# ATTACHMENT
# F

## Region 5 Evaluation of the Illinois' Integrated Report Assessment Methodology: ≥75% Silt/Mud Substrate to Identify Sedimentation/Siltation as a Cause of Impairment

### I. Background Information:

Illinois EPA's (IL EPA) 2008 Section 303(d) list proposed delisting siltation as a cause of impairment for 23 streams based on a revised assessment methodology. This methodology indicated that IL EPA would use a threshold of ≥75% silt/mud for identifying siltation as a cause of impairment. The methodology also indicates that biologists are given latitude to use best professional judgment (BPJ) to assign silt-mud as the cause of impairment at percentages below the 75% criterion. The Illinois' 2008 assessment methodology indicates that the silt/mud habitat metric is used to identify a cause of impairment based on the narrative criterion -- waters shall be free from bottom deposits of other than natural origin[1] (see Table C-5 in the Illinois 2008 Integrated Report).

U.S. EPA-Region 5 (Region 5) requested additional information from IL EPA to understand the change in methodology and was provided with the attached information (attachment A). IL EPA noted the following as a reason for the change in a 9/03/2008 email to Region 5.

*"As stated in the report, our initial justification was that for each of our other habitat guidelines (Stream Habitat Assessment Procedure – SHAP, and Qualitative Habitat Evaluation Index – QHEI, metrics), we use the worst-case (called "Poor") category to indicate the potential for aquatic life use impairment. However, >34% silt/mud was originally considered fair and >75% was considered poor, based on the 85$^{th}$ and 98$^{th}$ percentiles of statewide data, respectively (see Illinois Water Quality Report 2000). Using >75% is more consistent with both SHAP and QHEI."*

Along with this statement, IL EPA provided two scatterplots: one comparing fish community scores with percent silt/mud and one with macroinvertebrate scores to percent silt/mud. Illinois also provided a written interpretation of those two graphs.

*"When looking at the plots, when the percentage of silt mud (x-axis) is plotted with fish or macroinvertebrate IBI scores (y-axis), the points form a conspicuous wedge-shaped gap in the upper right-hand portion of the graphs. When a diagonal line is used to delineate this gap, a limiting factor threshold emerges that approximates the maximum IBI score attained at a given silt-mud percentage. In other words, IBI never exceeds the threshold and silt-mud is the limiting factor for points near the diagonal threshold. The intersection of this diagonal line with a horizontal line placed at the full support Aquatic Life Use criterion can be interpreted along the x-axis as the percentage of silt-mud that limits full aquatic life use support and is the primary cause of impairment. Full aquatic life use support IBI criterion for fish and macroinvertebrates are 41.0 and 41.8, respectively. Mandatory assignment of cause is reserved for those points that both fall below the full use criterion and exceed 75% silt-mud. Field biologists are given*

[1] Title 35: Environmental Protection. Subtitle C: Water Pollution. Chapter I: Pollution Control Board. Part 302.203

*latitude to use best professional judgment to assign silt-mud as the cause of impairment at percentages below the 75% criterion."*

In addition, during conference calls, IL EPA staff indicated to Region 5 that they believe there is a subset of low gradient streams in Illinois that are naturally high in silt/mud[2]. In considering what silt/mud thresholds should be established, it makes sense to evaluate data for both high and low gradient streams.

## II. Region 5's Evaluation

Despite this clarification by IL EPA, Region 5 does not think that a ≥75% threshold for identifying silt/mud as the cause of impairment in Illinois streams is appropriate. When IL EPA establishes a threshold value for silt/mud to implement their narrative criterion, they are performing a form of stressor identification. U.S. EPA's Stressor Identification guidelines[3] suggests that multiple lines-of-evidence (strength-of-evidence) should be considered in specifying the appropriate threshold value that would identify streams in which impairment is caused by silt/mud while minimizing the number of false positives. The primary approach used by IL EPA to establish a threshold was to apply the 98$^{th}$ percentile of all data.

Region 5 recognizes that Illinois EPA's Integrated Report (IR) methodology does allow biologists to apply BPJ to identify silt/mud as a cause when the percentage is less than 75%. Prior to applying BPJ, however, it is important to first ensure that the threshold for silt/mud is set at the appropriate level. Once the threshold is set, BPJ can be used to identify those instances where the threshold inappropriately assigned silt/mud as a cause based on other data and information. Region 5's analysis indicates that the current threshold is set too high.

In addition to establishing a more appropriate threshold, Region 5 believes Illinois' BPJ approach should be refined for three reasons. First, biologists are not required to consider whether silt/mud is causing a problem below the ≥75% threshold and as summarized above EPA's analysis of Illinois data suggests there are impacts below that level. Second, Illinois provided no information for when biologists should apply BPJ in this or other situations. Finally, Illinois provides no information on what criteria should be used by biologists in their application of BPJ. Region 5 believes a more appropriate BPJ process would include additional documentation and would be used to identify when silt/mud above the selected threshold is not one of the causes of impairment.

Below is a summary of our findings.

- Our evaluation shows that in addition to other documented impacts, siltation has been identified as a major stressor to a number of Illinois fish that have been reduced in abundance and/or distribution.
- IL EPA's IR methodology -- including the establishment of a threshold at the 98$^{th}$ percentile of all data and use of an optional BPJ process to identify sites where silt/mud

[2] 8/7/08 conference call between IL EPA and Region 5.

[3] U.S. EPA. Stressor identification guidance document. EPA-822-B-00-025. http://www.epa.gov/waterscience/biocriteria/stressors/stressorid.pdf

causes impairment below that threshold-- implies that silt/mud is a cause of impairment in only about 2% of Illinois streams (sites below the 98th percentile are deemed exceptions to be addressed by BPJ). Region 5 found this does not reflect other studies and research on sediment impacts such as the results of the Wadeable Streams Assessment which indicates that 32% of streams are in either fair or poor condition.

- In fact, Region 5 did not find support for the use of 98th percentile of all data as a threshold based on documented means of selecting thresholds for water quality parameters such as silt/mud.
- Our analysis does show that at the 98th percentile, the likelihood of incorrectly identifying silt/mud as a cause of impairment is very low. However, the likelihood of attainment at approximately 60% silt/mud is the same. Other approaches evaluated by Region 5 such as reference condition suggest that silt/mud is a cause of impairment at even lower levels.
- Additionally, Region 5 was not able to identify a class of streams that appears to have a naturally high silt/mud substrate by analyzing data based on slope or IL EPA IBI region. Our analysis shows that most streams in Illinois (based on the 1999-2007 data used by IL EPA) do not have this level of silt/mud. The analysis also suggests that even low gradient streams are more likely to achieve aquatic life use IBI thresholds for full attainment with substantially lower levels of silt/mud. Region 5 does not believe there is sufficient evidence at this time of such a class of streams to warrant setting a 75% silt/mud threshold to avoid identifying siltation as cause of impairment for such streams. If there is a subset of streams that have a naturally high silt/mud substrate, our data suggest they either make up a very small proportion of streams or additional classification would need to take place to make that determination.
- The strength-of-evidence from Region 5's analyses indicates that the previous IL EPA threshold of >34% silt/mud is not an unreasonable threshold to use.

Our complete reasoning is described below in more detail and includes:

- A description of the water quality impacts of siltation generally and specific references to siltation impacts in Illinois
- A summary of threshold setting processes
- An evaluation of IL EPA data used in the analysis provided to Region 5 (1999-2007 data).

*A. Water Quality and Siltation*

1. General Information on Impacts of Siltation and Sediment:

Excess sediment, including silt and mud, is acknowledged to have an adverse impact on aquatic communities and water quality. Wood and Armitage[4] note that "the causes and deleterious effects of fine sediment suspension and deposition on the ecology of running waters have been widely reported…with the most marked impact on primary productivity, faunal diversity, and abundance." They describe impacts on primary producers (e.g. periphyton), benthic macroinvertebrates, and fish. Wood and Armitage state, "an increase in the volume of fine

[4] Wood, PJ and PD Armitage. 1997. Biological effects of fine sediment in the lotic environment. Environmental Management 21: 203-217.

sediment clearly favors some benthic invertebrates at the expense of others." Similarly, they document a number of ways in which fine sediments adversely affect fish in rivers/streams.

U.S. EPA's Framework for Developing Suspended and Bedded Sediments (SABS) Water Quality Criteria document (SABS document) includes information on the impacts of siltation and other sedimentation issues on biological communities and water quality. The SABS document notes that "Increased sedimentation also may functionally shift the fish community from generalist feeding and spawning guilds to more bottom-oriented, silt tolerant fishes." Additionally, sedimentation alters the structure of aquatic communities by causing a shift in proportions from one functional group to another. "...invertebrate drift is a behavior that is directly affected by increased suspended sediment load in fresh water streams. These changes may be associated with a shift in dominance from ephemeroptera, plecoptera and trichoptera (EPT) insect taxa to other less sediment-sensitive taxa of the benthic assemblage."[5]

Studies identify excess sedimentation (a parameter related to silt and/or including silt) as a major cause of poor water quality in the United States and across specific ecoregions pertinent to Illinois. State Clean Water Act Section 305(b) Water Quality Reports have consistently listed turbidity, suspended solids, sediment, and siltation as dominant polluting factors in rivers and streams. As noted in the SABS document, siltation was ranked as either the first or second stressor among all stressors for rivers and streams in 1996, 1998 and 2000.

