APPENDIX B

Assessment Scoring Criteria

Multimetric Indices and Regulatory Thresholds For Benthic Macroinvertebrate Data In Wadeable Streams

Multimetric Index Development

New Jersey's benthic macroinvertebrate communities can be statistically grouped into three distinct structures based on geographical regions: high gradient (above the Fall Line), low gradient (Coastal Plain excluding the Pinelands), and Pinelands. To accurately assess biological conditions, a multimetric index was developed, using genus level taxonomic identifications for each distinct region using guidelines outlined in USEPA *Rapid Bioassessment Protocols(RBP) for Use in Wadeable Streams and Rivers* (see http://www.epa.gov/bioindicators/html/rbps.html). Before these three indices were developed, a single index was used statewide, the New Jersey Impairment Score (NJIS), which is based on family level taxonomic identifications. All current assessments will use the three genus level indices.

High Gradient and Low Gradient Streams

Two of the indices (see Table A1) to be employed in New Jersey, the High Gradient Macroinvertebrate Index (**HGMI**) [Jessup, 2007] and Coastal Plain Macroinvertebrate Index (**CPMI**) [Maxted, 2000] , were developed using guidelines outlined in USEPA *Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers.* The resolution of index scoring thresholds was further enhanced by establishing a graphical relationship between the scores for each index and the tiers these scores represent in the context of a Biological Condition Gradient (BCG)[see summary of BCG below, and Figure(s) A2 & A3]. The final index scoring thresholds serves to assess each site from two perspectives: the condition of the macroinvertebrate community and the regulatory use attainment.

The final index scores were derived in coordination with professional staff from Water Monitoring and Standards' Bureau of Freshwater and Biological Monitoring, Water Monitoring and Standards' Bureau of Water Quality Standards and Assessment, USEPA, United States Geological Survey (USGS), and the Delaware River Basin Commission (DRBC). For each index, four descriptive categories were established at break points along the statistical distribution of scores from reference to degraded conditions, coordinated to the BCG to increase the accuracy; "Excellent", "Good", "Fair", and "Poor" (see Table A1). "Excellent" and "Good" fall into the acceptable regulatory range of fully attaining the aquatic life use. "Fair" and "Poor" fall below the acceptable regulatory range and are considered impaired, from a Federal Clean Water Act (CWA) perspective, and not attaining the use.

Pinelands Streams

The Pinelands Macroinvertebrate Index (**PMI**) was developed using the same USEPA guidelines and professional coordination as above. However, since a BCG was not developed, and not necessary from a regulatory standpoint, a graphical relationship between index scores and the BCG tiers was not generated. As with the high and low gradient indices, four descriptive categories were established at break points along the statistical distribution of scores from reference to degraded conditions "Excellent", "Good", "Fair", and "Poor" (see Table A1). For PL waters, "Excellent" and "Good" are classified as reference or natural conditions of Pineland waters and fall into the acceptable regulatory range of fully attaining the aquatic life use. "Fair" and "Poor" fall below the acceptable regulatory range and are considered impaired, from a CWA perspective, and not attaining the use.

The unique chemical, physical, and biological properties characteristic of waters contained with the Pinelands area are also present for varying distances outside this jurisdictional delineation. To assess these Pinelands-like waters outside the Pinelands area, the Department delineated a 5 kilometer buffer around the Pinelands Area and will apply the PMI to this region. Pinelands-like waters outside the jurisdictional delineation are, however, classified as FW2 and not PL. From a regulatory standpoint FW2 waters are held to a somewhat lower level of biological expectation than the Outstanding National Resource Waters (ONRW)waters contained within the PL designated Pinelands area. Because of this lower regulatory expectation for FW2 waters, the PMI category of "Fair" and above will be regarded as fully attaining the aquatic life use, i.e. biologically *nonimpaired* from a regulatory perspective. FW2 waters in this buffer region assessed as "Poor" will be regarded as *impaired* and not supporting the aquatic life use.

