Illinois Water Quality Monitoring and Stream Maintenance Methods

Chemical Monitoring

To assess pollutant loading in the watershed before and after implementation of BMPs, it will be necessary to collect and analyze water samples for parameters predicted by the pollutant loading model. This brief description is meant only as a guideline on sampling, handling, and analyses of the collected water samples. There are many references available from the USEPA, IEPA, and the standard laboratory methodologies, which should be consulted if more information is required. In any water quality sampling program, it is crucial to collect representative samples using grab, composite, or continuous sampling methods. Unrepresentative or samples contaminated during collection or handling are useless. Therefore, careful collection and handling throughout the process is important. The sampling program must take into account the parameters to be analyzed and special collection procedures may be necessary for some parameters. The collected samples should be submitted to a certified laboratory (NELAC) for analysis. Generally, the certified laboratory of choice works closely with the client to assure that the samples are collected in the proper containers with preservatives for the parameter of interest.

The laboratory often provides the containers, ice chest for transport, labels, and chain-of-custody forms to the client as part of their service. It is in the labs interest to work closely with the client to assure proper collection, handling, and security (chain-of-custody) of the samples. Quality control is important to any sampling program. The certified laboratory has routine internal procedures to assure the accuracy of their procedures or instruments. Confidence in the laboratory results is also important. The client should include quality control samples to the laboratory as part of their sampling program. This could be done by submitting split samples or a sample with a known concentration of a parameter to the laboratory and comparing the results.

Table 1 below includes typical information about holding time, preservatives required, container type, and handling for specific parameters including in the pollutant loading analysis. These are general guidelines for information only, the certified laboratory will have guidelines specific to their analytic procedures.

Table 1. Water quality parameters collection and handling procedures

Parameter	Container	Volume	Preservative	Max. Hold Time
pH Conductivity Temperature	These parameters should be measured in the field			
Clarity				
Total Suspended Solids	glass/plastic	1,000 ml	Cool 4 °C	7 days
Total Dissolved Solids	glass/plastic	1,000 ml	Cool 4 °C	7 days
Biochemical Oxygen Demand	glass/plastic	500 ml	Cool 4 °C	48 hours
Chemical Oxygen Demand	glass	125 ml	Cool 4 °C Sulfuric Acid	28 days

INDIANA DIVISION OF FISH AND WILDLIFE
STREAM HABITAT EVALUATION FORM

STREAM: _____ RIVER MILE: _____

NEAREST TOWN: _____ COUNTY: White

QUADRANGLE: _____ TWP: _____ RNG: _____ SEC. _____

LATITUDE: (upstream) _____ LONGITUDE: (upstream) _____

LATITUDE: (downstream) _____ LONGITUDE: (downstream) _____

U.S.G.S. GAUGING STATION LOCATION: _____ AVG. DISCHARGE (cfs): _____

IS REACH REPRESENTATIVE OF STREAM (Y/N): Y IF NOT, WHY? _____

DESCRIPTION OF SAMPLE SITE (Access, length, direction sampled): _____

COLLECTION SUMMARY

DATE: _____ GEAR: _____ EFFORT _____

CREW: _____

OTHER GEAR/EFFORT: _____ WATER STAGE: _____

CANOPY (% OPEN): _____ PHOTOS (Y/N): _____ SECCHI DISK (inches): _____

AIR TEMP (oF) _____ WATER TEMP (oF) _____ D.O. (ppm) _____

CONDUCTIVITY _____ pH: _____ ALKALINITY (ppm) _____

TDS _____

STREAM MEASUREMENTS: AVG. WIDTH: _____ AVG. DEPTH: _____ MAX. DEPTH: _____

STATION LENGTH: (1st date) _____ (2nd date) _____

WIDTH (ft) :PTH (in)

☐ SUBJECTIVE RATING #

☐ AESTHETIC RATING #

ADDITIONAL COMMENTS/POLLUTION IMPACTS: _____

STREAM: _____ **RIVER MILE:** _____ **DATE:** _____ **QHEI SCORE** ☐

1) SUBSTRATE: (Check ONLY Two Substrate Type Boxes: Check all types present) **SUBSTRATE SCORE** ☐

