acute values for a species divided by the available chronic values
The same dilution water must be used throughout the testing.

Final Acute to Chronic Ratio (FACR) – When sufficient chronic values are not available for species in eight families, an acute to chronic ratio is calculated.

Criteria Continuous Concentration (CCC) – is the CMC divided by the FACR

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

Chloride Criteria Calculated

The final calculated acute/chronic ratio (FACR) from the acceptable data is 6.2.

FAV (final acute value)	**874.8**
FAV for lowest GMAV	698
FACR = (geo mean of SMAV/SMCV)	6.2
CMC = FAV for lowest GMAV/2	349
CCC = (CMC/FACR)	113

EPA has determined that the chloride toxicity is dependent on hardness and sulfate concentrations. As a result, the criteria will be equation based.

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

Recommended Aquatic Life Criteria

The recommended, proposed chloride criteria will be calculated using the following equations*:

Acute Chloride Criterion: CMC = 349

One hour average concentration should not exceed, more than once in three years

$$\text{Acute Criterion (mg/L)} = \mathbf{CMC}(\text{Hardness})^{0.205797}(\text{Sulfate})^{-0.07452}$$

Chronic Chloride Criterion: CCC = 113

4 day average concentration should not exceed, more than once in three years

$$\text{Chronic Criterion (mg/L)} = \mathbf{CCC}(\text{Hardness})^{0.205797}(\text{Sulfate})^{-0.07452}$$

*Hardness & sulfate exponents are based on studies done by the Great Lakes Environmental Center

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION



The Department would like to thank you for helping us take this course in developing a PA specific criterion for chloride.

Questions?

Rodney Kime
Bureau of Clean Water
rkime@pa.gov
(717) 787-9637