Water Quality Guidelines for Nitrogen (Nitrate, Nitrite, and Ammonia)

Addendum to Technical Appendix

Water Stewardship Division

Ministry of Environment

Province of British Columbia

Prepared by:

C.L. Meays, Ph.D.

†September, 2009

SUMMARY

This is an addendum to the Technical Appendix published in 1986 and is used to update the nitrate guidelines. This update assesses more recent information and makes amendments to suit BC conditions. The guidelines are safe conditions or levels that have province-wide application and are intended to protect the most sensitive species and sensitive life stage, indefinitely.

NOTE: The U.S. EPA is intending to re-evaluate the 1999 *Ammonia Aquatic Life Criteria Update* because new studies suggest that the early life stages of freshwater mussels (Unionidae) are amongst the most sensitive aquatic organisms. In North America, greater than 70% of freshwater mussel populations are listed as endangered, threatened, or of special concern (Augspurger et al. 2003). BC has at least 85 species of freshwater molluscs including 54 snails, 5 mussels, and 26 clams. The BC ammonia guideline will be revisited and updated based on the new scientific literature including the new studies with Unionidae.

For nitrate (as N), the 30-d average concentration to protect freshwater aquatic life is 3.0 mg L^{-1} and the maximum concentration is 32.8 mg L^{-1}. For nitrate (as N), the 30-d average concentration to protect marine aquatic life 3.7* mg L^{-1}.

* Interim Guideline

NOTE: The 30-d average (chronic) concentration is based on 5 weekly samples collected within a 30-day period.

Since few studies for nitrogen toxicity in estuarine environments are available, the marine guideline is the same as the interim guideline proposed by CCME (2003). The CCME (2003) interim guideline for marine life for nitrate was developed from a critical study that exposed temperate marine annelids to potassium nitrate under static conditions (Reish 1970). The interim marine guideline was derived for the nitrate by multiplying the 28-d LC50 for *Nereis grubei* by a safety factor of 0.05. A more conservative safety factor was chosen because the polychaete in the critical study was not tested at its most sensitive life stage; the critical endpoint was based on a median lethal effect rather than a low sublethal effect; and adverse effects have been observed

in non-indigenous tropical species exposed to much lower concentrations of nitrate (CCME 2003).

For freshwater studies, the 30-day maximum guideline for nitrate was derived based on acute (LC50s) of the most sensitive species reported in the literature (Camargo et al. 2005, Camargo and Ward 1992). The most sensitive acute toxicity estimates for invertebrates exposed to $NaNO_3$ were 62.5, 97.3, and 113.5 mg L^{-1} NO_3^- (as N, 96-h exposures) for the amphipod *Echinogammarus echinosetosus*, and the caddisflies *Hydropsyche occidentalis* and *Cheumatopsyche pettiti*, respectively (Camargo et al. 2005, Camargo and Ward 1992). *Echinogammarus* and *Gammarus* sp. are in the same couplet only separated by the length of a single projection on a uropod (personal communication Sue Salter and Christopher Rogers). Generally, some organisms used in guideline development may be indicators for others. In this case *Echinogammarus* sp. and *Gammarus* sp. are both in the same family Gammaridae. It is acceptable to use data from species in the same phylum for freshwater invertebrates however; it is more desirable to use native species. Since *Echinogammarus echinosetosus* is an introduced species (and potential invader) the acute guideline was not based on it. Future bioassays on native *Gammarus lacustris* would be beneficial to see if the toxicity is comparable. The next most sensitive species was *Hydropsyche occidentalis* with a 120-h LC50 of 65.5 mg L^{-1} and a 96-h LC50 of 97.4 mg L^{-1}(Camargo et al. 2005). Since the least conservative uncertainty factor (.5) is being applied and using scientific judgement, the new acute guideline is 32.8 mg L^{-1} nitrate (as N). The 120-h LC50 was chosen since it would be more representative of a continuous discharge of nitrate in the environment from point and non-point sources. The aquatic phase of the life cycle of *Hydropsyche occidentalis* can be up to 1 year.

For chronic studies on nitrate, the 2 most sensitive species identified in the literature from acceptable studies were embryo growth reduction in the red-legged frog (*Rana aurora*) (Schuytema and Nebeker 1999a) and larval growth reduction in the northern leopard frog (*Rana pipiens*) (Allran and Karasov 2000). CCME (2003) determined that the ecological relevance of the results were questionable because, although the reduction in length was significant, they only represented reductions in size of 3 to 6%. CCME (2003) therefore used the next most sensitive species, the Pacific treefrog (*Pseudacris regilla*) to determine the freshwater guideline. The recommended freshwater guideline for nitrate for BC is 3.0 mg L^{-1} nitrate (as N). The guideline