**Map 1: WSA Ecoregions**

The National Wadeable Streams Assessment[6] (WSA) indicates that approximately 20% of the streams in the temperate plains ecoregion, which includes Illinois (see map 1), had streambed sediments in poor condition and 12 percent were in only fair condition (condition categories were determined by comparison to least disturbed reference conditions for the ecoregion). While Region 5 recognizes that the WSA's sedimentation indicator is made up of more than just silt/mud, the data suggest that this ecoregion has a fairly widespread issue with sediment in streams.

[5] U.S. EPA. Framework for Developing Suspended and Bedded Sediments (SABS) Water Quality Criteria. EPA-822-R-06-001. 2006.

[6] U.S. EPA. Wadeable Streams Assessment: A Collaborative Survey of the Nation's Streams. EPA 841-B-06-002. 2006. www.epa.gov/owow/streamsurvey

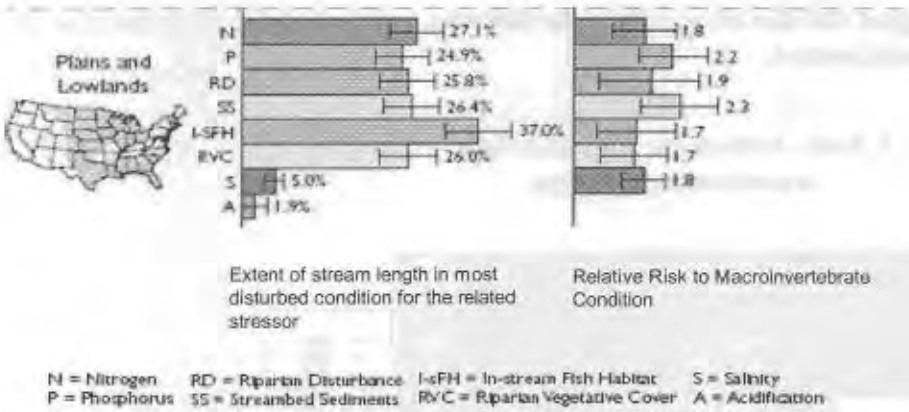



**Figure 1: Relative Risk of stressors to macroinvertebrate communities. Excerpted from the WSA.**

WSA also provides another way to look at this sediment information, although at a larger geographic scale. For the Plains and Lowlands ecoregion (see figure 1), findings show that streams with excess streambed sediments are 2.3 times more likely to have poor macroinvertebrate condition. This relative risk analysis is similar to information presented in the health field related to the increased risk to your health from smoking, for example. Again, while the parameter and scale do not match exactly with the Illinois' monitoring data, this information indicates that excess sedimentation including silt/mud, is a significant stressor to biological communities across the central U.S.

2. Illinois and Siltation - Specific Information

a. Fish: As noted above, fine inorganic sediments, especially silts and clays, can alter the distribution and abundance of fish species. "Fishes of Illinois" by Philip W. Smith[7] provides detailed information on the fishes of Illinois including declines, expansions and likely causes. In "Fishes of Illinois," Smith indicates that the distribution and/or abundance of a large number of fish have declined in Illinois. According to Smith, one of the most prevalent causes of these changes is increased siltation. For example, the Golden Redhorse, Northern Hogsucker, Spotted Sucker, and the Brook Silverside have declined in either range or abundance. Smith identified siltation as one the leading causes of these declines. Smith also indicates that a number of silt-tolerant species have expanded their range as silt has increased in the state. For example the Creek Chub, Red Shiner, and Gizzard Shad have expanded their distribution and/or increased in abundance in Illinois.

b. Macroinvertebrates: Information cited above indicates that increased sediment can result in a *shift in dominance from ephemeroptera, plecoptera and trichoptera (EPT) taxa to other less pollution-sensitive species.* An examination of IL EPA (1999-2007) EPT scores by percent silt/mud indicates a decline in overall EPT scores as silt/mud increases (see figure 2). Region 5 did not have information on specific tolerant macroinvertebrates to determine if a related change took place.

[7] Smith, Philip W. The Fishes of Illinois. Published for the Illinois State Natural History Survey by the University of Illinois Press Urbana, Chicago, London. 1979.

These data suggest that like other parts of the Midwest and the country, sedimentation is impacting Illinois streams.

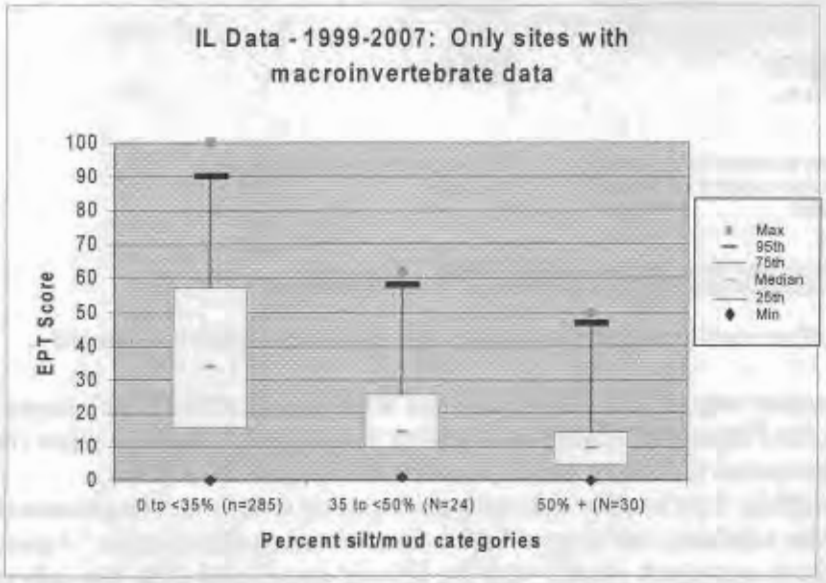



**Figure 2: IL EPA Data - EPT Score and Silt/Mud Levels**

*B. Establishing Thresholds:*

Illinois' explanation for the change in the silt/mud threshold between 2006 and 2008 Integrated Report (IR) methodologies indicated that the primary reason for the change was to facilitate consistency with the way other habitat metric scores were interpreted. Based on the IL EPA IR methodology, however, the silt/mud metric is used to evaluate a narrative criterion whereas the use of some habitat metrics to identify causes of impairment are not as directly linked to a specific criterion by IL EPA (e.g. alteration in stream-side or littoral vegetative covers, loss of instream habitat, etc.) (see Table C-5 in the Illinois report). Region 5 thinks this difference suggests that consistency is not automatically required in how the indicators are evaluated.

In order to determine whether the threshold selected by IL EPA for silt/mud (≥75% silt/mud) is appropriate, Region 5 attempted to evaluate the validity of the approach Illinois used – setting their threshold at the 98$^{th}$ percentile of all state-wide data (1978-1996 data) (that is, only 2% of streams are definitively impacted by silt/mud). Illinois appears to have employed a single line of evidence to support this threshold/causal analysis. Region 5 did not find references to the use of the 98$^{th}$ percentile of statewide data as an applicable approach for establishing water quality thresholds.

The Illinois 2008 revised assessment methodology raises the threshold for identifying siltation as a cause of biological impairment from the 84$^{th}$ percentile to the 98$^{th}$ percentile of all data. IL EPA indicated that both the previous (84$^{th}$) and revised (98$^{th}$) silt/mud thresholds are based on categories from Illinois habitat assessment protocols (Illinois' SHAP method and Ohio's QHEI). Based on the citation provided in the statement included above (*Illinois Water Quality Report 2000),* the SHAP thresholds for "good" "fair" and "poor" are based on percentiles of all Illinois

data between 1978 and 1996. To our knowledge, the QHEI categories are based on simple quartiles of the data (e.g. 0-25, 25-50, 50-75, and greater than 75% silt). The methodology states that the revised threshold reflects the "poor" category from SHAP/QHEI protocols.

IL EPA did not provide, and Region 5 was not able to find in other sources, an explanation as to why the 98th percentile of all data is an appropriate threshold to use. To the best of our knowledge, neither the SHAP nor QHEI categories were developed specifically for setting a numeric threshold for identifying aquatic life use impairment/cause or analyzed with that purpose in mind. Region 5 did not conduct further analyses of this approach.

We researched and examined other documented approaches for setting water quality benchmarks applicable to silt/mud when toxicity tests or other controlled experiments are not practical or variability across the country are expected based on specific geographical conditions. As suggested by the SABS document, we utilized field data by analyzing IL EPA data from 1997-2007 (the same dataset used by IL EPA for their analysis included in Appendix A) to determine if the ≥75 percent silt/mud threshold appears to be reasonable according to the more common, documented approaches we identified in U.S. EPA guidance and other sources. IL EPA indicated to Region 5 that they believe some Illinois streams with very low gradients (slopes) likely have naturally high levels of silt/mud, but did not provide further information or analysis to support this theory. None-the-less, we analyzed the available data to examine slope across the state and within IL EPA IBI regions with the lowest average slopes (IBI Regions 9, 10, and 11). See Appendix B for a map of the Illinois IBI regions.

The approaches considered by Region 5 were using reference site data to establish reference condition/least disturbed condition; using all data in a population; 95th best fit line; and likelihood of attaining aquatic life use. Please note, Region 5 did not attempt to address approaches that required significant statistical data manipulation such as multiple regression, conditional probability, etc.

