Ammonia Water Quality Criteria
Past, Present and Future

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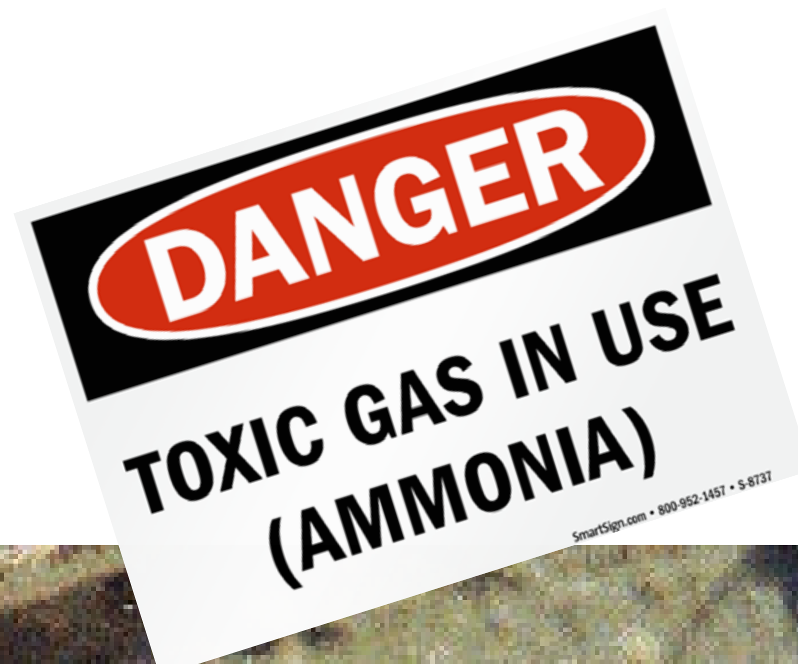
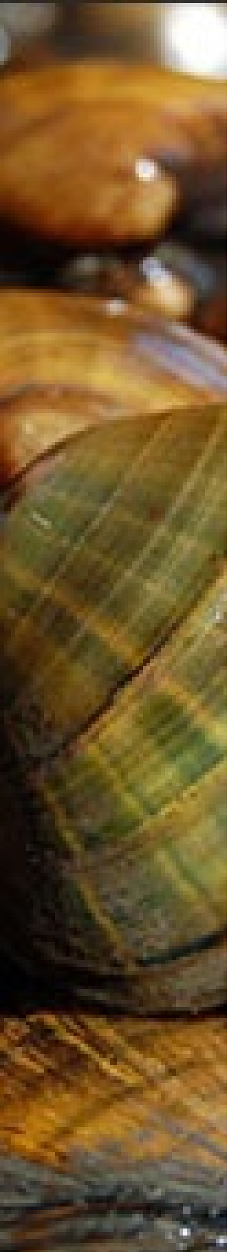
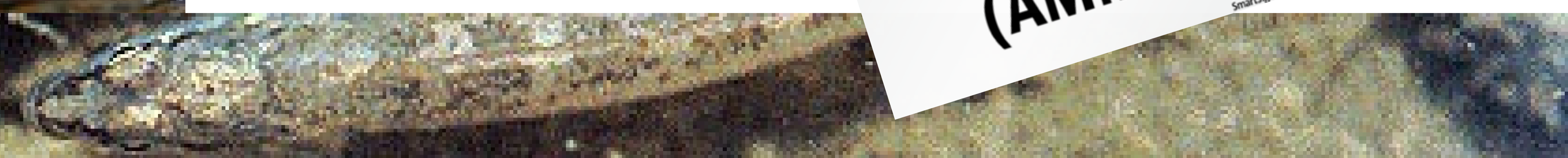






Ammonia 101

Natural Sources

- One of several forms of nitrogen present in aquatic environments
- Excreted by animals as a waste
- Produced during decomposition of vegetation
- Atmospheric gas exchange
- Forest fires
- Nitrogen fixation