was derived by multiplying the 10-d LOEC of 133 mg $NO_3^-L^{-1}$ (Schuytema and Nebeker 1999b) by a safety factor of 0.1 and converting to nitrate (as N). *Pseudacris regilla* (synonym *Hyla regilla*) is a relevant species in BC. Its present range is virtually all of central and southern BC (BC Frogwatch Program). Information taken from BC Species and Ecosystems Explorer (http://www.env.gov.bc.ca/atrisk/toolintro.html) suggest that 36% of amphibian species in BC are at risk. 30-day average guidelines are derived with the intention to protect all forms of aquatic life and all aquatic stages indefinitely. The most sensitive life stage of *Pseudacris regilla* to nitrate is the tadpole (30.1 mg L^{-1} nitrate (as N) resulted in a 15% reduction in body weight). The current CCME water quality guideline (3.0 mg L^{-1} NO_3 as N) is based on the *Pseudacris regilla* study. A study by McGurk et al. (2006) looking at acute and chronic toxicity of nitrate on early life stages of lake trout (*Salvelinus namaycush*) and lake whitefish (*Coregonus clupeaformis*) supports the validity of the nitrate guideline for freshwater life by showing that the early life stages of these species were as susceptible to sub-lethal effects as the early life stages of the Pacific treefrog. *Salvelinus namaycush* is widely distributed and of significant importance in BC. In the McGurk et al. (2006) study, larval weight of lake trout was significantly inhibited at low nitrate concentrations (6.25 mg L^{-1} LOEC and 1.6 mg L^{-1} NOEC). If the least conservative uncertainty factor is applied to the LOEC for the lake trout, the chronic water quality guideline would be 3.1 mg L^{-1} nitrate (as N). The maximum acceptable toxic concentration (MATC) is 3.16 mg L^{-1} nitrate (as N). Mean background nitrate + nitrite concentrations in lotic systems throughout BC fall below 0.5 mg L^{-1}. Therefore, a guideline of 3.0 mg L^{-1} nitrate (as N) allows an increase of 6 times above background concentrations.

It should be noted that in waterbodies that have mixtures of ammonium, potassium, and nitrate, the mixture is likely more toxic than the concentrations measured individually.

There are some concerns that nitrate may be an endocrine disruptor (Secondi et al. 2009, Edwards and Guillette 2007, Guillette and Edwards 2005). Further research into this issue is warranted.

†Revision note: Minor edits to the 2009 document were made in July 2010. The 30-d average guideline to protect freshwater aquatic life (3.0 mg L^{-1} nitrate (as N)) did not change. The maximum guideline for nitrate (as N) increased slightly from 31.3 to 32.8 mg L^{-1}.

References

Allran, J.W. and W.H. Karasov. 2000. Effects of atrazine and nitrate on northern leopard frog (*Rana pipiens*) larvae exposed in the laboratory from posthatch through metamorphosis. Environmental Toxicology and Chemistry 19:2850-2855.

Augspurger, T. A.E. Keller, M.C. Black, W.G. Cope, and F.J. Dwyer. 2003. Water quality guidance for protection of freshwater mussels (Unionidae) from ammonia exposure. Environmental Toxicology and Chemistry 22:2569-2575.

Canadian Council of Ministers of the Environment. 2003. Canadian Water Quality Guidelines for the Protection of Aquatic Life: Nitrate Ion.
http://www.ccme.ca CEQG Online.

Camargo, J.A. and J.V. Ward. 1992. Short-term toxicitiy of sodium nitrate ($NaNO_3$) to non-target freshwater invertebrates. Chemosphere 24:23-28.

Camargo, J.A., A. Alonso, and A. Salamanca. 2005. Nitrate toxicity to aquatic animals: a review with new data for freshwater invertebrates. Chemosphere 58: 1255-1267.

Edwards, T.M. and L.J.Guillette Jr. 2007. Reproductive characteristics of male mosquitofish (*Gambusia holbrooki*) from nitrate-contaminated springs in Florida. Aquatic Toxicology 85:40-47.

Guillette, L.J. Jr., and T.M. Edwards. 2005. Is nitrate an ecologically relevant endocrine disruptor in Vertebrates? Intergr. Comp. Biol. 45:19-27.

McGurk et al. 2006. Acute and chronic toxicity of nitrate to early life stages of lake trout (*Salvelinus namaycush*) and lake whitefish (*Coregonus clupeaformis*). Environmental Toxicology and Chemistry 25:2187-2196.

Reish, D.J. 1970. The effects of varying concentrations of nutrients, chlorinity, and dissolved oxygen on polychaetous annelids. Water Research 4:721-735.

Schuytema, G.S. and A.V. Nebeker. 1999a. Effects of ammonium nitrate, sodium nitrate, and urea on red-legged frogs, Pacific treefrogs and African clawed frogs. Bulletin of Environmental Contamination and Toxicology 63:357-364.

Schuytema, G.S. and A.V. Nebeker. 1999b. Comparative toxicity of ammonium and nitrate compounds to Pacific treefrog and African clawed frog tadpoles. Environmental Toxicology and Chemistry 18:2251-2257.

Secondi, J, E. Hinot, Z. Djalout, S. Sourice, and A. Jadas-Hecart. 2009. Realistic nitrate concentration alters the expression of sexual traits and olfactory male attractiveness in newts. Func. Ecol. 23:800-808.