TYPE		POOL	RIFFLE			POOL	RIFFLE
☐	☐ BLDER/SLAB(10)			☐	☐ GRAVEL(7)		
☐	☐ BOULDER(9)			☐	☐ SAND(6)		
☐	☐ COBBLE(8)			☐	☐ BEDROCK(5)		
☐	☐ HARDPAN(4)			☐	☐ DETRITUS(3)		
☐	☐ MUCK/SILT(2)			☐	☐ ARTIFIC(0)		

TOTAL NUMBER OF SUBSTRATE TYPES: ☐ >4(2) ☐ <4(0)

SUBSTRATE ORIGIN (all): ☐ LIMESTONE(1) ☐ RIP/RAP(0) ☐ TILLS(1) ☐ HARDPAN(0) ☐ SANDSTONE(0) ☐ SHALE(-1) ☐ COAL FINES(-2)

SILT COVER (one): ☐ SILT-HEAVY(-2) ☐ SILT-MOD(-1) ☐ SILT-NORM(0) ☐ SILT-FREE(1)

Extent of Embeddedness (check one): ☐ EXTENSIVE(-2) ☐ MODERATE(-1) ☐ LOW(0) ☐ NONE(1)

NOTE: (Ignore sludge that originates from point sources: score is based on natural substrates)

COMMENTS: _____

2) INSTREAM COVER: **COVER SCORE** ☐

TYPE (Check all that apply)

☐ UNDERCUT BANKS(1) ☐ OVERHANGING VEGETATION(1) ☐ SHALLOWS (IN SLOW WATER)(1)
☐ DEEP POOLS(2) ☐ ROOTWADS(1) ☐ BOULDERS(1)
☐ OXBOWS(1) ☐ AQUATIC MACROPHYTES(1) ☐ LOGS OR WOODY DEBRIS(1)

AMOUNT (Check only one or Check 2 and AVERAGE)

☐ EXTENSIVE >75%(11) ☐ MODERATE 25-75%(7) ☐ SPARSE 5-25%(3) ☐ NEARLY ABSENT <5%(1)

COMMENTS: _____

3) CHANNEL MORPHOLOGY: (Check ONLY ONE per Category or Check 2 and AVERAGE) **CHANNEL SCORE** ☐

SINUOSITY: ☐ HIGH(4) ☐ MODERATE(3) ☐ LOW(2) ☐ NONE(1)

DEVELOPMENT: ☐ EXCELLENT(7) ☐ GOOD(5) ☐ FAIR(3) ☐ POOR(1)

CHANNELIZATION: ☐ NONE(6) ☐ RECOVERED(4) ☐ RECOVERING(3) ☐ RECENT OR NO RECOVERY(1)

STABILITY: ☐ HIGH(3) ☐ MODERATE(2) ☐ LOW(1)

MODIFICATION/OTHER: ☐ SNAGGING ☐ RELOCATION ☐ CANOPY REMOVAL ☐ DREDGING ☐ ONE SIDE CHANNEL MODIFICATION ☐ IMPOUND ☐ ISLAND ☐ LEVEED ☐ BANK SHAPING

COMMENTS: _____

4) RIPARIAN ZONE AND BANK EROSION: (Check ONE box or Check 2 and AVERAGE per bank) **RIPARIAN SCORE** ☐

River Right Looking Downstream

RIPARIAN WIDTH (per bank)

L	R	(per bank)
☐	☐	WIDE >150 ft.(4)
☐	☐	MODERATE 30-150 ft.(3)
☐	☐	NARROW 15-30 ft.(2)
☐	☐	VERY NARROW 3-15 ft.(1)
☐	☐	NONE(0)

EROSION/RUNOFF-FLOODPLAIN QUALITY

L	R	(most predominant per bank)
☐	☐	FOREST, SWAMP(3)
☐	☐	OPEN PASTURE/ROW CROP(0)
☐	☐	RESID.,PARK,NEW FIELD(1)
☐	☐	FENCED PASTURE(1)