Anthropogenic

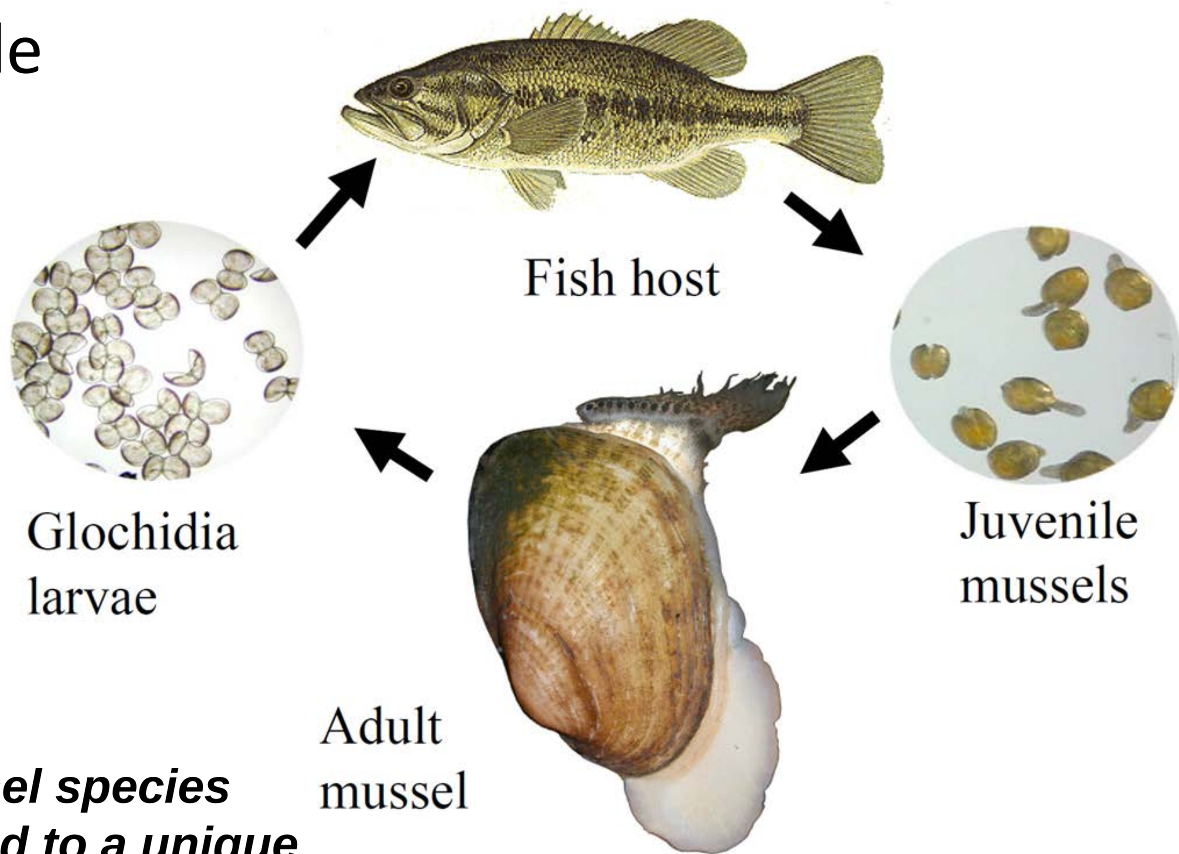
- Industrial uses
  - Metal treating
  - Alkali production
  - Pulp and paper
  - Food and beverage
- Commercial fertilizers
- Wastewater treatment plant effluent
- Atmospheric gas exchange

Ammonia Toxicity

- Direct toxic effects on aquatic life
  - Other forms of nitrogen have indirect effects on aquatic life
- Ammonia toxicity leads to lower reproduction and growth in sensitive organisms
- Ammonia toxicity is pH and temperature dependent
  - As temperature increases, organisms are more sensitive to ammonia
  - Ammonia toxicity also increases as pH increases

Freshwater Mussels 101

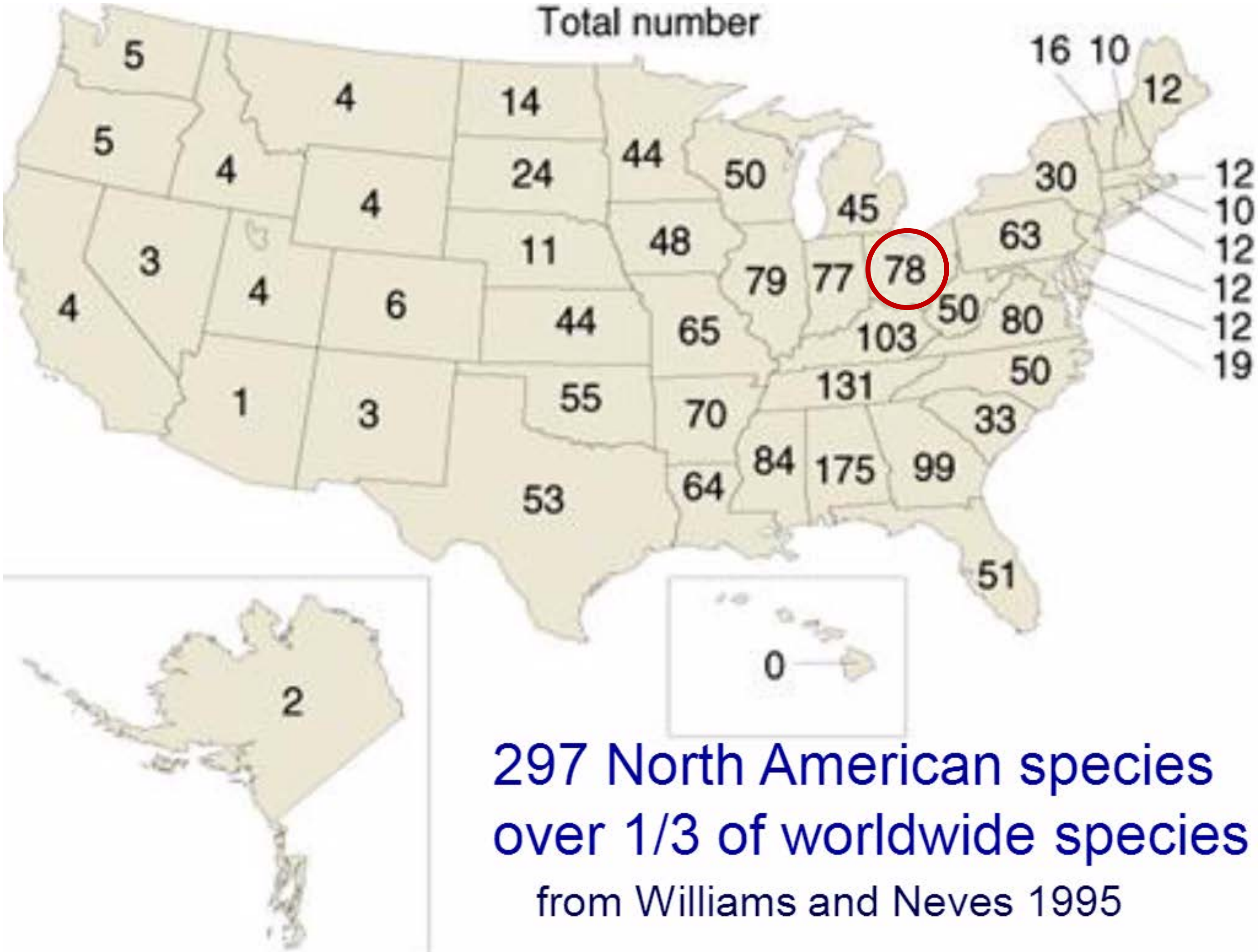
Native mussel
life cycle



Each mussel species has adapted to a unique fish host!

