Preamble: Proposed Stream Nutrient Assessment Procedure

Ohio EPA Nutrients Technical Advisory Group – Assessment Procedure Subgroup

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Background

Ohio EPA has been working for over a decade – collecting and analyzing data – to establish a nutrient reduction strategy[1] for Ohio waterways and corresponding water quality standards to protect aquatic life uses. The data analyses have included extensive work to establish scientifically sound criteria, including evaluating ways to account for confounding factors such as habitat limitations and other stressors that can prevent attainment of aquatic life uses. This work led to development of preliminary concepts and a framework for nutrient water quality standards rules for rivers and streams. In March 2013, the Agency issued an Early Stakeholder Outreach (ESO) public notice of its intent to begin the formal process of rule development to address the adverse impacts of excessive nutrients in Ohio's rivers and streams. As a result of recommendations submitted by commenters to the ESO, the Ohio EPA formed an external Nutrient Technical Advisory Group (TAG) to advise and consult with the Agency in the development of nutrient rules. The TAG consists of twelve members (plus alternates) representing numerous stakeholder groups within the state – including public and private point sources, the agriculture community, environmental groups and associated economic interests.

The anticipated nutrient rules are intended to apply to wadeable rivers and streams, with watershed drainage areas up to 1,000 square miles. Development of the proposed assessment procedure used to determine the condition of a water body relative to nutrient enrichment is based upon extensive monitoring data collected by Ohio EPA from Ohio rivers and streams within this catchment size. This rule will not apply to larger rivers, or lakes, both of which will be addressed by separate rules to be developed subsequently.

TAG Objectives

The TAG members support Ohio EPA's objective to adopt a nutrient water quality standards rule for rivers and streams. The TAG members are providing insight and advice to the Ohio EPA so that the proposed rulemaking is scientifically based, appropriately site specific, and achieves meaningful water quality improvements. A major objective for all stakeholders is development of rules that provide cost-effective and meaningful water quality improvements for water bodies with nutrient enrichment problems and to prevent degradation of waters due to nutrient inputs. The TAG members agree that the rule should include adaptive management,

[1] Ohio EPA, working with other State resource agencies and following the eight point framework for State nutrient strategies issued in guidance from U.S. EPA (2011), developed an Ohio Nutrient Reduction Strategy (2013). Ohio EPA is currently implementing a two year action plan to address significant issues raised in U.S.EPA's review of the 2013 strategy submittal, which include development of appropriate nutrient water quality standards rules.

which is expected to provide cost-effective implementation and avoid the cost of unnecessary or overly stringent controls that provide little or no water quality benefit. Benefits gained from initial and subsequent investments will be monitored and evaluated over time to assess progress.

A key goal of the TAG members' involvement as advisors to Ohio EPA in the rulemaking process is to build consensus for nutrient regulation. It is recognized that nutrient regulation and nutrient control strategies have the potential to become highly contentious. Consensus among stakeholders should help smooth the way for a successful rulemaking in Ohio.

Determination of Nutrient Impairment

The initial step in controlling and regulating pollutants in water bodies is to determine the level of a given pollutant which is expected to cause non-attainment of a designated use. Most existing numeric aquatic life water quality criteria are based upon a sound technical basis owing to well-defined dose-response relationships between individual pollutants and aquatic organisms, and accordingly provide a numeric threshold level to indicate impairment. However, unlike toxicants and oxygen-demanding substances, nutrient pollution effects on fish or macroinvertebrates are indirect, and therefore not predictable through simple dose-response relationships.

For most other pollutants, the 'bright line' of a clear dose-response relationship readily provides indication of an adverse pollutant impact as well as a target threshold for development of total maximum daily loads (TMDLs) and water quality based effluent limits (WQBELs) for point sources. In the case of nutrients, however, measurement of nutrient concentrations alone in a water body rarely provides an unequivocal indication of water quality impairment.

The "biological health" of a waterbody in the context of nutrient criteria development may best be determined by assessment of multiple biological indicators. USEPA stated the following in a nutrient criteria guidance document:

> "…*the primary goal of environmental assessment and management is to protect and restore ecosystem services and ecological attributes, which are often closely related to biological features and functions in ecosystems.* ***Therefore, it is the effects of nutrients on the living components of ecosystems that should become the critical determinant of nutrient criteria, rather than the actual nutrient concentrations***."
>
> (USEPA, *Nutrient Criteria Technical Guidance Manual: Wetlands*, 2008, page 8-4)

Ohio EPA has recognized the need to develop a suitable weight of evidence assessment procedure to identify water quality impairment associated with nutrients. A weight of evidence assessment considers multiple stressors, responses and/or other indicators to determine probable or likely nutrient-driven impairment.

