NC Nutrient Criteria Development Plan – Scientific Advisory Council (meeting #6)
12/9/2015

Attendees

SAC members in attendance:

Marcelo Ardon
Bill Hall
Annie Godfrey (for Lauren Petter)
David Kimmel
Martin Lebo
Linda Ehrlich
Clifton Bell
Deanna Osmond
Michael O'Driscoll
Hans Pearl (and alternate Nathan Hall)
James Bowen
Astrid Schnetzer

SAC members online:

Lauren Petter

SAC meeting facilitator:

Andy Sachs

NCDEQ NCDP Team members in attendance:

Steve Kroeger
Carrie Ruhlman
Tammy Hill
Mike Templeton
Connie Brower
Pam Behm
Jing Lin
Christopher Ventaloro
Jeff Manning
Jucilene Hoffman
Jim Hawhee
Cyndi Karoly
Jennifer Schmitz
Nora Deamer

Guest presenter:

Rebecca Sadosky – DWR

CIC members in attendance:

In person:

Andy McDaniel
Anne Coan

Call-in: Keith Larick
Tiffany Crawford
Alix Matos
2 call-ins that could not be unidentifie

Meeting notes

All questions, comments and answers are paraphrased

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1. **Convene** (Andy Sachs)
   a. SAC members, DWR staff and audience attendees provide names and affiliations.
   b. Facilitator asks for approval on meeting notes from 5th SAC meeting (November conference call).
      i. Comments on previous SAC meeting notes:
         1. October (SAC #4) notes:
            - Page 6, Part ii (Algal Assemblages), item 2 (Food Web Value), bullet 3: Question as to what the following statement may mean: "Biovolume is a good predictor of predation".
              i. DWR staff will amend the notes to read "Biovolume is a good indicator of primary production."
            - Page 6, item iii (pH), item 1:
              i. Comment → Not sure if "Is directly affected by the concentration of chlorophyll-a" is a good statement.
                 1. DWR staff will amend the notes to read "…[pH] is affected by the concentration of chlorophyll-a in the middle to lower part of the lake."
            - Page 6, part iv (Dissolved Oxygen), item 1, bullet 2:
              i. Comment → Lake Eerie is not a good Model for HRL.

1. DWR staff will amend the notes to clarify that Lake Eerie is not being recommended as a model for HRL.

- Page 7, part vi (Aesthetics), bullet 2:
  - i. Comment → "taste and odor must be accounted for." This is more a potable water issue at the point of intake.

2. November (SAC #5) notes:
   - Page 6, part B, bullet 2:
     - i. Comment → "DWR cannot **reveal** nutrient and chlorophyll-a concentrations when photosynthesis is not occurring"…Reveal is a poor choice of words.
   - Page 6, part B, bullet 5:
     - i. Comment → mg/L should be ug/L.
       1. DWR staff will amend notes to change mg/L to ug/L.

2. **Nutrient Over-Enrichment & Drinking Water** (Rebecca Sadosky)
   a. Topics:
      i. Algae
         1. N & P limiting factors to growth
         2. Proliferate quickly
         3. Primarily occur in spring/summer, but can appear anytime.
         4. Various concerns including potential for toxicity, filter clogging, taste and odor issues.
      ii. Indicators of nutrient over-enrichment
         1. Diurnal pH swings (increase with presence of algae)
         2. Drop in DO
         3. Taste & odor
      iii. Treatment challenges
         1. Settleability – requires use of chemicals or activated carbon.
         2. Filter clogging – increases backwash frequency.
         3. Disinfection byproducts
         4. Possible release of cyanotoxins due to disruption of algal cells.
      iv. Reservoir management
         1. Multiple methods used, including algaecides, potassium permanganate, aerators, alternative water sources, ultrasonic treatment, and surface skimming.
      v. Cost
         1. Additional costs -- impacts to treatment facilities due to such things as extra backwashing, chemical purchase, and basin cleaning.
      vi. EPA recommendations

1. Guidelines from EPA involve evaluating surface water sources, preparation & observation of the water source, monitoring for cyantoxins, and communicating with the public when cyanotoxins are detected.