http://water.epa.gov/scitech/swguidance/standards/criteria/aqlife/ammonia/upload/II-Barnhart.pdf

Mussel Distribution



297 North American species
over 1/3 of worldwide species

from Williams and Neves 1995

The Mussel Problem

- Loss of habitat/mussel beds
- Reduction in reproduction
- Causes
  - Dams and stream channelization
  - Siltation
  - Invasive species
  - Lack of host species
  - Sensitivity to ammonia, copper, chlorine, zinc

Federal Regulatory Timeline

- 1976 – Original freshwater ammonia criteria
- 1985 – First update to original criteria
  - – 4-day averaging period
  - – Unionized ammonia
- 1999 Significant updates
  - – pH and temperature dependent
  - – 30-day averaging period
  - – Total ammonia nitrogen
- 2004 – Revisions to criteria begin
- 2009 – Revised draft criteria
- 2013 – Final draft ammonia criteria

Debate over the numbers…

1999 Update CCC Magnitude			2009 Draft Update CCC Magnitude			2013 Final CCC Magnitude	
Species	**pH 8.0, T=25°C (mg TAN/L)**	**pH 7.0, T=20°C (mg TAN/L)**	**Species**	**pH 8.0, T=25°C (mg TAN/L)**	**pH 7.0, T=20°C (mg TAN/L)**	**Species**	**pH 7.0, T=20°C (mg TAN/L)**
Fathead minnow, *Pimephales promelas*	3.09	7.503	Long fingernailclam, *Musculium transversum*	<2.260	7.552	Long fingernailclam, *Musculium transversum*	7.547
Lepomis sp. (Centrarchidae), includes: Bluegill sunfish, *L. macrochirus*, and Green sunfish, *L. cyanellus*	2.85	6.92	*Lepomis* sp. (Centrarchidae), includes: Bluegill sunfish, *L. macrochirus*, and Green sunfish, *L. cyanellus*	2.852	6.924	*Lepomis* sp. (Centrarchidae), includes: Bluegill sunfish, *L. macrochirus*, and Green sunfish, *L. cyanellus*	6.92
Long fingernailclam, *Musculium transversum*	<2.26	7.547	Rainbow mussel, *Villosa iris*	<0.9805	3.286	Rainbow mussel, *Villosa iris*	3.501
Amphipod, *Hyalella azteca*	<1.45	4.865	*Lampsilis* sp. (Unionidae), includes: Wavy-rayed lamp mussel, *L. fasciola* and Fatmucket, *L. siliquoidea*	<0.3443	1.154	*Lampsilis* sp. (Unionidae), includes: Wavy-rayed lamp mussel, *L. fasciola* and Fatmucket, *L. siliquoidea*	2.216
CCC	1.2	**4.5**	**CCC**	0.26	**0.91**	**CCC**	**1.9**

Increasing Scientific Knowledge

- 2003 – toxicity data indicate larval and juvenile freshwater mussels are more sensitive to ammonia
- 2005 – protocol for testing larval and juvenile freshwater mussels was approved
- 2011 – studies demonstrated that certain snails are also sensitive to ammonia
- 2013 – ammonia criteria includes freshwater snail and mussel data
- Still…
  - Concerns about laboratory studies versus reality
  - Need for more holistic approaches to restoring reproducing mussels beds

2013 Final Ammonia Aquatic Life Criteria

- One set of freshwater criteria
- Developed to protect the aquatic community including sensitive mussel species
  - Site-specific recalculations are available when mussels are determined to be absent, when appropriate
- Removed invasive species from the dataset
- Updated literature review for toxicity data
- Renormalized data to pH 7 and 20°C

2013 Federal Aquatic Life Criteria

- Acute = 17 mg N/L at pH 7 and 20°C
  - Duration = 1 hour average
  - Frequency = not to be exceeded more than once in 3 years
- Chronic = 1.9 mg N/L at pH 7 and 20°C
  - Duration = 30-day average
  - Frequency = not be exceeded more than once in 3 years
  - Not to exceed the criterion continuous concentration (CCC) as a 4-day average within 30-days, more than once in 3-years

