Temperature Assessment Methodology for Use III(-P) Streams in Maryland

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Maryland Department of the Environment

Maryland Department of Natural Resources

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Background

Code of Maryland Regulations (COMAR) Section 26.08.02.08 assigns use classes and the corresponding designated uses for water bodies throughout Maryland. Designated uses define the water quality goals for a water body. At a minimum, the Maryland Department of the Environment (MDE) must provide water quality for the protection and propagation of fish, shellfish, and wildlife, and provide for recreation in and on the water, where attainable (Clean Water Act (CWA) Section 101(a)(2)). Where numeric thresholds are available, MDE adopts these as water quality criteria to protect designated uses. Such criteria must be scientifically defensible and relate, directly or indirectly, to attainment of the designated use.

Studies have shown that temperature is a key parameter for protecting aquatic life and Maryland has adopted numeric temperature criteria. Temperature is a physical property of water that affects most biological and chemical processes that occur in water (Bogan et al., 2003). Water temperature is an important measure of water quality and influences the overall health of aquatic ecosystems (Kelleher et al., 2011; Caissie, 2006; Coutant, 1999). In many cases, the geographic distribution of aquatic species (e.g., fish and benthic macroinvertebrates) is determined by the thermal regime of streams in the region. Anthropogenic activities can alter the temperature regime of streams and rivers causing changes (sometimes permanent) in the biological community (Allan 1995). For example, if the thermal tolerance of a fish species is exceeded in a stream reach, it can result in direct fish mortality (Easton and Scheller, 1996; Caissie et al., 2001). Since temperature can affect the attainment of designated uses, it is necessary to assess and protect stream temperature as an essential component of the total aquatic environment to achieve and maintain designated uses.

Code of Maryland Regulations groups waters of the State into four main use classes according to the unique water body types and the specific designated uses that apply. The four main use classes are listed below.[1]

- I(-P) - Water Contact Recreation, and Protection of Nontidal Warmwater Aquatic Life,
- II(-P) - Support of Estuarine and Marine Aquatic Life and Shellfish Harvesting,
- III(-P) – Nontidal Cold Water, and
- IV(-P) - Recreational Trout Waters

Each of these use classes has a numeric water temperature criterion. However, this temperature assessment methodology will focus only on assessing Use Class III(-P) Nontidal Cold Waters and the associated temperature criterion. A temperature assessment methodology for Use Classes I(-P), II(-P), and IV(-P) waters may be developed in the future.

Certain waters of the State possess water quality suitable to support cold water community assemblages. To protect the conditions necessary for cold water community survival and

[1] Each of these use classes can potentially have a "-P" suffix if the public water supply designated use applies to the water body.

persistence, Maryland's regulations (COMAR 26.08.02.02B(5)) establish Use Class III: Nontidal Cold Waters. Use Class III(-P) is defined in COMAR Section 26.08.02.02 as follows:

"Use III: Nontidal Cold Water. This use designation includes all uses identified for Use Class I and waters which have the potential for or are:

(a) Suitable for the growth and propagation of trout populations and other coldwater obligate species including, but not limited to the stoneflies tallaperla and sweltsa.
(b) Capable of supporting self-sustaining trout populations and their associated food organisms."

The temperature criteria associated with Use Class III(-P) (see COMAR 26.08.02.03-3 D. (3)) are:

"(a) The maximum temperature outside the mixing zone determined in accordance with Regulation .05 of this chapter or COMAR 26.08.03.03—.05 may not exceed 68°F (20°C) or the ambient temperature of the surface waters, whichever is greater.
(b) Ambient temperature—Same as Use Class I.
(c) A thermal barrier that adversely affects salmonid fish may not be established.
(d) It is the policy of the State that riparian forest buffer adjacent to Use Class III waters shall be retained whenever possible to maintain the temperatures essential to meeting this criterion."

Up until the 2014 Integrated Report cycle, Maryland did not have an established methodology for assessing water temperature. Before that time, stream temperature data was rarely assessed as assessments were focused on other parameters with more robust assessment methodologies. Prior to 2014, the State recognized that monitoring and assessing temperature was a critical component in evaluating and protecting Maryland's cold water streams. Eventually, with the advent of the Maryland Biological Stream Survey's (MBSS) temperature monitoring program, more data was gathered and consistent protocols were developed. This greatly enhanced the reliability of temperature data and helped to provide the basis for many of the protocols and analysis methods discussed herein. Created in collaboration with Maryland Department of Natural Resources (DNR), this document describes the temperature assessment methodology to be used for evaluating Use Class III(-P) non-tidal cold water streams.