Region 5 does not believe that any one of the approaches evaluated is the default "right" process. Rather we believe evaluating the results from these multiple lines of evidence can help identify thresholds and/or ranges of thresholds that will most effectively protect water quality. A strength-of-evidence approach is supported by U.S. EPA's Stressor Identification guidance document[8] and the SABS document. The SABS document states specifically "...analysis that develops SABS associations with response indicators should take advantage of the benefits of comparing results from several methods using different data sets, thereby, allowing criteria selection to be supported by the strength-of-evidence."[9]

1. Approach 1 - Using reference site data to establish reference condition/least disturbed condition - A common way for determining water quality thresholds is to examine data from reference sites to establish a reference "condition." Reference conditions are developed to reflect the least disturbed condition existing for specific waterbody types and/or regions (for example,

[8] U.S. EPA. Stressor Identification Guidance Document. EPA-822-B-00-025. 2000. http://www.epa.gov/waterscience/biocriteria/stressors/stressorid.pdf

[9] U.S. EPA. Framework for Developing Suspended and Bedded Sediments (SABS) Water Quality Criteria. EPA-822-R-06-001. 2006.

the least disturbed condition of streams in Illinois or Maine; the least disturbed condition of large rivers in the cornbelt plains ecoregion, etc.) Reference condition typically does not equate to "pristine" but does represent the best of what exists in the landscape.

By establishing this least disturbed condition, reference conditions serve as the benchmark of condition for a given indicator, metric or parameter against which a waterbody's condition is compared. A reference condition can be derived from reference sites, an empirical model of expectations that may include knowledge of historical conditions, or a model extrapolated from ecological principles. Actual sites that represent best attainable conditions of a waterbody are often used. Generally, U.S. EPA recommends the use of a regional reference condition based on an aggregate of sites. Typically, the threshold or benchmark used to determine whether a particular stream is within an acceptable range of a given parameter (in this case silt/mud) is set at a percentile of these least disturbed sites.

- U.S. EPA's Consolidated Assessment and Listing Methodology (CALM) indicates that the use of a reference based approach similar to that used for identifying multimetric indices is applicable for establishing habitat metric thresholds (such as silt/mud). CALM indicates that population statistics, such as the 25th or 10th percentile of data on the specific indicator from the reference sites, are commonly used[10]. A 25th or 10th percentile is used to recognize that conditions at candidate reference sites are variable, and those at the lower end of the reference scale (i.e. poorer quality) may not truly reflect least disturbed condition. (Note – for variables which decrease in quality as the numbers increase, the inverse percentiles would be appropriate – 75$^{th}$ and 90$^{th}$ percentile. Ex. Higher IBI scores are generally considered indicative of higher quality so the 25$^{th}$ percentile of IBI scores is closer to the "poor" end of the reference spectrum. Higher metals concentrations or higher silt/mud levels are generally considered indicative of poorer quality, so the 75$^{th}$ percentile of metals concentration would be closer to the "poor" end of the reference spectrum.)

---

[10] U.S. EPA. Consolidated Assessment and Listing Methodology. 2002. http://www.epa.gov/owow/monitoring/calm.html

CALM also includes the following citations for this approach:
Yoder CO, Rankin ET. 1995. Biological criteria program development and implementation in Ohio. In: Davis WS, Simon TP, eds. Biological assessment and criteria: Tools for water resource planning and decision making. Boca Raton, FL: Lewis Publishers, pp. 109-144.

DeShon JE. 1995. Development and application of the invertebrate community index (ICI). In: Davis WS, Simon TP, eds. Biological assessment and criteria: Tools for water resource planning and decision making. Boca Raton, FL: Lewis Publishers, pp. 217–243.

Barbour MT, Gerritsen J, Griffith GE, Frydenborg R, McCarron E, White JS, Bastian ML. 1996. A framework for biological criteria for Florida streams using benthic macroinvertebrates. J N Am Benthol Soc 15:185-211.

Roth NE, Southerland MT, Chaillou JC, Volstad JH, Weisberg SB, Wilson HT, Heimbuch DG, Seibel JC. 1997. Maryland biological stream survey: Ecological status of non-tidal streams in six basins sampled in 1995. Report no. CBWP-MANTA-EA-97-2, Maryland Department of Natural Resources, Annapolis, MD.

- U.S. EPA's national assessment of stream quality, the Wadeable Streams Assessment, used the 5th percentile of reference for individual parameters to determine the difference between poor and fair sites and 25th percentile to distinguish between fair and good sites.
- U.S. EPA's *Framework for Developing SABS Water Quality Criteria* document also referenced the use of the 75th percentile of reference data as one possible approach for setting sediment–related criteria/thresholds.

These and other documents also indicate that to refine the use of the reference based approach, sites can be further categorized to account for ecoregional or stream classification differences (low gradient streams, for example).

2. Approach 2 - Using all data in a population - If reference site data are not available, another threshold-setting process is to use the 5th to 25th percentile of all data (includes reference and non-reference data) as the cut off for estimating least disturbed condition. This was cited in U.S. EPA's nutrient criteria documents as one way to approximate reference condition[11]. See Figure 3 for an example of this approach. This range of percentiles is for variables for which higher levels are general considered to be "poorer" condition -- such as nutrients or sediment. For reverse direction variables (like IBI scores) the inverse percentiles would be appropriate.

In response to comments regarding the use of this approach, U.S. EPA stated "the scientific community uses frequency distributions as a common basic interpreter of data with the upper and lower quartiles as an admittedly subjective, but traditional, approach to viewing the extent of a distribution about a central tendency. It is not mandatory or expected that the reference condition so derived be translated directly into a criterion. The selection of an upper quartile (or lower quartile with mixed water quality samples) is also consistent with the EPA policy to set levels protective of the majority of waters and has been peer reviewed both by EPA's SAB and external peer reviewers of our water body type technical guidance.[12]"

This percentile approach for all data differs markedly from that used by IL EPA. The 98h percentile of all data would move the vertical lines in the example below to somewhere to the right of the 40 µg/l line.

[11] U.S. EPA. Nutrient Criteria Technical Guidance Manual: Rivers and Streams. EPA-822-B-00-002. 2000. http://www.epa.gov/waterscience/criteria/nutrient/guidance/rivers/index.html

[12] ACTION: Notice of ecoregional nutrient criteria for lakes and reservoirs, and rivers and streams. Federal Register: January 6, 2003. Volume 68, Number 3. Page 557-560. http://edocket.access.gpo.gov/2003/03-176.htm

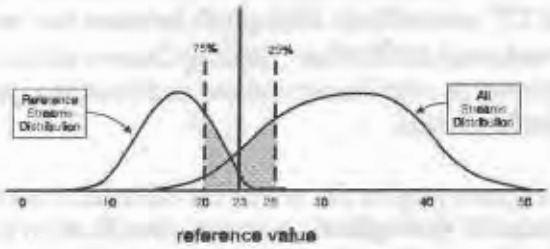



Figure 8. Selecting reference values for total phosphorus concentration (µg/L) using percentiles from reference streams and total stream populations.

**Figure 3: Example figure from U.S. EPA's Nutrient Criteria Development document. http://www.epa.gov/waterscience/criteria/nutrient/guidance/rivers/rivers-streams-full.pdf**

3. Approach 3 - 95th Best fit line - Another means of establishing thresholds is by drawing a "best fit line" to approximate the maximum expectations. Illinois appears to have used a version of this process in its analysis (refer to the graphs shown in Appendix A). The final report of the Intergovernmental Task Force on Monitoring Water Quality noted that that when dataplots show a triangle or wedge shape, a line with a slope fit to include about 95 percent of the sites is an appropriate approximation of a maximum line of expectations. This approach was suggested by Fausch, Karr and Yant[13]. Ohio EPA described this process as "A line drawn on the outer surface of the data points so that 95% of the points fall to the left or beneath the line…[14]" This line can be done by estimating the location of the line or by using a more objective process such as quantile regression. Quantile regression has been shown in some cases to be a robust estimate of the effects of an environmental factor on a biological endpoint[15].

4. Approach 4 - Likelihood of Attaining aquatic life use - Another useful approach in causal analysis can be evaluating the likelihood of attaining aquatic life uses (or biological thresholds as established through IBIs, etc.) at varying levels of a stressor. This entails looking at the relationship between biological endpoints (e.g., IBI scores) and a stressor variable (e.g., silt/mud). In some cases, this might involve simply plotting the data in scatterplots or running other statistical analyses. In other cases, including Region 5's analysis, this can involve categorizing the stressor variable to form groups (e.g., 0-35% silt/mud, 35-50% silt/mud, etc.) This allows us to examine whether and where a change in the likelihood of attaining biological endpoints takes place at varying levels of the stressor.

---

[13] Fausch KD, Karr JR, Yant PR. Regional Application of an Index of Biotic Integrity Based on Stream Fish Communities. Transactions of the American Fisheries Society: Vol. 113, No. 1 pp. 39–55. 1984

[14] Yoder, Chris O. Important Concepts and Elements of an Adequate State Watershed Monitoring and Assessment Program. 1997. http://www.epa.state.oh.us/dsw/documents/Adeq_Mon1.pdf

[15] Cade, BS, JW Terrell, and RL Schroeder. 1999. Estimating effects of limiting factors with regression quantiles. Ecology 80:311-323.

*C. Evaluation of IL EPA's silt/mud threshold*[16]

To evaluate whether IL EPA's threshold of 75% silt/mud is an appropriate threshold given the above cited U.S. EPA guidance and other literature, we conducted analyses with the dataset used by IL EPA to create the graphs referenced in Appendix A (1999-2007 data). Region 5 evaluated the data based on percentiles of all data in a population, reference or least disturbed data, 95% best fit line, and the likelihood of attainment.

