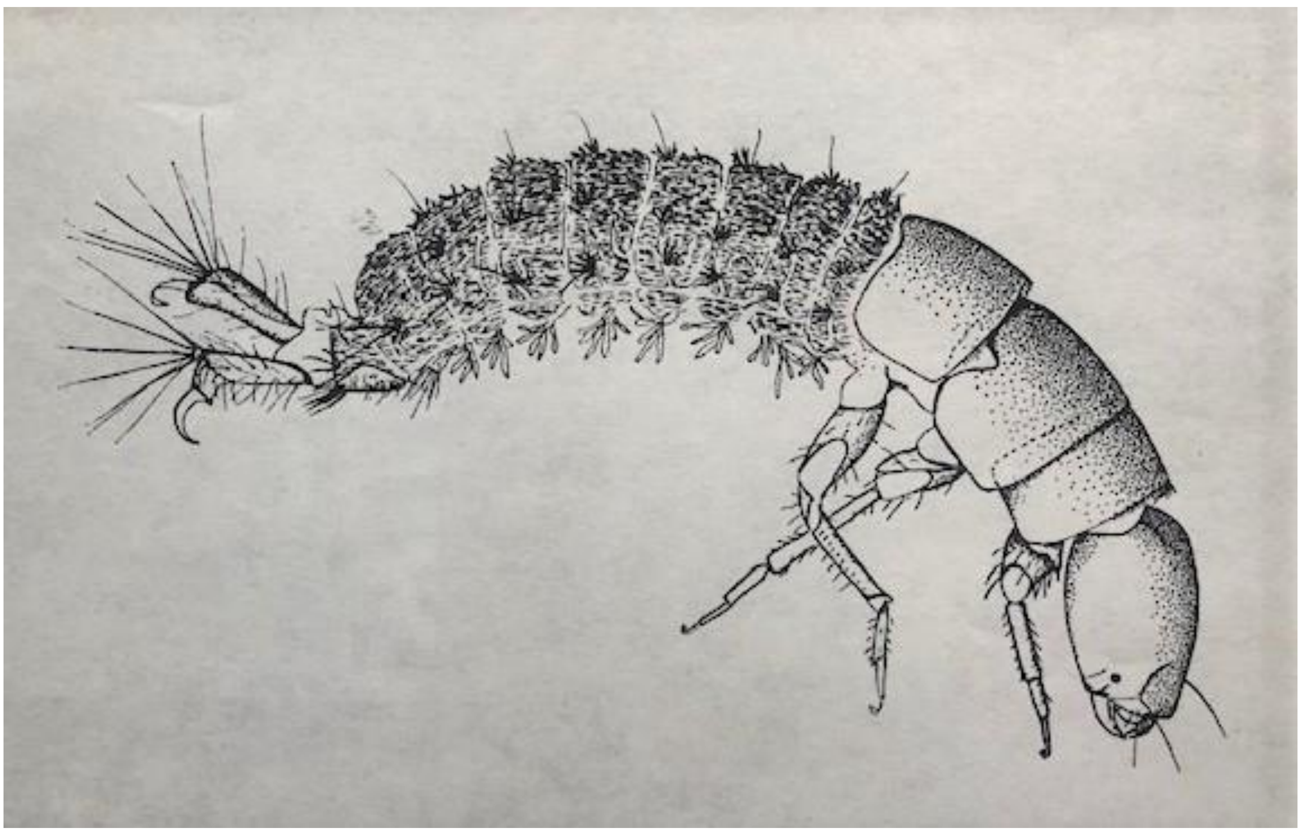
Kinnickinnic River Macroinvertebrate Monitoring: Past, Present, and Future

Kent Johnson, Kiap-TU-Wish Chapter, Trout Unlimited
Clarke Garry, Professor Emeritus, UW-River Falls

April 2023



Net-spinning Caddisfly (Trichoptera: Hydropsychidae)
Illustration by Janice Nelson Johnson

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Why Macroinvertebrate Monitoring?

Biotic indicators are used to complement physical and chemical measurements in stream monitoring programs. Biological data (fish, macroinvertebrates, vegetation) add a significant dimension to monitoring procedures because they provide an analysis that measures long-term phenomena and impacts. Because many of these organisms live in the stream environment for a year or more, they reflect past as well as present water quality conditions.

Aquatic macroinvertebrates (subsurface insects and crustaceans) can provide information on the ecological condition of streams that may otherwise be difficult to measure. As the majority of aquatic invertebrates have limited mobility, they can be good indicators of local water quality, integrating local and upstream watershed stressors. Additionally, most aquatic macro-invertebrates live from months to years in streams, integrating the effects of multiple environmental stressors over time. Instead of measuring the multitude of possible stressors over different spatial and temporal scales, measuring macroinvertebrate assemblages allows the direct examination of how stressors are impacting biologic integrity. In Wisconsin, the use of aquatic macroinvertebrates for evaluating stream health was initiated by William L. Hilsenhoff at UW-Madison in 1977, with development of the Hilsenhoff Biotic Index (HBI) (Hilsenhoff 1977).

Macroinvertebrate Monitoring Protocols

Several standard protocols are available for monitoring aquatic macroinvertebrates.

Single-Habitat (HBI) Protocol:

Currently, the Single-Habitat (S-H) protocol is recommended by the Wisconsin Department of Natural Resources (WDNR) for macroinvertebrate monitoring in Wisconsin streams (WDNR 2017). This protocol is very similar to the HBI protocol developed by Hilsenhoff (Hilsenhoff 1977, 1982, 1987) and used for many years by WDNR in long-term stream monitoring efforts.

The S-H protocol is used to collect macroinvertebrate samples from riffle habitats in wadeable streams. Samples should be collected during one of two index periods, either spring (March-May) or fall (September-November). Once a target riffle is selected at a monitoring site, a D-frame 500-micron mesh kick net is used to capture macroinvertebrates dislodged from the upstream substrate by kicking with one's feet. Three replicate samples within the riffle area comprise a complete collection at each monitoring site. For each replicate, an approximate 0.33 x 1.0 m area is "kicked" for a 30-second period; total sampling time is 1.5 minutes over an approximate area of 1.0 m^2. The three replicate samples are transferred to a single HDPE or glass wide-mouth jar of sufficient size, and the final composite sample is preserved in the field with 80% ethanol. Within 48 hours after sample collection, the "field" ethanol is removed, and the sample is refreshed with 95% ethanol. WDNR typically uses the Aquatic Biomonitoring Laboratory (ABL) at UW-Stevens Point for identification (to genus and species) of macroinvertebrates in the S-H samples.

Multi-Habitat Protocol:

The Multi-Habitat (M-H) protocol (Garry 2006) was developed to collect macroinvertebrate samples from a wide variety of habitat types (including riffles) in wadeable streams, at a time when no comprehensive technical survey of Kinnickinnic River macroinvertebrates existed. Figure 1 presents an example of this habitat diversity, based on four Kinnickinnic River M-H samples (40 subsamples) collected by Garry in 2002.

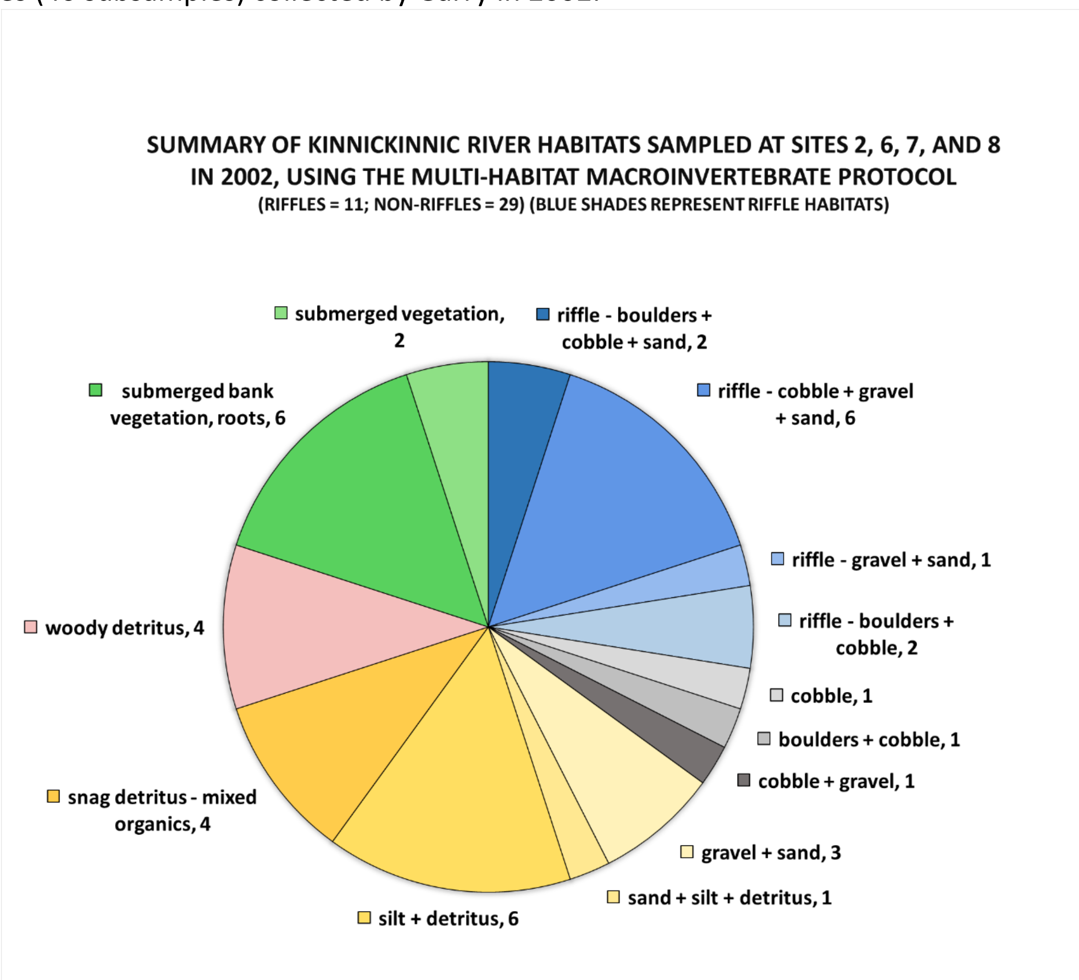


Figure 1. Summary of Kinnickinnic River habitats sampled at four sites in 2002, using the multi-habitat protocol.

If desired, M-H samples can be collected year-round, to evaluate seasonal changes in macroinvertebrate communities. The M-H protocol is designed to document the full range of macroinvertebrates present at a monitoring site. At each monitoring site, ten subsamples are collected, with an attempt to represent the full range of obvious structure, habitats, and substrates available. For instance, the sampled variety could include riffles and pools, substrates from silt to boulders, submerged vegetation, overhanging bank vegetation, and detritus (various accumulations, especially of leaves and wood). The ten subsampling locations are selected based on the proportions of different habitat types present at the monitoring site. At each subsampling location, a standard 1200-micron mesh D-net is held on the stream bottom while disturbing the upstream substrate and utilizing, when possible, the available current for capturing the dislodged macroinvertebrates. For specialized substrate sampling, such as in dense vegetation or under vertical or overhanging banks, the net is used in a shoveling manner. Netted materials are emptied into a level 36 cm x 46 cm cafeteria tray, holding approximately one cm of water, to allow efficient observation and picking of moving insects. Picking of macroinvertebrates from each subsample continues for 10 minutes, with an attempt to capture all of the different types of organisms present. At the end of the ten-minute picking period, the remaining materials in the tray are returned to the stream, and the next subsample is obtained. All ten subsamples are combined in a single 120 ml (4-ounce) glass jar, and the final composite sample is preserved in the field with 80% ethanol. Within 48 hours after sample collection, the "field" ethanol is removed, and the sample is refreshed with 95% ethanol. Two minutes of netting time at each subsampling location and ten minutes of picking time for each subsample takes approximately two hours at each monitoring site. The Aquatic Biomonitoring Laboratory (ABL) at UW-Stevens Point can be used for identification (to genus and species) of macroinvertebrates in the M-H samples.

