A Physical Habitat Assessment of Pennsylvania Lake Erie Watershed Streams

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June 2011

ACKNOWLEDGEMENTS

We would like to thank those who provided critical input to this document: Dr. Robert Light, Penn State Behrend; Lori Boughton, Pennsylvania Department of Environmental Protection; and Joseph Hudson and Gene Clemente, Erie County Conservation District. In addition we would like to thank the Pennsylvania Coastal Resources Management Program and Erie County Conservation District for providing the funding necessary to complete the project.

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1.0 ABSTRACT

The Pennsylvania portion of the Lake Erie watershed encompasses an area of 508 square miles, including 52 streams totaling a length of 1,122 miles. Many of these streams provide habitat essential for fish migration such as steelhead, which provides a unique experience for Pennsylvania anglers. An evaluation of stream habitat condition is important to the assessment of a stream's ecological integrity. In summer 2010, a physical assessment of 320 stream locations on 36 streams within the Pennsylvania Lake Erie watershed was conducted as part of efforts to complete the *Lake Erie Watershed Integrated Water Resource Management Plan*, which will serve as a blueprint for restoration and protection efforts within the Pennsylvania Lake Erie watershed.

Sites were assessed using USEPA's Rapid Bioassessment visual-based habitat assessment methodology, which evaluates 10 individual habitat parameters and sums the scores of each parameter to obtain a total habitat score. General parameters (biology, invasive species, presence of livestock, impediments to fish migration, pipes present, water appearance, streambank stability, riparian buffer, and wetland) were also assessed at each sampling location. The individual habitat parameters and total habitat rating at the sampling sites were compared to the fish and macroinvertebrate observation data using the two-proportion z-test. The relationship between the individual habitat parameters and total habitat score was tested using the Kendall tau (τ) rank correlation coefficient test.

Of the 280 high gradient stream sites evaluated for total habitat score, 32 sites (11.4%) were optimal, 209 sites (74.6%) were suboptimal, 38 sites (13.6%) were marginal, and one site (0.4%) was poor. Of the 21 low gradient streams evaluated for total habitat score, none of the sites were optimal, 14 sites (67.7%) were suboptimal, seven sites (33.3%) were marginal, and none of the sites were poor. Each of the 36 streams assessed were ranked from highest to lowest according to the mean total habitat scores and mean individual habitat parameter scores. Twelvemile Creek received the highest mean total habitat score of the streams with multiple sampling locations ($n = 14$; $\mu = 150.6$; $\sigma = 10.07$; suboptimal condition), and Tributary 62436 received the lowest mean total habitat score among all the streams ($n = 3$; $\mu = 86.7$; $\sigma = 27.76$). For the high gradient streams, there was a statistically significant relationship between each of the 10 habitat parameters and the total habitat score ($\tau \neq 0$; $p < 0.001$); the strongest relationship was between epifaunal/substrate cover and total habitat score ($\tau = 0.4666$; $p < 0.001$). For the low gradient streams, there was a statistically significant relationship between epifaunal/substrate cover, pool substrate, pool variability, channel flow status, channel alteration, and riparian vegetative zone width and the total habitat score ($\tau \neq 0$; $p < 0.05$); the strongest relationship was between epifaunal/substrate cover and total habitat score ($\tau = 0.73$; $p < 0.001$).

Habitat quality is an essential component of any biological survey because aquatic biota have very specific habitat requirements independent of water quality, and there is clear evidence that habitat alteration is a primary cause of degraded aquatic resources. Fish were observed in 241 of the 316 sites (76.3%) and macroinvertebrates were observed in 259 of the 314 sites (82.5%). The presence of fish was negatively impacted ($p < 0.05$) by degraded epifaunal and substrate cover, velocity and depth regimes, and riparian vegetative zone width. The presence of macroinvertebrates was negatively impacted ($p < 0.05$) by degraded epifaunal and substrate cover, embeddedness, velocity and depth regimes, and a reduced total habitat rating.

2.0 INTRODUCTION

The Pennsylvania portion of Lake Erie watershed encompasses an area of 508 square miles, including 52 streams totaling a length of 1,122 miles (**Map 1**). Many of these streams provide habitat essential for fish migration such as steelhead, which provides a unique experience for Pennsylvania anglers. Habitat impairment resulting from urbanization and agriculture practices poses a threat to the steelhead fishery as well as the local economy. Murray and Shields (2004) estimated that the steelhead fishery generated $5.71 million in new value-added activity in Erie County, Pennsylvania in 2003, supporting 219 jobs in the economy through direct and indirect effects.

An evaluation of stream habitat condition is important to the assessment of a stream's ecological integrity (Barbour *et al.* 1999). Specifically, the assessment of the physical habitat is useful in evaluating stream health as habitat provides the link between the physical environment and a stream's inhabitants (Maddock 1999). Assessment of physical habitat becomes particularly important when considering fishery enhancement projects and potential stream restoration and protection efforts. For example, the Pennsylvania Fish and Boat Commission utilizes the United States Environmental Protection Agency's (USEPA) Rapid Bioassessment Protocols described by Barbour *et al.* 1999 for evaluating stream habitat conditions prior to implementing fish habitat improvement projects (Lutz 2007).

In 2010, Pennsylvania Sea Grant completed the *Presque Isle Bay watershed restoration, protection, and monitoring plan* (http://pib.psu.edu). The plan summarizes a comprehensive GIS-based data collection, assessment, and analysis effort; and serves as a living document that provides the framework to drive coordinated restoration, protection, and monitoring projects within the Presque Isle Bay watershed. A major component of the plan was the development of GIS-based restoration and protection prioritization models. The models assist in identifying and ranking subareas within the Presque Isle Bay watershed most in need of restoration and protection efforts. Chemical, physical, and biological data collected as part of initial watershed monitoring efforts by Campbell *et al.* 2002 were used to develop the models.

Based upon the success of the plan, additional funding was obtained to apply the plan's framework to the Pennsylvania portion of the Lake Erie watershed in the development of a *Pennsylvania Lake Erie watershed integrated water resource management plan*. As part of initial integrated planning efforts, data gaps for the Lake Erie watershed were identified. Specifically, watershed-wide chemical, physical, and biological data were found to be lacking. In summer 2010, to address gaps in the physical data, a Pennsylvania Lake Erie watershed-wide stream physical habitat assessment was conducted using USEPA's Rapid Bioassessment Protocols. This report highlights the results of the Pennsylvania Lake Erie watershed physical habitat assessment.