One reason put forward by IL EPA for increasing the threshold value to 75% silt/mud was that naturally low gradient streams in Illinois have naturally high levels of silt. To test this point, we categorized available data by slope and ecoregion. Note, Region 5 did not have slope for all sites, so some sites are not included in this analysis.

1. Using all data in a population - IL EPA selected a threshold based on all Illinois data for the IR Report that falls in the range of the 98th percentile of all data. U.S. EPA's recommended guidance for using all data (including reference and non-reference sites) is to set the threshold between the 5th-25th percentiles to help establish a reference condition. As shown in Figure 4, the 25$^{th}$ percentile for all Illinois data falls well below the current threshold selected by IL EPA (≥75% silt/mud.). Region 5 does not believe that this threshold is supported by guidance or other available sources referenced above.

[16] Region 5's analysis uses data from:

- IL EPA 1999-2007 (same data set as used by IL EPA in their analysis.)
- Least disturbed identification for sites were identified from a dataset of fish sites used in developing IL EPA's fish IBI. Not all of the least disturbed sites provided in the dataset were also included in the 1999-2007 dataset so only a subset of the sites were used in this analysis.

Graphs were generated in Excel. Rank and Percentile statistical analysis tool was used to identify the 25$^{th}$, 75$^{th}$ and 95$^{th}$ percentiles for Box and Whisker Plots. When these percentiles were not identified exactly by the data analysis tool, the closest percentile (whether above or below) was used. Median, Minimum and Maximum data points were identified using the descriptive statistics data analysis tool.

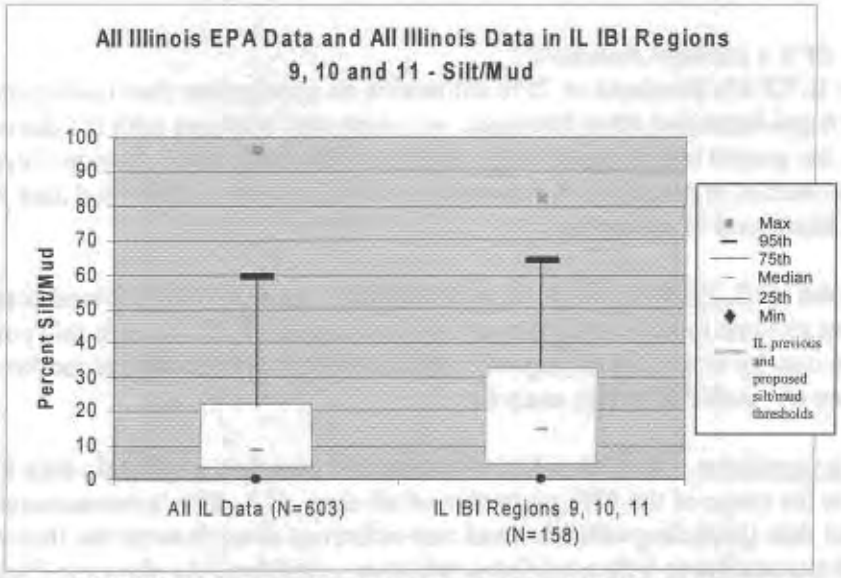



**Figure 4 - All data from Illinois (1997-2007) and selected low-gradient regions (IL IBI Regions 9, 10 and 11 - see Appendix B**

Because it can be important to classify streams to reduce variability when setting thresholds, Region 5 evaluated Illinois' data by slope categories and within three Illinois IBI regions with the lowest average stream slopes (based on data from the 1999-2007 Illinois dataset.) This evaluation can help determine whether the 75% silt/mud threshold might be applicable for a class of low-gradient streams.

In the Illinois database, slopes range from 0-0.94697%. The average slopes for Illinois IBI Regions and the slope ranges for each are show in Table 1. As shown in Figure 4, the data from all sites within IBI regions 9, 10 and 11 show that the 25$^{th}$ percentile (as well as the 75$^{th}$ percentile) of all data are below 35% silt/mud. Establishment of a 75% silt/mud threshold based on the use of all data does not appear to be in keeping with U.S. EPA's recommended guidance for this approach.

Table 1 - Comparison of the Percent Slope of Streams by Illinois EPA IBI Regions (1999-2007 Data)

| IBI Region | Average Slope (percent) | Range |
|---|---|---|
| 2 | 0.089986667 | 0.1479 |
| 4 | 0.06694069 | 0.30763 |
| 6 | 0.08268 | 0.36125 |
| 7 | 0.088014032 | 0.47349 |
| 8 | 0.101549355 | 0.31566 |
| 9 | 0.028400909 | 0.1 |
| 10 | 0.05976875 | 0.21469 |
| 11 | 0.0483602 | 0.13528 |
| 12 | 0.13618913 | 0.94339 |

Additionally, Region 5 categorized streams from the Illinois dataset into 4 categories: <.02,.02-<.04, .04-.1 and >.1 percent slope (Figure 5). If, as Illinois hypothesizes, low gradient streams often have levels of silt/mud that would argue for a 75% threshold, we would expect to see the box portion of the box and whiskers plot for the low gradient streams should approach that threshold. However, these Illinois data show that most streams – even in the lowest gradient streams – have significantly less than 75% silt/mud. Regardless of the category of slope, typical conditions do not come close to 75%. In fact, less than 2% of the data available in the <.02 slope range actually has silt/mud >75%. This is similar to the results for all data in Illinois (figure 4) where only 2% of the sites have silt/mud greater than 75%. For higher level slopes, the percent of sites above 75% silt/mud are also very low – about 3.5% for streams between .02 and <.04 percent slope, and virtually zero for the other two categories.

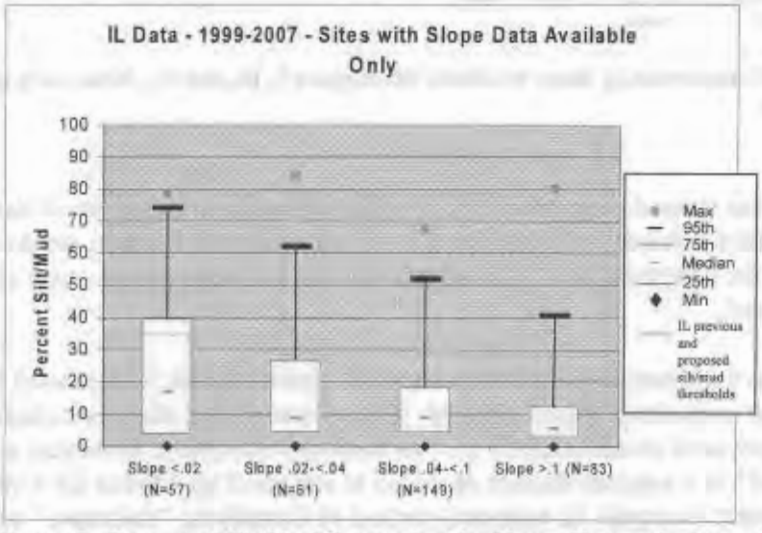



**Figure 5 - Percent of Silt/Mud Categorized by Slope. Note, only data with slope provided was used (350 sites out of 603 total in the IL dataset)**

Because it is possible that streams within some regions of Illinois might behave differently from others, we also evaluated the percent of silt/mud by slope for 3 selected IBI regions with lowest average slopes (based on the 1999-2007 used by IL EPA – IBI regions 9, 10, and 11) (Figure 6). The data for these three IBI regions do not look significantly different than those for the state as a whole (refer back to Figure 5). Again, the 25$^{th}$ (and even 75$^{th}$) percentiles of the data for these 3 regions are substantially less than IL's proposed threshold of ≥75% silt/mud. In these regions, less than 3% of the data in the <.02 slope category have >75% silt/mud. Less than 10% of the sites in the <.02 slope have silt/mud greater than 55%.

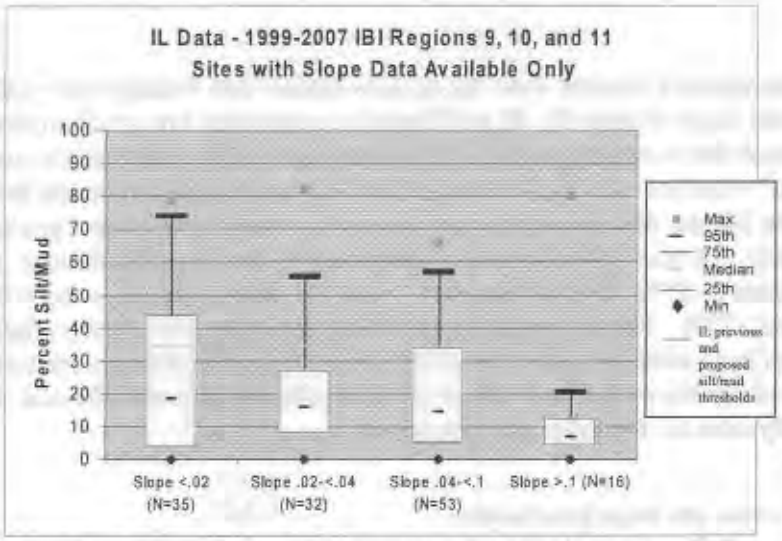



**Figure 6: Percent of Silt/Mud Categorized by Slope in Illinois IBI Regions 9, 10, and 11. Note - only sites with slope provided were used.**

Region 5 does not believe that these data support a 75% silt/mud threshold based on all data for the state or selected ecoregions, even when classified by region and slope. Further, we do not think these data show that that extremely low gradient streams are naturally prone – as a class – to such high levels of silt/mud.