Complementary Use of the S-H and M-H Protocols:

If resources allow, complementary use of the S-H and M-H protocols can maximize the information gained on macroinvertebrate presence and stream health. Both protocols can yield critical quantitative and qualitative data for evaluating stream conditions and assessing temporal and spatial changes. The S-H protocol recommended and used extensively (at hundreds of sites annually) by the WDNR allows a direct comparison of macroinvertebrate health in streams and rivers across the state. The S-H protocol also allows for the calculation of HBI and macroinvertebrate Index of Biotic Integrity (*m*-IBI) metrics (see below), which WDNR uses to evaluate aquatic ecosystem health in Wisconsin's streams and rivers. However, by representing the broader variety of habitats typically present in a stream or river, the M-H protocol provides the best information on the total types and relative numbers of macroinvertebrates present.

<u>Macroinvertebrate Sample Analysis and Metrics</u>

A high degree of taxonomic training and experience is required to correctly identify aquatic macroinvertebrates.

Analysis of macroinvertebrate samples by the Aquatic Biomonitoring Laboratory (ABL) at UW-Stevens Point involves randomly subsampling a target number of organisms (typically 250-300) from the "parent" sample, with identification and enumeration of all subsample specimens. All specimens in the subsample are identified to the genus-species level if possible, depending on the condition of the organism, life stage, instar stage, and limitations of the taxonomic keys.

With macroinvertebrates identified and counted, various metrics can be used to interpret the data. The term metric refers to any one of a number of various measurements or values that represent simple attributes of the macroinvertebrate community, from the total number of different taxa (most commonly genera or species) found in a sample or percentages of certain taxa relative to the total number of organisms in a sample, to more complex measures, such as the Hilsenhoff Biotic Index (Hilsenhoff 1987) or the macroinvertebrate Index of Biotic Integrity (*m*-IBI) (Weigel 2003). Along with the specimen identifications and counts, ABL provides 33 different types of metrics that can be used for data analysis. The Glossary (below) lists these metrics.

The Hilsenhoff Biotic Index (HBI) is particularly useful for determining the influence of organic pollution, as aquatic macroinvertebrates have varying tolerance levels for such pollution. The WDNR has extensively used the Hilsenhoff Biotic Index (HBI) values to interpret water quality conditions.

In addition, WDNR uses the macroinvertebrate Index of Biotic Integrity (*m*-IBI) as an indicator of aquatic ecosystem health, and to assess against appropriate aquatic life benchmarks. The *m*-IBI was built to reflect structural changes in macroinvertebrate communities in response to local and watershed-level disturbance, riparian condition, and local habitat quality. As such, the *m*-IBI reflects the response of the macroinvertebrate community to multiple types, and multiple scales, of environmental disturbance (Weigel 2003).

Besides the HBI and *m*-IBI, additional metrics are useful for describing macroinvertebrate composition. For example, generic richness, species richness, presence of Ephemeroptera, Plecoptera and Trichoptera, and relative abundance of functional feeding groups, among others, can be used to analyze macroinvertebrate community composition and evaluate the status or trends of particular waterbodies. The application and relative merit of many of these common macroinvertebrate metrics are discussed in detail in the WDNR's Macroinvertebrate Data Interpretation Manual (WDNR, 2003).

<u>History of Kinnickinnic River Macroinvertebrate Monitoring</u>

History of HBI (Single-Habitat) Monitoring

Few specifics were known regarding Kinnickinnic River (Kinni) macroinvertebrates (insects and crustaceans) prior to 1995, when the WDNR obtained five biotic index monitoring samples using the Hilsenhoff Biotic Index (HBI) protocol (Hilsenhoff 1982, 1987). These were followed in 1996 and 1997 with five additional collections. Thus began macroinvertebrate-based documentation not only of Kinnickinnic River water quality, but also of specific macroinvertebrate species inhabiting these seven sites.

The HBI protocol was also employed from 2004 to 2012 in the City of River Falls North Kinnickinnic River Monitoring Project (SEH 2014) led by Kent Johnson. Three sites were strategically selected to monitor the effectiveness of infiltration-based storm water management practices in the Sterling Ponds development area on the city's north side. This approach provided a valuable biological measure of river health, as well as potential degradation, not available by other means.

Dr. Joseph Gathman and Becca Jacobson (UW-River Falls) reported on additional Upper Kinnickinnic River ecological conditions, macroinvertebrate communities, and benthic habitats resulting from their Upper Kinnickinnic River 2011 Bioassessment Project (Gathman and Jacobson 2012). They combined community metrics, including diversity indices and EPT, with a modified HBI protocol and demonstrated a general consistency of their HBI values with earlier work.

Introduction of Multi-Habitat Surveying

The first Kinnickinnic River multi-habitat (M-H) macroinvertebrate survey designed to document the full range of macroinvertebrate life, including but not limited to those of riffle habitats, was carried out in 2001 and 2002 (Garry 2006). In each of these years, 17 evenly-spaced sites along the length of the river (WDNR Habitat Evaluation Stations established in 1996) were sampled bimonthly from January through December. The inclusion of additional aquatic habitats (fine and coarse substrates, pooled as well as running water, submerged vegetation, leaf-packs and other detritus, etc.) and a four-season perspective greatly expanded understanding of Kinni macroinvertebrate diversity.

<u>Macroinvertebrate Monitoring in 2022</u>

It's been two decades since a multi-habitat (M-H) river-length survey of Kinnickinnic River macroinvertebrates was carried out by Garry (Garry 2006). Single-habitat (HBI) sampling has served well in the interim for documenting macroinvertebrates and river conditions at certain points, an example being the continuous/contiguous series of S-H samples carried out from 2004 through 2012, as a part of the City of River Falls North Kinnickinnic River Monitoring Project (SEH 2014). With the current absence of river-length documentation of river quality, it is prudent to address the issue with a solid plan of action. Data need to be collected systematically over the length of the river using quantitative metrics provided by the S-H and M-H monitoring protocols.

A strong first step in filling the twenty-year macroinvertebrate monitoring gap occurred in 2022, with the collection and analysis of samples at six locations in the Kinnickinnic River. The 2022 monitoring sites were selected to match four of the 17 M-H sites surveyed by Garry in 2001 and 2002 and the six sites recommended as a part of the Kinnickinnic River Monitoring Plan (Morrison and Johnson 2021), established to evaluate the significant ecological changes expected relative to future Kinni dam removal and river restoration (Johnson 2023).

The following sites were monitored in 2022:

WDNR Site	Kinni Monitoring Plan Site	Location
Site 2	Site 120	Upstream from County Road F
Site 6	Site 478	Upstream from Rocky Branch Creek confluence
	Site 504	Below Powell Falls Dam
	Site 515	Lake Louise (new Kinnickinnic River channel)
Site 7	Site 574	Upstream from Division Street in River Falls
Site 8	Site 652	Upstream from State Highway 35 (Quarry Road)

At Sites 2/120, 6/478, 7/574, and 8/652, both M-H and S-H samples were collected, in close proximity to each other. At Sites 504 and 515, only S-H samples were collected. Preserving and packaging of all macroinvertebrate samples began at the river, with protocol-required sample re-preservation conducted in the UW-River Falls laboratory. All labor for sample collection (~60 hours) was provided by in-kind volunteers (UW-River Falls, Kiap-TU-Wish, and Kinni Corridor Collaborative (KinniCC)). The ten M-H and S-H samples collected in 2022 were submitted to the Aquatic Biomonitoring Laboratory (ABL) at UW-Stevens Point. Additionally, each 2022 M-H sample was matched (by site and date) with a similar M-H sample previously collected and preserved in 2002 by Clarke Garry and subsequently archived. ABL also analyzed these four 2002 M-H samples. The cost for analysis by ABL of the fourteen 2002/2022 samples ($6,200) was covered via contributions from Kiap-TU-Wish and KinniCC.

Kinnickinnic River Macroinvertebrate Monitoring Results: 2002/2022

After analysis of the 2002 and 2022 Kinni macroinvertebrate samples by ABL, the WDNR's Macroinvertebrate Data Interpretation Manual (WDNR, 2003) was used as a guide to select metrics for analysis of the Kinni data. Taxa richness metrics, including generic richness (GR), species richness (SR), and Ephemeroptera-Plecoptera-Trichoptera generic richness (EPTG) can be applied to data collected by both the M-H and S-H protocols. Biotic indices, including the Hilsenhoff Biotic Index (HBI) and the macroinvertebrate Index of Biotic Integrity (*m*-IBI) can only be applied to data collected using the S-H protocol. Short definitions for all of the metrics used in this assessment appear in the Glossary. More details can be found in the WDNR Macroinvertebrate Data Interpretation Manual (WDNR 2003).

Multi-Habitat (M-H) Monitoring Results: 2002 vs 2022

A primary objective of the 2022 M-H sampling work and the proposed work to follow in 2023-2025 (page 25) is to create a river-wide comparison of current Kinni macroinvertebrate community conditions to those documented in 2002. The following graphics begin to make that comparison at four Kinni sites, using the metrics selected. M-H generic richness (Figure 2), species richness (Figure 3), and EPT generic richness (Figure 4) are presented below.

For all figures that follow, the “Upper Kinni” represents that portion of the Kinnickinnic River upstream from Lake George and the Junction Falls Dam. The “Lower Kinni” represents that portion of the river downstream from the Powell Falls Dam.

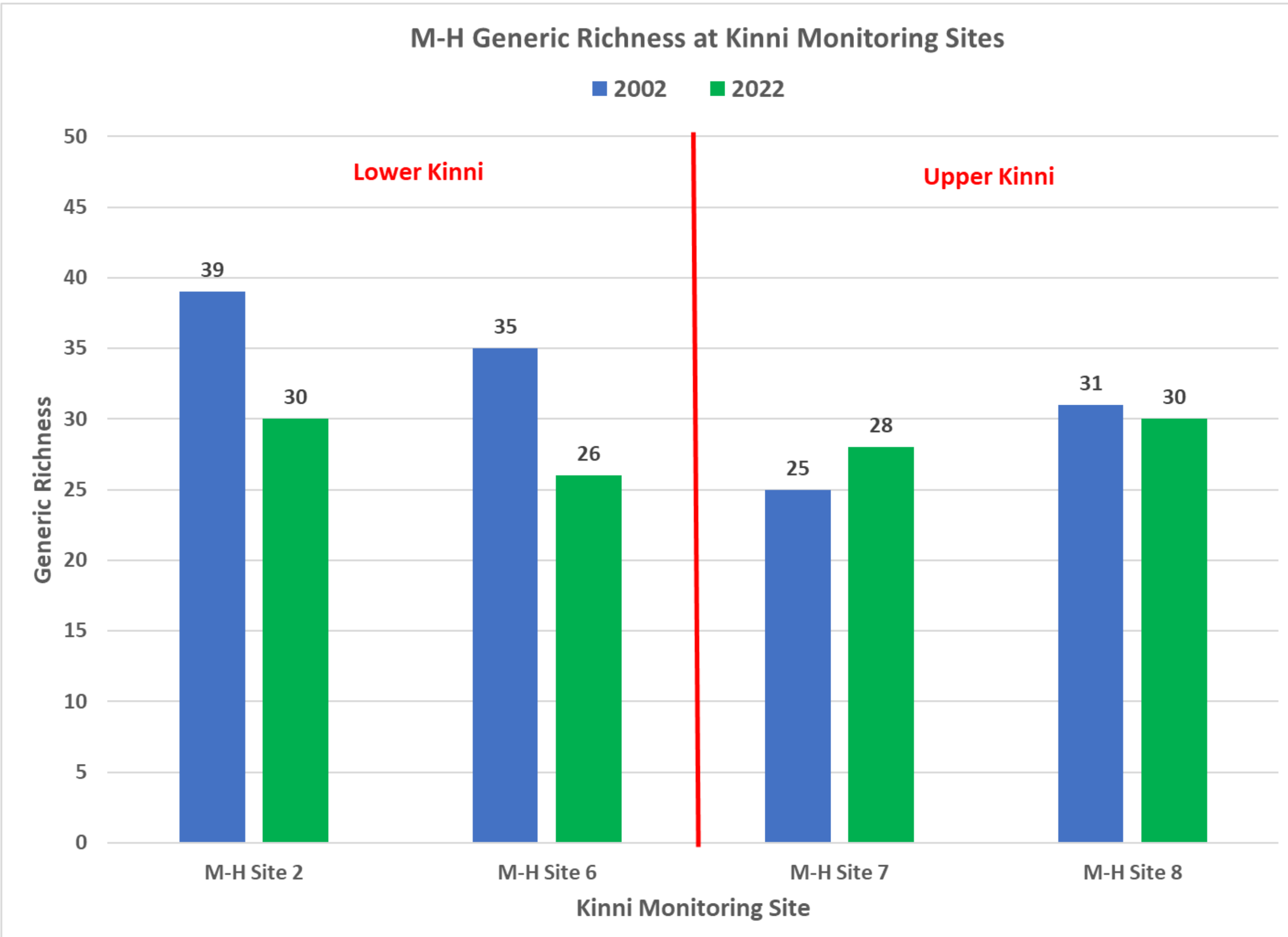


Figure 2. Multi-habitat generic richness (GR) at Kinnickinnic River monitoring sites: 2002 vs. 2022.