3.0 METHODOLOGY

3.1 Sampling Locations

A total of 320 stream locations on 36 streams within the Pennsylvania Lake Erie watershed were assessed between May and October 2010 (**Table 1**; **Map 2**). Assessment sites were selected based on accessibility and the presence of water. Generally, non-posted stream locations near road crossing and with visibly flowing water were evaluated. Sites were assessed using the visual-based habitat assessment methodology described by Barbour *et al.* 1999. In addition, the following data were recorded at each site: stream name; site name; latitude and longitude; weather conditions; stream and air temperatures; stream width; water depth; land use; water appearance; streambank stability; presence of pipes; presence of invasive species; livestock use; presence of fish and macroinvertebrates; presence of fish impediments; riparian buffer condition; and the presence of wetlands.

The data collected at each site did vary slightly depending on accessibility. For example, the visual-based assessment was performed at only 301 of the 320 sites, while pipe observations were made at all 320 sites. Data collected at each site were recorded on a *Pennsylvania Lake Erie Watershed Assessment Data Form* (**Form A** and **Form B**).

3.2 Habitat Assessment

USEPA's Rapid Bioassessment Protocol for evaluating habitat provides a way for quantifying the condition of existing habitat. The visual-based habitat assessment is dependent on stream gradient – high or low gradient. Streams were classified as high gradient in locations where riffles and runs were prevalent and low gradient in locations where pools were prevalent. At each location, a 100-meter stream segment was assessed. The visual based assessment evaluated and scored 10 parameters on a range of 0 to 20 (**Table 2** and **Table 3**) and classified each parameter as optimal (16-20), suboptimal (11-15), marginal (6-10), or poor (0-5). The individual parameter scores were then summed to get a total habitat score for each location. Total habitat scores were classified as optimal (160-200), suboptimal (110-159), marginal (60-109), or poor (< 60). The habitat parameters evaluated included:

- *Epifaunal Substrate/Available Cover*: the relative quantity and variety of natural structures in the stream (e.g. large rocks, fallen trees, logs and branches, and undercut banks) available as refuge, feeding, or sites for spawning and nursery functions of aquatic biota. Assessed for high and low gradient streams.
- *Embeddedness:* the extent to which rocks (e.g. gravel, cobble, and boulders) are covered by silt, sand, or mud of the stream bottom. Assessed for high gradient streams.
- *Pool Substrate Characterization:* the type and condition of bottom substrates found in pools. Assessed for low gradient streams.
- *Velocity/Depth Regimes:* patterns of velocity and depth (slow-shallow, fast-shallow, slow-deep, and fast-deep). Assessed for high gradient streams.
- *Pool Variability:* rates the overall mixture of pool types found in streams, according to size and depth (large-shallow, small-shallow, large-deep, and small-deep). Assessed for low gradient streams.
- *Sediment Deposition:* the amount of sediment that has accumulated in pools and the changes that have occurred to the stream bottom as a result of deposition. Assessed for high and low gradient streams.
- *Channel Flow Status:* the degree to which the channel is filled with water. Assessed for high and low gradient streams.
- *Channel Alteration:* a measure of large-scale changes in the shape of a stream channel. Assessed for high and low gradient streams.
- *Frequency of Riffles:* mechanism for measuring the sequence of riffles and the heterogeneity of the stream. Assessed for high gradient streams.
- *Channel Sinuosity*: evaluates the meandering of the stream. Assessed for low gradient streams.
- *Bank Stability:* measures whether the stream banks are eroded or have the potential for erosion. Assessed for high and low gradient streams.
- *Bank Vegetative Protection:* measures the amount of vegetative protection on the stream bank and near-stream portion of the riparian zone. Assessed for high and low gradient streams.
- *Riparian Vegetative Zone Width:* measures the width of natural vegetation from the edge of the stream bank through the riparian zone. Assessed for high and low gradient streams.

Each of the streams were ranked from best condition to worst condition based on the individual habitat parameters and total habitat scores. The mean score was calculated by averaging the individual parameter scores from each sampling location within the specified stream.

3.3 Correlation Analysis

The relationship between the individual parameters and total habitat score was tested using the Kendall tau (τ) rank correlation coefficient test described by Helsel and Hirsch 1992. The null hypothesis (H_o)

tested was there is no relationship between the parameters ($\tau = 0$; $p > 0.05$) and the alternative hypothesis (H_a) was there is a relationship between the parameters ($\tau \neq 0$; $p < 0.05$). All tau calculations were performed using the Kendall tau Rank Correlation – Free Statistics Software (Wessa 2008).

3.4 General Parameter Assessments

Similar to the visual-based habitat assessment, the general parameters were assessed on a 100-meter section of stream unless otherwise noted. The following parameters were recorded at each sampling location:

- *Stream Name:* the stream name or tributary number.
- *Site Name:* assigned using the initials of the stream and a number corresponding to the sequence in which the site was assessed.
- *Latitude and Longitude:* identifies the geographic location of the site recorded in decimal degrees.
- *Weather:* observation of the weather conditions at the time of the assessment.
- *Stream Temperature:* measured in degrees Fahrenheit (°F) and Celsius (°C).
- *Air Temperature:* measured in degrees Fahrenheit (°F) and Celsius (°C).
- *Stream Width:* measured the width (feet) of the stream from bank to bank, at the points which the dry bank meets the water.
- *Water Depth:* measured the average depth (inches) of the stream based on five measurements averaged across the stream channel.
- *Land Use:* approximated the percentage of land use by type (forest, agricultural, residential, commercial, industrial, and other). Land use was determined based on a visual assessment of the land surrounding the stream location.
- *Water Appearance:* observation of the turbidity of the water (clear or turbid).
- *Streambank Stability:* observation of whether the streambank was stable or eroding.
- *Pipe(s) Present:* observation of the number and type of pipe(s) present and whether the pipe was discharging or being used to withdraw water.
- *Biology:* observation for the visual presence of fish and macroinvertebrates, and the presence of any impediments to fish migration (e.g. dams or waterfalls). To determine the presence of macroinvertebrates a minimum of five rocks were assessed at each sampling location. The presence of fish was determined by visually assessing the stream.
- *Invasive Species:* observation of whether or not invasive plants or fish were present, and the type of invasive.
- *Livestock:* observation of whether livestock were visibly present in the area surrounding the stream, and if the livestock had access to the stream.
- *Riparian Buffer:* observation on the riparian buffer zone condition (protected or impaired).
- *Wetland(s):* observation for the presence of wetlands and whether the wetland was impacted.