The water quality goal with respect to nutrients should be to develop an implementable strategy to reduce and control the adverse impacts of nutrients. This is difficult to achieve solely by development and implementation of specific numeric criteria for nutrient concentrations in water bodies, since numerous other factors are interrelated in nutrient enrichment impairment. For nutrients, the TAG believes it is critical to develop a different approach to determine when a

specific stream segment is impaired or threatened as a result of nutrient enrichment. A weight of evidence approach can be developed that combines measurements of biological assemblages and key nutrient enrichment response indicators. This approach is considered to be a feasible and technically appropriate means to determine the status of a water body with respect to the nutrient enrichment continuum.

Trophic Index Criterion Proposal

Ohio EPA, with collaboration from U.S. EPA Region 5, developed a proposed composite index that included measures of biological assemblages, dissolved oxygen, periphyton, and nutrients in a multi-metric scoring index named the Trophic Index Criterion (TIC). The TIC awarded points to successive ranges for each indicator, where the ranges are defined by break points identified in the prior nutrient studies performed on Ohio streams and rivers. The four metrics incorporated into the TIC are: biological assemblages (Ohio's biocriteria for fish and macroinvertebrates – IBI, MIwb, ICI[2]), dissolved oxygen (DO) including DO swing (24-hour maximum DO minus minimum DO) and minimum DO, benthic algae (measured as chlorophyll *a* from periphyton attached to stream substrate), and nutrient concentrations (total phosphorus and dissolved inorganic nitrogen [sum of nitrate, nitrite and ammonia nitrogen]). Each metric is assigned a score based upon relative values measured for each, and the sum of the individual scores yields the overall TIC score. The overall TIC score is compared with threshold values based upon prior water quality nutrient studies, and intended to identify the condition of a water body relative to nutrient enrichment and designated as "acceptable", "threatened", "impaired", or requiring further assessment.

The preliminary TIC was tested with existing data from Ohio's stream water quality monitoring program to assess its ability to appropriately identify water bodies with nutrient enrichment caused impairment. Ohio EPA performed sensitivity analysis as a means of fine tuning the relative scoring weights of the individual metrics and the appropriate TIC score thresholds to differentiate acceptable, threatened and impaired status. This testing served to assess the accuracy of the TIC in identifying nutrient-caused impairment, by comparing each TIC score calculation with the associated assessment determination from Ohio's 305(b) and 303(d) listings. TIC was demonstrated to be generally accurate, although there were false positives and false negatives. It was apparent that the effect of confounding factors, such as habitat limitations, was not adequately incorporated into the TIC. Further, use of the TIC in systems where aquatic life was improving or impaired by other factors (such as habitat) but TIC scores remained relatively consistent could lead to costly nutrient controls with no discernable improvement in aquatic life. Tuning of the relative scoring weights for each metric and the TIC threshold (acceptable/threatened/impaired) score values appeared unable to eliminate incorrect determinations.

The TAG members agree that the TIC approach has many promising attributes and represents a reasonable starting point for a procedure to assess nutrient impairment given the intertwined relationship of habitat and nutrient stressors which may or may not result in impairment in a

[2] IBI = Index of Biological Integrity; MIwb = Modified Index of Well-Being; ICI = Invertebrate Community Index

specific stream segment. Many of the TAG members recognized that the TIC has certain shortcomings that have not been fully tested due to data limitations and biological variability leading to the following concerns:

- The TIC scores may be interpreted too rigidly in the regulatory environment and, if adopted as numeric water quality standards, may allow inadequate flexibility to incorporate field observations or confounding evidence for or against nutrient impairment determination.
- The nutrient concentration component of the TIC score does not appear to provide meaningful contribution to the weight of evidence assessment, since too many instances of contradictory nutrient concentration and relative nutrient enrichment exist (i.e., in some instances nutrient concentrations are relatively high while the stream presents no evidence of nutrient impairment based on other indicators, and in other instances nutrient concentrations are relatively low yet nutrient enrichment is clearly present.)

It should be noted that the use of "criterion" in the TIC name is a misnomer, since the TIC is actually a procedure or process used to identify nutrient impairment and is not a numeric water quality criterion. The TIC – or an alternative procedure described following – can be considered a first step in a nutrient rule to determine whether or not a water body needs implementation of controls or actions to reduce the adverse water quality impacts of nutrient enrichment.