vii. Examples
1. Almost all systems in Winston-Salem region have issues with algae.
   - DWR staff comment (made at the end of the meeting): For example, Denton is a nutrient-impacted water supply system situated directly below the HRL dam. We can try to get more information on the specifics.
2. Mooresville Regional Office has 2-8 occurrences per year most commonly after dry spring season.
3. Wilmington Regional Office has had algal issues occur at Cape Fear Public Utility Authority (CFPUA).

b. Questions/comments:

i. Linda E. asks: Are there any facilities that are using ultrasonic disinfections techniques?
1. Rebecca responds: Not aware of any facilities doing this at this time.
2. Linda comments: This is interesting because ultrasonic disruption is a standard method for releasing toxins from cells.

ii. Bill H. asks: Are the costs associated with disinfection additional costs for the facility or are they already accounted for in facility design?
1. Rebecca responds: Facilities may need to employ additional materials (chemicals, carbon) that they wouldn't normally use so there is potential for additional costs.
2. Bill H. follows up with: At what stage is activated carbon used?
3. Rebecca responds: It's usually used in the settling basins prior to filtration to help remove organic matter.

iii. Deanna O. asks: Have there been cost-benefit analyses completed with regard to treating cyanotoxins during the drinking water process vs. treating the source water to reduce nutrient load?
1. Rebecca responds: Not aware of any.

iv. Hans P. comments: Any treatments that disrupt cell structure may release toxins. Settling is a good way to go. Activated carbon is good at removing toxins. Rapid analysis kits could save money by ruling out presence of toxins.
1. Rebecca responds: Agree. However, facilities are not required to monitor for toxins. Some do, many don't.
2. Bill H. adds: Systems are not monitoring yet. EPA is looking to add requirements for this.
3. Rebecca responds: This will most likely happen in the future.

v. Astrid S. asks: What are the EPA Drinking Water Health Advisories for cyanotoxins based on?

1. Rebecca responds: A number of factors including amount of water consumed, frequency of consumption, etc…
2. Review of Health Advisories
    - See the EPA 2015 Drinking Water Health Advisories for Two Cyanobacterial Toxins Fact sheet here.
    - Also, see http://www.epa.gov/nutrient-policy-data/guidelines-and-recommendations for further information.

3. **Candidate Indicator Range Discussion** (SAC members)
    a. **Aesthetics** (Jim Bowen & Bill Hall)
        i. Typically a concern for recreational use.
        ii. Criteria development:
            1. References for aesthetic criteria in lakes back to 1980's.
            2. Little variation in approach taken by various states.
                - Based on user/observer surveys of physical condition and suitability for recreation & aesthetic enjoyment.
                    i. Limitations of this approach:
                        1. Requires a user survey be conducted.
                        2. Difficult to implement in systems with highly variable TSS concentrations.
                        3. Limited system sensitivity with regard to transparency as nutrient loading is reduced.
                        4. Criteria should not be derived by popular opinion.
                        5. Conditions during actual use vs. conditions that prohibit use.
                        6. How to establish exceedance frequency?
            3. Examples of nutrient criteria for aesthetics:
                - Lake Pepin, MN Site-specific criteria (Wasely & Heiskary,)
                    i. Lake shares some characteristics with HRL including shallow depth, low residence time, and low transparency.
                    ii. TP criteria developed using recreation surveys and:
                        1. Sediment sampling of diatoms to reconstruct historical TP record.
                        2. Model prediction of chlorophyll-a and secchi depth assuming TP limit.
                        3. Model prediction of bloom frequency and cyanobacteria fraction of biomass.
                - Survey of stream desirability for recreation, Montana
                    i. Used on-river & by-mail surveys
                    ii. Respondents rated pictures of streams for recreational desirability.

iii. Desirability percentage correlated with chlorophyll-a concentration at site.
iv. Candidate criteria value developed based on the chlorophyll-a concentration corresponding to undesirable rating by the majority of respondents.

iii. Questions/comments:
1. Andy S. asks: Do you have a recommendation for a range?
    - Bill and Jim answer: It is important for recreational use, but is probably not an indicator in itself. Would probably base it on water clarity.
2. David K. comments: Aesthetics is a semi-quantifiable indicator. How do you put a value on something that we can't quantify?
3. Astrid S. comments: A yes/no approach might be better. Is there scum? Does it smell?
4. Bill H. comments: MT set a light penetration standard for swimming based on being able to see down to some extent.
5. Nathan H. comments: Aesthetics has been shown to have some connection to downstream property values.