The 2002/2022 comparison of M-H sampling results indicates that generic richness (Figure 2) in the Upper Kinni (Sites 7 and 8) has remained relatively stable since 2002, even increasing slightly (12%) at Site 7 in 2022. In contrast, a 23-26% decrease in generic richness has occurred in the Lower Kinni (Sites 2 and 6) since 2002. In spite of this decrease, generic richness in the Lower Kinni in 2022 remains very similar to that in the Upper Kinni, reflecting a consistent and diverse river continuum.

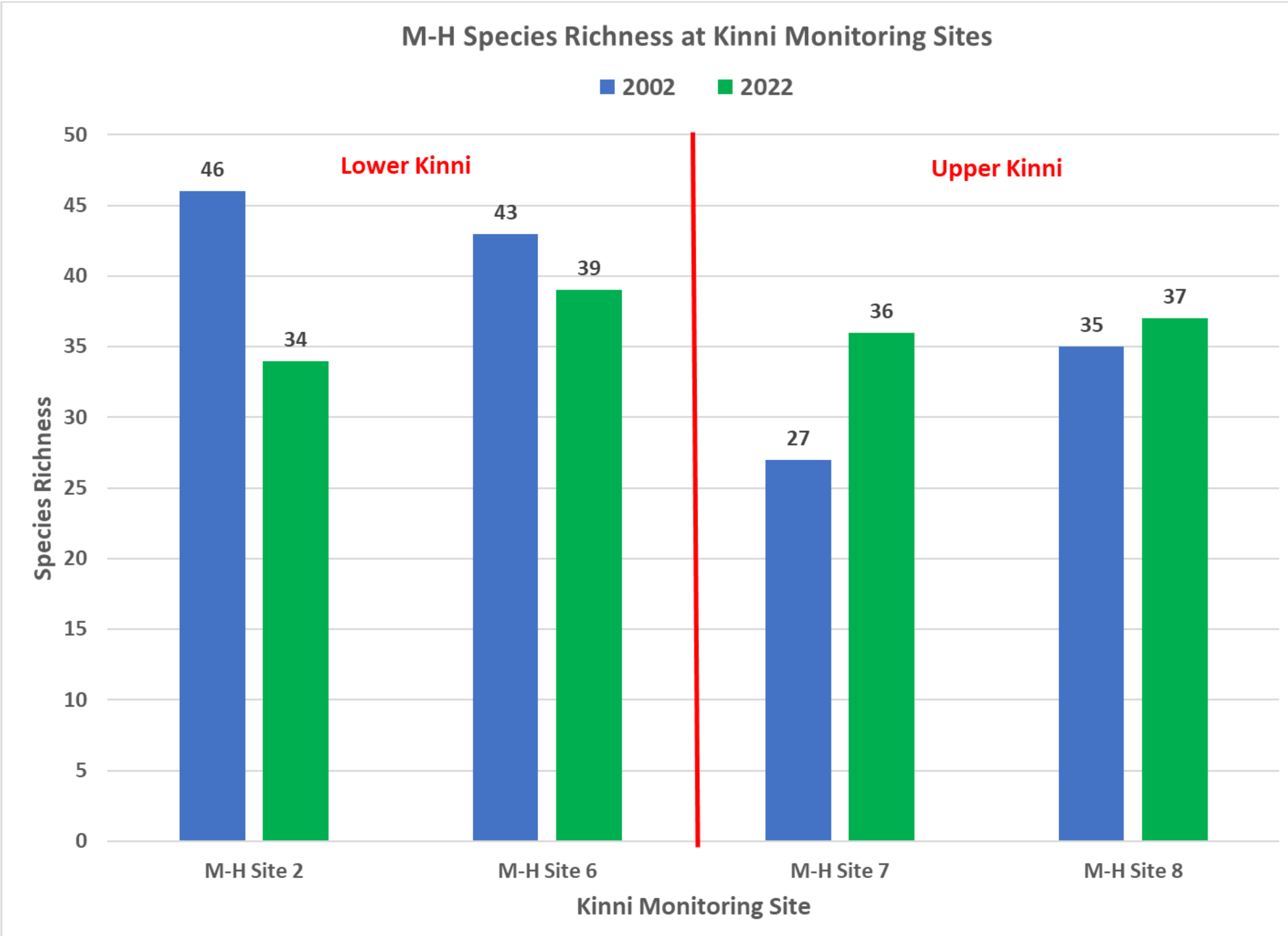


Figure 3. Multi-habitat species richness (SR) at Kinnickinnic River monitoring sites: 2002 vs. 2022.

The 2002/2022 comparison of M-H sampling results indicates that species richness (Figure 3) displays a similar pattern to that of generic richness. In the Upper Kinni (Sites 7 and 8) species richness has increased 6-33% from 2002 to 2022. In contrast, a 9-26% decrease in species richness has occurred in the Lower Kinni (Sites 2 and 6) since 2002. In spite of this decrease, species richness in the Lower Kinni in 2022 remains very similar to that in the Upper Kinni, reflecting a diverse and relatively consistent river continuum.

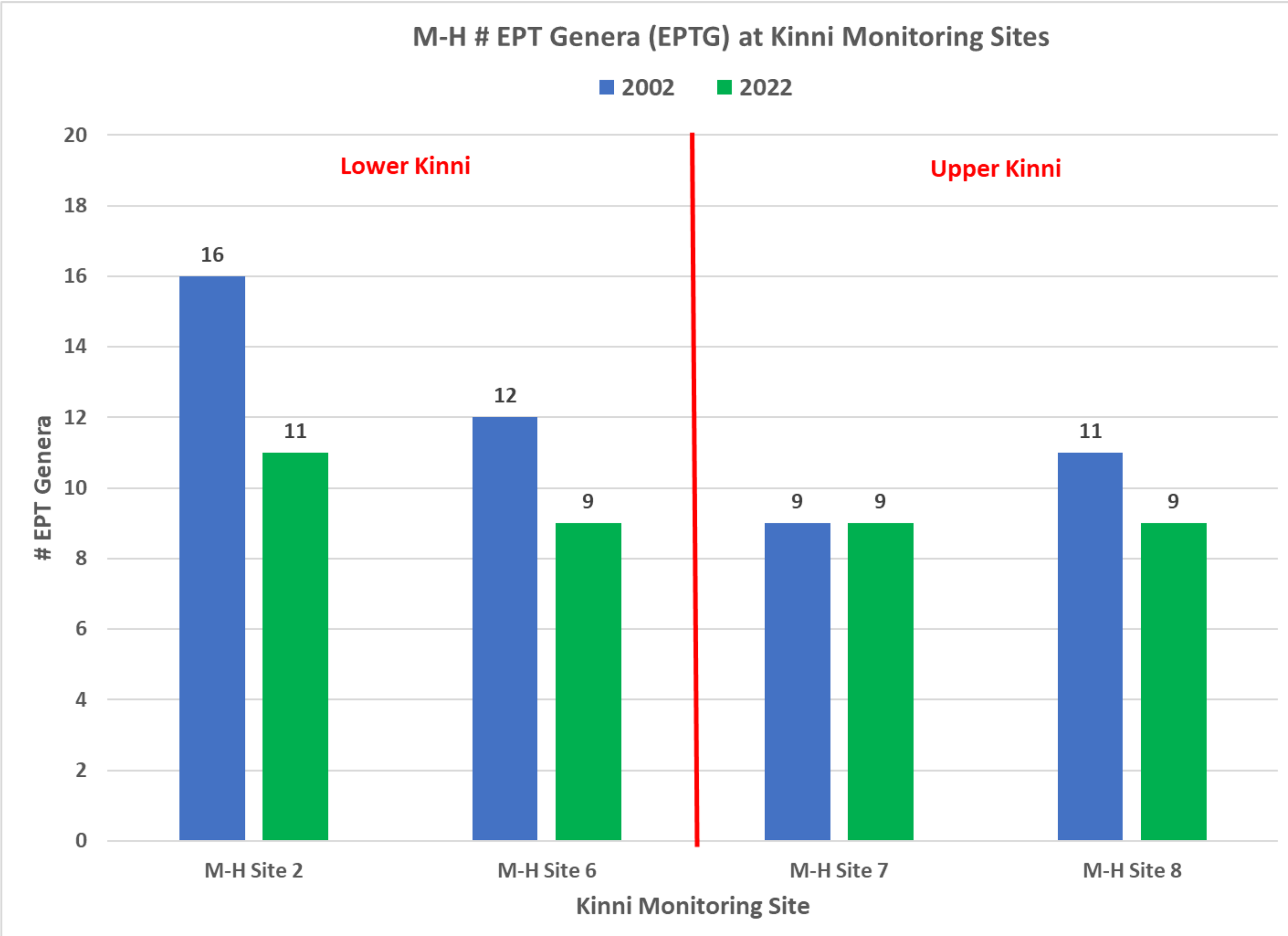


Figure 4. Multi-habitat EPT generic richness (EPTG) at Kinnickinnic River monitoring sites: 2002 vs. 2022.

The 2002/2022 comparison of M-H sampling results indicates that EPT generic richness (Figure 4) in the Upper Kinni (Sites 7 and 8) has remained relatively stable since 2002, although decreasing slightly (18%) at Site 8 in 2022. A 25-31% decrease in EPT generic richness has occurred in the Lower Kinni (Sites 2 and 6) since 2002. In spite of this decrease, EPT generic richness in the Lower Kinni in 2022 remains very similar to that in the Upper Kinni, reflecting a fairly diverse EPT community and a consistent river continuum.

Table 1. Multi-habitat temporal continuity of selected macroinvertebrates at Kinnickinnic River monitoring sites: 2002 vs. 2022.

Taxon and Common Name	Year	M-H Site 2	M-H Site 6	M-H Site 7	M-H Site 8
EPHEMEROPTERA (Mayflies)					
Baetis brunneicolor	2002	●	●		●
Blue-winged Rusty Dun	2022	●	●	●	●
Baetis flavistriga species complex	2002	●	●		●
Dark Blue-winged Olive	2022	●	●	●	●
Ephemerella excrucians	2002	●	●	●	●
Pale Morning Dun	2022	●	●	●	●
Ephemerella needhami	2002	●	●	●	●
Little Dark Hendrickson	2022	●	●	●	●
Maccaffertium vicarium	2002	●	●	●	
March Brown	2022	●	●	●	●
Maccaffertium mediopunctatum	2002	●	●	░	░
Cream Cahill	2022	●	●	░	░
PLECOPTERA (Stoneflies)					
Perlesta sp.	2002	●	●	░	░
	2022	●		░	░
Isoperla dicala	2002	●			●
Sable Stripetail	2022	●	●	●	●
TRICHOPTERA (Caddisflies)					
Ceratopsyche slossonae	2002	●	●	●	●
Spotted Sedge	2022	●	●	●	●
Ceratopsyche alhedra	2002		●		
Spotted Sedge	2022	●	●	●	●
Cheumatopsyche sp.	2002	●	●	●	●
Little Sister Sedge	2022	●		●	●
COLEOPTERA (Beetles)					
Optioservus fastiditus	2002	●	●	●	●
Riffle Beetle	2022	●	●	●	●
DIPTERA, Chironomidae (Midges)					
Orthocladius (Orthocladius)	2002	●	●	●	●
Midge	2022	●	●	●	●
AMPHIPODA (scuds)					
Gammarus pseudolimnaeus	2002	●	●	●	●
Scud or Sideswimmer	2022	●	●	●	●

Dot = Present

Blank = Absent

░ (shaded) = Taxon not collected at sites upstream from M-H Site 6 in 1999 or 2001

Table 1 provides a 2002/2022 comparison of the presence and absence of select Kinnickinnic River macroinvertebrates, based on M-H sampling results. Fourteen genera-species within six taxonomic orders were selected to represent macroinvertebrates of importance to anglers, and those with lower tolerance values that are typically reflective of cleaner water conditions (especially the 11 EPT taxa). Seven genera-species were present in both years, reflecting no change. Three mayfly species (*Baetis brunneicolor*, *Baetis flavistriga*, and *Maccaffertium vicarium*) expanded their presence in the Upper Kinni in 2022. One stonefly species (*Isoperla dicala*) and one caddisfly species (*Ceratopsyche alhedra*) expanded their presence in both the Lower and Upper Kinni in 2022. While present in 2002, one stonefly genus (*Perlesta sp*.) and one caddisfly genus (*Cheumatopsyche sp*.) were absent in the Lower Kinni (Site 6) in 2022. In summary, either no changes (seven genera-species) or net gains (five genera-species) in select genera-species presence were generally observed in the Kinni from 2002 to 2022.