2. Reference Data – Region 5 did not have access to a specific reference site dataset used by Illinois to develop both their macroinvertebrate and fish IBIs. Some of the streams included in the 1999-2007 Illinois dataset used in our analysis for this response document, however, were identified as "least disturbed" in a separate dataset provided to Region 5 by Illinois EPA (from IL EPA's fish IBI development process). As a second method of identifying "reference" or least disturbed sites, we examined those sites that were considered to be fully meeting Illinois' biological thresholds. Although this is not necessarily representative of a set of reference sites, the sites "meeting" biological thresholds may be presumed to be less disturbed than those not meeting the biological thresholds. Additionally, SABS document indicated that "using a population of sites that meets designated uses is defensible, but may put valued resources at risk if the sites do not protect downstream uses, if the designated uses are somewhat lax, or if waterbody sub-types were too broadly defined."[17]

IL EPA stated that "*Full aquatic life use support IBI criterion for fish and macroinvertebrates are 41.0 and 41.8, respectively.*" We compared these least disturbed sites to all others sites in the dataset and we compared the sites that were meeting biological thresholds to those that were not meeting biological thresholds to determine if there was a difference in silt/mud levels. It is important to note, in our use of the data, if either the fish or macroinvertebrate IBI scores were below their respective criterion, we identified the site as not fully supporting aquatic life use.

[17] U.S. EPA. Framework for Developing Suspended and Bedded Sediments (SABS) Water Quality Criteria. EPA-822-R-06-001. 2006.

a. Least Disturbed sites

We analyzed data for sites identified as least disturbed in the fish IBI dataset provided by IL EPA to Region 5 and for which we had corresponding data in the 1999-2007 dataset used by IL EPA in their analysis (see Appendix A). As noted above, typical threshold values for setting thresholds using reference data range from the 75$^{th}$ to the 90$^{th}$ percentile.

In Region 5's analysis, the least disturbed Illinois sites generally have less silt/mud than all other sites in the dataset. Least disturbed sites indicate that the 75$^{th}$ percentile of these data is approximately 10% silt/mud and the 95$^{th}$ percentile falls below 30% silt/mud (the 90$^{th}$ percentile is 17% silt/mud). In no case did the silt/mud levels rise above 42% (figure 7a). We also split the least disturbed sites out by slope. There was not a significant increase in the silt/mud for least disturbed sites in even the very low gradient sites (<.02% slope) (figure 7b) suggesting that these streams can maintain relatively low levels of silt/mud in a manner similar to other streams.

Region 5 believes that using the reference-based approach for identifying thresholds does not support the 98$^{th}$ percentile of silt/mud as an appropriate threshold for protecting aquatic life use.

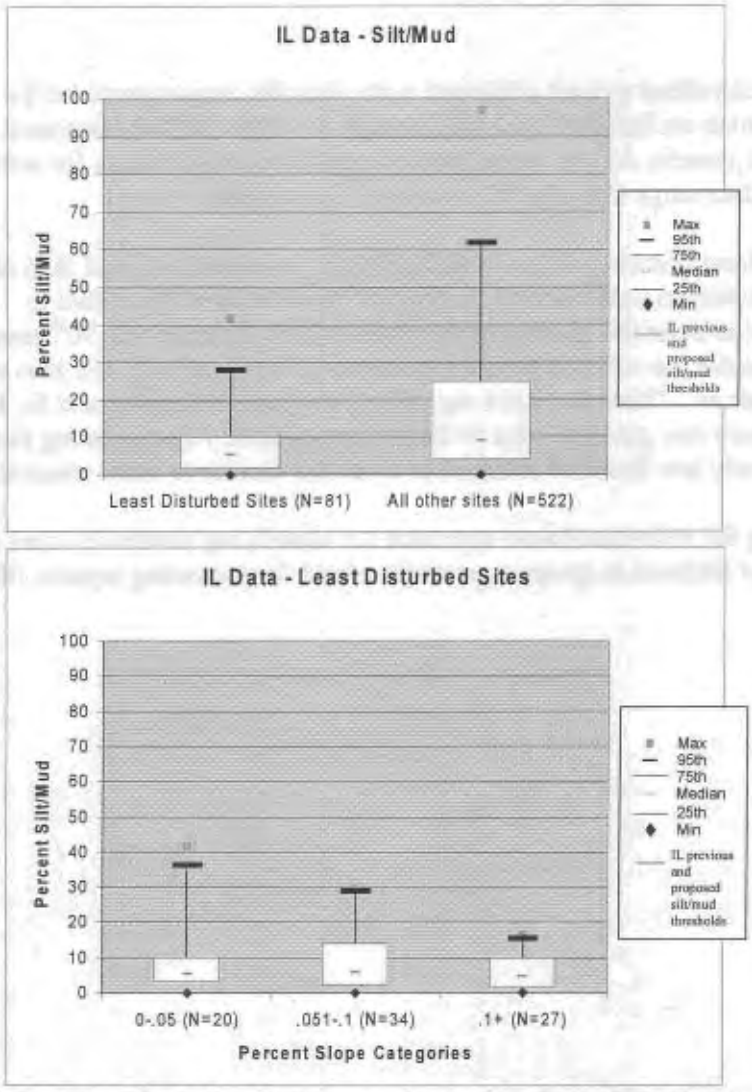



**Figure 7: a. Least disturbed sites v. all other sites and b. Least disturbed categorized by slope (IL data 1999-2007)**

b. Sites Meeting Aquatic Life Use:

Region 5 also evaluated the set of sites in the Illinois data set identified as meeting full aquatic life use (above the applicable fish and/or bug IBI scores of 41 and 41.8 respectively). Using this approach, the 75$^{th}$ percentile of data meeting Illinois's biological thresholds for aquatic life use full support occurs at less than 15% silt/mud. The 95$^{th}$ percentile is less than 40% silt mud; the 90$^{th}$ percentile equals 28.7% silt/mud (Figure 8). Less than 1% of sites meeting biological thresholds are above the 98% percentile set by IL EPA in their 2008 Integrated Report.

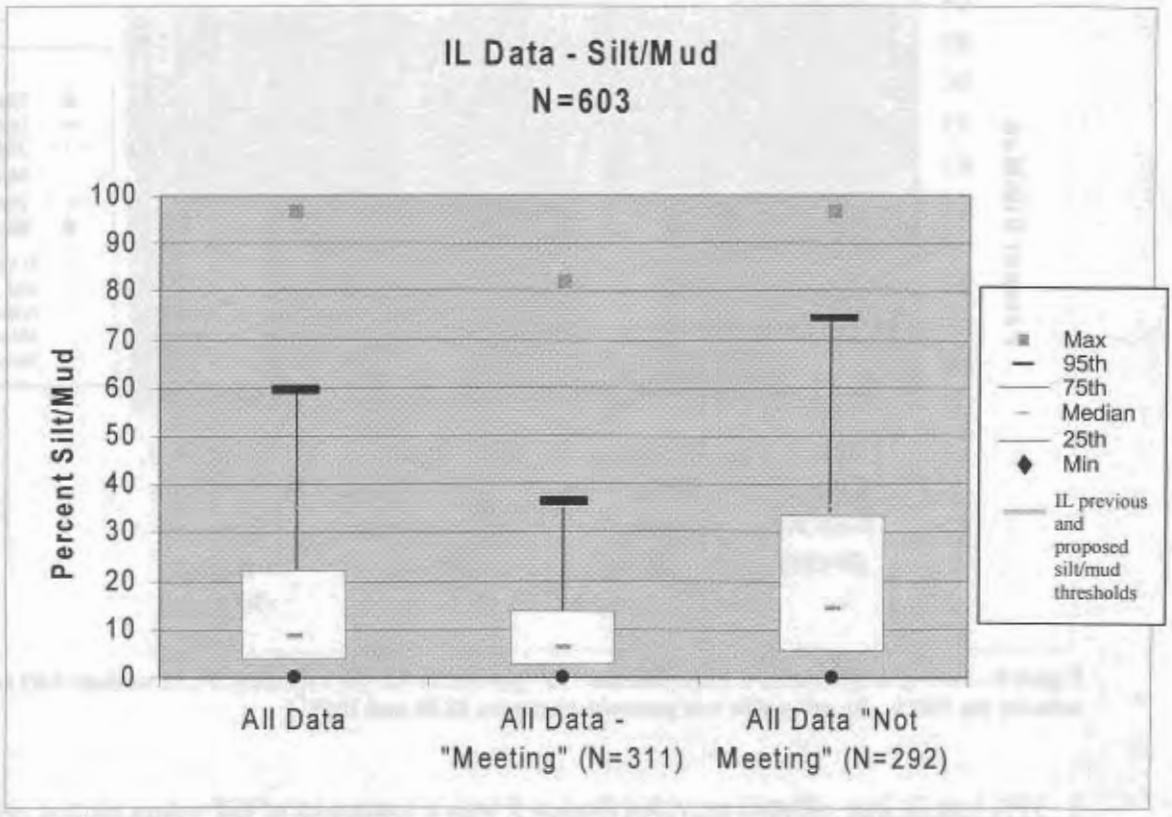



**Figure 8: All IL data (used in the IL Assessment to support their revised threshold) categorized by meeting/not meeting**

As with other approaches discussed already, Region 5 believes that the 75% silt/mud threshold is not supported when a reference-based approach is applied.

