

Establishing Benthic Index of Biotic Integrity (B-IBI) Thresholds for Use in the Water Quality Assessment

This information is intended to provide rationale for the 2014 Water Quality Assessment submittal to the Environmental Protection Agency (EPA) regarding B-IBI thresholds used for assessment of B-IBI data. The following are provided:

1. History of bioassessment in Washington's Water Quality Assessment.
2. Background on the 2012 Policy 1-11 revisions for bioassessment.
3. Defining Biotic Integrity for Bioassessment listing decisions in the WQA.
4. B-IBI thresholds used in 2014 Fresh Water Assessment.
5. Next steps after the 2014 Assessment is completed.

1. History of Bioassessment in Washington's Water Quality Assessment

The Department of Ecology began using macroinvertebrate bioassessment data to develop the state water quality assessment (WQA) in 2004. Chapter 1 of Ecology's Water Quality Program Policy 1-11 was modified to provide guidance for using bioassessment data. At that time, the method for assessing biological index information was to place waters displaying degradation of their macroinvertebrate communities into Category 2 (waters of concern) rather than Category 5 (the 303(d) list of impaired waters). The intention of this decision was to allow further study of these Category 2 waters to determine what pollutant(s) or other human disturbance were responsible for the degradation of the aquatic life use.

The Department of Ecology's statewide macroinvertebrate dataset was assessed based on the River Invertebrate Prediction and Classification System (RIVPACS) model scores. The other bioassessment dataset available for the 2004 assessment was Benthic Index of Biological Integrity (B-IBI) models scores submitted to Ecology from one county (Clallam County). The assessment of these datasets resulted in 82 Category 2 waterbody assessment units listings; 46 listings were based on RIVPACS scores and 36 were based on B-IBI scores.

In June 2006, Ecology revised Policy 1-11 to include greater detail on the numeric index thresholds for determining WQA categories and maintained that waters showing degradation of their macroinvertebrate communities should be placed into Category 2 until identification of pollutants or human disturbances were demonstrated. When the draft of Policy 1-11 went through public review, Ecology received comments from stakeholders and from EPA Region 10 stating that biological index scores that clearly show impairment of the macroinvertebrate community should be placed in Category 5, the 303(d) list of impaired waters, without additional information on pollutants or human disturbances. Ecology considered these comments and was convinced by EPA to establish Category 5 waters solely based on biological index (bioassessment) scores. This decision was in recognition that impairment of the biota in state waters is a violation of Surface Water Quality Standards, narrative protection criteria described in the WAC 173-201A-260, and Tier I antidegradation rules in WAC 173-201A-300.

Policy 1-11 was finalized in 2006 and included listing guidance for bioassessment that based listing decisions on data alone. The policy also established statistical thresholds for RIVPACS model scores to distinguish between Category 5 303(d) impaired waters, Category 2 (waters of concern) and Category 1 (waters that met tested standards). Policy 1-11 also retained the ability to use B-IBI scores for

Establishing Benthic Index of Biotic Integrity (B-IBI) Thresholds for Use in the Water Quality Assessment

determining impairment; however, Ecology did not have the staff expertise to establish thresholds in Policy 1-11 at that time. The bioassessment policy was written to allow B-IBI and other biologic index model results to be used by Ecology to determine Category 5 listings where index scores showed a definitive level of impairment to the aquatic life use in the waterbody.

During Ecology's assessment of bioassessment data collected for the 2008 WQA, EPA strongly encouraged Ecology to allow Category 5 impairment listings using the B-IBI scores that were identified by the data submitter as being impaired based on an interpretation of their model results, and Ecology accepted those calls. As an example, one data submitter used a B-IBI threshold range less than or equal to 34 as the threshold for determining Category 5 waters. This score was based on an expert opinion that a score of 35 or greater is necessary to support self sustaining populations of anadromous salmonids. In 2008, Ecology submitted a WQA that included Category 5, Category 2, and Category 1 listings for bioassessment and EPA subsequently approved these listings.

2. Background on the 2012 Policy 1-11 Revisions for Bioassessment

In the spring of 2012, Ecology revised Policy 1-11. At that time, Ecology had completed the Standard Operating Procedures (SOP) for bioassessment data and these SOPs were cited in the updated Policy 1-11. The 2012 updated Policy 1-11 maintained the numeric threshold scores established for the RIVPACS model, however, Ecology staff were still in the process of analyzing the statewide B-IBI dataset to determine category determination thresholds. Policy 1-11 was consequently updated without including threshold numeric scores for B-IBI.

As assessment of data for the 2014 fresh water WQA began, Ecology noted that there had been an increase in the volume of benthic data available in the region and most of the entities collecting this data were using it to develop B-IBI model scores rather than RIVPACS scores. Ecology recognized, after Policy 1-11 was updated in 2012 and the WQA was in progress, that it was necessary to establish a statistical set of B-IBI thresholds for the draft 2014 WQA in order to produce consistent listing decisions regardless of the data submitter. This paper outlines the steps that were taken.