b. **Algal Assemblages** (Linda Ehrlich & David Kimmel)

i. HRL algal assemblage data review
1. Data from previous SAC meetings (2015) as presented by Jing Lin and Mark Vander Borgh
    - Data from 2008-2010
    - Blooms showed an algal density increase from ~1,000 units/mL to >80,000 units/mL and were positively correlated with chlorophyll-a
    - Consistent blooms of >45,000 units/mL occurred in July and August during this time period
    - Algal community structure:
        i. 140 taxa observed
        ii. Most common were: cryptomonads, diatoms, and cyanobacteria
        iii. Cyanobacteria were clearly dominant (comprised 61.5% of algal density when chlorophyll-a was measured at >40 ug/L)
    - Cyanobacteria & Pseudanabaena were most influential (83% frequency, >60% total density, responsible for many DO, pH chl-a violations)

ii. Effects of Cyanobacteria dominated assemblage on food web

1. Some studies indicate poor food value (low fatty acid content) of Cyanobacteria, show reduced survival and fecundity in daphnids, and show a preference in shrimp for consuming species other than cyanobacteria
2. Some studies and observations suggest Cyanobacteria may support healthy grazers with *Spirulina* consumption increasing survival, growth, and pigment production in species of shrimp and synthesis of essential fatty acids in *Tilapia*

iii. Fishery Health in HRL
1. Based on information provided by Lawrence Dorsey (NC WRC) during presentation to SAC members on November 18, 2015
2. Fishery is considered to be healthy with high catch rates, large biomass, and good health of game species
3. Suggested that the high nutrient levels in HRL are supporting forage species

iv. Conclusion
1. Effect of Cyanobacteria-dominant algal assemblage on fishery health is uncertain.

v. Questions/comments:
1. Bill H. asks: Although we can't draw conclusions based on striped bass health, due to their being stocked, other species in the lake are doing well and do not seem to be negatively impacted by the algal assemblage in HRL.
2. Clifton asks: Is there any indication in the references you reviewed that suggests that we can make a more quantitative statement concerning what biovolume of a cyanobacteria-heavy algal assemblage would be detrimental to aquatic life?
    - Linda answers: I did see a statement in a reference about a certain level of biovolume being detrimental, but will have to follow up on that.
3. Martin L. comments: Are there any top-down factors influencing algal assemblages?
    - Linda answers: There probably is, but we probably don't have enough data right now. Not sure that the top-down effect is any more important than seasonal variation that HRL experiences.
    - Comment: It's not necessarily true that this is pelagic system. When the fish are juveniles they will rely on phytoplankton as food to some extent, but as they get older they will eat a wide variety of foods.
4. Nathan: What percent of the phytoplankton were blue-greens?
    - Linda answers: It was about 82% (?).

- Nathan comments: So there was still a good amount of the good phytoplankton by volume in those samples.

5. Some further discussion of biovolume.
6. Andy asks: Do we have any consensus on ranges for algal assemblages?
   - A lot of this will come back to toxins and whether they are present.

c. **Chlorophyll-a** (Bill Hall, Nathan Hall & Hans Pearl)

i. Conceptual model for chlorophyll-a indicator.
   1. There are a number of primarily abiotic factors that influence the amount of primary productivity that go on.
      - Phosphorus, nitrogen, light, alkalinity, temperature, and residence time.
   2. Primary productivity in lakes is primarily algal growth. Periphyton & macrophyte assemblages not significant in HRL.
   3. Direct effects of indicator:
      - Primary productivity does not have a direct effect on the potential use impairments in HRL, but it has an indirect effect on the indicators we are looking at to determine if the uses are being met:
        i. DO (diurnal variation, low DO)
        ii. Hypolimnion (DO depression)
        iii. pH (diurnal variation, high/low pH)
        iv. Transparency (algal turbidity, color)
        v. Algal toxins
        vi. Taste & odor (algal assembly)
        vii. Organic carbon
   4. Potential use impacts
      - Aquatic life (zooplankton (biomass, assemblage)
      - Macroinvertebrates (biomass, assemblage)
      - Fish (biomass, assemblage)
      - Recreation (primary, secondary)
      - Water supply (drinking water, agriculture)
      - Human health (taste & odor, algal toxins)

ii. Conceptual model for indicator direct effects.
   1. Chlorophyll-a probably also an indicator for amount of biomass and also the algal assemblage.
   2. Chlorophyll-a more related to DO, pH, and transparency.
   3. Biomass related to DO, pH, transparency, toxins, taste/odor, and organic carbon.
   4. Algal assemblages related to toxins and taste/odor.