Stream Nutrient Assessment Procedure

As an alternate approach, Ohio EPA decomposed the TIC concept into a decision matrix procedure based upon a step-wise evaluation of key indicator elements, using both quantitative numeric thresholds and narrative evaluation of measured and observed factors. The TAG subgroup started with this matrix including the four sets of factors from the TIC – i.e., biological criteria, DO swing, benthic chlorophyll, and nutrients. The matrix arranged these four factors in sequential columns for assessment, with each cell in the matrix representing a different measurement range or condition status. It is important to note that the same data break points developed using statistical data correlations for the previously proposed TIC were used for this alternative assessment procedure.

The first column uses biocriteria attainment with a pass/fail determinant used to enter an appropriate cell in the subsequent column in the sequential decision matrix. The second and third columns use low to high numeric thresholds (based upon statistical analysis of Ohio stream survey data for change point values) for the two response variables (DO and chlorophyll) to determine likely trophic condition. The fourth column was intended to use nutrient concentrations as the final piece of evidence to determine a preliminary nutrient status condition for the water body. However, it was observed for the Ohio stream data that nutrient concentration could be essentially any value, independent of the nutrient enrichment condition determined by the first three factors. This relatively poor relationship between trophic condition and nutrient concentration is explained by the fact that many other factors (e.g., light, temperature, hydraulic residence time, physical habitat) affect the response variables, as well as the fact that nutrients may be available from sediments or other biomass and are not measured

in water sample nutrient analyses. Accordingly, the nutrient concentration was removed from the assessment procedure matrix since biocriteria, DO swing and benthic chlorophyll provided appropriate weight of evidence to indicate the nutrient enrichment condition in the stream.

Note that removing nutrient concentration as a variable from this nutrient assessment procedure does not in any way diminish the weight of evidence determination of a water body's nutrient enrichment condition. The two important response variables (DO swing and benthic chlorophyll) coupled with the Ohio biological water quality criteria (IBI, MIWb and ICI) provide a very useful determination of nutrient enrichment or trophic condition. Target values for nutrient concentration or loading are anticipated to be incorporated in the implementation procedures to be integrated into the overall nutrient rulemaking.

To emphasize that the TIC structure should not be confused with a numeric nutrient criterion, the TAG subgroup proposes a new name for this procedure. The TAG recommends restructuring the TIC as an assessment procedure to determine the nutrient enrichment or trophic condition of a stream or river, hence the recommended name of Stream Nutrient Assessment Procedure (SNAP). This procedure is consistent with Ohio EPA's assessment of attainment of aquatic life uses.

Use of the SNAP matrix provides a preliminary determination of the trophic condition status as one of five classifications:

1. Attaining and not threatened
2. Attaining, but may be threatened
3. Impaired, but cause(s) other than nutrients
4. Impaired, with nutrients as a likely cause
5. Impaired, with nutrient enrichment as the cause

In the case of the first classification ("attaining"), no further assessment verification is necessary, and the water body is determined to not have a nutrient enrichment problem. In the case of the remaining four classifications, the proposed SNAP would use one of three decision flow charts to confirm or determine the nutrient condition status and whether there is a need for proceeding to implementation procedures to be developed for the nutrient rule. The proposed SNAP decision flow charts are as follows:

Flow Chart A: for determining when biologically attaining condition status is threatened by nutrients. (used with classification 2: Attaining but may be threatened)