L	R	(per bank)
☐	☐	URBAN OR INDUSTRIAL(0)
☐	☐	SHRUB OR OLD FIELD(2)
☐	☐	CONSERV. TILLAGE(1)
☐	☐	MINING/CONSTRUCTION(0)

BANK EROSION

L	R	(per bank)
☐	☐	NONE OR LITTLE(3)
☐	☐	MODERATE(2)
☐	☐	HEAVY OR SEVERE(1)

COMMENTS: _____

5) POOL/GLIDE AND RIFFLE/RUN QUALITY **NO POOL = 0** **POOL SCORE** ☐

MAX.DEPTH (Check 1)
☐ >4 ft.(6)
☐ 2.4-4 ft.(4)
☐ 1.2-2.4 ft.(2)
☐ <1.2 ft.(1)
☐ <0.6 ft.(Pool=0)(0)

MORPHOLOGY (Check 1)
☐ POOL WIDTH>RIFFLE WIDTH(2)
☐ POOL WIDTH=RIFFLE WIDTH(1)
☐ POOL WIDTH<RIFFLE WIDTH(0)

POOL/RUN/RIFFLE CURRENT VELOCITY (Check all that Apply)
☐ TORRENTIAL(-1) ☐ FAST(1) ☐ MODERATE(1) ☐ SLOW(1) ☐ EDDIES(1) ☐ INTERSTITIAL(-1) ☐ INTERMITTENT(-2)

COMMENTS: _____

RIFFLE SCORE ☐

RIFFLE/RUN DEPTH
☐ GENERALLY >4 in. MAX.>20 in.(4)
☐ GENERALLY >4 in. MAX.<20 in.(3)
☐ GENERALLY 2-4 in.(1)
☐ GENERALLY <2 in.(Riffle=0)(0)

RIFFLE/RUN SUBSTRATE
☐ STABLE (e.g., Cobble,Boulder)(2)
☐ MOD.STABLE (e.g., Pea Gravel)(1)
☐ UNSTABLE (Gravel, Sand)(0)
☐ NO RIFFLE(0)

RIFFLE/RUN EMBEDDEDNESS
☐ EXTENSIVE(-1) ☐ MODERATE(0) ☐ LOW(1) ☐ NONE(2) ☐ NO RIFFLE(0)

COMMENTS: _____

6) GRADIENT (FEET/MILE): _____ **% POOL** _____ **% RIFFLE** _____ **% RUN** _____ **GRADIENT SCORE** ☐

Total Kjeldahl Nitrogen [1]	glass/plastic	500 ml	Cool 4 °C Sulfuric Acid	28 days
Nitrate-nitrogen [2]	glass/plastic	125 ml	Cool 4 °C	48 hours
Total Phosphorus	glass amber	500 ml	Cool 4 °C Sulfuric Acid	28 days
Dissolved Phosphorus [3]	glass amber	125 ml	Cool 4 °C Sulfuric Acid	28 days
Metals: (Cadmium, Lead, Copper, Zinc)	plastic	125 ml	Cool 4 °C Nitric Acid	6 months

[1] TKN measures organic nitrogen and ammonia-nitrogen in the sample.
[2] Nitrate-nitrogen is measured on a filtered sample (adding TKN and nitrate-nitrogen gives the total nitrogen of the sample).
[3] The sample needs to be filtered in the field for dissolved P analysis.

Trophic State Index (TSI)

Most water quality samples are taken in stream systems because the data provides estimates of pollutant loading following different sized rain events. In lakes however, the water is usually slow to cycle through the system and different techniques are needed to assess water quality. Biologists and limnologists use "productivity" of a lake to assess health. Productivity is measured via the Trophic State Index (TSI), an index that uses total phosphorus (TP) concentrations as the primary means to assess lake health. The state of Illinois set the standard for TP at 0.05 mg/L while the Lake County average is 0.066 mg/L. When phosphorus levels exceed 0.05 mg/L lake-wide algal blooms can occur. Increases in algal blooms lead to decreased water clarity, a decrease in light penetration, and increase in total suspended solids. The TSI is used to categorize lakes as oligotrophic (TSI <40), mesotrophic (TSI 40-49), eutrophic (TSI 50-69), and hypereutrophic (TSI >70). TSI values greater than 70 indicate that a lake is in poor health. The work required to develop TSI values should be conducted by IDNR or EPA staff or others trained in this type of work.