Region 5 also evaluated the data by slope and three Illinois IBI regions. Figure 9 shows the results for the sites with <.02 percent slope across the state and those within IBI regions 9, 10 and 11. Those sites meeting IBI scores had silt/mud scores lower than those that did not. No sites at this low gradient were able to attain IBI thresholds at more than 40% silt/mud. Applying a reference based approach to sites that attain Illinois biological thresholds suggests that the ≥75% silt/mud threshold selected by IL EPA is too high.

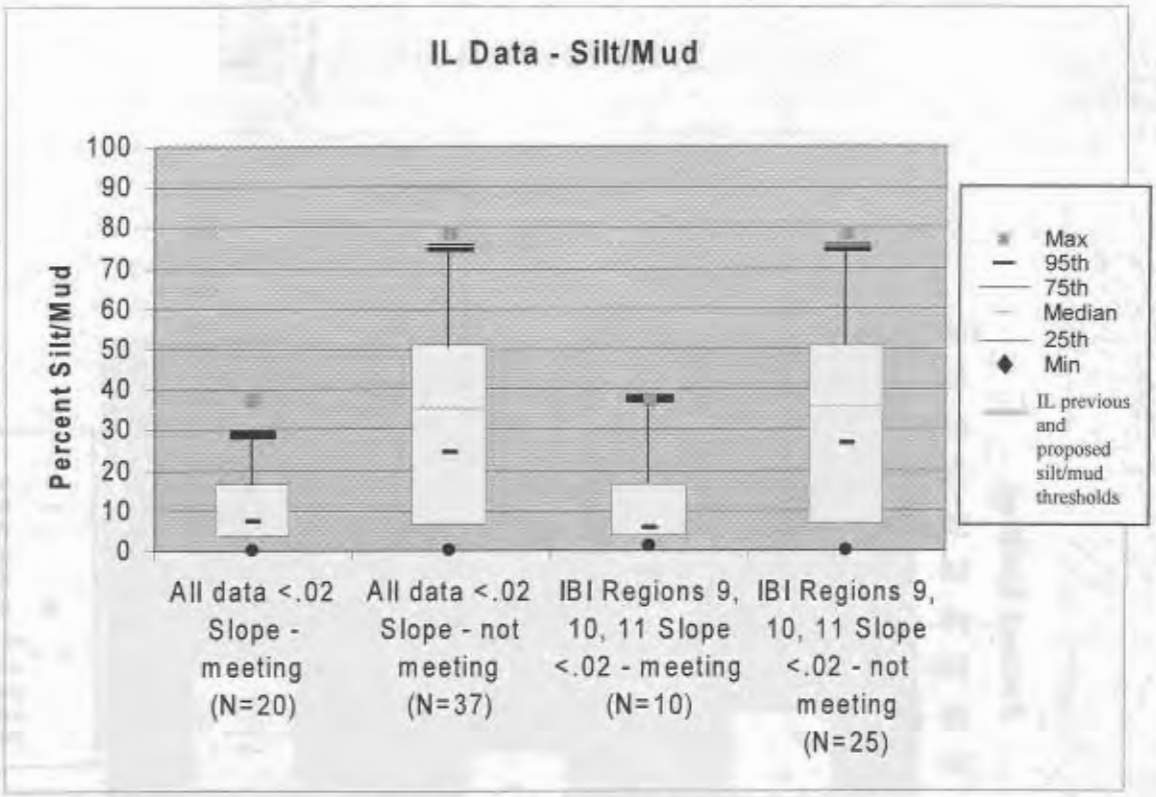



**Figure 9 - Low-gradient streams (note that the "95th percentile for IBI regions 9, 10, 11 at slope <.02 is actually the 100%. No percentile was generated between 88.80 and 100%.)**

3. 95% best fit line - Illinois provided Region 5 with a scatterplot of IBI values plotted against silt/mud. These plots included what appears to be a "best fit" line (as described under II.B.4 above.) While IL EPA has drawn in a line to define the wedge plot, it is not clear what process was used to determine where the line should be drawn other than it was at the far edge of the data points. Typically, these "best fit" lines are drawn in with 95% of the data to the left or below the line or a more objective process using quantile regression is used. Quantile regression can also be used to define such lines at various percentiles (e.g. 90th, 75th, etc.)

Following an approach of subjectively drawing in a 95th best fit line by Region 5, the results of the best fit line would alter the suggested threshold. Figures 10 and 11 shows a second line added (in red) which has 95% of the data points to the left and below the line and 5% of the data points to the right and above the line.

There are several issues to keep in mind when interpreting these types of wedge plots. First, the vertical line drawn in is interpreted as defining a level above which there are clearly unsafe levels of the parameter. It does not indicate that levels below that are safe. Secondly, some consideration must be given to how well distributed the data are in interpreting the data (are they heavily skewed or not). This can impact the reliability of the results. Finally, consideration

should be given to adding a confidence band around the line[18]. Additionally, because these Illinois plots may not represent well defined wedges, there is some question as to whether this approach is the most effective for establishing a threshold.

Region 5 believes the results of these types of graphs should be used in combination with other approaches to set an appropriately protective level for making use and/or cause determinations not as a sole arbiter.

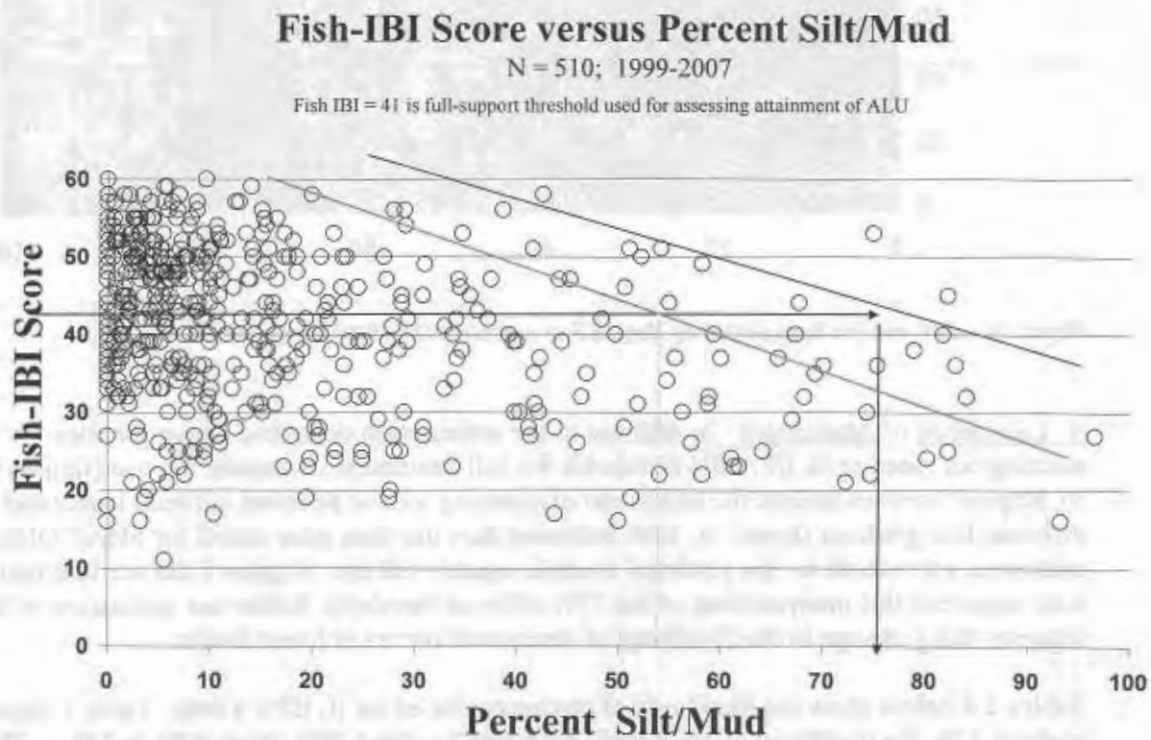



**Figure 10 - Red and tan lines added by Region 5 to represent the 95th line of best fit.**

[18] Based on 12/05/08 conversation with Ed Rankin, Senior Research Associate, Ohio University, Edward Hammer and Sarah Lehmann).