3.5 Two-Proportion Z-test Analysis

The individual habitat parameters and total habitat rating at the sampling sites were compared to the fish and macroinvertebrate observation data described under *Section 3.4*. The statistical relevance between the percentage of sites rated as optimal with fish present versus the percentage of sites rated as poor and/or marginal with fish present, and the percentage of sites rated as optimal with macroinvertebrates present versus the percentage of sites rated as poor and/or marginal with macroinvertebrates present were tested using the two-proportion z-test. Marginal sites were only included when there were less than 10 sites rated as poor. The null hypothesis (H_o) tested was there is no difference between the habitat ratings and presence of fish or macroinvertebrates ($p_1 = p_2$; $p > 0.05$) and the alternative hypothesis (H_a) was there is a difference between the habitat ratings and the presence of fish or macroinvertebrates ($p_1 \neq p_2$; $p < 0.05$). All calculations were performed using the online Z-Test for Two Proportions Calculator (http://www.dimensionresearch.com/resources/calculators/ztest.html).

3.6 Photo Documentation

Digital photographs were taken at each of the locations assessed. The photographs provide a visual record of the stream habitat as well as any impairment such as erosion, pipes, and riparian impacts. Copies of the photographs are available upon request. Contact Sean Rafferty, Pennsylvania Sea Grant, via e-mail (sdr138@psu.edu) to obtain photographs.

4.0 RESULTS AND DISCUSSION

4.1 General Parameter Assessments

The general parameters assessed provide a characterization of the general condition of the streams and serve as baseline information for future stream assessments. For the purposes of this report, only the biology, invasive species, livestock, impediments to fish migration, pipe(s) present, water appearance, stream bank stability, riparian buffer, and wetland(s) were evaluated. Stream and air temperature, and stream width and depth were recorded but not evaluated.

4.1.1 Stream Biology

Figure 1. Fish observed in Elk Creek

The biota of a stream reflects the current and recent conditions of the habitat, water quality, and hydrological factors, and determinations of their diversity and abundance can be used to assess the health of the stream. While the current study did not evaluate the diversity of fish and macroinvertebrate communities present in Pennsylvania Lake Erie streams, the general presence of fish and macroinvertebrates was assessed, which can be used to guide future biological investigations. Fish were observed in 241 of the 316 sites (76.3%) (**Map 3**), and macroinvertebrates were observed in 259 of the 314 sites (82.5%) (**Map 4**). Most of the sites assessed were high gradient and likely experience increased stream velocities during rain events, particularly in areas with impervious surfaces. The absence of macroinvertebrates and fish at the sampling sites may be the result of scouring and increased stream velocities during storm events. To better characterize the macroinvertebrate and fish communities within the Pennsylvania Lake Erie watershed, a more detailed evaluation should be considered.

4.1.2 Invasive Species

Figure 2. Multiflora rose observed along Orchard Beach Run

Invasive species pose a significant risk to native flora and fauna. Invasive plants are displacing native plants and degrading habitat for native insects, birds, and animals. Endangered, rare, and threatened species are particularly vulnerable because they often occur in small populations. The evaluation of invasive species within the Pennsylvania Lake Erie watershed focused primarily on assessing the presence of aquatic invasive plants and terrestrial invasive plants. Invasive plants were observed at 260 of the 319 sites (81.5%) (**Map 5**). The most common invasive species observed were multiflora rose, common privet, Japanese knotweed, oriental bittersweet, purple loosestrife, Japanese honeysuckle, and garlic mustard. In accordance with the *Pennsylvania Aquatic Invasive Species Management Plan* (AISMPC 2006), the feasibility of controlling and eradicating these invasive species should be investigated.

4.1.3 Livestock

The presence of livestock along streams can result in pollutants (e.g. nutrients and bacteria) being discharged to the stream, resulting in negative impacts to the stream ecosystem as well as negatively impacting receiving waters. All the streams assessed empty into Lake Erie, which serves a source of drinking water for millions of residents. Bacterial contamination from runoff may impact receiving waters and bathing beaches, and increased nutrient inputs to Lake Erie as a result of agricultural uses can result in eutrophication. Livestock were observed near the stream at 17 of the 318 sites (5.3%) (**Map 6**), and livestock only had access to the stream at 4 of the 17 locations where they were present. Assistance (to property owners) in implementing agricultural best management practices should be considered for sites impacted by livestock.

Figure 3. Livestock observed along Elk Creek

4.1.4 Fish Impediments

Fish impediments are natural or human created obstacles that can impede the movement of fish. Changes in habitat, population, or water quality as result of barriers can create pressure for fish to relocate. Fish impediments, including natural waterfalls, concrete waterfalls, culverts, and sediment deposition at the mouth of the stream, were observed at 26 of the 318 sites (8.2%) (**Map 7**). The impediments may impede steelhead migration; therefore, the feasibility of removing or bypassing these impediments should be investigated to promote more fishing opportunities for anglers.

Figure 4. Fish impediment in Fourmile Creek

4.1.5 Pipe(s) Present

Pipes along streams, especially pipes discharging storm water and sewage treatment effluent, can result in significant impacts to the streams quality, biota, and hydrology. Pipes were observed at 112 of the 320 sites (35.0%) (**Map 8**); pipes at 35 of the 112 sites (31.3%) were observed to be discharging at the time of the evaluation (**Map 9**). Pipes were classified as storm water, gauge station, pump station, roof drain, sewage, water intake, or unknown. Of the 35 sites with pipes observed to be discharging, 30 were related to storm water, four were unknown, and one was related to sewage effluent discharge.