Coastal Plain Macroinvertebrate Index (CPMI)[1]

Study area: southern New Jersey, below the geologic fall-line; Middle Atlantic Coastal Plain ecoregion, excluding the Pinelands National Reserve. See figure A1.

Index Metrics
1. Total number of genera
2. Total number of EPT genera
3. Percent Ephemeroptera genera
4. Hilsenhoff Biotic Index
5. Percent Clinger genera

	Score			
Index Metric	6	4	2	0
Number of genera	>25	17-25	9-16	<9
Number of EPT genera	>9	7-9	4-6	<4
% of Ephemeroptera	>29	20-29	10-19	<10
Hilsenhoff Biotic Index	<4.9	4.9-6.0	6.1-7.3	>7.3
% Clingers	>51	34-51	17-33	<17

Assessment Rating	Score
Excellent	22-30
Good	12-20
Fair	10-6
Poor	< 6

Reference

J.R. Maxted, et al. Assessment framework for mid-Atlantic coastal plain streams using benthic macroinvertebrates. J.N. Am. Benthol. Soc. 2000, 19(1):128-144.

Attributes

Excellent: Minimal changes in structure of biological community and minimal changes in ecosystem function. Virtually all native taxa are maintained with some changes to biomass and/or abundance; ecosystem functions are fully maintained within the range of natural variability.

Good: Some evident changes in structure of the biotic community and minimal changes in ecosystem function. Some changes in structure due to loss of some rare native taxa; shifts in relative abundance of taxa but sensitive-ubiquitous taxa are common and abundant; ecosystem functions are fully maintained.

Fair: **Moderate to major changes in structure of biological community and moderate changes in ecosystem function.** Sensitive taxa are markedly diminished; conspicuously unbalanced distribution of major groups from that expected; organism condition shows signs of physiological stress; system function shows reduced complexity.

Poor: Extreme changes in structure of biological community and major loss of ecosystem function. Extreme changes in structure; wholesale changes in taxonomic composition; extreme alterations from normal densities and distributions; organism condition is often poor; ecosystem functions are severely altered.

[1] Based on 100 organism subsample, genus level taxonomy

Pinelands Macroinvertebrate Index (PMI)[1]

Study area: southern New Jersey, below the geologic fall-line within the Pinelands National Reserve and extending 5 kilometers outside the Reserve boundary. See figure A1.

Index Metrics

1. Number of Insect genera
2. Number of Non-insect genera
3. Percent Plecoptera (P) and Trichoptera (T)
4. Percent Diptera genera excluding Tanytarsini
5. Percent Mollusca and Amphipoda
6. Beck's Biotic Index
7. Percent Filterers

Assessment Rating	Score
Excellent	≥ 63
Good	< 63-56
Fair	< 56-34
Poor	< 34

Reference

Benjamin Jessup, et al. Report. Development of the New Jersey Pinelands macroinvertebrate index (PMI). TetraTech, Inc. Owings Mills, MD. March, 2005.

Attributes

Excellent: Minimal changes in structure of biological community and minimal changes in ecosystem function. Virtually all native taxa are maintained with some changes to biomass and/or abundance; ecosystem functions are fully maintained within the range of natural variability.

Good: Some evident changes in structure of the biotic community and minimal changes in ecosystem function. Some changes in structure due to loss of some rare native taxa; shifts in relative abundance of taxa but sensitive-ubiquitous taxa are common and abundant; ecosystem functions are fully maintained.

Fair: **Moderate to major changes in structure of biological community and moderate changes in ecosystem function.** Sensitive taxa are markedly diminished; conspicuously unbalanced distribution of major groups from that expected; organism condition shows signs of physiological stress; system function shows reduced complexity.

Poor: Extreme changes in structure of biological community and major loss of ecosystem function. Extreme changes in structure; wholesale changes in taxonomic composition; extreme alterations from normal densities and distributions; organism condition is often poor; ecosystem functions are severely altered.