3. Defining Biotic Integrity for Bioassessment Listing Decisions in the WQA

Ecologists originally defined Biotic Integrity in the following way:

“capable of “supporting and maintaining a balanced, integrated, adaptive community of organisms having a composition and diversity comparable to that of the natural habitats of the region” (Frey 1977).”

Since then the term Biotic Integrity has been refined to mean:

“a balanced, integrated, adaptive system having a full range of ecosystem elements (genes, species, assemblages) and processes (mutation, demographics, biotic interactions, nutrient and energy dynamics, metapopulation dynamics) expected in areas with no or minimal human influence (Karr 2000).”

Establishing Benthic Index of Biotic Integrity (B-IBI) Thresholds for Use in the Water Quality Assessment

This definition is supported by the USEPA (Davies and Jackson, 2006) and is a key concept in their Biological Condition Gradient.

The State of Ohio is one of a limited number of states that have adopted numeric biological criteria such that a B-IBI score equating to “Fair” biotic integrity is considered to NOT meet the goals of the Clean Water Act (http://www.epa.ohio.gov/portals/35/documents/BioCrit88_Vol1PartC.pdf). In aquatic communities with “Fair” biotic integrity there is a significant decline in taxa diversity, and in the number of sensitive taxa, while tolerant taxa become more dominant in the community. These characteristics typically represent a departure from the natural conditions in wadeable streams and rivers that have minimal human-caused impacts.

4. B-IBI thresholds used in 2014 fresh water Assessment

The following information provides the process Ecology used to develop standardized thresholds for assessing multiple B-IBI datasets to determine waters are non-impaired (Category 1), waters of concern (Category 2), or impaired (Category 5).

Initially, Ecology conducted a review of how other states in the region handle bioassessment data for assessing waterbodies. Our review found that although some states use a single threshold to determine whether the aquatic life use is in good condition (above the threshold score) or the aquatic life use is in poor condition (below the threshold score) they did not rely on the index score alone to make a determination that an assessment unit is impaired. Other habitat information or associated pollutant information was required to make a final determination. Based on EPA’s recommendations from 2006, Ecology’s bioassessment methodology uses the index score alone, without reference to ancillary environmental data and/or information to identify a probable cause or source of impairment.

Ecology made the determination that Category 2 designations are necessary for those scores that do not reasonably demonstrate impairment. Ecology similarly uses Category 2 for other parameters, where there is some evidence that impairment *may* be occurring but there is not enough data to demonstrate persistent impairment that requires placement into Category 5. Until it has been determined which scores clearly indicate distinct shifts in the biological communities associated with impairment, Ecology plans to maintain a Category 2, water of concern, within the B-IBI scale. The basis for maintaining a Category 2 is that Ecology’s data gathered from statewide sites indicates that some scores may apply to both human impacted and least-impacted reference sites, i.e., some reference sites can have lower scores due to natural conditions affecting the macroinvertebrate community. In other words, there is a range of scores in which the B-IBI model output, by itself, cannot distinguish a site with minimal human disturbance from a site that is degraded. Category 1 and Category 5 thresholds on the upper and lower ranges of the B-IBI scale, respectively, are set at scores that provide a high level of confidence that the impairment category determination for a given assessment unit is correct.

As noted previously, in past WQ assessments data submitters established their own threshold for determining impairment. Ecology found discrepancies between individual data submitters that would lead to inconsistent impairment determinations among separate datasets. For example, a score of 34 was interpreted by one data submitter to mean “fair” which would be placed in Category 2 while another data submitter described this score to be “impaired” which would be placed in Category 5.

Establishing Benthic Index of Biotic Integrity (B-IBI) Thresholds for Use in the Water Quality Assessment

While the 2012 updates to Policy 1-11 included a requirement that SOPs for bioassessment data be followed in order to continue to improve upon the use of consistent methodologies on a statewide basis, the policy did not include numeric thresholds for B-IBI data. Based on concerns that category determinations previously relied on individual interpretations of B-IBI scores, Ecology initiated an analysis of the available B-IBI data in the state to determine the appropriate statewide thresholds for listing for the draft 2014 WQA. Ecology used available statewide monitoring program data on benthic aquatic macroinvertebrate communities (i.e. the Ambient Biological, Sentinel, and Watershed Health Monitoring programs) to set statistical thresholds for category designations rather than rely on the interpretation of impairment from individual data submitters, as was done in 2008. The resulting B-IBI score ranges in Table 1 were selected based a review of all available bioassessment data and a comparison to RIVPACS score thresholds.