Physical Monitoring

Many different parameters are included in physical monitoring of water quality. They include but are not limited to temperature, pH, conductivity, clarity, and habitat assessments/channel monitoring. Temperature, pH, and conductivity measurements are usually collected at the same time that chemical water quality samples are taken. The difference is that these parameters can and should be taken directly in the field using portable devices. Continuous recorders are also available. These units are typically placed in a stream or lake and left for given periods of time allowing for continuous reading of a given parameter.

Qualitative Habitat Evaluation Index (QHEI)

Stream assessments comprise a major component of physical water quality monitoring. Many habitat assessment protocols are available for assessing streams. Applied Ecological Services, Inc. (AES) has used several versions including those developed by the IDNR and Ohio EPA. Both assess similar components of the stream system however the Qualitative Habitat Evaluation Index (QHEI) developed by the Ohio EPA is a quick, accurate, and straight forward analysis. The index should first be used to document the baseline conditions of a stream reach prior to a restoration project. A stream reach is defined as a stream segment having fairly homogenous hydraulic, geomorphic, riparian cover, and land use characteristics. The index can then be used following restoration to document and measure improvements. A blank QHEI form can be found in Appendix J and a narrative explaining how to use the index can be located on the web at rock.geo.csuohio.edu/norp/qhei.htm.

This QHEI was developed by the Ohio EPA for use in streams and rivers in Ohio but has been adopted throughout the Midwestern states (Rankin 1989, 1995). The QHEI is a repeatable physical habitat index designed to provide empirical, quantified evaluation of the general macrohabitat characteristics of a stream segment that are suitable for fishes and other warm-water fauna. The QHEI was found to correlate well with biological integrity of streams in the Midwest. It is composed of six criteria. Each is scored individually then summed to provide the total QHEI score. The best possible score is 100.

QHEI scores from hundreds of stream segments indicate that habitat values greater than 60 generally support average quality warm-water faunas. Scores greater than 80 typify pristine habitat conditions that have the ability to support exceptional warm-water faunas (Ohio EPA 1999). Areas with habitat scores lower than 60 may support warm-water faunas but usually exhibit significant degradation. Table 2 summarizes QHEI score classifications. .

Table 2. QHEI score classifications

QHEI	Class	Usual Characteristics
80-100	Excellent	Comparable to pristine conditions; exceptional assemblage of habitat types; sufficient riparian zone
60-79	Good	Impacts to riparian zone
30-59	Fair	Impacts to riparian zone; channelization; most in-stream habitat gone
0-29	Poor	All aspects of habitat in degraded state

Stream Channel Maintenance

The condition of the stream channel can be assessed using the QHEI habitat analysis but can be evaluated in more detail as part of a stream maintenance and monitoring program. Stream maintenance includes an ongoing program to remove blockages caused by accumulated sediment, fallen trees, overgrown non-native vegetation, or debris, along with the repair of eroded or failed streambanks. "Debris" refers to a wide range of materials, which may include tree limbs, branches, trash, or lawn waste. Routine clearing of debris from streams is a cost effective way to minimize flooding and improve water quality. Any debris removal from the stream channel should follow "Stream Obstruction Removal Guidelines" developed by the American Fisheries Society (SRGS, 1983) (Appendix D). In addition to sediment and debris removal, stream maintenance can also involve stabilization of eroding streambanks to decrease erosion and improve water quality.

A regular stream maintenance and monitoring program should be standardized to the extent practicable, so observations performed by different personnel will result in similar recommendations for maintenance. All natural and created drainage infrastructure should be inventoried, with the results compiled into a GIS database. Stream reach information (see Section 3.0) that is currently available should be incorporated into the database, followed by an initial visit to those sites where baseline conditions are unknown. A stream reach is defined as a stream segment having fairly homogenous hydraulic, geomorphic, riparian cover, and land use characteristics. Assessments conducted by stream reach are often more convenient and easier than looking at an entire stream system. Routine maintenance and monitoring could commence once all reaches have been inspected and existing conditions are known. The types of monitoring are summarized below:

- Initial – Conducted as the first inventory assessment of a watercourse segment; or after the implementation of a watercourse improvement project.