[1] Based on 100 organism subsample, genus level taxonomy

High Gradient Benthic Index (HGMI)[1]

Study area: northern New Jersey, above the geologic fall-line including the following ecoregions: North Central Appalachians, Central Appalachian Ridges and Valleys, Northeastern Highlands, Northeastern Coastal Zone, and Northern Piedmont. See figure A1.

Index Metrics

1. Total number of genera $_{adj}$ = 26.53 + Metric – [22.776 + 4.173*log10(areasqkm)]
2. Percent of genera that are not insects
3. Percent sensitive EPT (excluding Hydropyschidae, including Diplectrona) $_{adj}$ = 37.49 + Metric – [49.922 – 13.800*log10(areasqkm)]
4. Number of scraper genera $_{adj}$ = 5.44 + Metric – [3.889 + 1.724*log10(areasqkm)]
5. Hilsenhoff Biotic Index $_{adj}$ = 4.23 + Metric – [3.407 + 0.918*log10(areasqkm)]
6. Number of New Jersey TALU attribute 2 genera
7. Number of New Jersey TALU attribute 3 genera

ADJ (Adjusted metric value) = Mean $_{reference}$ + Metric $_{observed}$ – Metric $_{predicted}$, where predictions are based on linear regression analysis of reference metric values on catchment size.

Assessment Rating	Score
Excellent	≥ 63
Good	< 63 - 42
Fair	< 42 - 21
Poor	< 21

Reference

Benjamin Jessup, et al. Report. Development of the New Jersey high gradient macroinvertebrate index (HGMI). TetraTech, Inc. Owings Mills, MD. February, 2007.

Attributes

Excellent: Minimal changes in structure of biological community and minimal changes in ecosystem function. Virtually all native taxa are maintained with some changes to biomass and/or abundance; ecosystem functions are fully maintained within the range of natural variability.

Good: Some evident changes in structure of the biotic community and minimal changes in ecosystem function. Some changes in structure due to loss of some rare native taxa; shifts in relative abundance of taxa but sensitive-ubiquitous taxa are common and abundant; ecosystem functions are fully maintained.

Fair: **Moderate to major changes in structure of biological community and moderate changes in ecosystem function.** Sensitive taxa are markedly diminished; conspicuously unbalanced distribution of major groups from that expected; organism condition shows signs of physiological stress; system function shows reduced complexity.

Poor: Extreme changes in structure of biological community and major loss of ecosystem function. Extreme changes in structure; wholesale changes in taxonomic composition; extreme alterations from normal densities and distributions; organism condition is often poor; ecosystem functions are severely altered.