Table 1: B-IBI scores used in the 2014 Proposed Water Quality Assessment

Category	RIVPACS Score	B-IBI Score
Category 1	≥ 0.86	≥ 38
Category 2	≥ 0.73 up to 0.85	> 27 up to 37
Category 5	< 0.73	≤ 27

B-IBI scores of ≤ 27 (Category 5) and ≥ 38 (Category 1) were selected because they correlated to the RIVPACS thresholds of < 0.73 and ≥ 0.86 , which are already established in Policy 1-11; e.g. samples with RIVPACS scores below 0.73 tended to have B-IBI scores ≤ 27 . Although the two models use different metrics to evaluate biotic integrity, these B-IBI scores were selected to keep consistent WQA category determinations between the two models. These B-IBI thresholds were compared to the statewide B-IBI data Ecology had available at that time (ca. 2012) and it was found that they corresponded approximately to the 25th and 75th percentiles of the distribution of B-IBI scores.

After Ecology established statistical thresholds for Categories 1, 2, and 5 based on available data, we then shared the results and asked for a review from outside staff with expertise in bioassessment and statistics, including staff from King County, Puget Sound Partnership, and EPA Region 10 office. Upon getting concurrence from other experts that the thresholds seemed reasonable for identifying impairment and non-impairment, the resulting B-IBI thresholds were used by Ecology to make category determinations for the 2014 draft freshwater assessment.

Prior to releasing the proposed 2014 WQA, Ecology's Water Quality Program (WQP) requested that the Environmental Assessment Program (EAP) again review the suitability of these score thresholds for determining WQA categories. EAP staff gathered the most current data available to analyze the distribution of B-IBI scores generated for macroinvertebrate communities sampled by Ecology. Scores from 'least impacted' reference sites (i.e. from the Ambient Biological and Sentinel programs) were compared to 571 randomly selected sites sampled across the state (Watershed Health Monitoring program). Based on internal and external concerns that these statistical thresholds can change with the addition statewide data, the WQP requested that the selected thresholds also be compared to reference site scores to determine the error of incorrectly listing waters in Category 5 and Category 1. The following graph illustrates the results of this analysis.

Establishing Benthic Index of Biotic Integrity (B-IBI) Thresholds for Use in the Water Quality Assessment