M-H Site 6/S-H Site 478 in the Lower Kinni at Glen Park (2022 photo by Kent Johnson)

Single-Habitat (S-H) Monitoring Results: 2022

As a part of the Kinnickinnic River Monitoring Plan (Morrison and Johnson 2021), a primary objective of the 2022 S-H sampling work was to evaluate the current condition of the Kinni macroinvertebrate community, prior to future dam removal and river restoration. The following graphics provide an analysis of the current condition, using the metrics selected. S-H generic richness (Figure 5), species richness (Figure 6), EPT generic richness (Figure 7), HBI (Figure 8), and *m*-IBI (Figure 9) are presented below. For the purpose of analyzing the 2022 S-H monitoring results, Sites 574 and 652 are located in the Upper Kinni, Sites 120, 478, and 504 are located in the Lower Kinni, and Site 515 is located in the new Kinni river channel that has emerged within the former Lake Louise, since the 2020 drawdown.

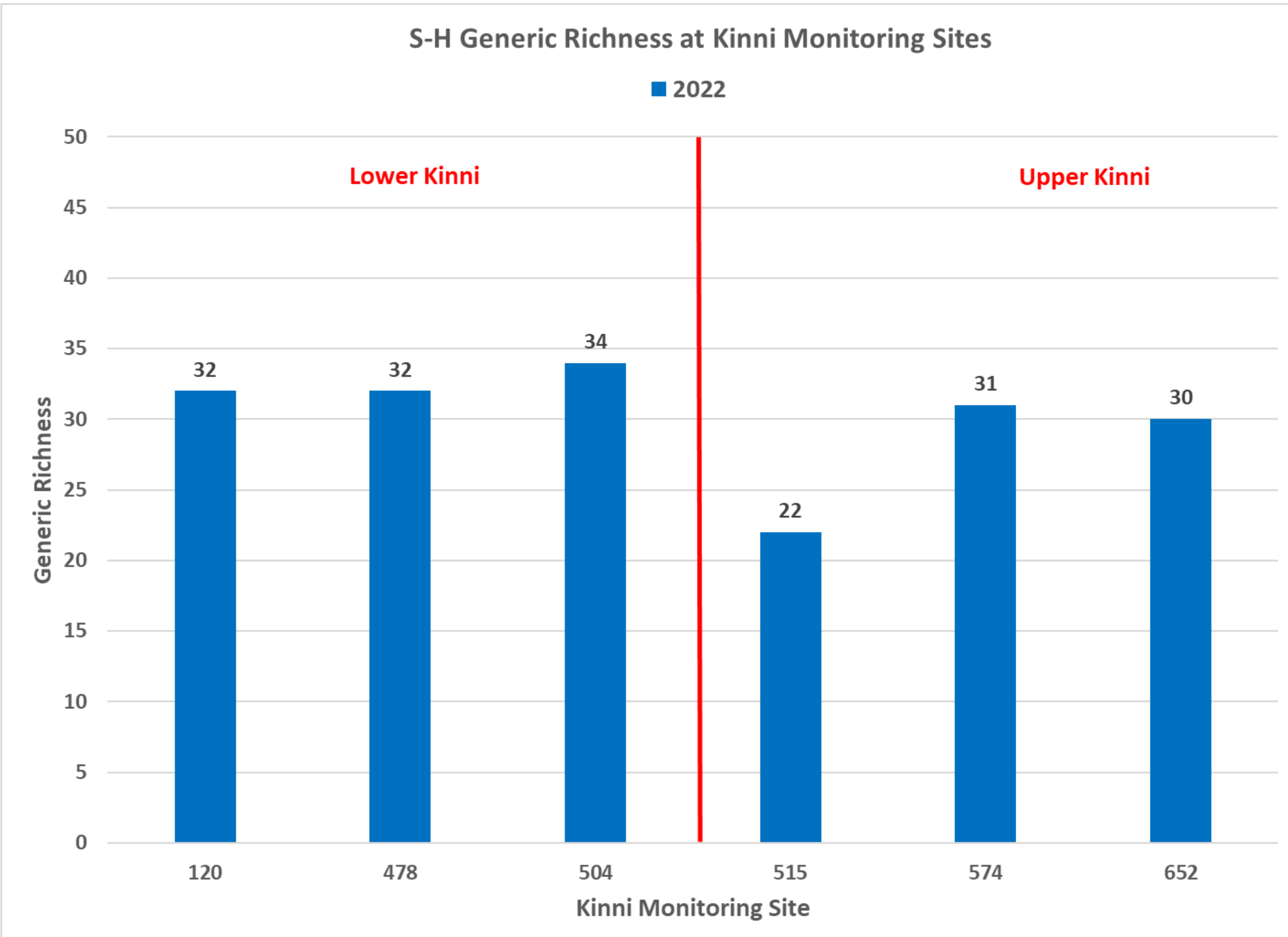


Figure 5. Single-habitat generic richness (GR) at Kinnickinnic River monitoring sites in 2022.

The 2022 S-H sampling results indicate that generic richness (Figure 5) is very consistent across all five Upper and Lower Kinni monitoring sites, ranging from 30-34 genera. At Site 515, generic richness (22 genera) is markedly reduced, possibly due to the instability of the new river channel and ongoing presence of fine sediments that can impact suitable macroinvertebrate habitat.

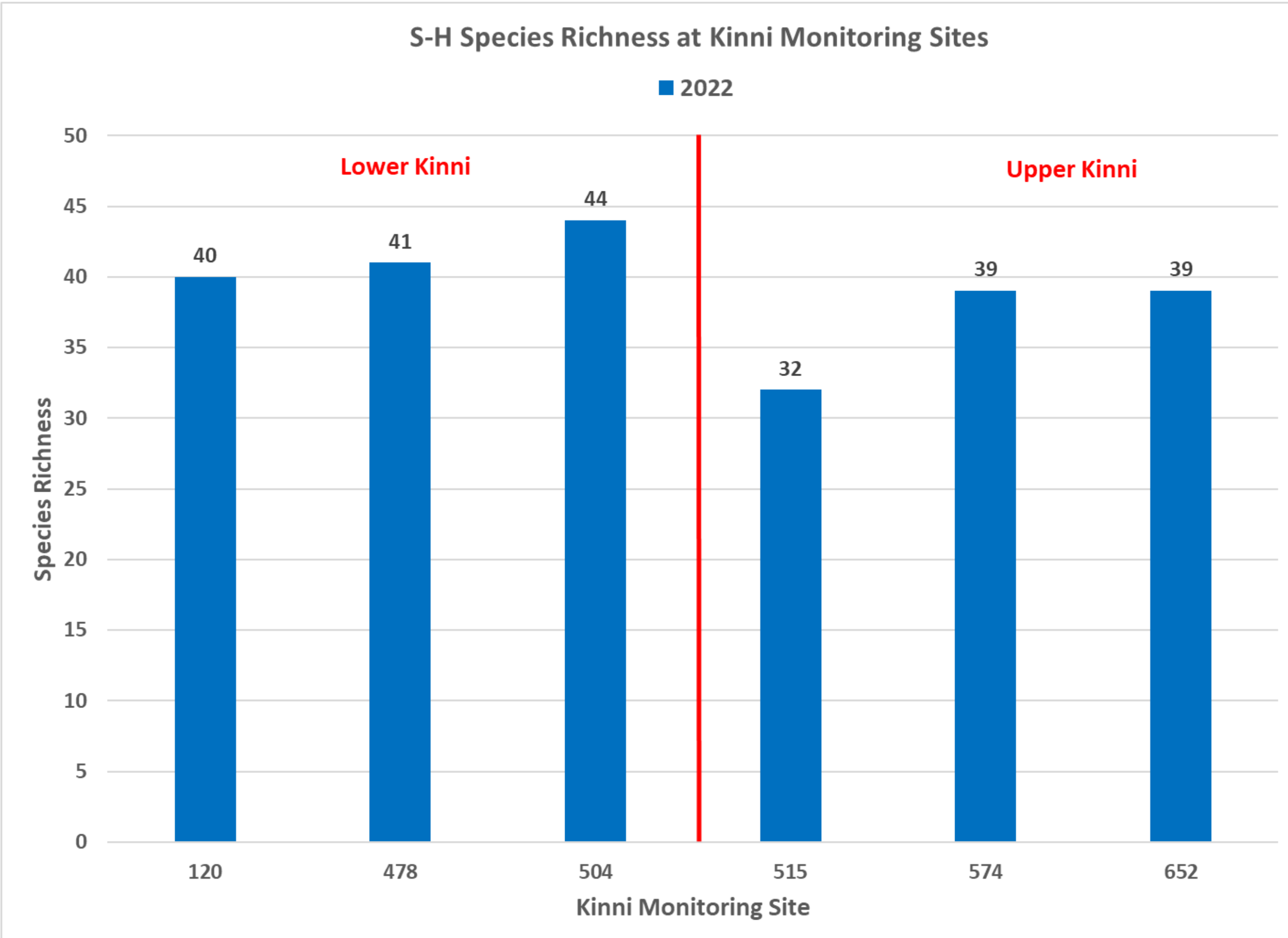


Figure 6. Single-habitat species richness (SR) at Kinnickinnic River monitoring sites in 2022.

The 2022 S-H sampling results indicate that species richness (Figure 6), like generic richness, is very consistent across all five Upper and Lower Kinni monitoring sites, ranging from 39-44 species. As with generic richness, species richness (32 species) is markedly reduced at Site 515, possibly due to the instability of the new river channel and ongoing presence of fine sediments that can impact suitable macroinvertebrate habitat.