[1] Based on 100 organism subsample, genus level taxonomy

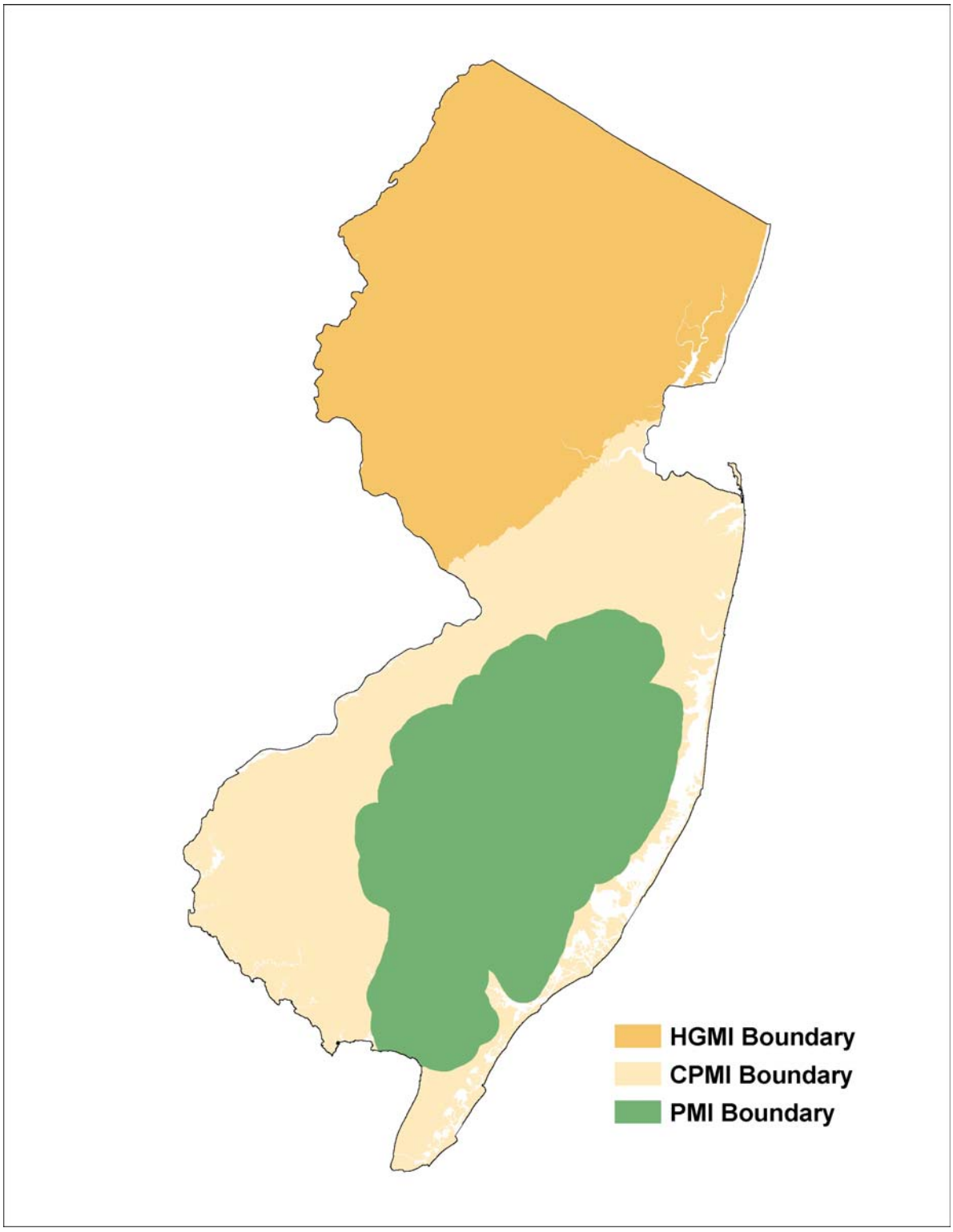


Figure A1. Boundaries for generic level index use.

Table A1: Descriptive and regulatory thresholds for Fresh Water High Gradient (Highlands, Ridge And Valley, Piedmont), Low Gradient (Coastal Plain, Excluding Pinelands Waters) and Pinelands Waters.

High Gradient Macroinvertebrate Index (HGMI) (Highlands, Ridge and Valley, Piedmont):		
Assessment category	**Index Score**	**Regulatory Threshold**
Excellent	63 - 100	Full Attainment
Good	<63-42	Full Attainment
Fair	<42-21	Non-Attainment
Poor	< 21	Non-Attainment
Coastal Plain Macroinvertebrate Index (CPMI)		
Assessment category	**Index Score**	**Regulatory Threshold**
Excellent	22 - 30	Full Attainment
Good	20 - 12	Full Attainment
Fair	10 - 6	Non-Attainment
Poor	< 6	Non-Attainment
Pinelands Macroinvertebrate Index (PMI)		
Assessment category	**Index Score**	**Regulatory Threshold**
Excellent	63 - 100	Full Attainment
Good	<63-56	Full Attainment
Fair	<56-34	Non-Attainment(PL) Full Attainment(FW2)
Poor	< 34	Non-Attainment

New Jersey Impairment Score (NJIS)[1]

Study Area: All of New Jersey. The NJIS was used for assessments in reports prior to 2007. This table can be used when referring to these historical documents.