Figure 5. Discharging pipe along Sixteenmile Creek

4.1.6 Water Appearance

The streams water appearance was used as a surrogate for measuring the turbidity of the stream. Generally, turbidity measures the clarity of the water and is the result of suspended particles such as sediment, plankton, and microbes present in the water. Of the 317 sites evaluated for water appearance, 252 sites (79.5%) appeared clear and 65 sites (20.5%) were classified as turbid (**Map 10**).

4.1.7 Streambank Stability

Streambank stability is an active process and while erosion does occur naturally, human-related activities often accelerate erosion. The removal of streamside vegetation can dramatically increase the erosion of stream banks. The streambank was observed to be unstable or eroding at 187 of the 318 sites (58.8%) (**Map 11**). Streambank stability is assessed further under the habitat assessment section (*Section 4.2.8*).

4.1.8 Riparian Buffer

Riparian buffers serve as a link between stream environments and their terrestrial surroundings. Riparian ecosystems have been widely accepted as a viable and useful tool for restoring and managing streams because of their ability to moderate stream temperatures; reduce sediment, pathogen, metal, pesticide, toxin, and nutrient input; provide important sources of organic matter to stream communities; provide important wildlife habitat; and stabilize stream banks (Osborne and Kovacic 1993; Klapproth and Johnson 2000). The riparian buffer was observed to be impacted at 123 of the 318 sites (38.7%) (**Map 12**). Riparian buffers are assessed further under the habitat assessment section (*Section 4.2.10*).

4.1.9 Wetlands

Wetlands play a vital role in regulating movement of water within watersheds. Wetlands store precipitation and surface water and release it into other surface and groundwater reserves and to the atmosphere, and in doing so, serve an important role in controlling water flow, regulating discharge of water from catchments, retarding flows and mitigating flood damage, and protecting against erosion (Werren *et al.* 2000). Wetlands were observed at 37 of the 318 sites (11.6%) (**Map 13**).

Figure 6. Wetland in the Elk Creek Watershed

4.2 Habitat Assessment

Each of the 10 parameters assessed at each site were evaluated independently. Sites were also evaluated using a total habitat score calculated as the sum of the 10 parameters assessed at each site. In total, 280 high-gradient (**Map 14**) and 21 low-gradient (**Map 15**) stream sites along 36 streams were assessed. In addition, results from the analysis of each parameter (optimal versus poor/marginal ratings) were compared to the fish and macroinvertebrate observations. Low-gradient stream results were not compared to the fish and macroinvertebrate observations because of the small sample size.

4.2.1 Epifaunal/Substrate Cover

Of the 280 high-gradient stream sites assessed for epifaunal/substrate cover, 104 sites (37.1%) were optimal, 99 sites (35.4%) were suboptimal, 67 (23.9%) sites were marginal, and 10 sites (3.6%) were poor (**Map 16**). Of the 21 low-gradient sites, four sites (19.0%) were optimal, six sites (28.7%) were suboptimal, seven sites (33.3%) were marginal, and four sites (19.0%) were poor (**Map 17**). Raccoon Creek received the highest mean epifaunal/substrate cover score of the streams with multiple sampling locations (n = 7; $\mu = 16.3$; $\sigma = 2.86$; optimal condition), and Duck Run received the lowest mean epifaunal/substrate cover score of the streams with multiple sampling locations (n = 4; $\mu = 6.8$; $\sigma = 4.65$; marginal condition) (**Table 4**).

Figure 7. Site on Sixteenmile Creek with optimal epifaunal/substrate cover

A variety and abundance of epifaunal/substrate cover in streams provide aquatic biota, particularly fish and macroinvertebrtates, with a number of areas to inhabit. As the abundance and variety of cover decreases so does the diversity of fish and macroinvertebrates. The presence of fish in the high-gradient streams appeared to be negatively affected by the availability of epifaunal/substrate cover ($z = 3.64$; $p < 0.05$). As the availability of cover decreased, the presence of fish declined. Fish were observed in 93 of the 104 sites (89.4%) ranked as optimal opposed to 51 of the 77 sites (66.2%) ranked as marginal or poor. The availability of cover also appeared to negatively affect the presence of macroinvertebrates ($z = 2.33$; $p < 0.05$). As the availability of cover decreased, the presence of macroinvertebrates declined. Macroinvertebrates were observed in 95 of the 104 sites (91.3%) ranked as optimal opposed to 60 of the 77 sites (77.9%) ranked as marginal or poor. These results suggest that stream locations with a greater variety and abundance of epifaunal and substrate cover provide better habitat for fish and macroinvertebrates.

Figure 8. Site on Sevenmile Creek with poor epifaunal/substrate cover

4.2.2 Embeddedness and Pool Substrate Characterization

Of the 280 high-gradient stream sites assessed for embeddedness, 86 sites (30.7%) were optimal, 91 sites (32.5%) were suboptimal, 82 sites (29.3%) were marginal, and 21 sites (7.5%) were poor (**Map 18**). McDannel Run received the highest mean embeddedness score of the streams with multiple sampling locations ($n = 2$; $\mu = 17.5$; $\sigma = 1.50$; optimal condition), and Tributary 62436 received the lowest mean embeddedness score ($n = 3$; $\mu = 4.7$; $\sigma = 1.25$; poor condition) (**Table 5**).

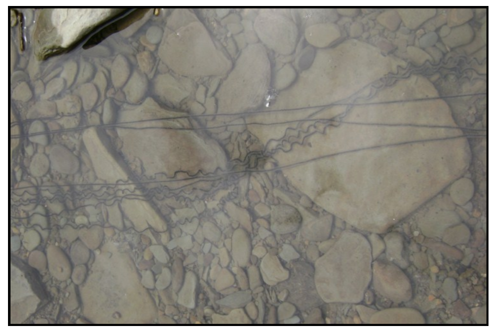

Figure 9. Site on Twentymile Creek with optimal embeddedness

Embeddedness results from large-scale sediment movement and deposition, and as rocks become embedded, the area available for fish and macroinvertebrates decreases; therefore, potentially impacting the abundance and diversity of aquatic biota. The presence of fish in the high-gradient streams was not affected by embeddedness ($z = 0.12$; $p > 0.05$). Fish were observed in 61 of the 86 sites (70.9%) ranked as optimal and 14 of the 21 sites (66.7%) ranked as poor. The embeddedness appeared to negatively affect the presence of macroinvertebrates ($z = 1.77$; $p < 0.05$). As the embeddedness in the streams increased, the presence of macroinvertebrates decreased. Macroinvertebrates were observed in 71 of the 86 sites (82.6%) ranked as optimal opposed to 13 of the 21 sites (61.9%) ranked as poor. These results suggest that stream locations with optimal embeddedness conditions provide better habitat for macroinvertebrates; however, the degree of embeddedness does not affect the presence of fish.