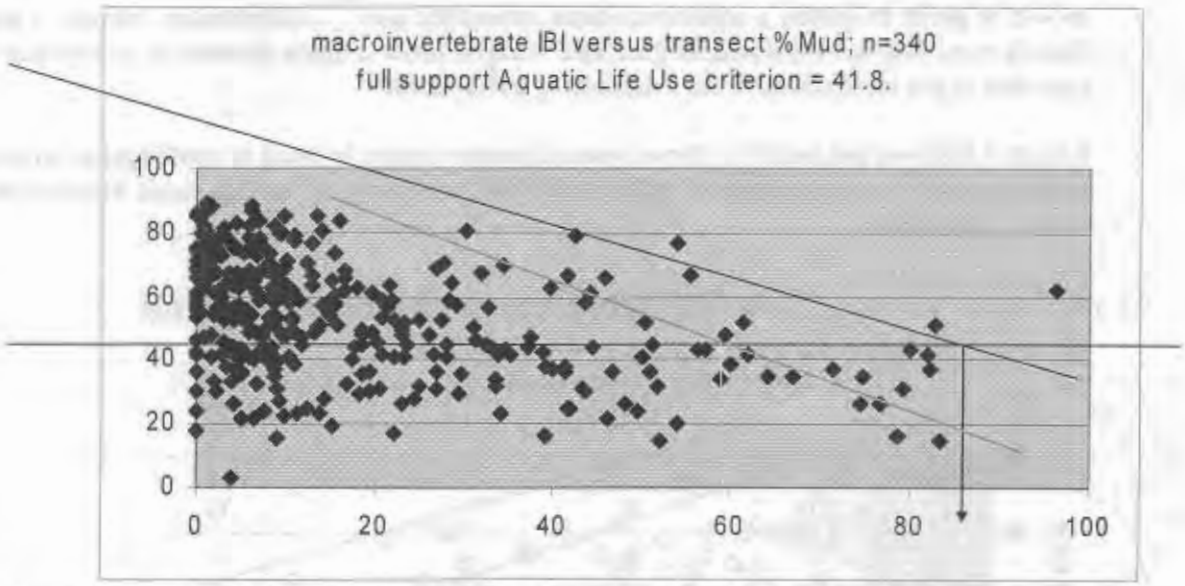



**Figure 11 - Red and tan lines added by Region 5 to represent the 95th line of best fit.**

4. Likelihood of Attainment - In addition to the information described above for sites meeting/not meeting IL EPA IBI thresholds for full attainment of aquatic life use (figures 8 and 9), Region 5 also examined the likelihood of attaining uses at different silt/mud levels and for different low-gradient slopes. IL EPA indicated they use their poor cutoff for SHAP/QHEI metrics as a threshold for the potential to attain aquatic life use. Region 5 did not find that the data supported this interpretation of the 75% silt/mud threshold. Rather our evaluation of the data suggests that a change in the likelihood of attainment occurs at lower levels.

Tables 2-4 below show the likelihood of attainment based on IL EPA's data. Table 2 shows that at about 35% the likelihood of attainment decreases by about 50% (from 47% to 22%). The likelihood of attaining aquatic life uses at >75% silt/mud is approximately 7%. At >60% silt/mud, the likelihood is about the same. It is significant that even at >35% silt/mud the likelihood of attainment remains relatively low – at only about 17% -- suggesting that a large number of sites negatively impacted by silt/mud occur below the current ≥75% Illinois threshold.

To ascertain whether this was different for streams with very low gradient, we also split out the data into streams with slopes of ≤.02 and then ≤.05. In each of these low-gradient categories, the likelihood of attaining aquatic life uses is significantly lower when silt/mud is >35%. These data suggests that even very low-gradient streams are much more likely to attain Illinois' biological thresholds when silt/mud levels are low.

**Table 2 - Percent of Attainment for sites by Silt/Mud Categories**

| Percent Silt/Mud | Number of sites in category | Number of sites attaining | Percent attainment |
|---|---|---|---|
| 0-10 | 335 | 209 | 62% |
| 10.1-20 | 105 | 54 | 51% |
| 20.1-35 | 78 | 37 | 47% |
| 35.1-50 | 35 | 9 | 22% |
| 50.1-60 | 21 | 5 | 23% |
| 60.1-75 | 15 | 1 | 5% |
| 75.1+ | 14 | 1 | 7% |
| | | | |
| 0-35 | 518 | 263 | 51% |
| 35.1+ | 85 | 16 | 17% |
| 60.1+ | 29 | 2 | 7% |

**Table 3 - Percent of Attainment for sites with </= .02% Slope by Silt/Mud Categories**

| Percent Silt/Mud | Number of sites in category | Number of sites attaining | Percent attainment |
|---|---|---|---|
| 0-35 silt | 43 | 20 | 47% |
| 35.1+ | 16 | 1 | 6% |

**Table 4 - Percent of Attainment for sites with </= .05% Slope by Silt/Mud Categories**

| Percent Silt/Mud | Number of sites in category | Number of sites attaining | Percent attainment |
|---|---|---|---|
| 0-10 silt | 76 | 43 | 57% |
| 10.1-20 | 21 | 5 | 24% |
| 20.1-35 | 24 | 5 | 21% |
| 35.1-50 | 12 | 3 | 25% |
| 50.1-75 | 19 | 1 | 5% |
| 75.1+ | 4 | 0 | 0% |
| | | | |
| 0-35 | 121 | 55 | 45% |
| 35.1-100 | 35 | 4 | 11% |

Region 5 believes this information suggests that thresholds set at the 75% silt/mud level do not effectively protect streams in Illinois even when broken out by low-gradient.

## III. Summary

Section 303(d) of the CWA and EPA's rules at Section 130.7 require states to identify waters not attaining water quality standards and the pollutant causes of impairment, and to prepare TMDLs to restore the waters to attainment. To accomplish this, states develop a methodology for

identifying the impaired waters and the potential causes of impairment. EPA reviews each state's methodology to make sure that, in following the methodology, the state is going to be able to identify those waters not meeting water quality standards and the causes of impairment. As the foregoing discussion and analysis sets out, EPA does not find that Illinois' 2008 methodology will identify all waters impaired by sedimentation.

EPA's national assessment of wadeable streams indicates that 32% of streams are impacted by excess sediments (fair and poor categories). Based on evidence from the Wadeable Streams Assessment and silt related impacts occurring in Illinois, Region 5 believes it is inappopriate to assume without further evidence that

- only a small percentage of streams in Illinois (~2%) are negatively impacted by silt/mud; and
- that the few exceptions to this rule will be picked up through the BPJ process.

After evaluating several approaches for establishing thresholds, Region 5 could find no evidence supporting the 98$^{th}$ percentile of all data as an appropriate approach for setting thresholds. In fact, the strength-of-evidence from other approaches used in our analysis suggests that a number of streams are impacted by silt/mud at levels well below the ≥75% silt/mud threshold selected by IL EPA.

Region 5 believes setting a lower threshold and using a documented BPJ process for addressing exceptions (i.e., those sites where silt/mud levels above the threshold is not a cause of impairment) is a more reasonable approach. Based on our evaluation, the threshold used by IL EPA in previous Integrated Reports (>34% silt/mud) is reasonable for identifying whether silt/mud is a cause of biological impairment.

Appendix A:

---- Message from "Good, Gregg" <Gregg.Good@Illinois.gov> on Wed, 3 Sep 2008 14:32:55 -0600 ----

**To:** <keclik.donna@epa.gov>, <Lehmann.Sarah@epamail.epa.gov>, "Hammer, Ed" <Hammer.Ed
<Vasaturo.Gaylene@epamail.epa.gov>

**cc:** "Studer, Dean" <Dean.Studer@Illinois.gov>, "Muir, David" <David.Muir@Illinois.gov>, "Sm
Mark" <Mark.Joseph@Illinois.gov>, "Willhite, Marcia" <Marcia.Willhite@Illinois.gov>, "Sof

**Subject:** Further Justification: ALU Stream Sedimentation/Siltation Cause Guideline

Per our August 27th conference call, you had asked for further justification and documentation for our stated change in IEPA's draft 2008 Integrated Report (IR; page 12) regarding the guideline for indicating that sedimentation/siltation is impairing aquatic life use in streams (Table C-4, page 60; and Table C-5, page 64). As you know, the previous guideline was substrate >34% silt/mud. As we state in the 2008 IR, a reevaluation resulted in changing it to >75% silt/mud.

As stated in the report, our initial justification was that for each of our other habitat guidelines (Stream Habitat Assessment Procedure – SHAP, and Qualitative Habitat Evaluation Index – QHEI, metrics), we use the worst-case (called "Poor") category to indicate the potential for aquatic life use impairment. However, >34% silt/mud was originally considered fair and >75% was considered poor, based on the 85th and 98th percentiles of statewide data, respectively (see Illinois Water Quality Report 2000). Using >75% is more consistent with both SHAP and QHEI.

During our discussion on August 27th, we mentioned to you that we had just recently plotted actual percentage of silt-mud data vs. actual fish and macroinvertebrate Index of Biotic Integrity (IBI) scores. We feel strongly that these plots (attached) provide additional justification for using this new >75% guideline.

When looking at the plots, when the percentage of silt mud (x-axis) is plotted with fish or macroinvertebrate IBI scores (y-axis), the points form a conspicuous wedge-shaped gap in the upper right-hand portion of the graphs. When a diagonal line is used to delineate this gap, a limiting factor threshold emerges that approximates the maximum IBI score attained at a given silt-mud percentage. In other words, IBI never exceeds the threshold and silt-mud is the limiting factor for points near the diagonal threshold. The intersection of this diagonal line with a horizontal line placed at the full support Aquatic Life Use criterion can be interpreted along the x-axis as the percentage of silt-mud that limits full aquatic life use support and is the primary cause of impairment. Full aquatic life use support IBI criterion for fish and macroinvertebrates are 41.0 and 41.8, respectively. Mandatory assignment of cause is reserved for those points that both fall below the full use criterion and exceed 75% silt-mud. Field biologists are given latitude to use best professional judgment to assign silt-mud as the cause of impairment at percentages below the 75% criterion.

With this additional "biologically-based" justification added to our original "lets be more consistent" justification, we hope for your concurrence that 75% silt/mud bottom

substrate is a more sound guideline (lacking a promulgated water quality standard) for assigning causation of sedimentation/siltation when aquatic life use is less than full support.