iii. Conceptual model for direct effects and potential use impairment.
   1. Aquatic life impacted by DO, pH, and toxins.

- Condition of the fishery in HRL implies that these factors are not currently negatively impacting aquatic life.

2. Recreation impacted by transparency.
3. Water supply impacted by toxins taste/odor, and organic carbon.
4. Human health impacted by toxins. This may already be accounted for by the aquatic life or recreation uses.

iv. Discussion of data availability, impairments, and setting a chlorophyll-a criteria.

1. Nathan H. comments on the last slide which investigates which uses might actually be impaired in HRL based on current data.
    - See slide #5 for details.

v. Questions/comments:

1. Martin L. asks: Where does the fishery fit in?
    - Bill answers: Aquatic life for fishery health, secondary recreation for fishing, maybe? There are also competing uses. Studies show that if you decrease phosphorous for recreation purposes there may be a negative effect on the fishery.
2. Hans P. comments: Analysis of different pigments can now be used to determine algal assemblages
    - Bill adds: A lot of the time we look at chlorophyll-a, but the real questions is what is really causing the effect that is being seen? Is it the algal assemblage, the biomass, etc…?
    - Question: Can diagnostics to determine algal assemblages by pigments be done by the state lab? Is it prohibitively expensive?
        i. Hans answers: It is not prohibitively expensive. There are other labs in the state that could do it.
3. Andy S. asks: Is there a suggestion for a range for chlorophyll-a?
    - Bill answers: The issue we are concerning with are protecting the uses. Any range should be decided on based on protecting the uses. Here we try to relate them to chlorophyll-a. The fishery is looking good. We have not heard any problems from the water supply side. It will probably come down to the recreation uses which would most likely be related to transparency. Transparency will likely be the driver rather than aquatic life or water supply.
4. Marcelo A. asks: Why are nutrients not in all of the conceptual models presented?
    - Bill answers: Nutrients do not cause loss of uses by themselves, the loss of the use is mediated through a variety of steps. First we need to understand the impact and then we can work back to identify the relationship with the nutrients.

5. Martin L. comments: There is probably a connection? Or tension? between the aquatic life and recreation uses that needs to be identified and maintained. There needs to be a certain degree of nutrient availability to support the fishery, but not so much that transparency is overwhelmingly impacted causing a reduction in recreational use.
    - Bill responds: All uses need to be protected, but do we favor one use over another?
    - Martin L. comments: I wouldn't put fishery under aquatic life. Aquatic life covers a broad number of species while fishery production is a different thing.
        i. Bill responds: So you think fishery would go under recreation?
            1. General discussion among SAC members:
                a. Fishery should go under both aquatic life and recreation.

d. **Dissolved Oxygen** (Dave Kimmel & Marcelo Ardon)
    i. Factors that directly influence DO in HRL:
        1. Primary productivity
        2. Respirations
        3. Temperature
        4. Depth
    ii. Fish tolerance to DO
        1. Striped bass recommended lower limit of 5mg/L for all life stages.
        2. Lower tolerance for most other fish 2-3 mg/L.
        3. References indicate lethality for most species occurs at < 2 mg/L DO.
    iii. Candidate criteria
        1. Recommend a floor of 2 mg/L and a possible range of 2-5 mg/L DO.
        2. May also consider % saturation.
        3. May also want to consider incorporating hypoxic volume:
            - Frequency is already known (summer)
            - Would need to define magnitude and duration