Figure 1: Distribution of scores in Ecology’s B-IBI data as of 2014

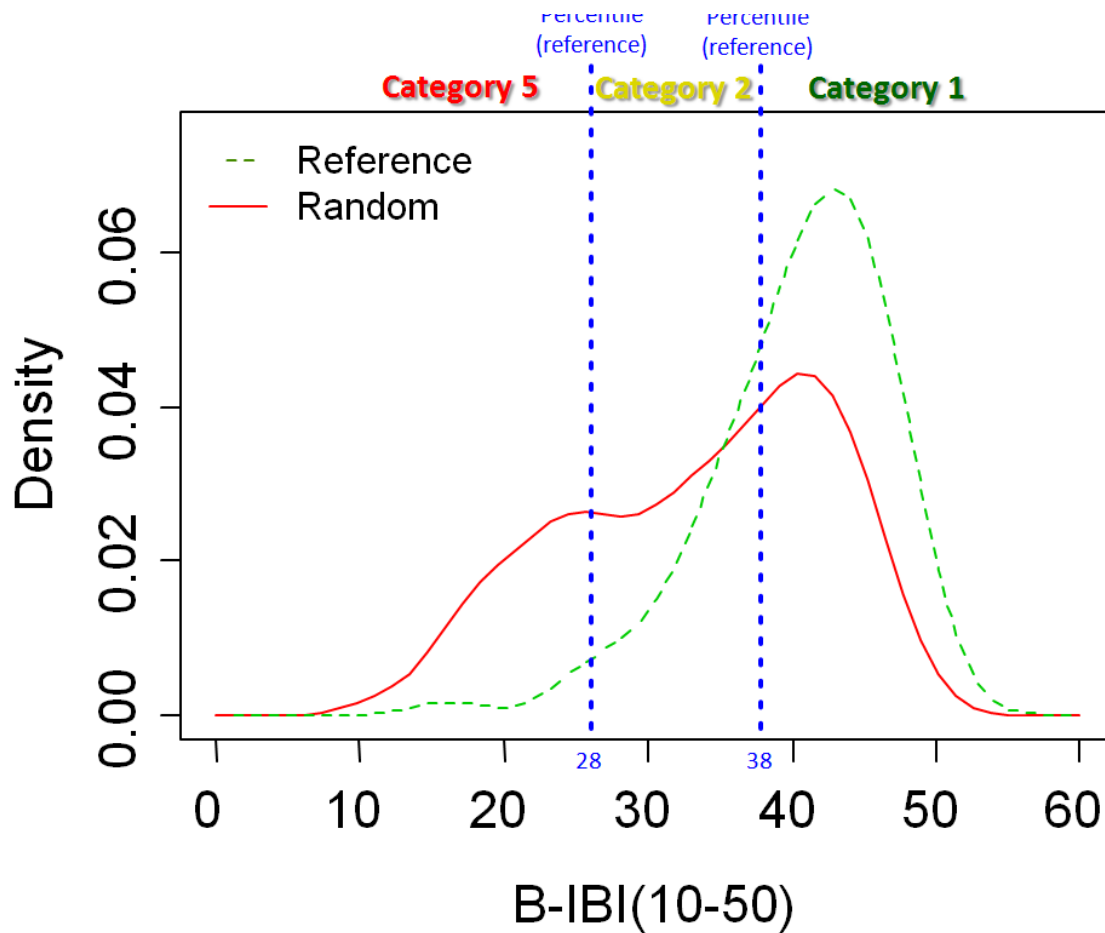


Table 2: Selected percentiles of B-IBI scores from random site and reference site data

	1%	5%	10%	25%	50%	75%
random	13.40	18	20.0	26	36	42
reference	23.36	28	32.4	38	42	44

Given the new, larger dataset, the distribution of the B-IBI scores from statewide randomly selected sites changed from the previous analysis. Scores for the 25th and 75th percentiles of the distribution in this new analysis are 26 and 42, respectively. Ecology considered changing these numbers for the current proposed assessment but determined that there would be very little change to the proposed listing categories and also because the threshold scores correspond to the reference conditions statistics is arguably a better for methodology since the random site data is too easily influenced by the type and location of the random dataset. Therefore, <28 and ≥38 were maintained as the threshold for the categories 5 and 1, respectively.

Establishing Benthic Index of Biotic Integrity (B-IBI) Thresholds for Use in the Water Quality Assessment

Ecology considered revising the B-IBI thresholds based on the 25th and 75th percentiles of the most recent, larger dataset derived from randomly selected sites across the state (see Figure 1 and Table 2 above, red circles in table correspond to 25th and 75th percentiles of the random sites). This consideration was based on the concurrence of the B-IBI thresholds in Table 1 with the 25th and 75th percentiles of the earlier statewide dataset. This approach would have shifted the thresholds from ≤ 27 to ≤ 26 (Category 5) and from ≥ 38 to ≥ 42 (Category 1). However, a more commonly employed approach for setting expectations for stream biological condition is the evaluation of index scores for each sampled site against those from reference or “least impacted” condition (Stoddard et al. 2006).

In summary, a comparison of the random and reference site distributions indicated that it would not be appropriate to use the 25th and 75th percentile of the random site distribution to designate thresholds for Categories 1 and 5 in the 2014 proposed assessment.

In contrast, a comparison of all available B-IBI scores with reference site data shows that the previously selected thresholds of ≤ 27 and ≥ 38 minimizes the error of placing a bioassessment score into an incorrect category. A score of ≤ 27 for a determination of Category 5 correlates to 5th percentile of the distribution of scores for reference sites (see blue circles in Table 2 above) and approximately the 30th percentile of the distribution of scores for random sites. The selection of this index score for the Category 5 minimizes the risk of incorrectly listing a waterbody as impaired, allowing Ecology to say with a very high degree of confidence that a site with a score below ≤ 27 is impaired relative to reference condition. The error rate of incorrectly listing a stream as category 5 would be 5% based on the current analysis, which Ecology determined is an acceptable error rate because of the regulatory impacts of incorrectly making an impairment determination.

The threshold score for determining Category 1 is ≥ 38 . In the current analysis, a score of 38 corresponds to the 25th percentile in the distribution of reference site scores and approximately the 58th percentile of the distribution of random site scores. This shows that approximately 75% of reference site scores and 42% of random site scores would qualify for Category 1. Ecology determined that this is an acceptable error rate for listing in Category 1, because the resulting category for the majority of these errors are Category 2, which does not result in an incorrect impairment determination and has no regulatory impacts. B-IBI scores within the 5th and 25th percentile of reference site scores are placed in the Category 2, waters of concern.

5. Next Steps after the 2014 Assessment is Completed

Ecology will review and update the bioassessment methodology in Policy 1-11, including the addition of B-IBI thresholds and further precision of thresholds in the RIVPACS model on which Ecology’s Environmental Assessment Program is currently working. As in past policy revisions, this will involve input from the public, EPA, tribes, and stakeholders. Although these efforts may or may not result in significant changes to the current category determination thresholds, we recognize that as more data are collected, it will be necessary to evaluate these thresholds statistics and make recommendations for changes in Policy 1-11. Ecology will also explore modifications to the data requirements that are necessary to make a category determination. We will consider options from other states’ policies to minimize Category 2 determinations, such as requiring further habitat or pollution data for waters from which an index score alone is insufficient to delineate Category 1 from Category 5 conditions.