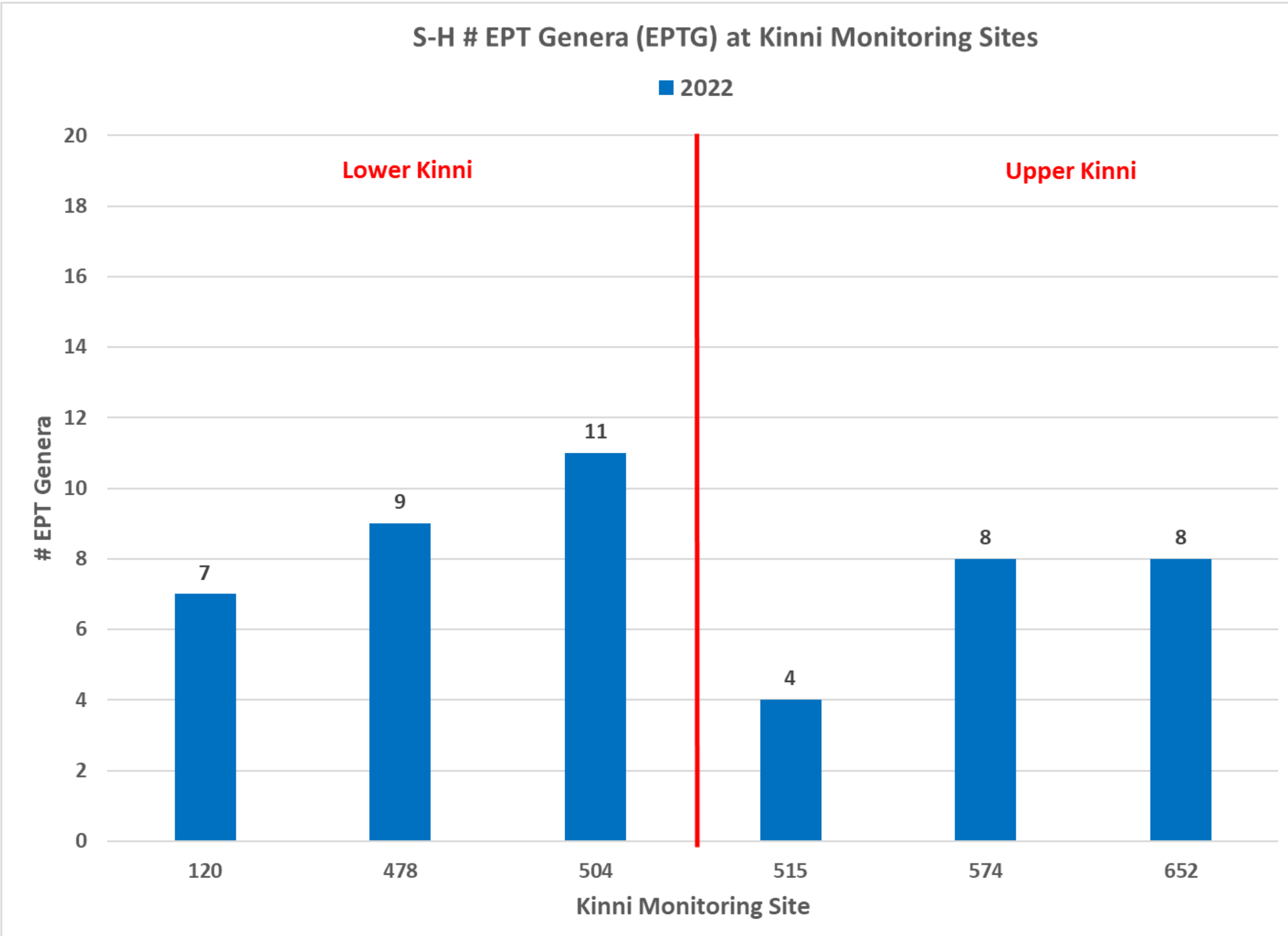


Figure 7. Single-habitat EPT generic richness (EPTG) at Kinnickinnic River monitoring sites in 2022.

As with generic and species richness, the 2022 S-H sampling results indicate that EPT generic richness (Figure 7) is also very consistent across all five Upper and Lower Kinni monitoring sites, ranging from 7-11 genera. Generic richness (34), species richness (44), and EPT generic richness (11) are consistently highest at Site 504 (Lower Kinni), located downstream from the Powell Falls Dam. As with generic and species richness, EPT generic richness (4) is markedly reduced at Site 515.

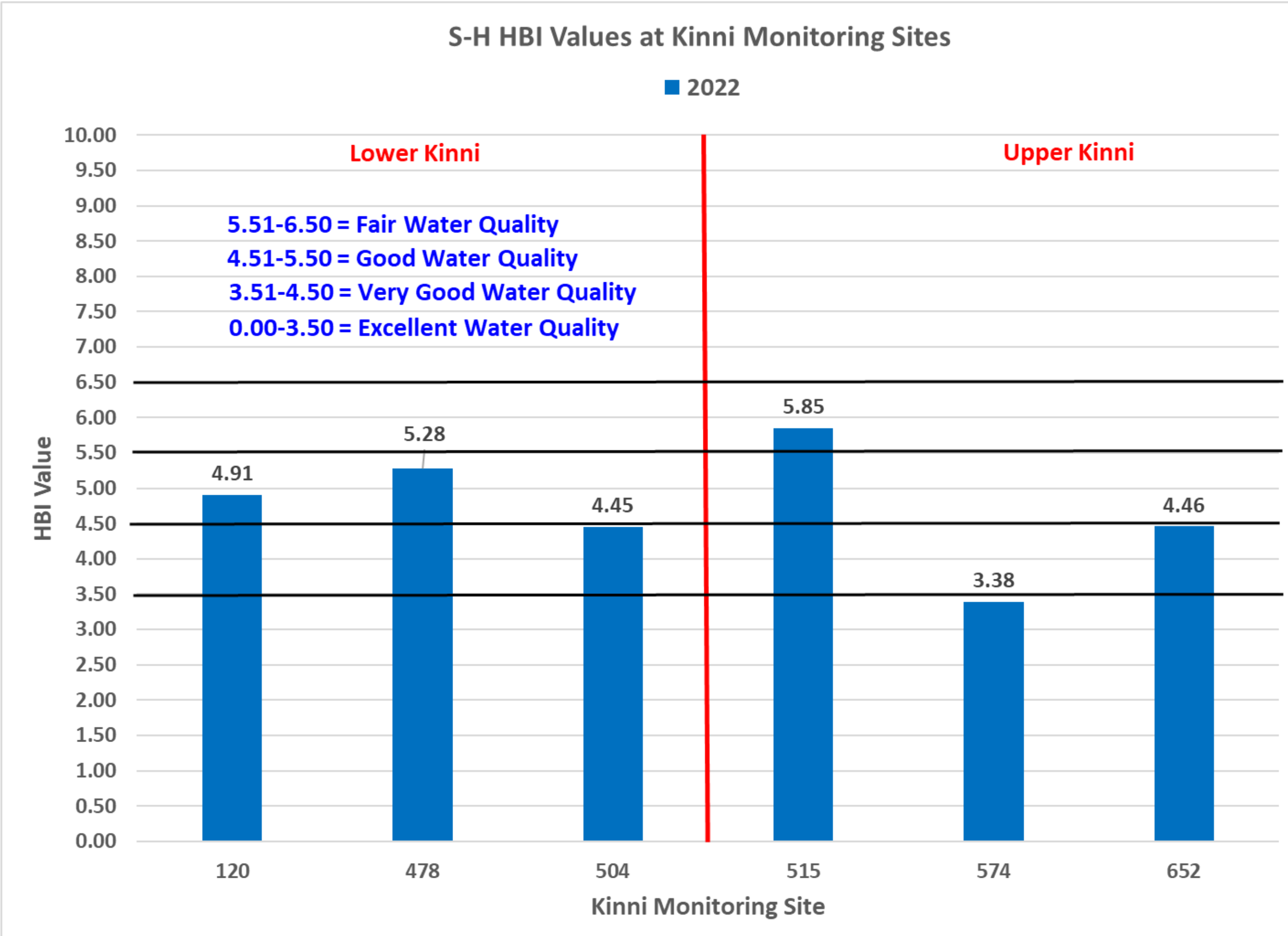


Figure 8. Single-habitat HBI Values at Kinnickinnic River monitoring sites in 2022.

As described in the Glossary (below), the Hilsenhoff Biotic Index (HBI) is a water quality index of organic pollution, based on a macroinvertebrate community's response to the combination of high organic loading (typically nutrient-related) and decreased dissolved oxygen levels. Note that lower HBI values indicate better water quality.

The 2022 S-H HBI values at Kinnickinnic River monitoring sites are presented in Figure 8. At Site 574, the HBI value is indicative of excellent water quality, while HBI values at Sites 504 and 652 are indicative of very good water quality. HBI values at Sites 120 and 478 are indicative of good water quality. The HBI value at Site 515 reflects fair water quality. Based on HBI values, water quality in the Upper Kinni (very good-excellent) is slightly better than water quality in the Lower Kinni (good-very good). The elevated HBI value at Site 515 (fair water quality) may reflect the presence of fine, nutrient-laden sediments in the new Kinni channel and the ongoing water quality influence of Lake George.

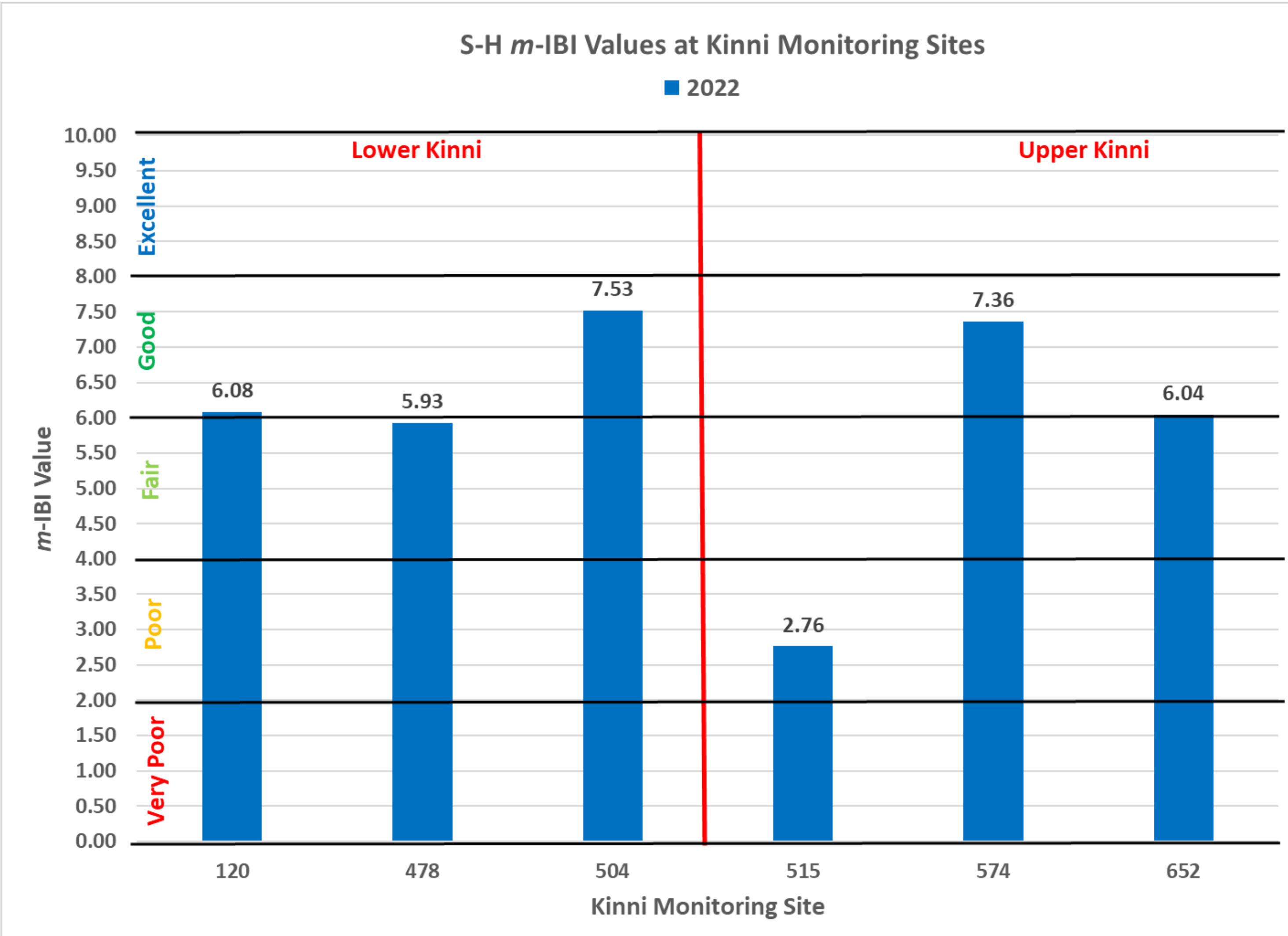


Figure 9. Single-habitat *m*-IBI Values at Kinnickinnic River monitoring sites in 2022.

As described in the Glossary (below), the macroinvertebrate Index of Biotic Integrity (*m*-IBI) is a numerical index (0-10 scale) that provides an integrated expression of site condition by combining multiple macroinvertebrate metrics and environmental stressors (Weigel 2003).