References

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iv. Questions/comments:
   1. Deanna O. asks: Referring to the Chesapeake Bay, were the DO values data driven or model driven?
      - Marcelo answers: Both
   2. Question: How would you relate HRL to the Chesapeake?
      - Marcelo answers: I wouldn't. Fish tolerance drives the established DO ranges so it would be different based on species present.
   3. James B. asks: Is there an upper limit in hypoxic volume where you would start see an effect on fish populations?
      - Dave answers: The literature suggests that it would be very difficult to get to that value unless the system goes completely hypoxic. There is usually an upper oxygenated surface layer.
   4. Clifton B. comments: Hypoxic volume vs. fishery, look at the interplay between % saturation and temperature. Habitat squeeze for striped bass.
   5. Martin L. asks: In the data review for DO can you tell the current saturation state?
      - Marcelo answers: There will always be an aerated volume above the hypoxic zone. Also, due to sedimentation, HRL may experience a certain degree of hypoxia naturally.

e. **Fishery & Benthos** (Clifton Bell)
   i. Much of this is derived from a personal communication with Lawrence Dorsey of the NC Wildlife Resource Commission (WRC).
   ii. Fishery metrics
      1. See Table 1 – Examples of Fish Metrics Utilized by WRC in the presentation notes.

- No single metric is sufficient to describe the sport fishery.
- WRC attempts to manage HRL to attain a catch rate and size distribution desired by anglers.
- WRC does not track fish anomalies such as lesions, tumors, or deformities.
- There is no data for benthic organisms in reservoirs.

2. Potential targets:
   - Compare HRL fishery metrics to an average of metrics from other piedmont reservoirs using catch rate and length distribution data from annual surveys conducted by WRC.
   - Establish a management goal for HRL based on maintaining the quality of the existing fishery.
   - Sport fisheries may thrive in eutrophic conditions, but we must balance maintaining the fishery with impacting other uses of HRL.

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Axler R., L. Paulson, P. Vaux, P. Sollberger, D. Baepler. 1988. Fish aid – the Lake Mead fertilization project. Lake and Reservoir Management, 4(2):125-135.

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Ney, J.J. 1996. Oligotrophication and its discontents: effects of reduced nutrient loading on reservoir fisheries. in L.E. Miranda and D.R. Devires editors, Multidimensional Approaches to Reservoir Fisheries Management. American Fisheries Society. Bethesda, MD.

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iii. Questions/comments:

1. Jim H. comments: These metrics are used for the management of fisheries. Caution should be used when applying this data for developing water quality standards.
2. Martin L. comments: Not sure if the fisheries index should be a part of nutrient criteria, but it should be considered as a use.

f. **pH** (Clifton Bell)
   i. Existing pH criteria:
      1. Current EPA criteria and NC standards are similar and can be traced back to the EPA "Red Book" (EPA 440-9-76-023, 1976).
         - EPA criteria = 6.5-9.0
         - NC standard = "shall be normal for the waters in the area, which range between 6.0 and 9.0 except that swamp waters may have a pH as low as 4.3 if it is the result of natural conditions."
      2. Neither EPA nor NC have duration or frequency components. Implemented as not-to-exceed values.
      3. NC uses a 10% rule for assessing impairment of water bodies → More than 10% of data are outside criteria range at 90% confidence level.
   ii. Effects of pH on aquatic life:
      1. Both low and high pH can affect aquatic organisms. See Table 1 – Summary of pH effects on Aquatic life in the presentation notes.
      2. Three general categories of impacts high pH on aquatic life:
         - Increasing toxicity of other substances.
         - Disrupting electrolytic balance and metabolism.
         - Physical damage to tissues.
   iii. Observations in HRL
      1. Two mainstem segments (YAD152C & YAD169B) listed as 303(d) impaired.
         - Surface water pH at these stations commonly exceeds 9.0, but rarely 9.5.
         - Some correlation with chlorophyll-a, though not in summer when pH values are highest.
   iv. Potential pH targets for HRL (see Table 3 –Summary of pH Target Approaches in the presentation notes):
      1. Two approaches
         - Approach #1: Shift upper end of current pH standard range
            i. Increase the upper end of the existing pH standard from 9.0 to 9.5 S.U.
            ii. Based on:
               1. The attainability/practicality of the 9.0 target cannot currently be determined for HRL.
               2. pH values up to 9.5 may be protective based on:

a. The excellent status of the fishery, which experiences surface pH in the 9.0-9.5 S.U. range.
b. The scientific literature, which suggests the 9.0 value was based primarily on salmonids and that most other fish species can accommodate pH up to 10 S.U. for extended periods.

iii. Possible disadvantages of the 9.5 target:
1. The 9.5 target is less conservative.
2. Inconsistency with long-established pH range recommendations.
3. Increasing the target could allow for pH increases relative to HRL current pH tendencies (<9.0, expressed as 90th percentile).