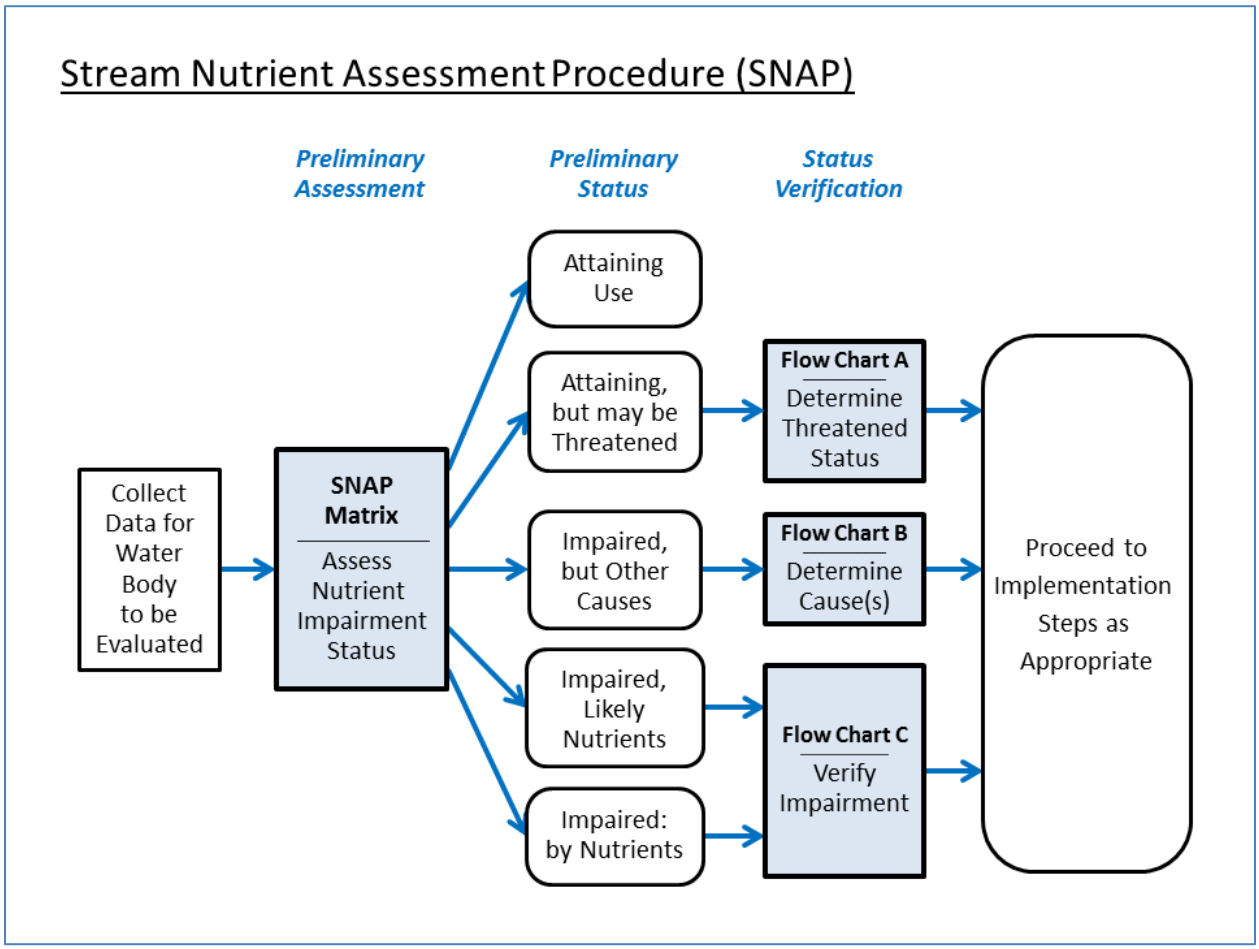
Flow Chart B: for determining biological impairment caused by stressors other than nutrients. (used with classification 3: Impaired but other causes)

Flow Chart C: for confirming biological impairment caused by nutrients. (used with classifications 4 and 5: Impaired with nutrients likely or identified)

Key components of a nutrient water quality standards rule are the implementation steps that arise out of a determination that excessive nutrient loads are the primary cause of non-attainment of aquatic life uses and that reduction of nutrient loads will result in meaningful

improvements in aquatic life. The TAG is working with Ohio EPA to evaluate appropriate implementation steps.

A conceptual diagram showing use of the proposed SNAP within a nutrient water quality standards rule is shown following:

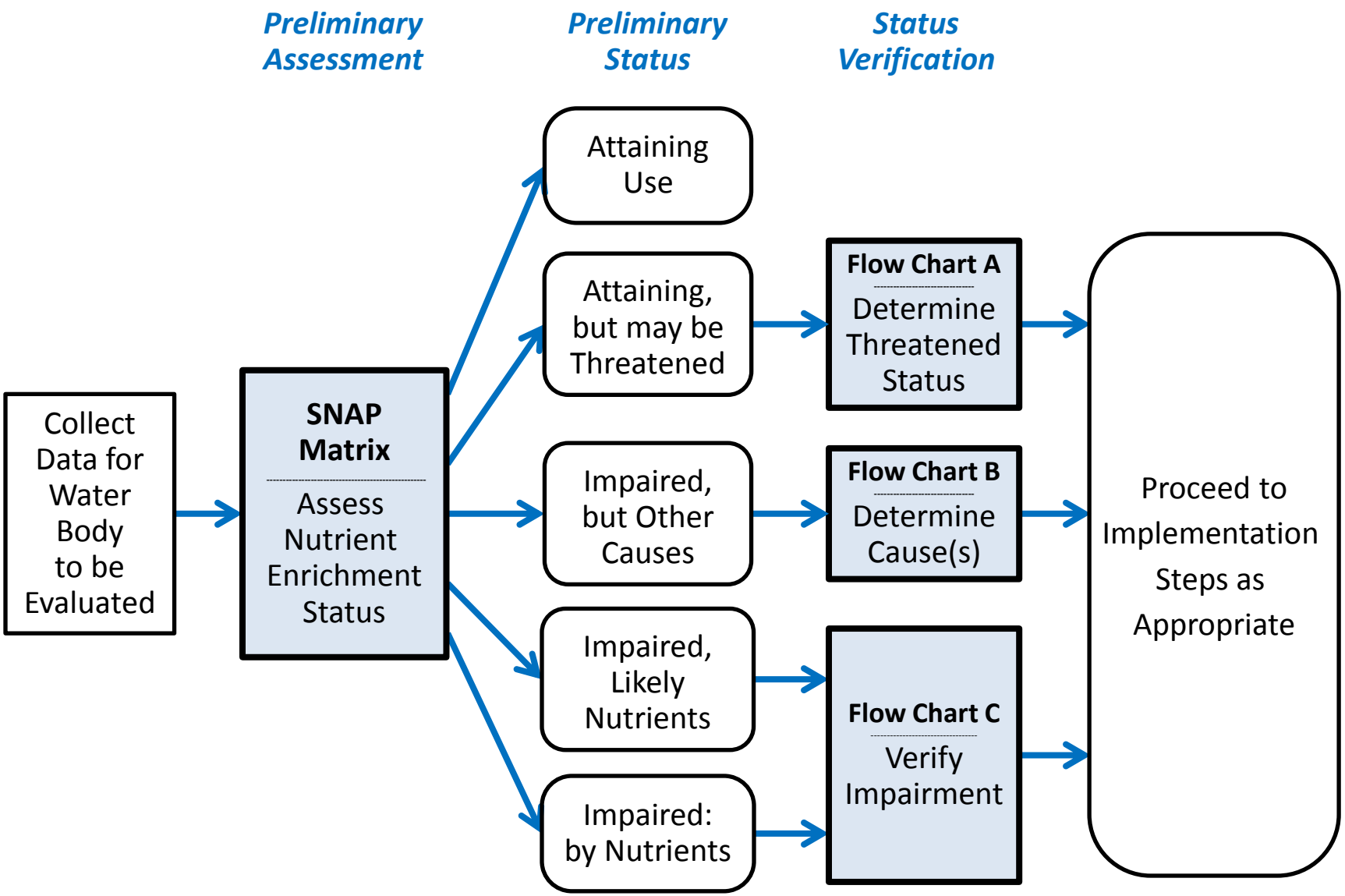


Proposed Final **SNAP**:

Stream Nutrient Assessment Procedure

9/11/2014

Stream Nutrient Assessment Procedure (SNAP)



9/11/14 – Revisions from prior versions of SNAP, Flow Charts and Tables are shown in red on following slides.

Proposed **Stream Nutrient Assessment Procedure (SNAP)**

1	2	3	4	
Biological Criteria	**DO Swing**	**Benthic Chlorophyll**	**Preliminary Assessment: Trophic Condition Status**	
All indices attaining or non-significant departure	Normal or low swings (≤6.5 mg/l)	Low to moderate (≤320 mg/m^2)	Attaining use / not threatened	
		High (>320 mg/m^2)	Attaining use, but may be threatened	*See Flow Chart A*
	Wide swings (>6.5 mg/l)	Low (≤182 mg/m^2)		
		Moderate to high (>182 mg/m^2)		
Non-attaining (one or more indices below non-significant departure)	Normal or low swings (≤6.5 mg/l)	Low to moderate (≤320 mg/m^2)	Impaired, but cause(s) other than nutrients	*See Flow Chart B*
		High (>320 mg/m^2)	Impaired / likely nutrient enriched	*See Flow Chart C*
	Wide swings (>6.5 mg/l)	Low (≤182 mg/m^2)		
		Moderate to high (>182 mg/m^2)	Impaired / Nutrient enriched	

FLOW CHART A.