Rationale for Temperature Analysis Thresholds

Analysis by the University of Maryland Center for Environmental Science (UMCES) and DNR confirm the appropriateness of the current Use Class III(-P) temperature criterion (68°F/20°C) in protecting healthy populations of Maryland's cold water obligates. However, these studies also noted that even in streams holding healthy populations of brook trout (*Salvelinus fontinalis*), a cold water obligate, that water temperatures do occasionally exceed 68°F/20°C. The following paragraphs describe the results from those studies.

Hilderbrand (2009) analyzed stream temperature data, from 236 Maryland Biological Stream Survey (MBSS) sampling records from 2001 to 2008 and recorded during the critical summer

period (June 1 through August 31). Hilderbrand's study found that brook trout-bearing streams exceeded 68°F/20°C approximately 10.7% of the time. In addition, the average daily mean for brook trout-bearing streams was 16.8°C.

Table 1: Temperature Statistics for Streams with brook trout (Hilderbrand, 2009).

Temperature Statistic	Mean
Percent of Time Temperature > 20C	10.7%
Average Daily Mean (degrees C)	16.8°C

One limitation of this study was that it included all streams containing brook trout, including those streams that had only one individual. As a result, these statistics were calculated on a population of brook trout-bearing streams that likely included streams with a degraded (warm) thermal regime. To further clarify, some of these streams may have had a remnant or transient brook trout at the time of sampling, but for all intents and purposes, have an impaired thermal regime.

In order to overcome this limitation, DNR developed a more appropriate reference condition to effectively describe the thermal regime for healthy/persistent cold water streams. To be considered a non-degraded cold water site (i.e., reference condition), DNR chose locations sampled in July and August (generally the hottest months of the year) that had 25 or more brook trout[2] and which demonstrated multiple year classes. In all, thirty-eight sites qualified as reference sites. From this vetted dataset, DNR found that stream temperature still exceeded 68°F/20°C approximately 10% of the time (Table 2).

Table 2: Temperature Statistics for Non-impaired Cold Water Streams.

Temperature Statistic (n = 84,950 temperature measurements)	Empirically Derived Value
Percent time >20°C	10.9%
Mean Temperature (°C)	17.3
90th Percentile Temperature (°C)	20.1

Since both the UMCES and DNR studies' arrived at nearly an identical result, the Department decided to use the 90th percentile of temperature measurements to help determine whether a Use Class III(-P) stream is meeting temperature criteria. Therefore, the 90th percentile temperature of a Use Class III(-P) stream must be equal to or less than 68°F/20°C, outside of any mixing zone established by the Department, to be considered not impaired. In so doing, this assessment rule is consistent with the United States Environmental Protection Agency's (EPA) 10% rule as

[2] Self-sustaining brook trout populations were effective indicators of healthy cold water conditions as their thermal regime matches very closely with *Tallaperla* and *Sweltsa*, two other cold water obligate taxa.

described in EPA guidance for the development of state's 305(b) reports (EPA 1997 and Regas 2005).

The Department will also utilize a secondary assessment threshold, that being an upper limit of 23.8°C, to help identify potential impairments. The purpose of this secondary threshold is to help identify those Use Class III(-P) streams that are impacted by short duration, high temperature events. In effect, this secondary threshold ensures that monitored Use Class III(-P) streams will not experience extreme increases in temperature beyond the thermal limit of cold water obligates without being identified as impaired. This value is based on literature by Embody (1921), Kendall (1924), Bean (1909), McAfee (1966), and MacCrimmon and Campbell (1969).

Temperature Assessment Process

Under Section 303(d)(1) of the federal CWA, MDE is required to develop a list of those waters that do not meet applicable water quality standards and are therefore considered "impaired" (placed in Category 5 of the Integrated Report). To achieve this, MDE considers all existing and readily available water quality data and information, and develops methods to interpret these data for each impairing substance. An impairment is identified when water quality monitoring data suggest that a water body does not meet or is not expected to meet water quality standards or applicable criteria. When a water body is assessed as impaired, the cause (pollutant or pollution) and level of priority for TMDL development of the impairment is identified.

EPA provides guidance on making 'use support determinations' for the State Water Quality Assessments 305(b) Report (EPA 1997) (referred herein as the Integrated Report). Maryland's 303(d) list and 305(b) report are combined as the Integrated Report (IR) which describes waters using five unique categories, including: Category 1 – waters attaining all standards; Category 2 – waters attaining some standards; Category 3 – waters with insufficient information to determine if water quality standards are attained; Category 4 – impaired or threatened waters that do not need or have an already completed TMDL; and, Category 5 – impaired waters for which a TMDL is required.