- Approach #2: Establish a target based on anti-degradation
  i. Assuming existing pH conditions do not impair the uses of HRL.
  ii. Recommended range of 9.2-9.4 (long-term 90th percentile) for segments YAD152C & YAD169B.
  iii. Range would be lower in other segments of HRL.
  iv. pH would not be a controlling parameter for nutrient reduction, but might decrease in response to nutrient reductions from other parameters.
  v. Consistent with the narrative portion of the current pH standards which reads pH "shall be normal for the waters in the area."

2. Preliminary recommendation:
   - Take an anti-degradation approach
     i. Relatively simple, does not require explicit modeling.
     ii. Continue monitoring pH response to nutrient reductions associated with other parameters as part of an adaptive nutrient management strategy.
   - Set a pH target for HRL that would not cause impairments to downstream uses, based on the typical 6.0-9.0. This may require further investigation.

- Apply as a long-term percentile target (e.g. 90th percentile), rather than an instantaneous, not-to-exceed value.

3. Other thoughts:
   - Spatial averaging:
     i. May want to consider vertical or horizontal monitoring.
4. Questions/comments:
   - Bill H. comments: Measurements have all been taken during the day. We would expect the pH to be lower at night. It might be better to do a daily average.
     i. Clifton answers: Data is biased high as sampling is taken during the day, at the surface, and during the warmest months. We're looking at the worst case pH. We may not need to go as high 9.5 if we were to go with an integrated approach that was more in line with what the fish need.
   - Hans P. asks: Should pH even be an indicator?
     i. Clifton answers: I don't think there is an impairment, but there should be an upper limit.
   - Bill H. asks: Lake is impaired for pH and chlorophyll-a so we ~~can't not~~ have to do something with pH.
     i. Clifton answers: Might need a site-specific approach.
   - Martin L. comments: There is a data gap. Should do a 24-hour evaluation of pH in lake to obtain a daily average. This would need to be considered for any site-specific criteria.

References

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g. **Toxins** (Linda Ehrlich & Clifton Bell)

i. Known or possible toxin producers in HRL (as per Mark Vander Borgh, 2015):
   1. Mycrocystis – 7% of samples
   2. Aphanizomenon – 17% of samples
   3. Anabaena – 22% of samples
   4. Pseudanabaena – 83% of samples

ii. EPA has released Cyanotoxin Health Advisory Guidelines for drinking water in 2015
   1. Microcystins (0.3 ug/L children under 6 yrs, 1.6 ug/L above 6 yrs).
   2. Cylindrospermopsin (0.7 ug/L children under 6 yrs, 3.0 ug/L above 6 yrs).

iii. Other cyanotoxins of concern:
   1. Anatoxin-a (EPA determined data inadequate to develop guideline).
   2. Saxatoxin (mostly associated with marine waters, but has been seen in freshwater).

iv. There are no data for cyanotoxin in HRL.

v. Questions/comments
   1. Nathan H. comments: There are 3 or 4 data points for cyanotoxins in HRL from 2007. These were all <1 ug/L for total microcystin.
   2. Question (?): Is there a conceptual model for toxin production?
      - Linda E. answers: This would be challenging to establish as blooms that are capable of producing toxins won't always produce them.
   3. Astrid S. asks: Are the analytical measurements done as dissolved toxin?
      - Linda E. answers: Yes, analytical methods do total dissolved toxins.
   4. Clifton B. comments: Some states have taken the World Health Organization guidelines and have modified them for recreational use.
   5. Hans P. comments: You can estimate toxicity is some cases, but it will be difficult to do this for blooms in HRL.
   6. Bill H. comments: There are other factors that may influence toxin production. Some studies have shown:

            - An association between TN and microcystin production in Lake Eerie.
            - N & P increasing toxicity.
            - The age of a bloom may affect toxicity with decreasing toxicity as bloom ages.
        7. Astrid S. asks: Are there appropriate indicator organisms available in HRL. For example, mussels are often used for marine waters?
            - Some discussion among group, but no answer.
        8. Hans P. comments: It would be worthwhile to do a seasonal study of HRL using toxin test kits.
        9. Jing asks: Do these toxins persist in the water column?
            - Linda E. answers: They tend to break down quickly in natural water bodies, but they can persist for days to weeks. In the lab they may last years.

h. **Water Clarity** (Mike O'Driscoll)
    i. Water clarity issues:
        1. Can be reduced by mineral sediment, dissolved organic matter, plankton, and chlorophyll.
        2. Issues pertaining to poor clarity include: benthic smothering, irritation of fish gills, transport of sorbed contaminants, reduced visual range for feeding fish, reducing light availability, increasing water treatment costs, and impacts on aesthetics/recreation value.
        3. Water clarity indicators include turbidity (inversely related to water clarity), Secchi depth (directly related), and total suspended sediments.
    ii. Water clarity in lakes & reservoirs:
        1. EPA Ambient Water Quality Criteria Recommendations for Lakes and Reservoirs in Nutrient Ecoregion IX (2000).
            - Reference Conditions for Piedmont Lakes & Reservoirs (Table 3f):
                i. Secchi depth = 1.66 meters
                ii. Comparable to the aggregate ecoregion IX secchi depth of 1.53 meters.
                iii. Provides a starting point.
        2. High Rock lake data (2008-2010):
            - There is a 1-meter discrepancy between EPA's Piedmont Lake/Reservoir Secchi depth reference condition of 1.66 m and North Carolina's existing turbidity standard of 25 NTU which is equal to ~0.5 meters Secchi depth. (a higher Secchi depth indicates increased clarity).

- Based on HRL turbidity data (2008-2010), water clarity was below the 1.66 meter Secchi depth reference condition. Max Secchi depth recorded was 1.4 m @ YAD 169F on 6/4/2008.
- May need to develop more localized reference condition for NC Piedmont Lakes.

3. Data gaps?
    - Lack historical analysis of turbidity and Secchi depth for HRL.
    - Lack present-day reference conditions for similar Piedmont lakes in and around NC.
    - Lack models of historical and reference condition to understand the importance of mineral vs. organic contributions to turbidity.
4. Remote sensing:
    - Has potential to provide better understanding of turbidity and spatial variability of water clarity.
5. Questions/comments:
    - Bill H. asks: How is clarity linked to use impairments? (Open question to group.)
        i. Comments:
            1. Some studies show that people want what they're used to. What are people used to in this region.
            2. What should be a more natural reference for HRL? Something to work on.
    - Clifton B. comments: Agree that reference lakes should be narrowed down.
    - Hans P. asks: Historically, how much has turbidity changed?
        i. Answer: Haven't had time to look into this, but it would be useful to go back into the data to see how turbidity may have changed over time.

4. **Wrap-up** (Andy Sachs, Steve Kroeger)
    a. Discussion of presentations:
        i. Indicators:
            1. High priority indicators:
                - Algal assemblages.
                - Toxins.
                - Water clarity (optical properties).
                - Indicator that represents productivity.
            2. Low priority indicators (consider dropping?):
                - pH (relationship hard to understand).
        ii. Data gaps?
            1. Toxins (presence, type, frequency, duration).

2. pH (need daily average, depth average).
3. Dissolved oxygen (hypoxic volume vs. fish species, % saturation vs. temperature).
4. Information that DWR can collect that would be helpful?
    - Diurnal sampling for pH and DO, especially during bloom events.
    - Focused sampling in areas of HRL that are experiencing blooms.
    - Use toxin kits to determine how much toxin is being produced in HRL over time.
    - Remote sensing (Mike O. will look into this).

iii. Questions/comments:
- Mike O. asks: What resources would the water quality standards people need from us?
    i. Connie B. answers: We would need help with obtaining references that would support any changes being recommended by the SAC.

b. Meeting schedule for 2016.
    i. Consensus: meet bi-monthly in 2016.
    ii. Meetings in February, April & June.