Index metrics	6	3	0
Taxa Richness (total Families)	>10	10-5	4-0
E+P+T Index (EPT)	>5	5-3	2-0
Percent Dominance (%CDF)	<40	40-60	>60
Percent EPT[2] (%EPT)	>35	35-10	<10
Modified Family Biotic Index[3] (FBI)	<5	5-7	>7

Biological Assessment	Total Score
Non-impaired	24-30
Moderately Impaired	9-21
Severely Impaired	0-6

Reference
Kurtenbach, J. A method for rapid bioassessment of streams in New Jersey using benthic macroinvertebrates. Bull. N. Am. Benth. Soc. 8(1):129. 1991.

Attributes

Non-impaired: Benthic community comparable to other undisturbed streams within the region. A community characterized by a maximum taxa richness, balanced taxa groups and good representation of intolerant individuals.

Moderately Impaired: Macroinvertebrate richness is reduced, in particular EPT taxa. Taxa composition changes result in reduced community balance and intolerant taxa become absent.

Severely Impaired: A dramatic change in the benthic community has occurred. Macroinvertebrates are dominated by a few taxa which are very abundant. Tolerant taxa are the only individuals present.

[1] Based on 100 organism subsample, family level taxonomy. Used in previous assessments, replaced in favor of genus level indices.

[2] Including the hydropsychid family

[3] Also known as the Hilsenhoff Biotic Index

Summary of Biological Condition Gradient

A Biological Condition Gradient (BCG) defining aquatic use attainment, from a regulatory perspective, was established for wadeable streams in New Jersey by TetraTech, a USEPA contractor (Gerritsen and Leppo, 2005). A BCG establishes a conceptual framework of biological condition categories or tiers (6 in all) reflecting a gradient from pristine undisturbed biological communities to the most severe levels of anthropogenic impairment (Figure A4)(Davis and Jackson, 2006) (also see http://www.epa.gov/bioindicators/html/bcg.html for an explanation of a BCG).Theoretically, the BCG and resulting tiers can be applied consistently across broad multi-state regions or even nationally (Davis and Jackson, 2006), and they can provide a tool for states to establish consensus regarding what levels of biological condition do meet the goals of the federal Clean Water Act (CWA) and which do not. Based upon such USEPA sponsored discussions involving 23 states and one tribe, a consensus was established whereby tiers 1-4 are seen as meeting the interim goals of the CWA while tiers 5 and 6 do not (Davis and Jackson, 2006).

The effort to establish a BCG in New Jersey for macroinvertebrate data did not include the Pinelands region of the State because the region represented a unique biological system, different from the high and low gradient streams covered under the scope of the USEPA BCG contract. In addition, waters contained within the Pinelands jurisdiction (as defined under N.J.S.A. 13:18 A1-29) are classified as Outstanding National Resource Waters or ONRW (PL in the New Jersey Surface Water Quality Standards) and as such, the aquatic life designated use for PL waters requires a higher level of protection than that provided by the interim goals of the CWA. The NJ Surface Water Quality Standards delineates the aquatic life designated use in these waters as "Maintenance, migration and propagation of the natural and established biota indigenous to this unique ecological system," hence a BCG was not necessary to establish regulatory cutoffs for benthic macroinvertebrate data. Instead, biological conditions defined within the context of the Pinelands Macroinvertebrate Index (PMI) development were used. (Jessup 2005) .

Figure A2. Comparison of HGMI Scoring Distribution and BCG Tier. (Jessup, 2007)