This assessment methodology provides the decision framework, including data collection requirements and analysis techniques, used to determine if a Use III(-P) stream or river is meeting the required temperature criteria. MDE considers all current and readily available stream and river temperature data to determine if a water body should be assessed as impaired for temperature on the Integrated Report. MDE evaluates the monitoring plans, quality assurance and quality control protocols of any data provided to determine what data can be included in assessments. The rules below describe how water temperature data assessed for Use Class III(-P) will be used in Integrated Reporting. As a general rule, there are three potential outcomes of the assessment of a water body, these include: Category 2 – waters attaining some standards; Category 3 – waters with insufficient information to determine if water quality standards are attained; Category 5 – impaired waters for which a TMDL is required. Categories 1 and 4 may be assigned, but are contingent on other Department actions not covered within this assessment methodology (e.g. assessment of other criteria, development of a TMDL).

Assessment Scale

The data collected by a single water temperature logger will generally be considered representative of a single stream segment, from the location of the logger upstream to the next confluence, according to the 1:100,000 scale National Hydrography Dataset (NHD). In this case, the upstream confluence is defined as either the next upstream confluence with a perennial stream or, if no upstream confluence exists, the headwaters of the stream itself. This geographic scale will therefore be the default assessment scale for the Integrated Report of Surface Water Quality (IR). However, this methodology recognizes that unforeseen environmental settings may complicate the assessment scenario and thereby require adaptability of the assessment scale. For that reason, State biologists reserve the right to use best professional judgment when specifying the final scale of assessment. It is worth noting, that regardless of using a stream segment as the defaulting listing scale, upstream waters must protect downstream uses, and all upstream sources of thermal pollution will be considered during the assessment process.

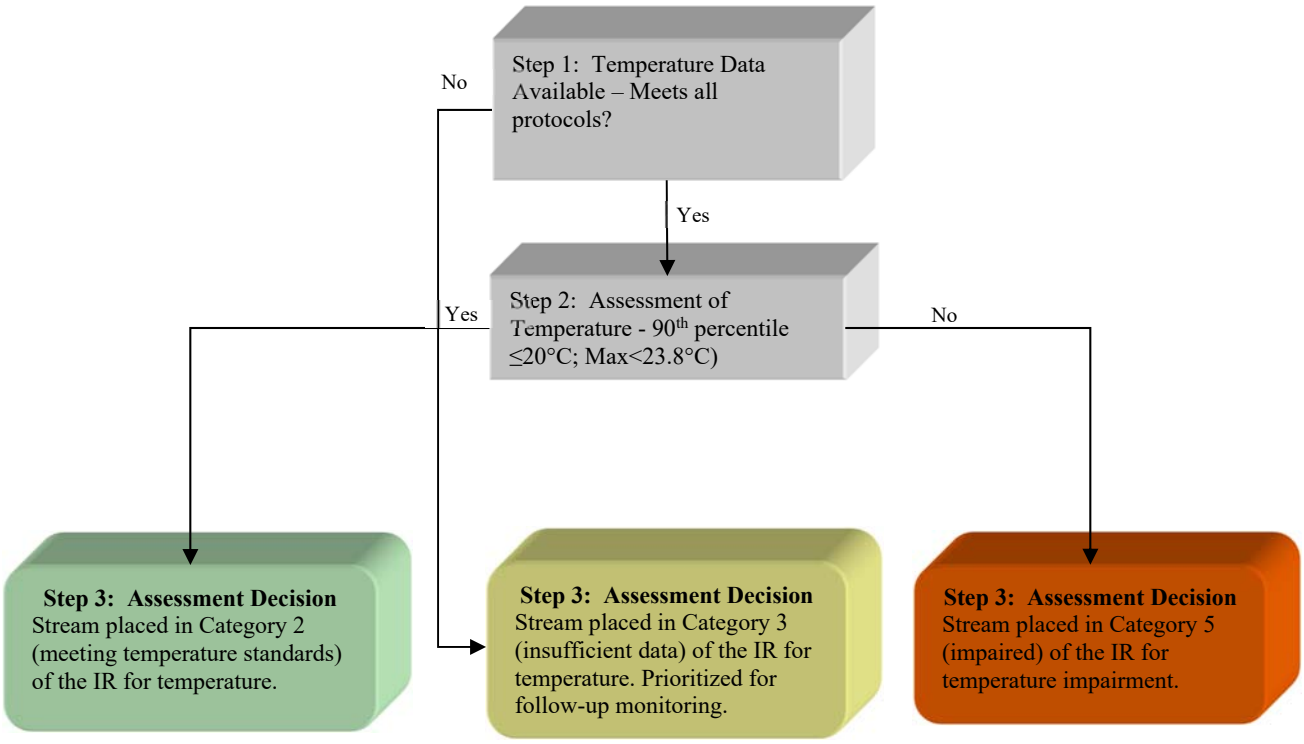

Figure 1: Decision diagram for assessing attainment of temperature criteria in Use III(-P) streams in Maryland.