1999 versus 2013

Acute

Ohio = 13

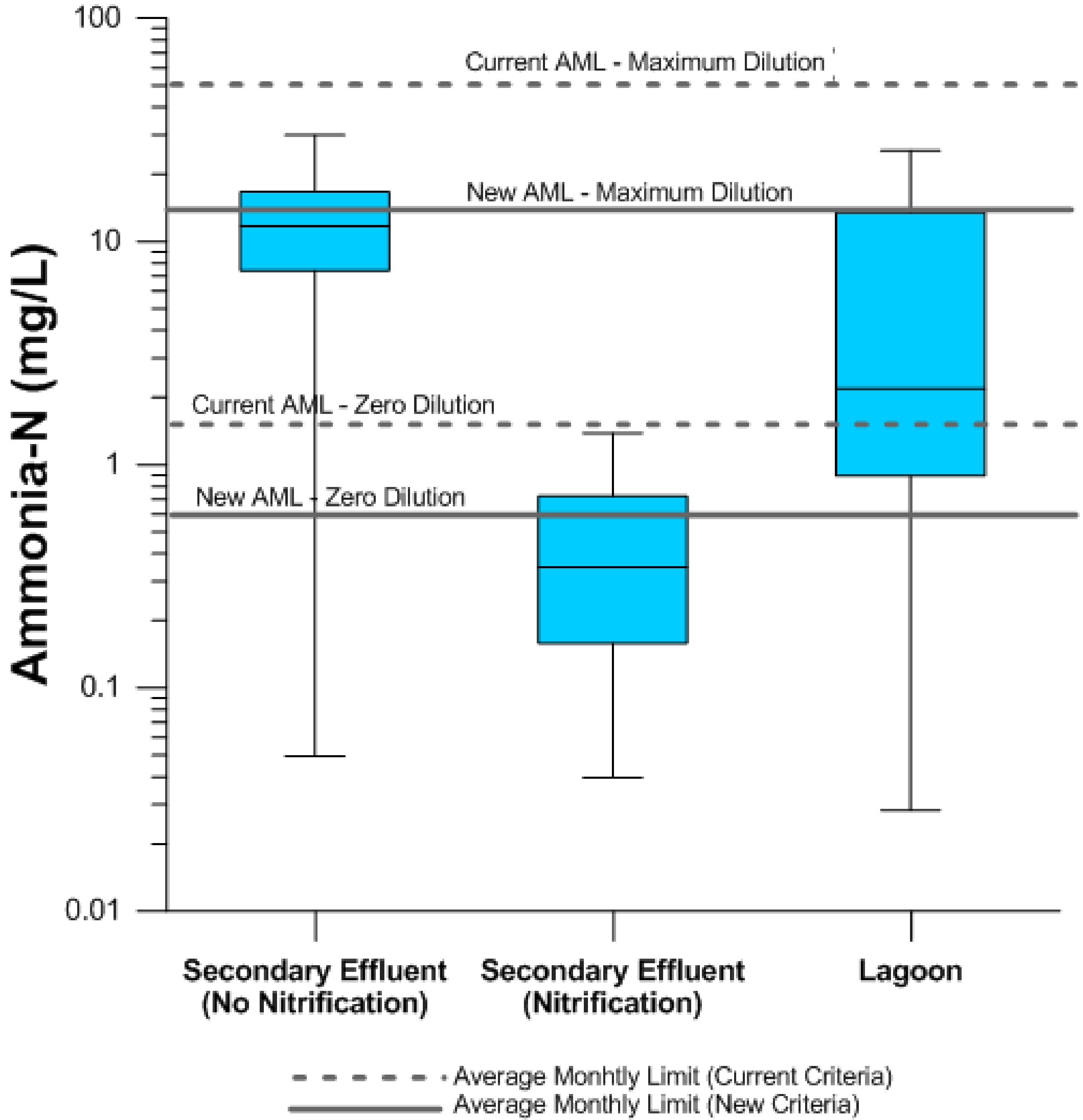
24 → 17

Chronic

Ohio = 5.9W / 2.2 S

4.5 → 1.9

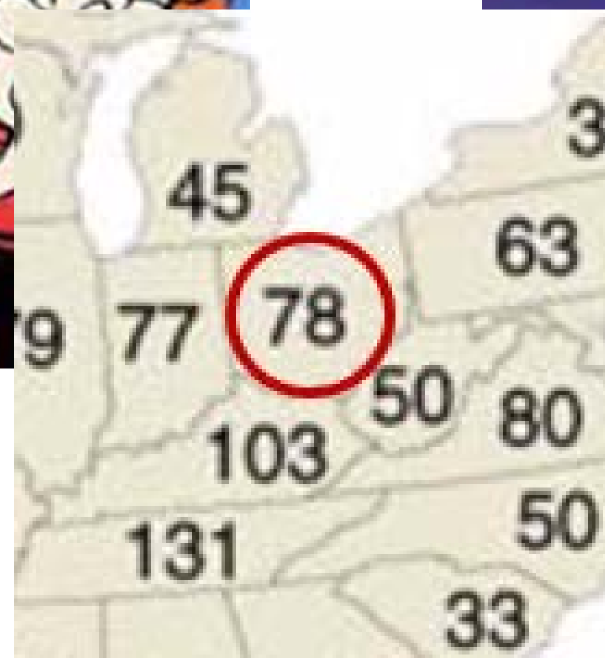
Impact on Effluent Levels?