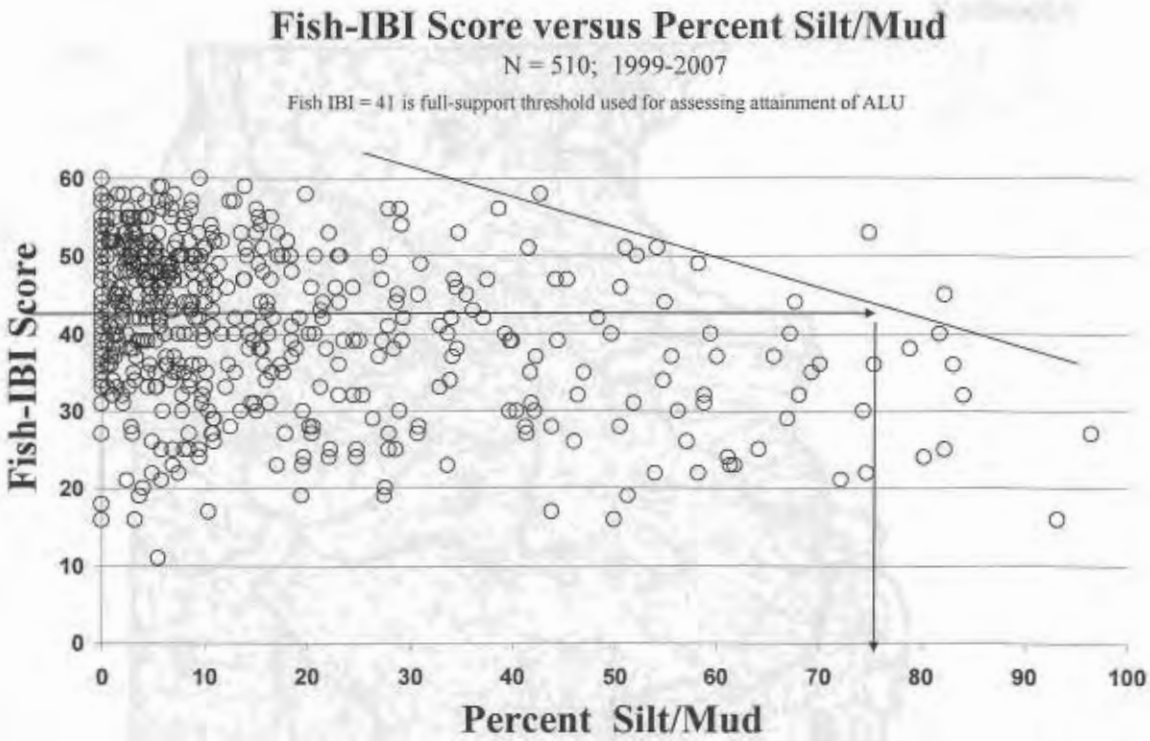
Finally, we have not yet received the information (provided by Ed Rankin to USEPA Region 5) from USEPA Region 5 that Ed Hammer mentioned in the telephone call last week. We'd respectfully ask that you send that to us at your earliest possible convenience.

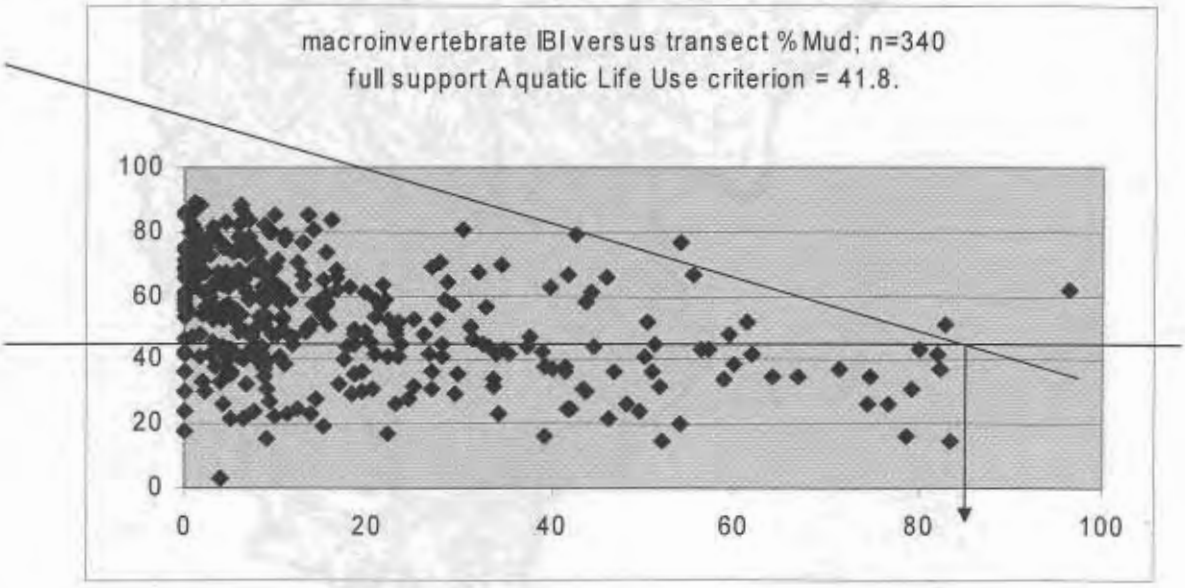
If you have any additionally comments or questions, please advise.

---

Gregg Good, Manager
Surface Water Section
Bureau of Water
Illinois Environmental Protection Agency
P.O. Box 19276
Springfield, Illinois 62794-9276
Phone: 217/782-7028
Fax: 217/785-1225
E-mail: Gregg.Good@illinois.gov

mudthreshold.ppt FishIBIVersusPercentSiltMud_2008_08_28.ppt (PPT Figures shown below)


Fish-IBI Score versus Percent Silt/Mud
N = 510; 1999-2007
Fish IBI = 41 is full-support threshold used for assessing attainment of ALU
Fish-IBI Score
Percent Silt/Mud
0
10
20
30
40
50
60
70
80
90
100


macroinvertebrate IBI versus transect % Mud; n=340
full support Aquatic Life Use criterion = 41.8.
0
20
40
60
80
100

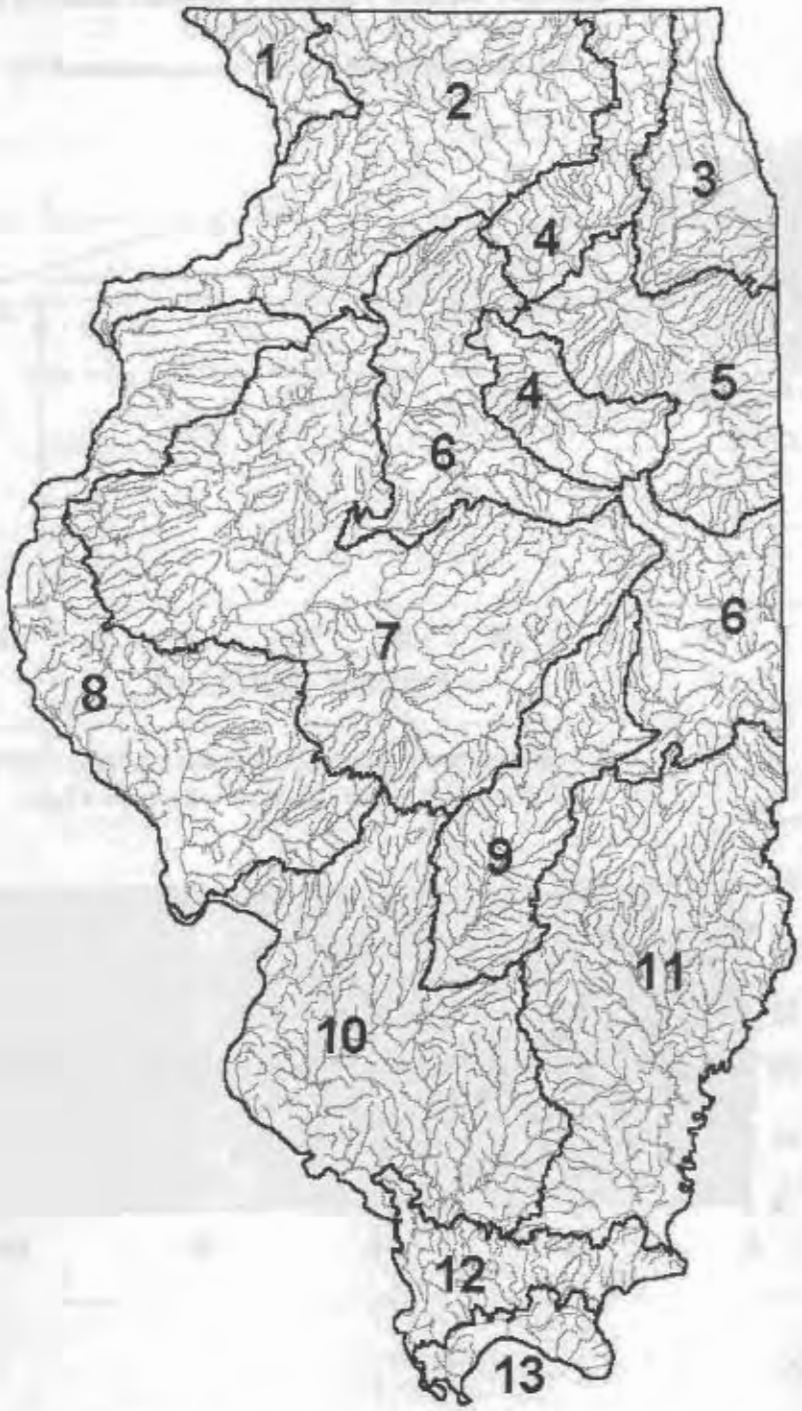



Figure 1. IBI Regions in Illinois. Region 4 comprises two noncontiguous areas.