The 2022 S-H *m*-IBI values at Kinnickinnic River monitoring sites are presented in Figure 9. At Sites 120, 504, 574 and 652, *m*-IBI values indicate that the macroinvertebrate communities are in good condition. The *m*-IBI value at Site 478 reflects a fair macroinvertebrate community condition. Based on *m*-IBI values, macroinvertebrate community conditions in the Lower Kinni are very comparable to those in the Upper Kinni. The *m*-IBI value at Site 515 indicates a poor macroinvertebrate community condition, likely influenced by the instability of the new Kinni channel, including bank erosion, embedded substrate, and lack of habitat diversity.

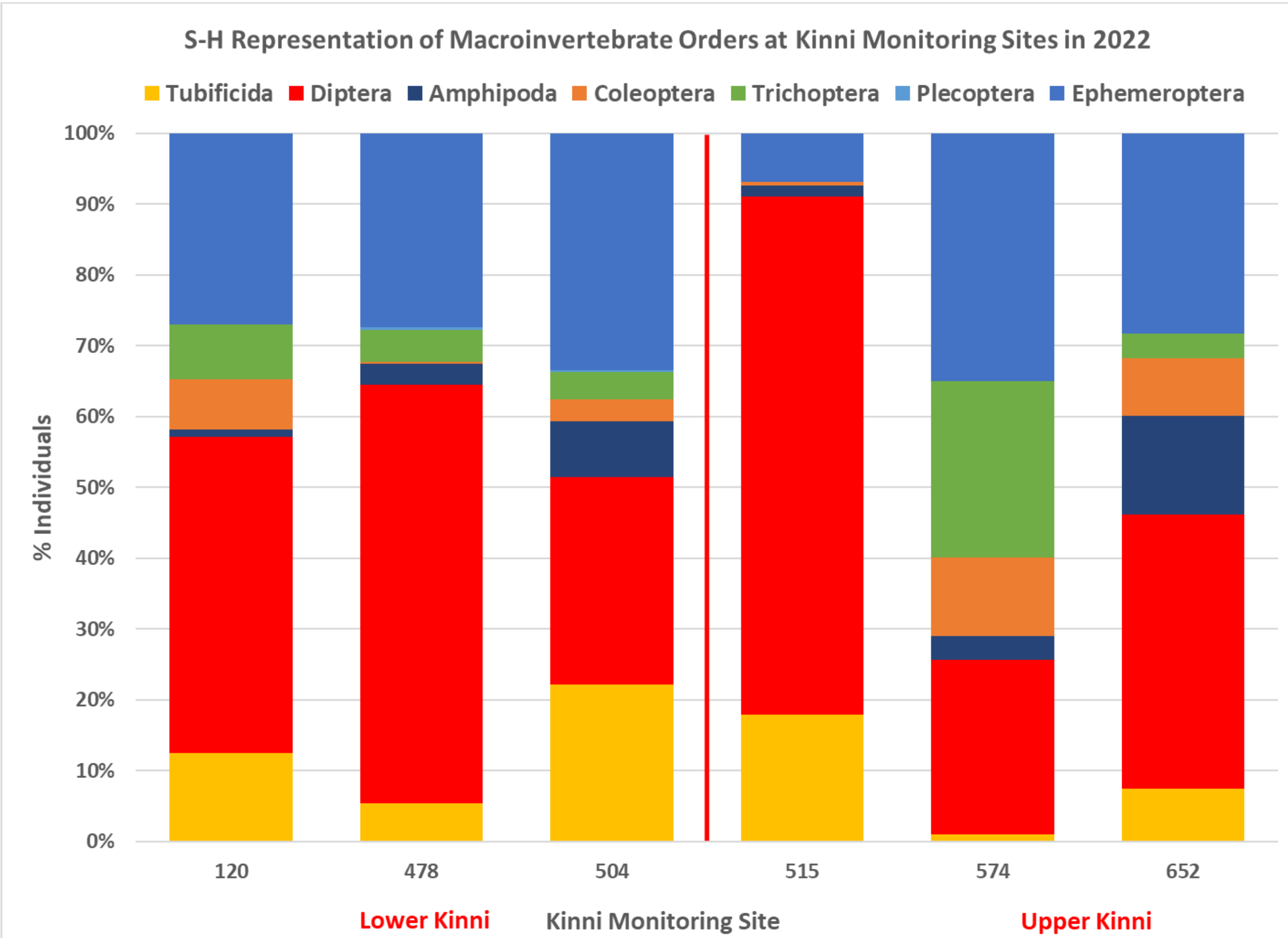
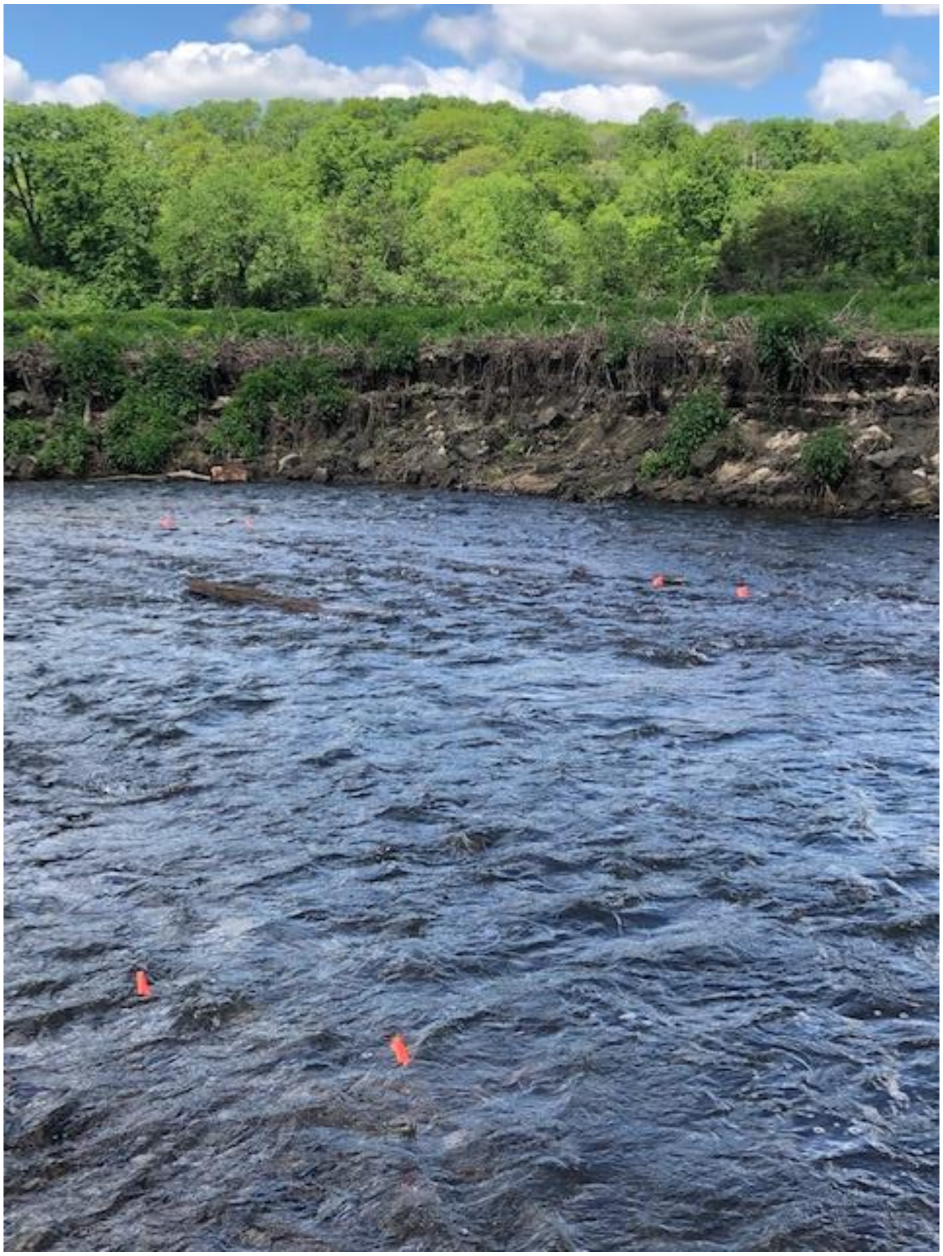


Figure 10. Single-habitat representation of major macroinvertebrate orders at Kinnickinnic River monitoring sites in 2022.

The S-H representation (by percent individuals) of the major macroinvertebrate orders present at Kinnickinnic River monitoring sites in 2022 is shown in Figure 10. The Ephemeroptera, Plecoptera, and Trichoptera (EPT) orders, typically comprised of pollutant intolerant organisms, were most common at Site 574 (60% presence). EPT presence was very similar at Sites 120, 478, 504, and 672, ranging from 32-37%. EPT presence at Site 515 was just 7%, consisting only of five Ephemeroptera species. Within the EPT orders, Plecoptera is poorly represented, appearing only at Sites 478 (<1%) and 504 (<1%) as a single genus (*Perlesta*). The Diptera and Tubificida orders, generally comprised of more pollution tolerant organisms, were dominant (91%) at Site 515. Diptera and Tubificida presence in the Lower Kinni at Sites 120 (58%), 478 (64%), and 515 (51%) was greater than that in the Upper Kinni at Sites 574 (26%) and 652 (46%). The dominance of Diptera and Tubificida orders at Site 515 and increased presence of these orders in the Lower Kinni may be associated with the presence of finer, more organic sediments. The orders Amphipoda (1-14%) and Coleoptera (<1-11%) were present in relatively small proportions across all Kinni monitoring sites.



S-H Site 515 in the former Lake Louise (2022 photo by Kent Johnson)

Multi-Habitat (M-H) vs Single-Habitat (S-H) Monitoring Results: 2022

The M-H protocol is the basis for the only river-wide assessment of Kinni macroinvertebrates in 2001 and 2002, with the strength of representing a broad variety of aquatic habitats at each monitoring site. The S-H protocol is the WDNR-recommended protocol for wadeable streams in Wisconsin, with a history of occasional use for assessing Kinni macroinvertebrates at a limited number of locations. The 2022 Kinni macroinvertebrate data at four monitoring sites can be used to compare the results of these two sampling protocols, employing the metrics of generic richness (GR), species richness (SR), and EPT generic richness (EPTG).