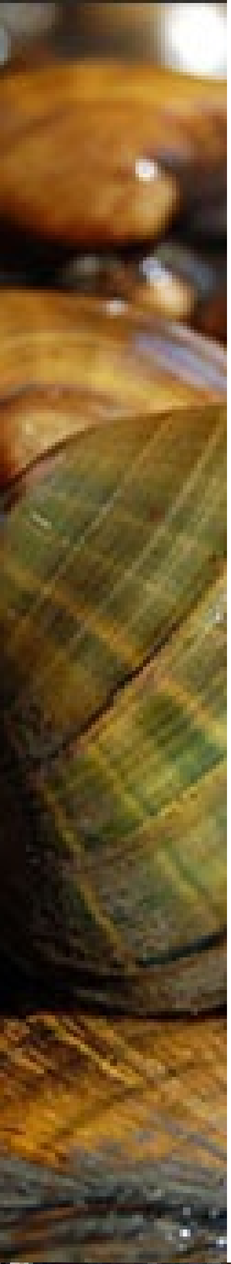


Effluent Challenges

- Competing priorities
- Even well-designed and well operated WWTPs plants will occasionally exceed criteria
  - Need new permitting approaches
- Biological nutrient removal (BNR) is one of the most cost-effective technologies to remove nitrogen and phosphorus
  - But not to achieve very low levels of ammonia
- Spending money to remove ammonia may not restore mussel beds
  - Need site-specific restoration strategies beyond traditional Clean Water Act compliance

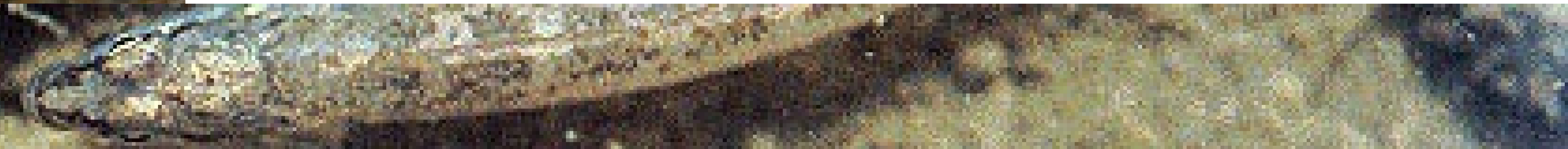
REGULATORY FLEXIBILITIES





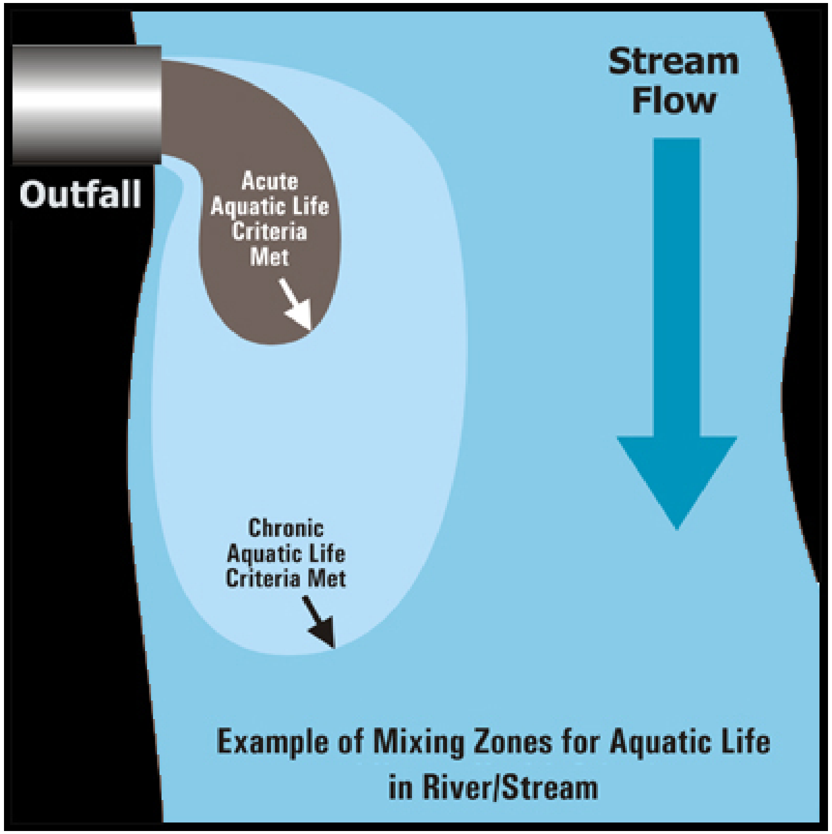
REGULATORY FLEXIBILITIES

- Resident Species Recalculation
- Variances
- Revisions to Designated Uses
- Compliance Schedules
- Stochastic Forecasting of pH and Temperature
- Mixing Zones
- Integrated Planning



Mixing Zones

- Estimate initial dilution in receiving waters
- Flow of river or stream, or a portion thereof
- Allowed to mix with effluent before water quality criteria must be met
- Criteria met at edge of mixing zone