- Routine – Conducted on a cyclical basis to assess current conditions and needed maintenance.
- Event – Conducted after a significant flow or weather event, which may have altered the existing conditions.
- Interim – Conducted upon the request of a concerned party or individual.

A significant flow event is defined as a flow that is great enough to potentially alter or damage the watercourse. Depending on the characteristics of a particular location in a watercourse, a significant flow event can be associated with different flows.

Any inventory of a stream reach should include, at a minimum, the following items:

- Date of visit
- Name of inspection crew members
- Arrival / departure time
- Site Identification (major watershed, watercourse name, reach boundaries, length)
- Type of inspection / maintenance
- Weather conditions at time of visit
- Last rainfall date/depth/duration (mandatory for post-storm event)
- Photograph documentation
- Maintenance performed since last inspection
- Flow, Velocity, and Stage Characteristics
- Historic Data (known extremes)
- Channel and Floodplain Condition (Include numerical rating, see Table 3)
- Required Maintenance Needs or Alteration to Monitoring Frequency

To quantify the condition of each stream reach inspected, Table 3 should be used to score the quality of each site. This will allow for prioritization of maintenance activities. Table 4 details the Recommended Action Options specified in Table 3.

Table 3. Channel and floodplain condition assessment ratings.

Rating	Condition	Description of Observations	Recommended Action Option
6	Good	Channels and floodplains do not exhibit erosion/scour, sediment accumulation, debris build-up, or resistance to flow. Structural controls may show minor deterioration, but all components are stable.	Routine Monitoring
5	Satisfactory	Channels and floodplains exhibit minor erosion/scour, sediment accumulation, debris buildup, or resistance to flow. Structural controls exhibit limited, minor defects or deterioration, such as corrosion, overstressing, and movement.	Routine Monitoring
4	Fair	Channels and floodplains exhibit increased scour, sediment accumulation, debris buildup, or resistance to flow. Minor deterioration may be observed to conveyance structures. Structural controls are sound and stable, but minor to moderate defects or deterioration is observed. Localized areas of moderate to advanced deterioration may be present but do not significantly reduce the ability of the structure to function as intended.	Increased Monitoring Frequency
3	Poor	Channels and floodplains exhibit scour, sediment accumulation, debris buildup, and resistance to flow. Moderate deterioration is observed to conveyance structures. Conveyance and flow structures not functioning as intended. Structural controls exhibit advanced deterioration or overstressing, but structure is functioning as intended. Maintenance/repairs may need to be performed with moderate urgency to avoid further deterioration or increased likelihood of flooding.	Maintenance /Repair
2	Serious	Channels and floodplains exhibit serious scour, sediment accumulation, debris buildup, and resistance to flow. Advanced deterioration is observed to conveyance structures. Conveyance and flow structures not functioning as intended. Structural controls exhibit advanced deterioration, overstressing, or breakage. Repairs may need to be performed on a high-priority basis with urgency. Conditions may result in flooding.	Redesign /Replacement
1	Critical	Channels and floodplains exhibit critical scour, sediment accumulation, debris buildup, and resistance to flow. Advanced deterioration is observed to conveyance structures. Conveyance and flow structures not functioning as intended. Structural controls exhibit extreme deterioration, overstressing, or breakage and have resulted in localized failure(s). Repairs may need to be performed on a very high priority basis. Flooding is imminent.	Redesign /Replacement

Table 4. Recommended stream monitoring and maintenance action option descriptions.