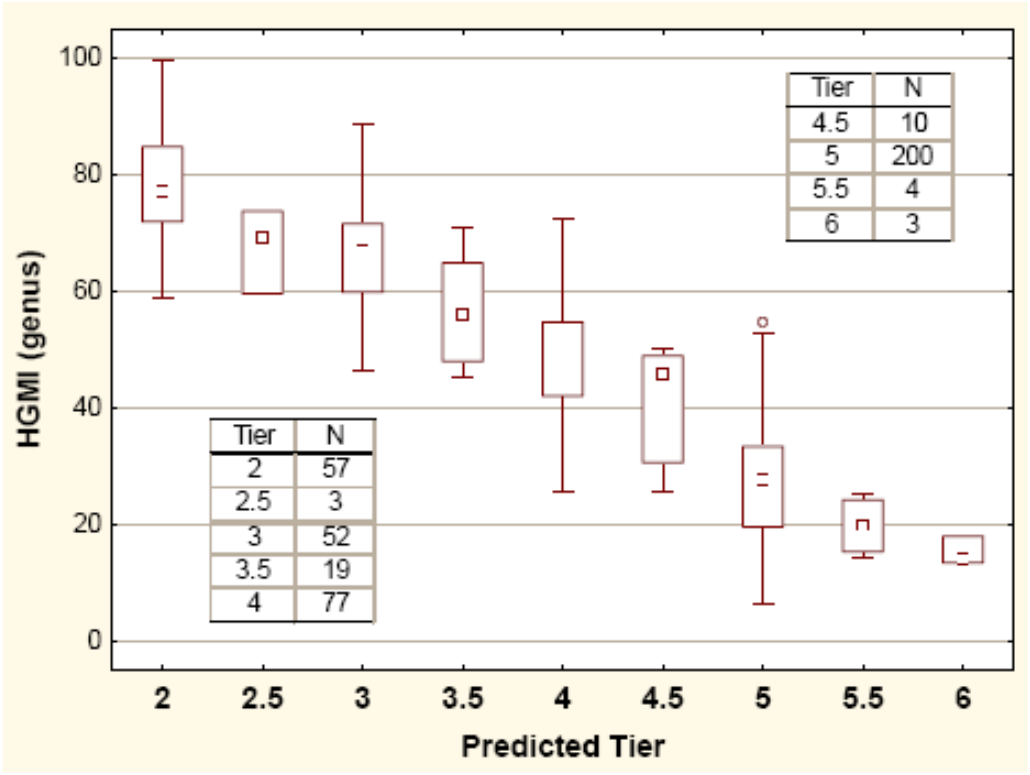


Figure A3. Comparison of CPMI Scoring Distribution and BCG Tier.