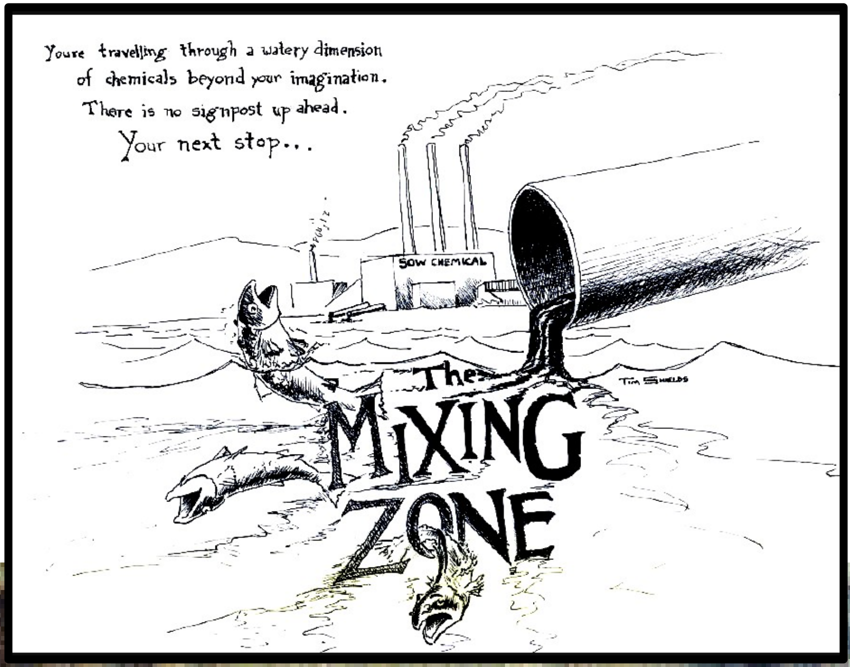


Mixing Zones

EPA's Water Quality Standards Handbook

"A mixing zone is a **limited area or volume** of water where **initial dilution** of a discharge takes place and where **certain numeric water quality criteria may be exceeded**."

- ✓ Small portion of waterbody
- ✓ Protects uses of the waterbody
- ✓ Re-evaluated with NPDES permit renewals
- ~~Not for bio-accumulative chemicals~~
- ~~Not a license to pollute~~



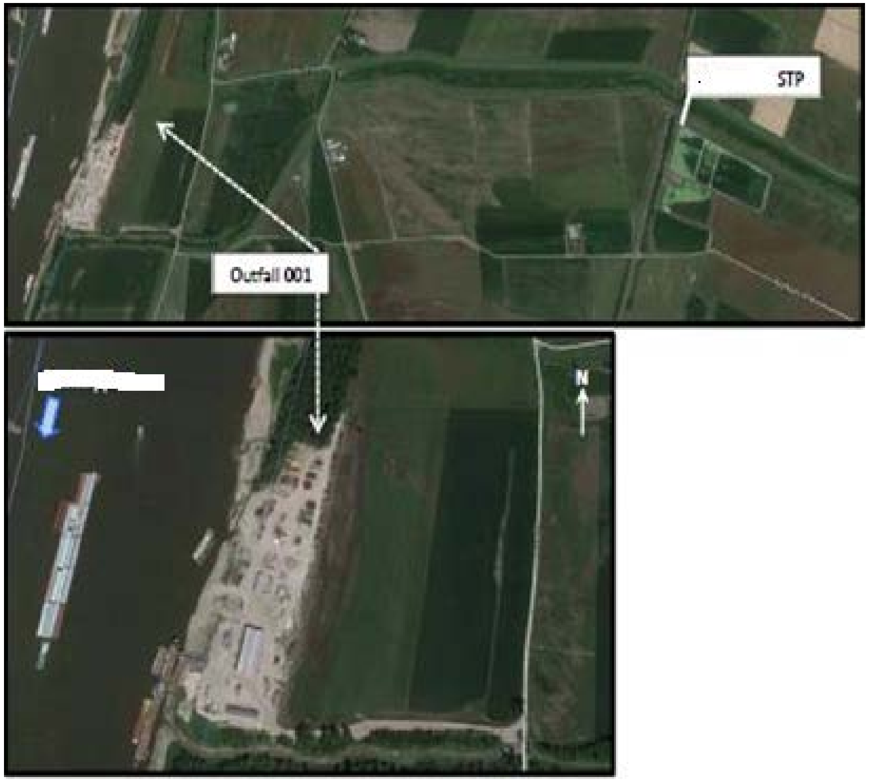
earthisland.org/csaw/MZ_files_web_docs/CSAW_MZ_Manual.pdf

Typical Mixing Zone Models

- Visual Plumes
  - Limited application to “shallow water” conditions with no local recirculation
- Cornell Mixing Zone Expert System (CORMIX)
  - Mix of theory and best professional judgement
  - Most widely used for mixing zone analysis
- Computation Fluid Dynamics
  - More complex, typically more accurate
  - Addresses non-standard discharges
  - Accommodates geographic features (wind dams, sharp bends in river)

Example Mixing Zone Study

- The city operates a WWTP discharging to a large river
- 3-cell aerated lagoon system
- Design flow of 1.5 MGD
- IEPA requested mixing zone modeling as part of permit renewal process