Figure 10. Site on Fivemile Creek with poor embeddedness

Of the 21 low-gradient streams assessed for pool substrate characterization, two sites (9.5%) were optimal, 11 sites (52.4%) were suboptimal, six sites (28.6%) were marginal, and two sites (9.5%) were poor (**Map 19**). The mean pool substrate score was in the suboptimal range ($\mu = 11.0$; $\sigma = 4.49$). Firmer sediments (e.g. gravel and sand) and rooted vegetation support a larger diversity of aquatic biota than substrate dominated by mud or bedrock. Also, streams with uniform substrate tend to support fewer species of aquatic biota.

4.2.3 Velocity/Depth Regimes and Pool Variability

Figure 11. Site on Fourmile Creek with optimal velocity/depth regimes

Of the 280 high-gradient stream sites assessed for velocity/depth regimes, 77 sites (27.5%) were optimal, 111 sites (39.6%) were suboptimal, 72 sites (25.7%) were marginal, and 20 sites (7.2%) were poor (**Map 20**). Fourmile Creek received the highest velocity/depth regime score of the streams with multiple sampling locations ($n = 12$; $\mu = 17.6$; $\sigma = 2.81$; optimal condition), and Orchard Beach Run received the lowest mean velocity/depth regime score of the streams with multiple sampling locations ($n = 4$; $\mu = 5.5$; $\sigma = 1.50$; poor/marginal condition) (**Table 6**).

Figure 12. Site on Orchard Beach Run with poor velocity/depth regimes

High-gradient streams categorized as optimal will have all four patterns of velocity and depth present, including slow-deep, slow-shallow, fast-deep, and fast-shallow. High-gradient streams categorized as poor will be dominated by one velocity and depth regime. This is important as the occurrence of the varying velocity and depth regimes relates to a stream's ability to support a stable aquatic environment. The presence of fish in the high-gradient streams appeared to be negatively affected by the velocity and depth regimes ($z = 3.96$; $p < 0.05$). As the diversity of the velocity and depth regimes decreased, the presence of fish decreased. Fish were observed in 68 of the 77 sites (88.3%) rated as optimal opposed to nine of the 20 sites (45.0%) rated as poor. The presence of macroinvertebrates in the high-gradient streams appeared to be negatively affected by the velocity and depth regimes ($z = 1.77$; $p < 0.05$). As the diversity of the velocity and depth regimes decreased, the presence of macroinvertebrates decreased. Macroinvertebrates were observed in 71 of the 77 sites (92.2%) rated as optimal opposed to 15 of the 20 sites (75.0%) rated as poor. These results suggest that stream locations with a variety of velocity and depth regimes provide better habitat for fish and macroinvertebrates.

Of the 21 low-gradient stream sites assessed for pool variability, two sites (9.5%) were optimal, seven sites (33.3%) were suboptimal, seven sites (33.3%) were marginal, and five sites (23.9%) were poor (**Map 21**). The mean pool variability score was in the marginal range ($\mu = 9.3$; $\sigma = 4.33$). Generally, streams with a mixture of pool types will support a greater diversity of aquatic biota.

4.2.4 Sediment Deposition

Figure 13. Site on Elk Creek with optimal sediment deposition

Of the 280 high-gradient stream sites assessed for sediment deposition, 56 sites (20.0%) were optimal, 110 sites (39.3%) were suboptimal, 96 sites (34.3%) were marginal, and 18 sites (6.4%) were poor (**Map 22**). Of the 21 low-gradient stream sites, seven sites (33.3%) were optimal, 10 sites (47.6%) were suboptimal, three sites (14.3%) were marginal, and one site (4.8%) was poor (**Map 23**). Orchard Beach Run received the highest mean sediment deposition score of the streams with multiple sampling locations ($n = 4$; $\mu = 17.3$; $\sigma = 1.92$; optimal condition), and Tributary 62436 received the lowest mean sediment deposition score of the streams with multiple sampling locations ($n = 3$; $\mu = 5.0$; $\sigma = 0.00$; poor condition) (**Table 7**).

Deposition occurs from the large-scale movement of sediment, and may cause the formation of islands, point bars, and shoals or result in the filling of pools and runs. Increased amounts of sediment deposition are indications of an unstable stream system that may become unsuitable for aquatic biota. The presence of fish in the high-gradient streams was not affected by sediment deposition ($z = -0.17$; $p > 0.05$). Fish were observed in 35 of the 56 sites (62.5%) rated as optimal and 11 of the 18 sites (61.1%) rated as poor. The presence of macroinvertebrates in the high-gradient streams was not affected by sediment deposition ($z = 0.95$; $p > 0.05$). Macroinvertebrates were observed in 48 of the 56 sites (85.7%) rated as optimal and 13 of the 18 sites (72.2%) rated as poor. These results suggest that the presence of macroinvertebrates and fish are not affected by increased sediment deposition.

Figure 14. Site on Tributary 62684 with poor sediment deposition

4.2.5 Channel Flow Status

Of the 280 high-gradient stream sites assessed for channel flow status, 56 sites (20.0%) were optimal, 99 sites (35.4%) were suboptimal, 117 sites (41.8%) were marginal, and eight sites (2.8%) were poor (**Map 24**). Of the 21 low-gradient stream sites, eight sites (38.1%) were optimal, nine sites (42.9%) were suboptimal, two sites (9.5%) were marginal, and two sites (9.5%) were poor (**Map 25**). Orchard Beach Run received the highest channel flow status score ($n = 4$; $\mu = 18.3$; $\sigma = 0.43$; optimal condition), and Motch Run received the lowest mean channel flow status score of the streams with multiple sampling locations ($n = 3$; $\mu = 7.0$; $\sigma = 1.41$; marginal condition) (**Table 8**).