Decision Diagram Step 1: Temperature Data

All data used for temperature impairment determinations must meet Maryland's stream temperature measurement protocols as detailed in Maryland's Temperature Measurement Protocols for Wadeable Streams. This document describes the procedures for measuring water temperatures in 1st through 4th order lotic systems (as defined by Strahler 1952 and 1964) that are well mixed and have nearly constant temperatures from surface to bottom (Allan 1995). This document provides information on temperature equipment, the time period and frequency for measurements, logger deployment and retrieval, quality assurance/quality control procedures, and data management. For Use Class III(-P) waters, the critical period for temperature measurement is defined as June 1 through August 31. In all cases, data should be collected with the use of continuous temperature loggers deployed in streams/rivers to record water temperature at 30 minute intervals or less. Data collected outside the critical period can be used for assessment purposes, however, temperature criteria violations are unlikely to occur at these times of year. Adequate documentation is necessary to ensure that data are of known quality. Documentation should include a detailed monitoring plan and an explicit quality assurance/quality control document whenever water temperature data are submitted to MDE. Data that do not meet these quality assurance protocols can be used to place a water body in Category 3 (insufficient information) and MDE will prioritize the water body for follow-up monitoring.

Decision Diagram Step 2: Assessment of Temperature Regime

Use III(-P)

The Department will review all valid temperature data taken outside of any permitted thermal mixing zones and recorded between the period from June 1 to August 31. (Measurements should be taken at a minimum frequency of every 30 minutes.) If the 90th percentile of these values is equal to or less than 20°C and the maximum temperature recorded during that time period is less than 23.8°C, that stream reach will be placed in Category 2 (not impaired) of the Integrated Report. In cases where some temperature data is available but not for the entire assessment period (June 1 – August 31), a lesser quantity of data may still be useful for making an impairment determination. For instance, if one-third or more of the water temperature measurements recorded in a single month (June, July, or August) exceed the 20°C criterion, it is not possible for a stream reach to attain a 90th percentile temperature equal to or below 20°C during the entire 3-month assessment period (June 1 to August 31). In such cases, it is possible to conclude that, even with a complete dataset covering the entire assessment period, the stream reach will not have met the temperature criterion. In these cases, it may be scientifically defensible to place the stream reach in Category 5 (impaired) of the Integrated Report.

It is important to note that deviations (up to 10%) above 20°C apply only to the summer months. Temperature measurements recorded between September 1 and May 31 of any year are not permitted to exceed 20°C.[3] However, to be considered valid, any data collected between September 1 and May 31 must also be collected according to the aforementioned protocols which include taking measurements in 30 minute or shorter intervals. Although data providers

[3] In rare cases where a few exceedances occur in early September due to weather-related events, State Biologists may determine that an impairment does not exist if summer data meets the listing threshold.

can conduct use support determinations, MDE reserves the right to analyze the raw data provided by individuals or groups to determine if the numeric temperature criteria are met for Use III(-P) waters.

Decision Diagram Step 3: Integrated Reporting (IR) of Assessment Results

For the Integrated Report, temperature assessments will generally fall into Categories 2, 3 or 5. Temperature data used to put waters in Category 2 (unimpaired) or 5 (impaired) must be of sufficient quality and collected according to proper protocols (Maryland's Temperature Measurement Protocols for Wadeable Streams). Data that do not meet these quality assurance protocols can be used to place a water body in Category 3 (insufficient information). Examples in which data would not meet quality assurance protocols include data not representative of the stream segment, e.g., only collecting temperature data during the hottest time of the day, or continuous data measurement intervals of more than of 30 minutes. If data does not meet quality assurance protocols the Department will prioritize these streams, as resources permit, for additional temperature sampling.

Use Class III(-P) streams with temperature data that meets both impairment thresholds (90^{th} percentile$\leq$20°C and maximum$\leq$23.8°C) will be placed in Category 2 as unimpaired by temperature. Streams with temperature data that exceeds one or both of the applicable thresholds (90^{th} percentile or thermal maxima) will be placed in Category 5 as impaired by temperature[4].

[4] A single exceedance of one or both of the applicable thresholds would trigger an impairment.

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