Action Options	Description
Routine Monitoring	Recommended when no further action is necessary until the next scheduled routine inspection.
Increased Monitoring Frequency	Recommended when no further action is necessary, but shorter inspection schedule is warranted to monitor potential problems.
Maintenance/ Repair	Recommended whenever monitoring deems necessary. The Project Manager will determine and notify the responsible party for maintenance.
Redesign/ Replacement	Recommended whenever monitoring deems necessary. The Project Manager will determine priority and implement action. Depending on the specific conditions, several phases may be utilized, such as: Engineering Evaluation: Recommended whenever significant damage or defects are encountered that require an evaluation to quantify the existing condition, determine whether repairs are required, or determine which method of repair is appropriate. This may include underwater inspection, in-depth inspection, etc. Special Investigation: Recommended to determine the cause or significance of a typical deterioration, before designing repairs. Special analysis, monitoring, or field data gathering is typically required. This may include surveys, soil borings, etc. Repair Design Inspection: Recommended immediately prior to, or during the preparation of necessary design documents. Develop Design Documents: Recommended after all evaluations, investigations, and inspections have been completed. Indicates that the field data has been collected and that the watercourse is ready to have repair documents prepared.
Emergency Action	Recommended whenever an unsafe condition is observed. If the situation is life threatening or if significant property damage or environmental damage may occur, appropriate Project Manager or owner representation should be contacted immediately.

Biological Monitoring

Monitoring the biological (fish and macroinvertebrates) components of a stream system is useful and important when assessing the success of BMPs. Fish and macroinvertebrates are chosen because they are relatively easy to sample/identify and reflect specific and predictable responses to human induced changes to the landscape, stream habitat, and water quality. Two indexes have been developed that accurately measure water quality using fish and macroinvertebrates, the Index of Biotic Integrity (IBI) and Macroinvertebrate Biotic Index (MBI). These indexes are best used prior to a stream restoration project to obtain baseline data then conducted periodically following restoration to measure the success of the project.

Index of Biotic Integrity (IBI)

The IBI is designed to assess biological health directly through several attributes of fish communities in streams. IDNR biologists or qualified firms should be contracted to perform the fish collection and identification. Collection is usually done within a stream reach using electrofishing equipment such as backpack shockers or electric seines. After the fish have been collected and identified, the data is used to evaluate 12 metrics and a rating is assigned to each metric based on whether it deviates strongly from, somewhat from, or closely approximates the expected values. The sum of

these ratings gives a total IBI score for the site. The best possible IBI score is 60 (Table 5). A manual for calculating IBI scores for streams in Illinois is available from IDNR.

Table 5. Biological Stream Characterization (BSC) criteria for the classification of Illinois Streams.

IBI	Class	BSC Category	Biotic Resource Quality Description
51-60	A	Unique Aquatic Resource	Excellent. Comparable to the best situations without human disturbance.
41-50	B	Highly Valued Aquatic Resource	Good. Good fishery for important game fish species; species richness may be somewhat below expectations for stream size or geographic region.
31-40	C	Moderate Aquatic Resource	Fair. Fishery consists predominantly of bullhead, sunfish, and carp. Species diversity and number of intolerant fish reduced. Trophic structure skewed with increased frequency of omnivores, green sunfish, or tolerant species.
21-30	D	Limited Aquatic Resource	Poor. Fishery predominantly for carp; fish community dominated by omnivores and tolerant forms. Species richness may be notably lower than expected for geographic area, stream size or available habitat.
≤20	E	Restricted Aquatic Resource	Very poor. Few fish of any species present; no sport fishery exists.

Macroinvertebrate Biotic Index (MBI)

The MBI is designed to rate water quality using macroinvertebrate taxa tolerance to degree and extent of organic pollution in streams and is a modification of the Hilsenhoff Biotic Index (HBI) (Hilsenhoff 1988). IDNR biologists or qualified firms should be contracted to perform the macroinvertebrate collection and identification. Each taxa is then assigned a known tolerance value to pollution. The MBI is calculated by taking an average of tolerance ratings weighted by the number of individuals in the sample. Scores lower than 6 represent good water quality while scores greater than 9 indicate very poor water quality (Table 6). A manual for calculating MBI scores for streams in Illinois is available from IDNR or EPA.

Table 6. Water Quality Correlation to Macroinvertebrate Biotic Index (MBI) Score.

Macroinvertebrate Biotic Index	Water Quality
< 6.0	Good
6.1-7.5	Fair
7.6-8.9	Poor
> 9.0	Very Poor