Figure 15. Site on Conneaut Creek with optimal channel flow

Figure 16. Site on Walnut Creek with poor channel flow

The flow of a stream will change as the channel enlarges or as flow decreases as a result of dams or other obstructions. In high-gradient streams when riffles and cobble substrate are exposed or in low-gradient streams when logs and snags are exposed, the amount of suitable habitat for aquatic biota may be limited. The presence of fish in the high-gradient streams appeared to be positively affected by the channel flow ($z = 4.08$; $p < 0.05$). As the channel flow status of a stream decreased, the presence of fish increased. Fish were observed in 31 of the 56 sites (55.4%) rated as optimal opposed to 106 of the 125 sites (84.8%) rated as poor or marginal. The presence of macroinvertebrates in the high-gradient streams appeared to be positively affected by the channel flow ($z = 2.88$; $p < 0.05$). Macroinvertebrates were observed in 42 of the 56 sites (75.0%) rated as optimal opposed to 115 of the 125 sites (92.0%) rated as poor. These results suggest that as the channel flow is reduced, the presence of fish and macroinvertebrates increases. However, this may be as a result of fish and macroinvertebrates being easier to observe in low flow conditions.

4.2.6 Channel Alteration

Of the 280 high-gradient stream sites assessed for channel alteration, 56 sites (20.0%) were optimal, 195 sites (69.6%) were suboptimal, 28 sites (10.0%) were marginal, and one site (0.4%) was poor (**Map 26**). Of the 21 low-gradient stream sites, two sites (9.5%) were optimal, 17 sites (80.9%) were suboptimal, one site (4.8%) was marginal, and one site (4.8%) was poor (**Map 27**). McDannel Run received the highest mean channel alteration score of the streams with multiple sampling locations ($n = 2$; $\mu = 16.5$; σ

= 1.50; optimal condition), and Duck Run received the lowest mean channel alteration score (n = 4; μ = 9.8; σ = 4.65; marginal condition) (**Table 9**).

Figure 17. Site on Conneaut Creek with optimal channel alteration

Channelized streams provide fewer habitats for fish and macroinvertebrates than do naturally meandering streams. Channel alteration is present when artificial embankments, rip rap, and other forms of artificial bank stabilization structures are present; when dams and bridges are present; and when the stream is straight for significant distances. The presence of fish in the high-gradient streams was not affected by channel alteration ($z = -0.28$; $p > 0.05$). Fish were observed in 44 of the 56 sites (78.6%) rated as optimal and 22 of the 28 sites (78.6%) rated as marginal or poor. The presence of macroinvertebrates in the high-gradient streams was not affected by channel alteration ($z = 1.12$; $p > 0.05$). Macroinvertebrates were observed in 52 of the 56 sites (92.9%) rated as optimal and 23 of the 28 sites (82.1%) rated as marginal or poor. These results suggest that the presence of macroinvertebrates and fish are not affected by channel alteration.

Figure 18. Site on Sixteenmile Creek with poor channel alteration

4.2.7 Frequency of Riffles and Channel Sinuosity

Of the 280 high-gradient stream sites assessed for frequency of riffles, 148 sites (52.9%) were optimal, 68 sites (24.3%) were suboptimal, 48 sites (17.1%) were marginal, and 16 sites (5.7%) were poor (**Map 28**). Twelvemile Creek received the highest mean frequency of riffles score of the streams with multiple sampling locations (n = 14; μ = 18.3; σ = 1.30; optimal condition), and Turkey Creek received the lowest mean frequency of riffles score (n = 2; μ = 7.0; σ = 1.00; marginal condition) (**Table 10**).

Figure 19. Site on Sixmile Creek with optimal frequency of riffles

Riffles provide a source of high quality habitat and an increased occurrence of riffles enhances the diversity of aquatic biota. The presence of fish in the high-gradient streams was not affected by the frequency of riffles ($z = 0.86$; $p > 0.05$). Fish were observed in 110 of the 148 sites (74.3%) rated as optimal and 14 of the 16 sites (87.5%) rated as poor. The presence of macroinvertebrates in the high-gradient streams was not affected by the frequency of riffles ($z = 1.20$; $p > 0.05$). Macroinvertebrates were observed in 123 of the 148 sites (83.1%) rated as optimal and 11 of the 16 sites (68.8%) rated as poor. These results suggest that the presence of macroinvertebrates and fish are not affected by the frequency of riffles.

Figure 20. Site on Trout Run with poor frequency of riffles

Of the 21 low-gradient stream sites assessed for channel sinuosity, one site (4.8%) was optimal, four sites (19.0%) were suboptimal, 11 sites (52.4%) were marginal, and five sites (23.8%) were poor (**Map 29**). The mean channel sinuosity score was in the marginal range (μ = 8.6; σ = 3.75). Increased sinuosity of a stream provides for diverse habitat and aquatic biota, and better protects a stream from fluctuations during storm events. Adsorption of energy from storm events by the bends of the stream protects the stream from erosion and flooding and provides protection for macroinvertebrates and fish.

4.2.8 Bank Stability

Figure 21. Site on Peck Run with optimal bank stability

Of the 280 high-gradient stream sites assessed for bank stability (both banks combined), 136 sites (48.6%) were optimal, 82 sites (29.3%) were suboptimal, 56 sites (20.0%) were marginal, and six sites (2.1%) were poor (**Map 30**). Each bank was also assessed separately. Of the 280 sites assessed for left-bank stability, 109 sites (38.9%) were optimal, 96 sites (34.3%) were suboptimal, 65 sites (23.2%) were marginal, and 10 sites (3.6%) were poor (**Map 31**). Of the 280 sites assessed for right-bank stability, 115 sites (41.1%) were optimal, 95 sites (33.9%) were suboptimal, 58 sites (20.7%) were marginal, and 12 sites (4.3%) were poor (**Map 32**).