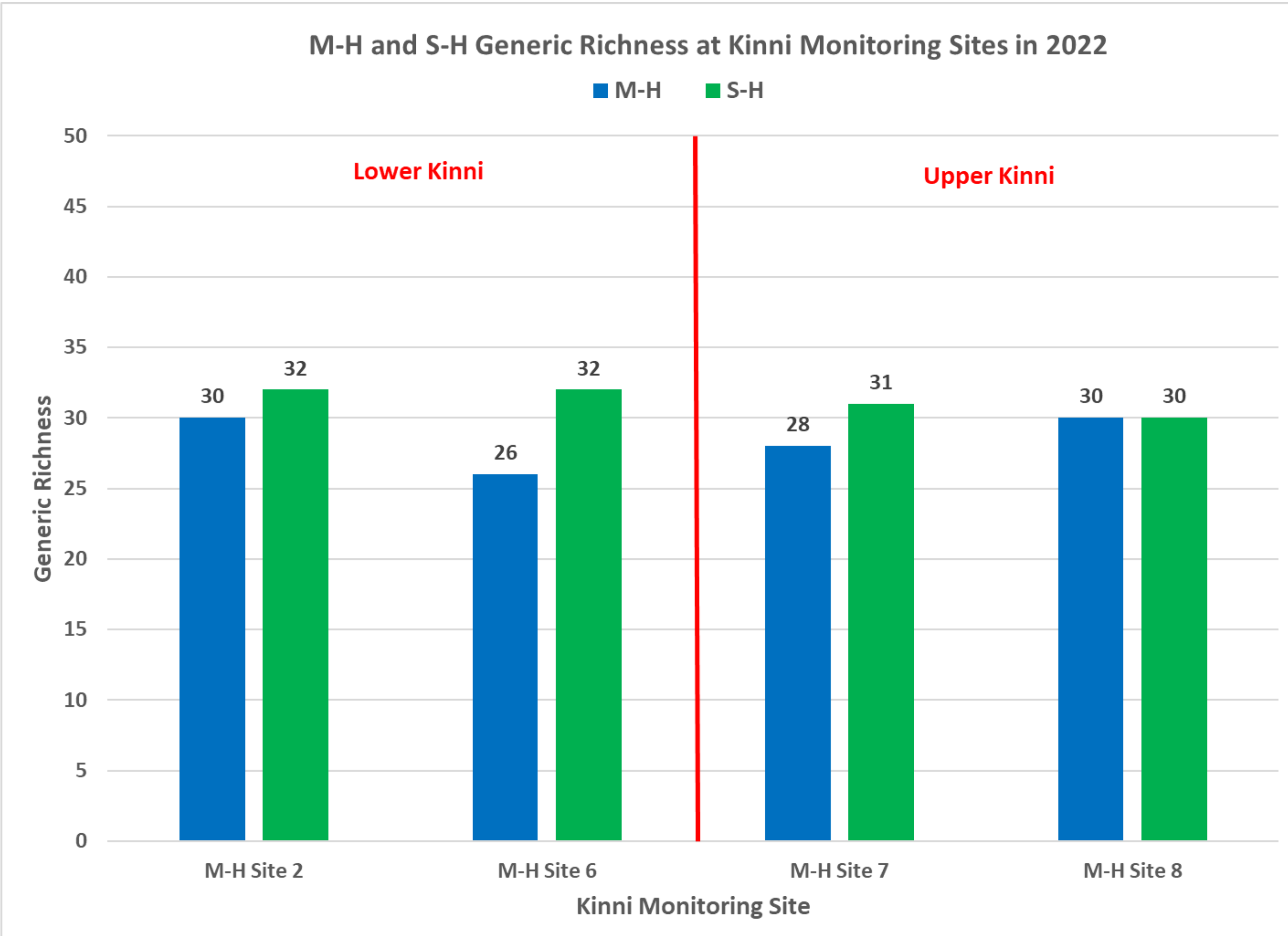


Figure 11. Multi-habitat vs. single-habitat generic richness (GR) at Kinnickinnic River monitoring sites in 2022.

Figure 11 presents a comparison of M-H and S-H generic richness values at four Kinni monitoring sites in 2022. While the M-H and S-H generic richness values are identical at M-H Site 8, S-H generic richness values are slightly higher than M-H generic richness values at M-H Site 2, M-H Site 6, and M-H Site 7, with the greatest difference (6 genera) occurring at M-H Site 6. It appears that the S-H protocol is associated with higher generic richness values, possibly favoring use of the S-H protocol to best estimate generic richness. However, details related to the diversity of generic representation across the major macroinvertebrate orders have yet to be examined for these limited M-H and S-H results. If the M-H and S-H genera lists are different at a given monitoring site, overall generic richness at the site may increase by combining the two lists created by the use of both protocols.

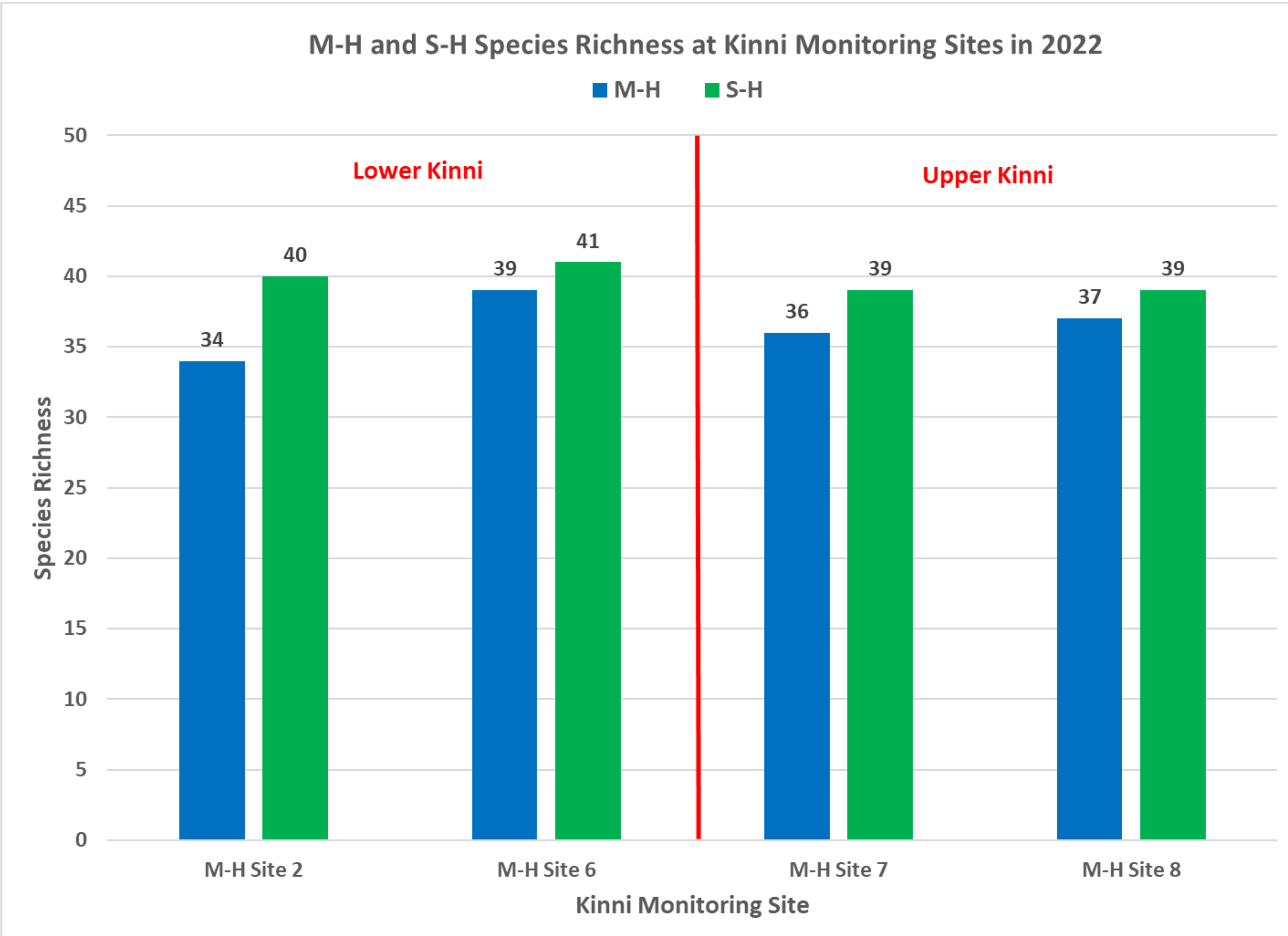


Figure 12. Multi-habitat vs. single-habitat species richness (SR) at Kinnickinnic River monitoring sites in 2022.

Figure 12 presents a comparison of M-H and S-H species richness values at four Kinni monitoring sites in 2022. At all four monitoring sites, S-H species richness values are slightly higher than the M-H species richness values, with the greatest difference (6 species) occurring at M-H Site 2. It appears that the S-H protocol is associated with higher species richness values, possibly favoring use of the S-H protocol to best estimate species richness. However, details related to the diversity of species representation across the major macroinvertebrate orders have yet to be examined for these limited M-H and S-H results. If the M-H and S-H species lists are different at a given monitoring site, overall species richness at the site may increase by combining the two lists created by the use of both protocols.

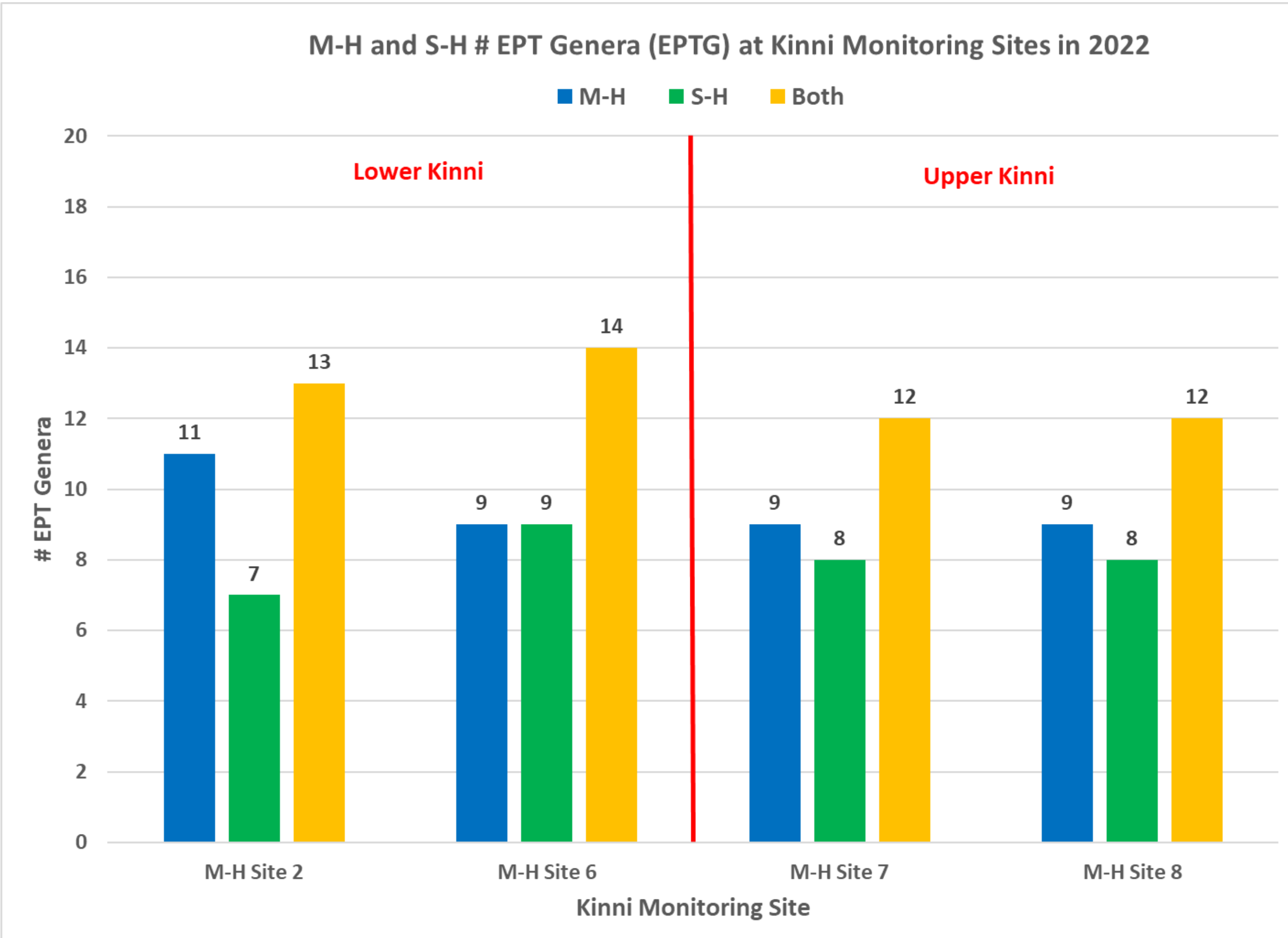


Figure 13. Multi-habitat vs. single-habitat EPT generic richness (EPTG) at Kinnickinnic River monitoring sites in 2022.

Figure 13 presents a comparison of M-H and S-H EPT generic richness values at four Kinni monitoring sites in 2022. While the M-H and S-H EPT generic richness values are identical at M-H Site 6, M-H EPT generic richness values are slightly higher than S-H EPT generic richness values at M-H Site 2, M-H Site 7, and M-H Site 8, with the greatest difference (4 genera) occurring at M-H Site 2. It appears that the M-H protocol is associated with higher EPT generic richness values, possibly favoring use of the M-H protocol to best estimate EPT generic richness. However, EPT generic richness increases notably (by 18-86%) at all sites when the M-H and S-H EPT genera lists are combined (see "Both" in Figure 13), clearly demonstrating the benefit of using both protocols (M-H and S-H) to characterize overall EPT generic richness at any monitoring site. The use of both protocols would likely increase generic richness and species richness values as well (Figures 11 and 12), although further analysis of the Kinni data is needed to confirm that benefit for these two metrics.