Decision matrix for determining when biologically attaining condition status is threatened

- For application when biological criteria are attaining

  but

- One or both nutrient response indicators (DO swing or benthic chlorophyll) are elevated

FLOW CHART A.

Decision matrix for determining when biologically attaining condition status is threatened

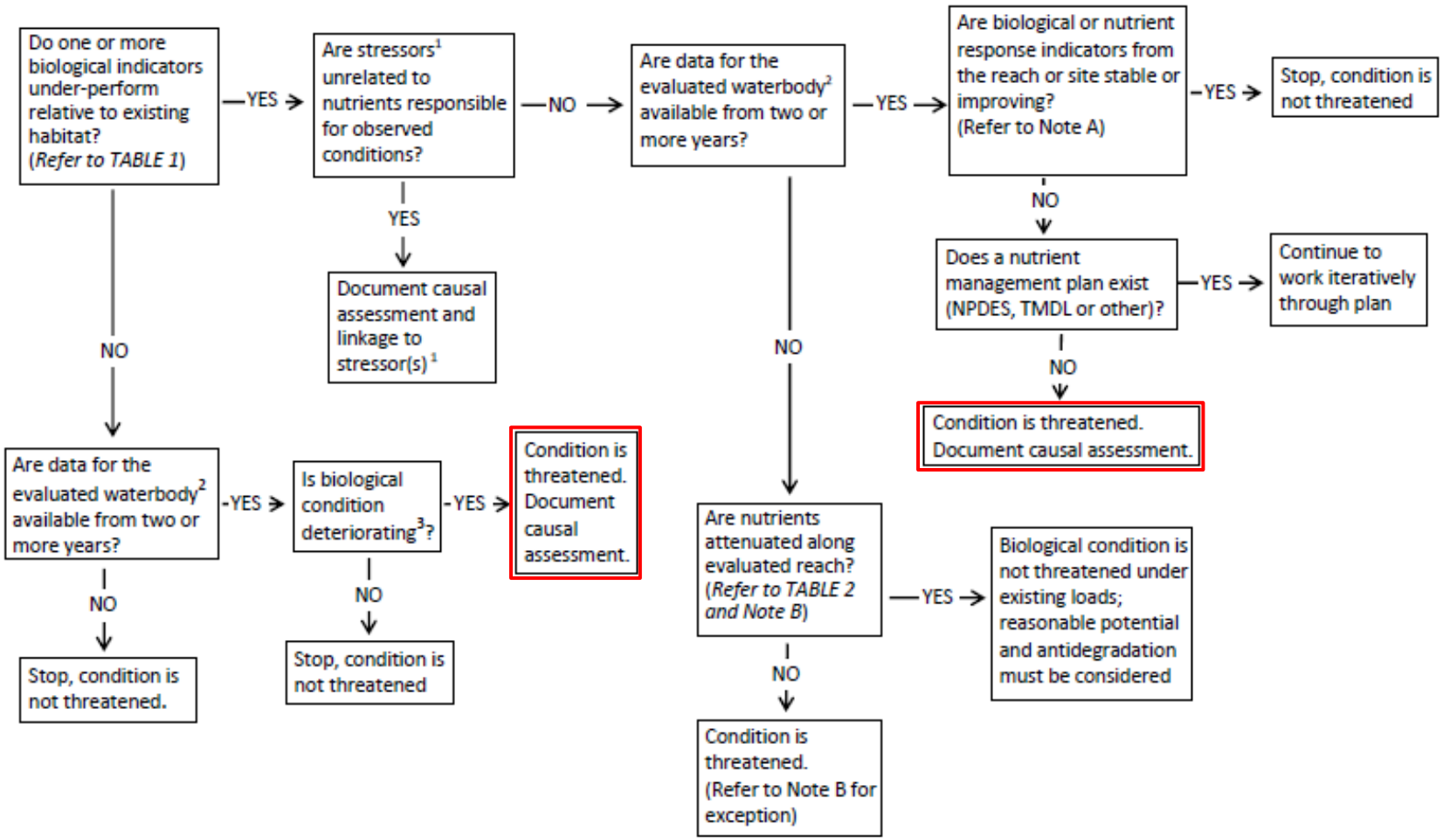


TABLE 1 – Equations used as guidance to help determine whether biological indicators are underperforming relative to existing habitat.