Figure 22. Site on Motch Run with poor bank stability

Of the 21 low-gradient stream sites assessed for bank stability, 15 sites (71.4%) were optimal, five sites (23.8%) were suboptimal, one site (4.8%) was marginal, and none of the sites were poor (**Map 33**). Of the 21 sites assessed for left-bank stability, 14 sites (66.7%) were optimal, four sites (19.0%) were suboptimal, two sites (9.5%) were marginal, and one site (4.8%) was poor (**Map 34**). Of the 21 sites assessed for right-bank stability, 15 sites (71.5%) were optimal, four sites (19.0%) were suboptimal, two sites (9.5%) were marginal, and none of the sites were poor (**Map 35**). McDannel Run received the highest mean bank stability score ($n = 4$; $\mu = 18.8$; $\sigma = 1.29$; optimal condition), and Motch Run received the lowest mean bank stability score ($n = 3$; $\mu = 4.7$; $\sigma = 0.94$; poor condition) (**Table 11**).

Eroded stream banks indicate a problem of sediment movement and deposition, and suggest a lack of cover to the stream. As previously discussed, increased sediment deposition as a result of erosion may negatively impact the presence and diversity of aquatic biota. The presence of fish in the high-gradient streams was not affected by the bank stability ($z = 0.04$; $p > 0.05$). Fish were observed in 105 of the 136 sites (77.2%) rated as optimal and 47 of the 62 sites (75.8%) rated as marginal or poor. The presence of macroinvertebrates in the high-gradient streams was not affected by the bank stability ($z = 1.20$; $p > 0.05$). Macroinvertebrates were observed in 120 of the 136 sites (88.2%) rated as optimal and 50 of the 62 sites (96.2%) rated as marginal or poor. These results suggest that the presence of macroinvertebrates and fish are not affected by degraded bank stability.

4.2.9 Bank Vegetative Protection

Figure 23. Site on Raccoon Creek with optimal bank vegetative protection

Of the 280 high-gradient stream sites assessed for bank vegetation protection (both banks combined), 160 sites (57.2%) were optimal, 70 sites (25.0%) were suboptimal, 39 sites (13.9%) were marginal, and 11 sites (3.9%) were poor (**Map 36**). Each bank was also assessed separately. Of the 280 sites assessed for left-bank vegetation, 132 sites (47.1%) were optimal, 86 sites (30.7%) were suboptimal, 42 sites (15.0%) were marginal, and 20 sites (7.2%) were poor (**Map 37**). Similarly, of the 280 sites assessed for right-bank vegetation, 135 sites (48.2%) were optimal, 87 sites (31.1%) were suboptimal, 43 sites (15.4%) were optimal, and 15 sites (5.3%) were poor (**Map 38**).

Of the 21 low-gradient stream sites assessed for bank vegetation protection, 16 sites (76.2%) were optimal, two sites (9.5%) were suboptimal, none of the sites were marginal, and three sites (14.3%) were poor (**Map 39**). Of the 21 sites assessed for left-bank vegetation, 14 sites (66.7%) were optimal, three sites (14.3%) were suboptimal, one site (4.8%) was marginal, and three sites (14.2%) were poor (**Map 40**). Of the 21 sites assessed for right-bank vegetation, 14 sites (66.7%) were optimal, four sites (19.0%) were suboptimal, none of the sites were marginal, and three sites (14.3%) were poor (**Map 41**). Twelvemile Creek received the highest mean bank vegetative protection score of the streams with multiple sampling locations (n = 14; μ = 17.9; σ = 2.45; optimal condition), and Motch Run received the lowest mean bank vegetative protection score of the streams with multiple sampling locations (n = 3; μ = 8.7; σ = 5.25; marginal condition) (**Table 12**).

Figure 24. Site on Eightmile Creek with poor bank vegetative protection

Root systems of plants growing on stream banks assist in holding soil in place and as a result, reduce the amount of erosion. Banks with full plant growth are better for macroinvertebrates and fish than banks without vegetative protection. The presence of fish in the high-gradient streams was not affected by the bank vegetation protection ($z = 0.41$; $p > 0.05$). Fish were observed in 125 of the 160 sites (78.1%) rated as optimal and 37 of the 50 sites (74.0%) rated as marginal or poor. The presence of macroinvertebrates in the high gradient streams was not affected by the bank vegetation protection ($z = 0.75$; $p > 0.05$). Macroinvertebrates were observed in 140 of the 160 sites (87.5%) rated as optimal and 41 of the 50 sites (82.0%) rated as marginal or poor. These results suggest that the presence of macroinvertebrates and fish are not affected by decreased bank vegetative protection.

4.2.10 Riparian Vegetative Zone Width

Of the 280 high-gradient steam sites assessed for riparian vegetative zone width (both sides of the stream combined), 101 sites (36.1%) were optimal, 64 sites (22.9%) were suboptimal, 43 sites (15.3%) were marginal, and 72 sites (25.7%) were poor (**Map 42**). The riparian zone was also assessed for each side of the stream separately. Of the 280 sites assessed for left-bank riparian zone width, 103 sites (36.8%) were optimal, 47 sites (16.8%) were suboptimal, 47 sites (16.8%) were marginal, and 83 sites (29.6%) were poor (**Map 43**). Of the 280 sites assessed for right-bank riparian zone width, 95 sites (33.9%) were optimal, 50 sites (17.9%) were suboptimal, 47 sites (16.8%) were marginal, and 88 sites (31.4%) were poor (**Map 44**).

Figure 25. Site on Twelvemile Creek with an optimal bank vegetative zone width

Figure 26. Site on Fivemile Creek with a poor bank vegetative zone width

Of the 21 low-gradient stream sites assessed for riparian vegetative zone width, nine sites (42.9%) were optimal, four sites (19.0%) were suboptimal, two sites (9.5%) were marginal, and six sites (28.6%) were poor (**Map 45**). Of the 21 sites assessed for left-bank riparian zone width, nine sites (42.9%) were optimal, three sites (14.2%) were suboptimal, none of the sites were marginal, and nine sites (42.9%) were poor (**Map 46**). Of the 21 sites assessed for right-bank riparian zone width, nine sites (42.9%) were optimal, two sites (9.5%) were suboptimal, four sites (19.0%) were marginal, and six sites (28.6%) were poor (**Map 47**). Raccoon Creek received the highest mean riparian vegetative zone width score of the streams with multiple sampling locations (n = 7; μ = 18.0; σ = 2.62; optimal condition), and Sevenmile Creek received the lowest mean riparian vegetative zone width score of the streams with multiple sampling locations (n = 12; μ = 5.2; σ =

3.48; poor/marginal condition) (**Table 13**).