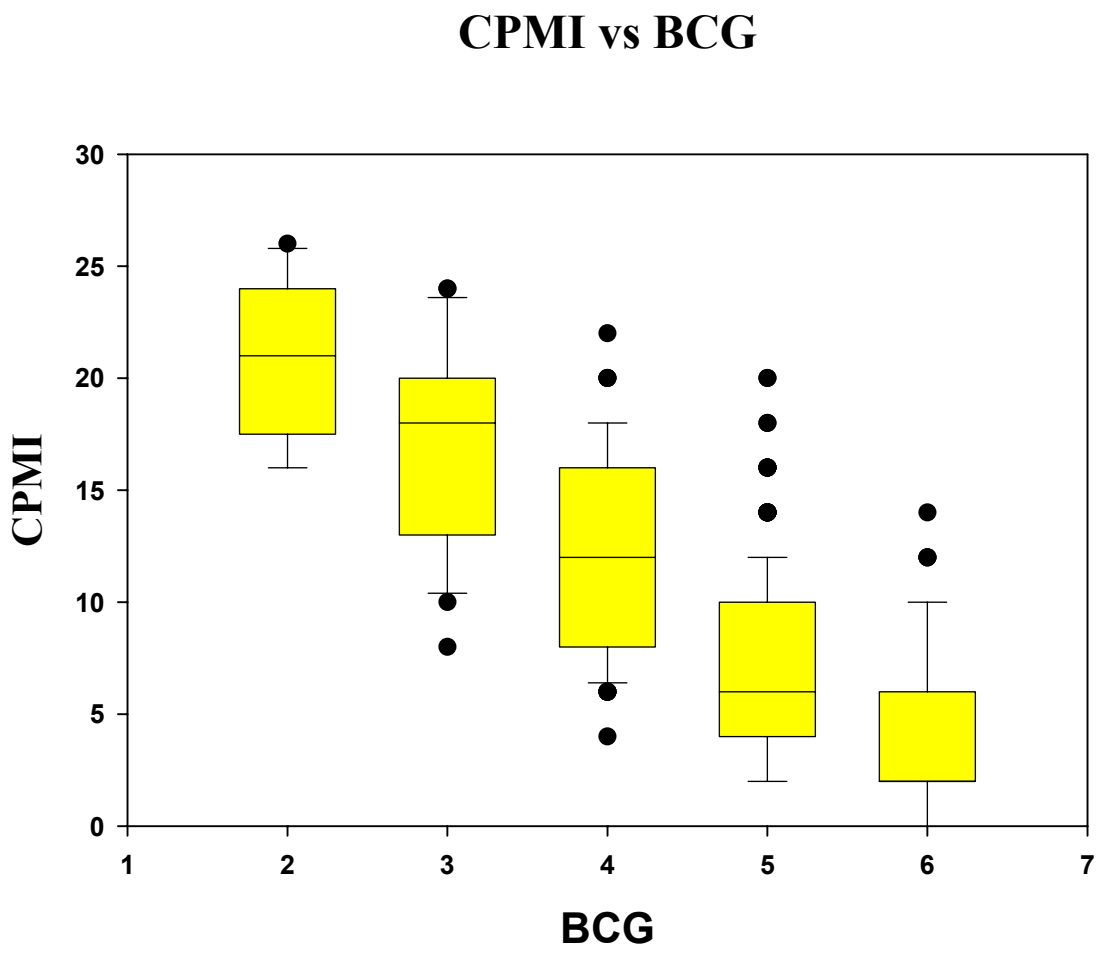


Figure A4.

The Biological Condition Gradient: Biological Response to Increasing Levels of Stress (Davies, Jackson. 2006)

Levels of Biological Condition

Natural structural, functional, and taxonomic integrity is preserved.

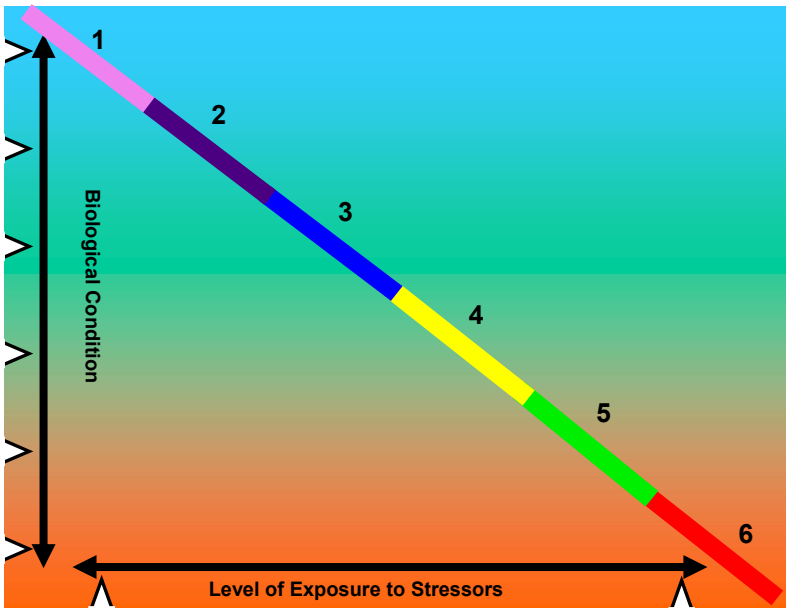
Structure & function similar to natural community with some additional taxa & biomass; ecosystem level functions are fully maintained.

Evident changes in structure due to loss of some rare native taxa; shifts in relative abundance; ecosystem level functions fully maintained.

Moderate changes in structure due to replacement of sensitive ubiquitous taxa by more tolerant taxa; ecosystem functions largely maintained.

Sensitive taxa markedly diminished; conspicuously unbalanced distribution of major taxonomic groups; ecosystem function shows reduced complexity .

Extreme changes in structure and ecosystem function; wholesale changes in taxonomic composition; extreme alterations from normal densities.



Watershed, habitat, flow regime and water chemistry as naturally occurs.

Chemistry, habitat, and/or flow regime severely altered from natural conditions.