INTRODUCTORY TEXT:

To assist in determining whether measured biological indicator values at the site being assessed underperform relative to the existing habitat, the measured value(s) are compared with the 25th and 15th percentile values of all data classified as unimpaired in the Ohio EPA assessment database and stratified by the designated classification (EWH, WWH or MWH) within the specific ecoregion for the site. The 25th and 15th percentiles represent levels that most sites equal or exceed. If the respective measured biological indicator value is less than the 15th percentile value then the site is likely underperforming relative to what could be expected given the local habitat quality (QHEI). If the indicator value is between the 15th and 25th percentile values, additional information or observations should be used to determine whether or not the site is underperforming with respect to its habitat. If the indicator value is above the 25th percentile value, the site would be considered performing within the range expected for the existing habitat.

The following equations calculate the 25th and 15th percentile values as determined by regression analysis for the respective biological indicators for a given QHEI score, or a combination of QHEI score and drainage area. For small and headwater streams where insufficient stream flow prevents collection of a quantitative sample, thereby precluding calculation of an ICI score, the number of EPT taxa is used as the macroinvertebrate indicator. Such small streams are typically less than 20 square miles in drainage area, or larger if stream velocity is insufficient to collect a quantitative sample.

FLOW CHART B.

Decision matrix for determining when biological impairment is caused by stressors other than nutrients

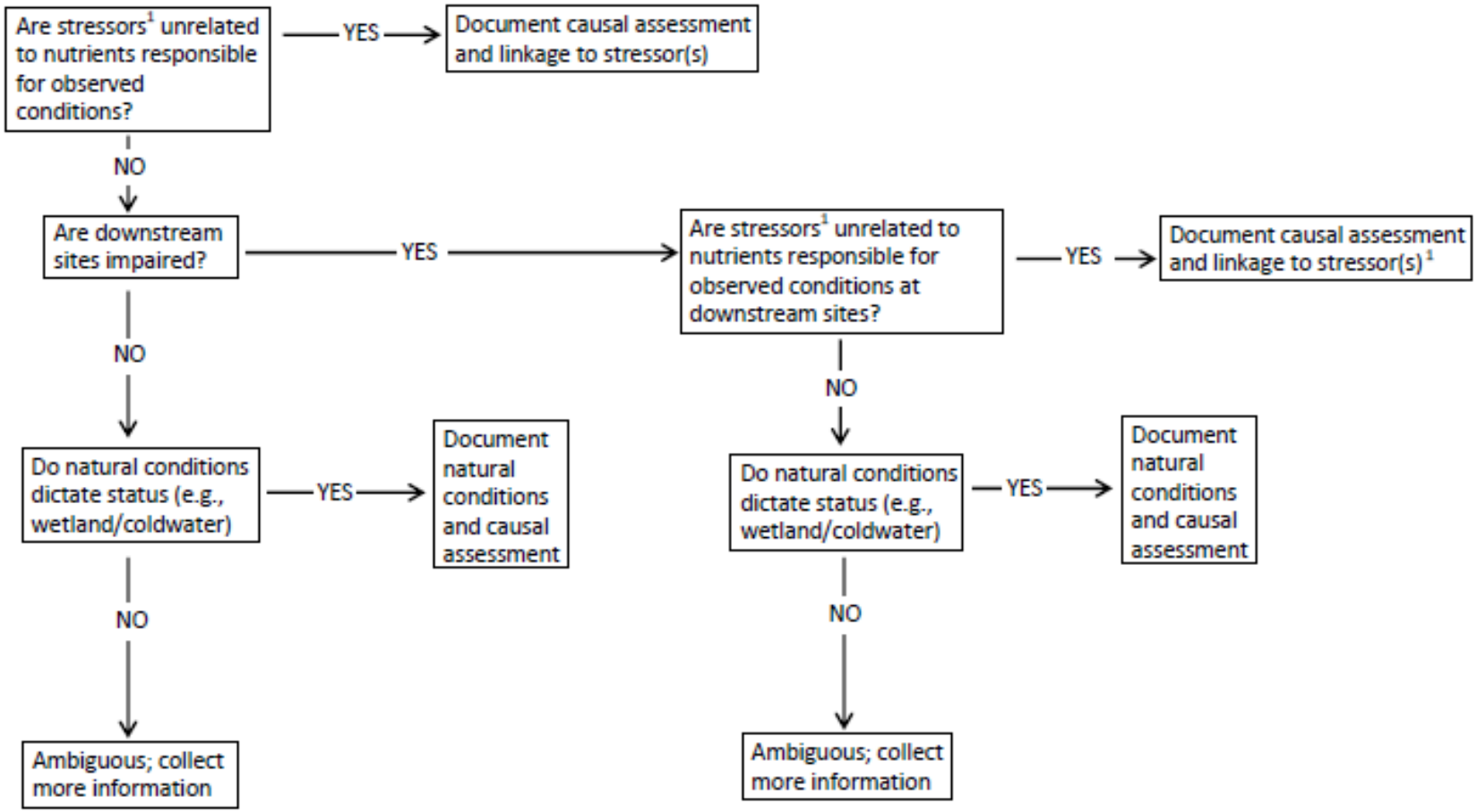
- For application when one or more biological criteria are non-attaining