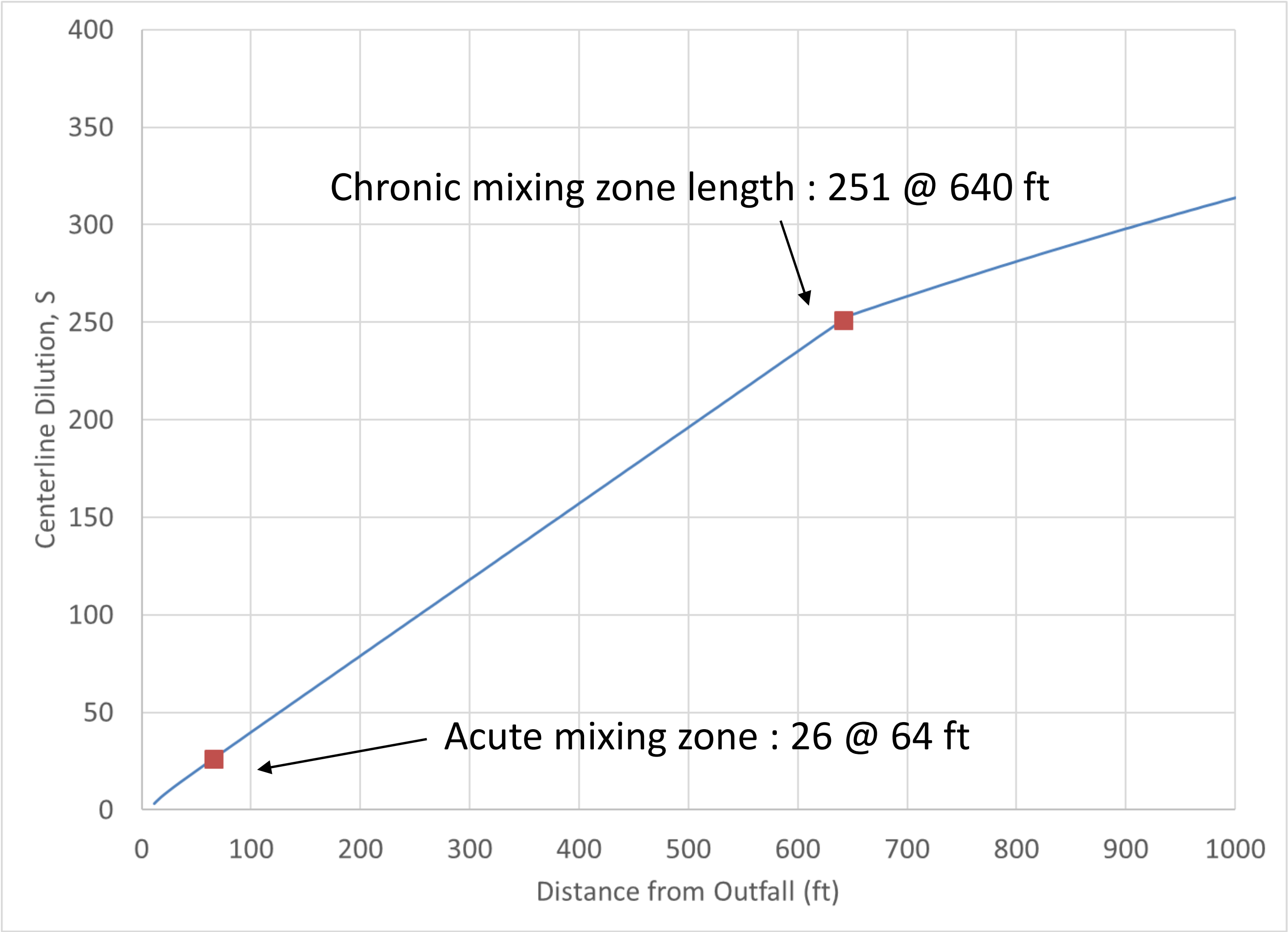
Modeling Approach

- CORMIX model developed to simulate mixing
- Assess whether discharge has reasonable potential to exceed ammonia criteria
- Available discharge and receiving water used to parameterize the CORMIX model
- Worst case effluent concentration - 25 mg/L (based on effluent monitoring data)