Summary of Kinnickinnic River Macroinvertebrate Monitoring Results: 2002/2022

Multi-Habitat (M-H) Monitoring Results: 2002 vs 2022

A primary objective of the 2022 M-H sampling work and the proposed work to follow in 2023-2025 is to create a river-wide comparison of current Kinni macroinvertebrate community conditions to those documented by Garry (Garry 2006) in 2002. At four Lower and Upper Kinni monitoring sites, M-H generic richness, species richness, and EPT generic richness metrics were used to make this comparison.

The 2002/2022 comparison of M-H sampling results indicates that generic richness, species richness, and EPT generic richness values have remained relatively stable in the Upper Kinni since 2002. In contrast, decreases in generic richness, species richness, and EPT generic richness values have occurred in the Lower Kinni since 2002. In spite of these decreases, generic richness, species richness, and EPT generic richness values in the Lower Kinni remain very similar to those in the Upper Kinni in 2022, reflecting a consistent and diverse river continuum.

Single-Habitat (S-H) Monitoring Results: 2022

As a part of the Kinnickinnic River Monitoring Plan (Morrison and Johnson 2021), a primary objective of the 2022 S-H sampling work was to evaluate the current condition of the Kinni macroinvertebrate community, prior to future dam removal and river restoration. Three taxa richness metrics (generic richness, species richness, and EPT generic richness) and two biotic indices (Hilsenhoff Biotic Index (HBI) and the macroinvertebrate Index of Biotic Integrity (*m*-IBI)) were used to analyze the 2022 S-H monitoring results at six Kinni monitoring sites. These sites included three in the Lower Kinni, two in the Upper Kinni, and one in the new Kinni river channel that has emerged within the former Lake Louise, since the 2020 drawdown.

Generic richness (30-34 genera), species richness (39-44 species), and EPT generic richness (7-11 genera) are all very consistent across the five Upper and Lower Kinni monitoring sites. Generic richness (22 genera), species richness (32 species), and EPT generic richness (4 genera) are all markedly reduced in the new Kinni river channel within Lake Louise.

Based on HBI values, water quality in the Upper Kinni (very good-excellent) is slightly better than water quality in the Lower Kinni (good-very good). However, the HBI value in the new Kinni river channel within Lake Louise reflects only fair water quality.

Based on *m*-IBI values, the macroinvertebrate communities in the Lower Kinni are in fair-good condition, while communities in the Upper Kinni are in good condition. In general, *m*-IBI values indicate that macroinvertebrate community conditions in the Lower Kinni are very comparable to those in the Upper Kinni. However, the *m*-IBI value in the new Kinni river channel within Lake Louise indicates a poor macroinvertebrate community condition.

Multiple metrics (generic richness, species richness, EPT generic richness, HBI, and *m*-IBI) indicate that the macroinvertebrate community in the new Kinni river channel within Lake Louise is in a degraded condition. Factors contributing to this condition may include river channel instability (bank erosion and embedded substrate), lack of habitat diversity (presence of fine sediments that reduce suitable macroinvertebrate habitat), and the ongoing water quality influence of Lake George. Given this degraded condition, the new Kinni river channel within Lake Louise will greatly benefit from active river restoration after the Powell Falls Dam is removed.

<u>Multi-Habitat (M-H) vs Single-Habitat (S-H) Monitoring Results: 2022</u>

The M-H protocol is the basis for the only river-wide assessment of Kinni macroinvertebrates in 2001 and 2002, with the strength of representing a broad variety of aquatic habitats at each monitoring site. The S-H protocol is the WDNR-recommended protocol for wadeable streams in Wisconsin, with a history of occasional use for assessing Kinni macroinvertebrates at a limited number of locations. The 2022 Kinni macroinvertebrate data at four monitoring sites can be used to compare the results of these two sampling protocols, employing the metrics of generic richness, species richness, and EPT generic richness.

A comparison of M-H and S-H generic and species richness values at the four Kinni monitoring sites indicates that S-H generic and species richness values are slightly higher than M-H generic and species richness values, possibly favoring use of the S-H protocol to best estimate generic and species richness.

Conversely, the comparison of M-H and S-H EPT generic richness values indicated that M-H EPT generic richness values are slightly higher than S-H EPT generic richness values, possibly favoring use of the M-H protocol to best estimate EPT generic richness. EPT generic richness increases notably at all sites when the M-H and S-H EPT genera lists are combined, clearly demonstrating the benefit of using both protocols (M-H and S-H) to characterize overall EPT generic richness at any monitoring site. The use of both protocols would likely increase generic richness and species richness values as well, although further analysis of the Kinni data is needed to confirm that benefit for these two metrics.

Plans for Future Macroinvertebrate Monitoring (2023-2025)

In February 2023, Clarke Garry and Kent Johnson prepared a proposal that provides a solution to a twenty-year absence of Kinnickinnic River macroinvertebrate monitoring. The plan recommends systematic sampling of macroinvertebrates over the full length of the river (17 sites), using the M-H and S-H protocols. With the completion of four sites (2, 6, 7, and 8) in 2022, 13 sites remain to be sampled. Funding for ABL taxonomic analyses and available volunteer time pose potential obstacles in the realization of this goal. But a yearly stepwise plan during 2023-2025 could make it possible. Thirteen site visits (each with a S-H sample and a M-H sample, plus analysis of the associated 2002 M-H sample collected at that site) make the plan feasible. Experienced personnel are ready and willing to volunteer their services for this effort, as demonstrated in 2022. Specimens collected and archived in 2002 are available for analysis as a baseline for comparison to current conditions. A primary hurdle is securing the funding required for sample analysis by ABL. The suggested multi-year approach (2023-2025) allows support through tiered, stepwise funding. Kiap-TU-Wish has pledged funding to cover the cost of sample collection at Sites 4, 10, 12, and 14 in 2023. Additional funding sources are welcome as the project advances in 2024 and 2025.

Kent Johnson (L) and Reid Dawald (R) at S-H Site 515 in the former Lake Louise (2022 photo by John Wheeler)

Acknowledgments

The authors wish to acknowledge the generous support of the Kiap-TU-Wish Chapter of Trout Unlimited and the Kinnickinnic Corridor Collaborative (KinniCC), for their funding to cover the analysis of 14 M-H and S-H macroinvertebrate samples collected in 2002 and 2022, thereby making this report possible.

We also gratefully acknowledge the dedicated volunteers who assisted with collection of the 10 M-H and S-H samples in 2022, including the KinniCC Stream Team (Reid Dawald, Amber Rappl, and Tovah Flygare) and Sean Morrison (Inter-Fluve). Dr. John Wheeler (UW-River Falls) deserves a special thanks for his field support and provision of monitoring material and supplies and lab space for preliminary sample processing. The field collection of samples was entirely volunteer-driven, including time and mileage. The authors are very appreciative of this volunteer support and commitment.

Finally, we thank Jeffrey Dimick and his staff at the Aquatic Biomonitoring Laboratory at UW-Stevens Point, for their expert taxonomic analysis of the Kinni macroinvertebrate samples.

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Glossary of Macroinvertebrate Metrics Used in This Report

Taxa Richness:

Taxa richness measures represent the number of distinctly different taxa found in a sample. A richness value does not represent the total number of taxa at a site, but rather it is a relative measure or index. Often it is only necessary to process a small fraction (subsample) of a sample to compute a richness value. The remainder of the sample is not included in the calculations and any information regarding additional taxa present at the site is lost. This reflects established laboratory procedures and the need to minimize sample processing costs. Consequently, the data derived from the subsample represent relative measures per total number of specimens examined.

Generic Richness (GR):

Generic Richness (GR) refers to the number of different genera represented in a biotic index subsample. A single unidentified specimen that is identified to family but not to genus will be counted as a genus within that family if no other specimens in that family are identified.

Species Richness (SR):

Species Richness (SR) refers to the number of different species represented in a biotic index subsample. An unidentified specimen that is identified to genus but not to species will be counted as a species within the genus if no other specimens in that genus are identified.

Ephemeroptera-Plecoptera-Trichoptera Generic Richness (EPTG):

EPT Generic Richness (EPTG) represents the number of distinct genera found only among the orders Ephemeroptera, Plecoptera, and Trichoptera (EPT) in a biotic index subsample. These three orders are separated from other aquatic taxa because they generally represent the more organic pollution intolerant organisms present in rivers and streams. Consequently, the EPTG is believed to be a more sensitive metric to organic pollution than GR or SR. The number of EPT taxa generally decreases with increasing stream disturbance.

Biotic indices:

Hilsenhoff Biotic Index (HBI):

The Hilsenhoff Biotic Index (HBI), developed in Wisconsin by William L. Hilsenhoff (Hilsenhoff 1982, 1987), is a water quality index of organic pollution, based on a macroinvertebrate community's response to the combination of high organic loading (typically nutrient-related) and decreased dissolved oxygen levels. The index represents the average weighted pollution tolerance value of all macroinvertebrates present in a sample. Lower HBI values reflect better water quality, based on the following scale:

Water Quality Ratings for HBI Values (from Hilsenhoff 1987):

HBI Value	Water Quality Rating	Degree of Organic Pollution
≤ 3.50	Excellent	None Apparent
3.51-4.50	Very Good	Possible Slight
4.51-5.50	Good	Some
5.51-6.50	Fair	Fairly Significant
6.51-7.50	Fairly Poor	Significant
7.51-8.50	Poor	Very Significant
8.51-10.00	Very Poor	Severe

Macroinvertebrate Index of Biotic Integrity (*m*-IBI):

The macroinvertebrate Index of Biotic Integrity (*m*-IBI) is a numerical index (0-10 scale) that provides an integrated expression of site condition by combining multiple macroinvertebrate metrics and environmental stressors (Weigel 2003). *m*-IBI values are interpreted as follows:

m-IBI Value	Site Condition Rating
<2	Very Poor
2-4	Poor
4-6	Fair
6-8	Good
>8	Excellent

Nine metrics were used to develop the *m*-IBI for Wisconsin's Driftless Ecoregion, and the *m*-IBI reflects multiple environmental stressors within a watershed, including land use, land cover, riparian condition, stream habitat heterogeneity, and stream bed and bank condition. The *m*-IBI is WDNR's primary macroinvertebrate stream classification tool, used as an indicator of aquatic ecosystem health. The *m*-IBI was built to reflect structural changes in macroinvertebrate communities in response to local and watershed-level disturbance, riparian condition, and local habitat quality. As such, the *m*-IBI reflects the response of the macroinvertebrate community to multiple types, and multiple scales, of environmental disturbance. The *m*-IBI can also help in decision-making for prioritizing stream management efforts, restoring habitat, purchasing land for watershed protection, and classifying at-risk streams and watersheds.

ABL Macroinvertebrate Metrics

Generic richness - benthic
Species richness - benthic
HBI (Hilsenhoff 1977, 1982, 1987)
Count of specimens in HBI
10-Max HBI (Hilsenhoff 1998)
Count of specimens in HBI 10-MAX Modification
Mean tolerance value (Lillie and Schlesser 1994)
Count of specimens in HBI that are EPT
% of specimens in HBI that are EPT
FBI (Hilsenhoff 1988)
Count of specimens in FBI
Count of specimens in FBI that are EPT
% of specimens in FBI that are EPT
Count of specimens in sample - includes non-HBI and non-benthic specimens
Count of benthic specimens in sample
Count of EPT specimens in benthic sample
% of specimens in benthic count that are EPT
Count of EPT genera in benthic sample
% of benthic genera that are EPT taxa
Shannon's diversity index
Macroinvertebrate-based Index of Biotic Integrity (Weigel 2003)
Count of Chironomidae genera in benthic sample
% of benthic genera that are Chironomidae taxa
Count of Chironomidae specimens in benthic sample
% of specimens in benthic sample that are Chironomidae
Count of depositional tolerant genera in benthic sample
% of genera in benthic sample that are depositional tolerant
Count of Amphipoda individuals in benthic sample
% of specimens in benthic sample that are Amphipoda
Count of Isopoda individuals in benthic sample
% of specimens in benthic sample that are Isopoda
Count of Diptera individuals in benthic sample
% of specimens in benthic sample that are Diptera