  but

- No nutrient response indicators (DO swing or benthic chlorophyll) are elevated

FLOW CHART B.

Decision tree for determining biological impairment caused by stressors other than nutrients



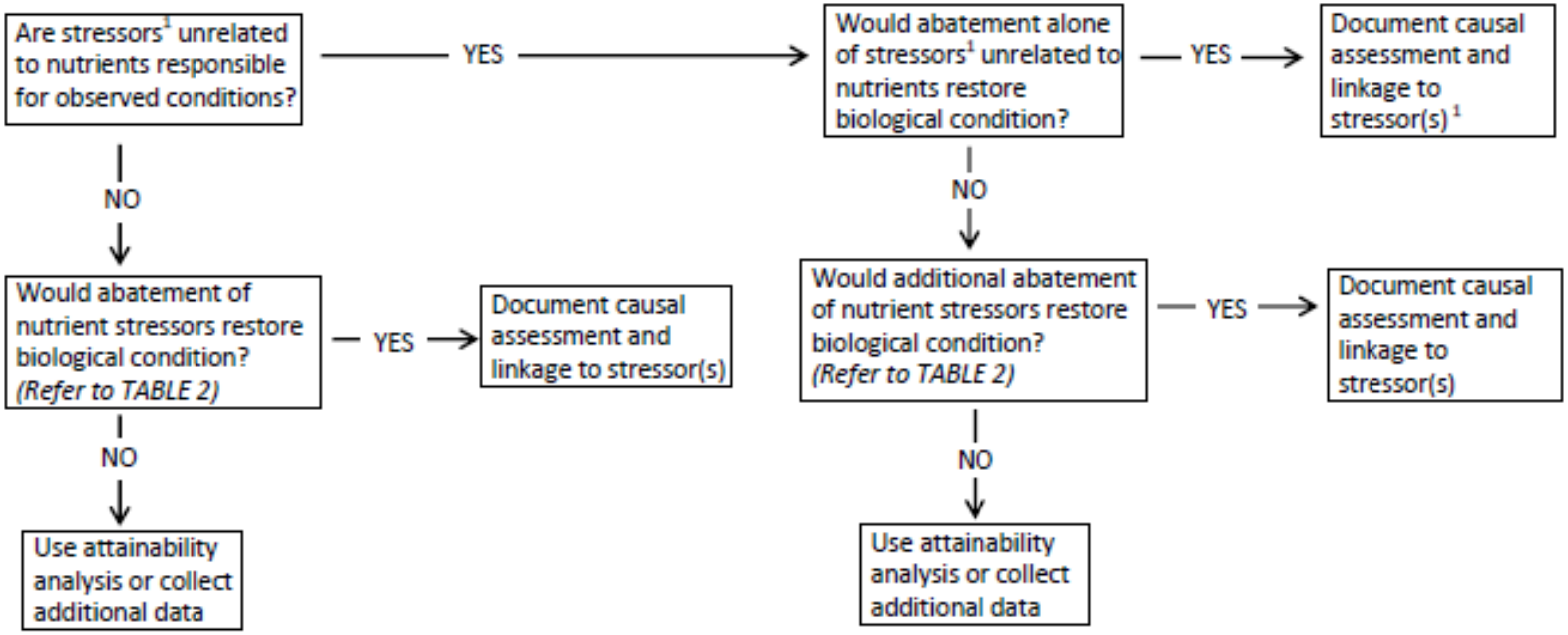
FLOW CHART C.

Decision matrix for confirming whether biological impairment is caused by nutrients

- For application when one or more biological criteria are non-attaining

  and

- Either nutrient response indicator (DO swing or benthic chlorophyll) is elevated

FLOW CHART C.

Decision tree for confirming biological impairment caused by nutrients