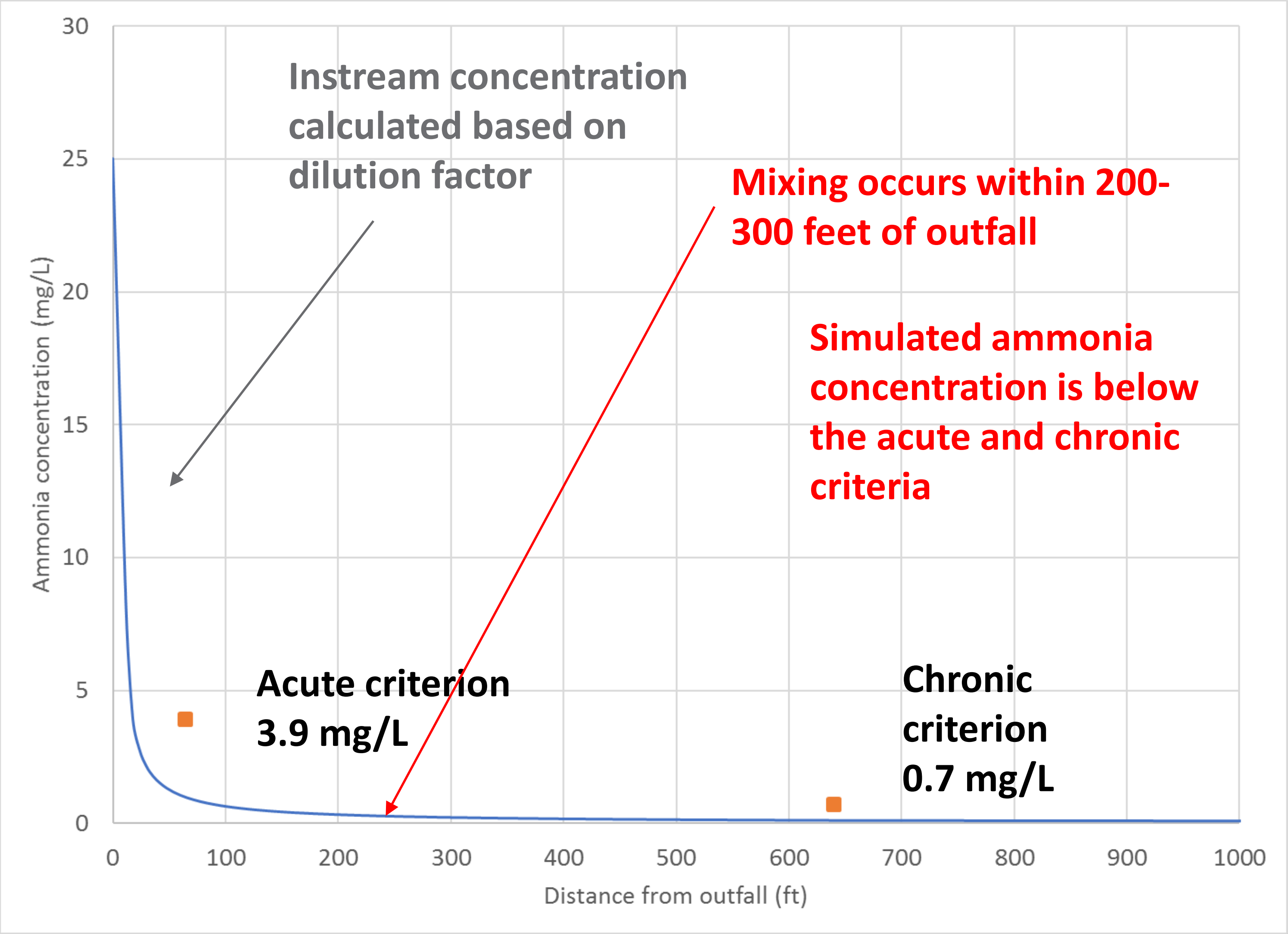
Criteria and Mixing Zones

- Ammonia criteria calculated based on historical 75th percentile pH and temperature
  - Acute criterion – 3.9 mg/L (summer)
  - Chronic criterion – 0.7 mg/L (summer)
- Chronic mixing zone length assumed to be distance at which simulated plume started interacting with river bottom
- Acute mixing zone length – 10% of chronic mixing zone length (USEPA Technical Support Document for Toxics Control – 1991)

Model Results – Dilution Factors

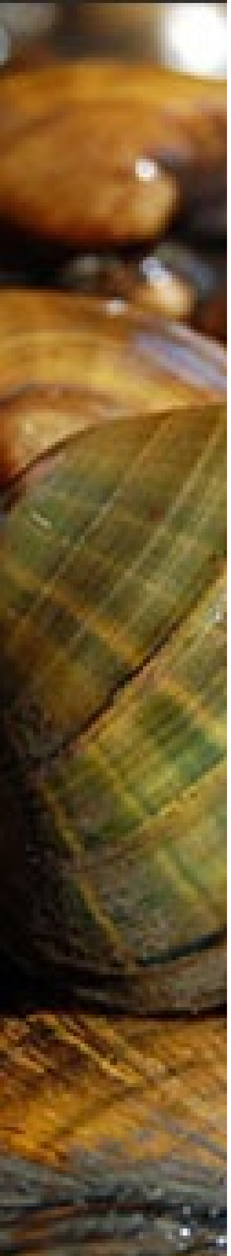


Model Results - Concentrations



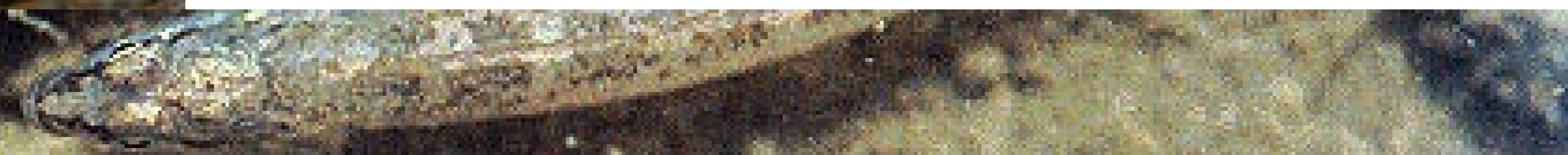
Findings and Future Implications

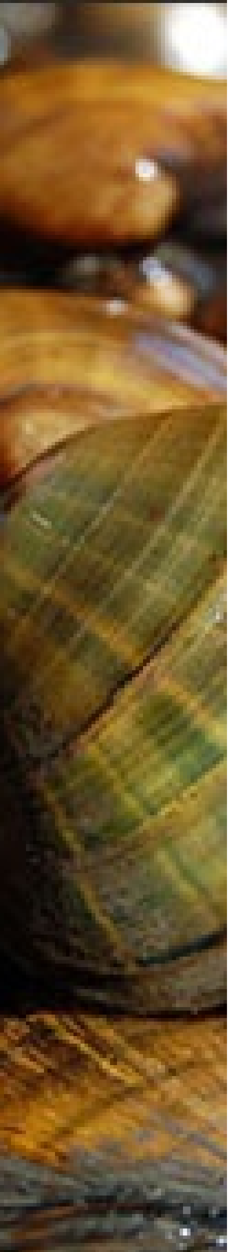
- Mixing zone modeling demonstrated
  - Rapid and complete mixing of effluent discharge downstream
  - Discharge does not have reasonable potential to exceed water quality criteria for ammonia
  - Effluent permit limit for ammonia not required
- If criteria are revised, model can be used to evaluate alternative options for compliance
  - Different assumptions about upstream and effluent concentrations
  - Diffusers
  - Plant operational changes



Integrated Planning

- New policy in 2012
- Response to cities’ concerns about CWA compliance
  - – Costs exceed localized affordability
  - – No measurable improvements in water quality
- Allows communities to prioritize CWA projects
  - – Possible incorporation of watershed projects that provide higher value for aquatic life
- Strengthens ability to make case on high cost – low benefit projects that should be delayed





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