The vegetative riparian zone serves as a buffer to pollutants entering a stream from runoff, controls erosion, and provides habitat. Typically, an undisturbed riparian zone will support a robust stream system. The presence of fish in the high-gradient streams appeared to be negatively affected by the riparian vegetative zone width ($z = 1.41$; $p < 0.05$). As the width of the riparian zone was reduced so was the presence of fish. Fish were observed in 82 of the 101 sites (81.2%) ranked as optimal opposed to 51 of the 72 sites (70.8%) ranked as poor. The riparian vegetative zone width did not affect the presence of macroinvertebrates ($z = -0.042$; $p > 0.05$). Macroinvertebrates were observed in 86 of the 101 sites (85.1%) ranked as optimal and 62 of the 72 sites (86.1%) ranked as poor. These results suggest that stream locations with a wider vegetative riparian zone provide better habitat for fish.

4.2.11 Total Habitat Score

Of the 280 high-gradient stream sites assessed for total habitat, 32 sites (11.4%) were optimal, 209 sites (74.6%) were suboptimal, 38 sites (13.6%) were marginal, and one site (0.4%) was poor (**Map 48; Table 14**). The mean total habitat score for the high-gradient streams was in the suboptimal range ($\mu = 132$; $\sigma = 21.73$), with scores ranging from a high of 180 to a low of 53. Of the 21 low-gradient streams assessed for total habitat, none of the sites were optimal, 14 sites (66.7%) were suboptimal, seven sites (33.3%) were marginal, and none of the sites were poor (**Map 49; Table 15**). The mean total habitat score for the low-gradient streams was in the suboptimal range ($\mu = 122$; $\sigma = 26.41$), with scores ranging from a high of 159 to a low of 76.

Figure 27. Site on Conneaut Creek with an optimal total habitat rating

Figure 28. Site on Tributary 42436 with a poor total habitat rating

Each of the streams were ranked from best condition (rank = 1) to worst condition (rank = 36) based on the mean total habitat scores. The mean score was calculated by averaging the total habitat scores from each high and low gradient sampling location within the specified stream. The mean total habitat scores ranged from a low of 86.7 to a high of 169.0. Twelvemile Creek received the highest mean total habitat score of the streams with multiple sampling locations ($n = 14$; $\mu = 150.6$; $\sigma = 10.07$; suboptimal condition) and Tributary 62436 received the lowest mean total habitat score among all the streams ($n = 3$; $\mu = 86.7$; $\sigma = 27.76$) (**Table 16**).

Habitat quality is an essential component of any biological survey because aquatic biota have very specific habitat requirements independent of water quality, and there is clear evidence that habitat alteration is a primary cause of degraded aquatic resources (reviewed in Barbour *et al.* 1999). The presence of fish in high-gradient streams was not affected by the total habitat condition ($z = 0.504$; $p > 0.05$). Fish were observed in 24 of the 32 sites (75.0%) rated as optimal and 26 of the 39 sites (66.7%) rated as marginal or poor. The presence of macroinvertebrates in high-gradient streams appeared to be negatively affected by the total habitat condition ($z = 1.69$; $p < 0.05$). As the total habitat condition deteriorated, the presence of macroinvertebrates decreased. Macroinvertebrates were observed in 29 of the 32 sites (90.6%) rated as optimal opposed to being observed in 28 of 39 sites (74.4%) rated as poor. These results suggest that the presence of macroinvertebrates is negatively impacted by deteriorated habit conditions; however, the presence of fish is not affected by the total habitat condition. It is important to note that only the presence of macroinvertebrates and fish were assessed and the diversity was not evaluated, which is likely a better indicator of the impact of habitat condition on the biological communities.

4.3 *Habitat Correlation Analysis*

The strength of the relationship between the individual parameters and total habitat score was assessed using the *Kendall tau rank correlation coefficient*. The relationships were assessed to determine which, if any, habitat parameters had the greatest influence on the total habitat score. For the high-gradient streams, the results indicate that there was a statistically significant relationship between each of the 10 habitat parameters and the total habitat score ($\tau \neq 0$; $p < 0.001$); the strongest relationship was between epifaunal/substrate cover and total habitat score ($\tau = 0.4666$; $p < 0.001$) (**Table 17**). These results suggest that all 10 habitat parameters had an influence on the total habitat condition at the high-gradient stream locations, and epifuanal/ substrate cover had the greatest influence on the total habitat score. Therefore, improvements to the streams with impaired epifaunal/substrate cover should result in a better total habitat condition; however, improvements to the other nine parameters will also improve the total habitat condition.

For the low-gradient streams, the results indicate that there was a statistically significant relationship between epifaunal/substrate cover, pool substrate, pool variability, channel flow status, channel alteration, and riparian vegetative zone width, and the total habitat score ($\tau \neq 0$; $p < 0.05$); the strongest relationship was between epifaunal/substrate cover and total habitat score ($\tau = .73$; $p < 0.001$) (**Table 18**). There were no significant relationships between sediment deposition, channel sinuosity, bank stability, and bank vegetation protection, and the total habitat score (τ not significantly different than zero; $p > 0.05$). These results suggest that not all habitat parameters had an influence on the total habitat condition at the low-gradient stream locations, and epifaunal/substrate cover had the greatest influence on the total habitat condition. Therefore, improvements to the streams with impaired epifaunal/substrate cover should improve the total habitat condition; however, improvements to the pool substrate, pool variability, channel flow status, channel alteration, and riparian vegetative zone width will also improve the habitat condition.

The relationships between the individual parameters were also assessed to determine which, if any, parameters had an influence on the bank stability and riparian vegetative zone width. For the high-gradients streams, there was a statistically significant relationship between sediment deposition, channel flow status, and bank vegetative protection, and streambank stability ($\tau \neq 0$; $p < 0.001$); the strongest relationship was between bank vegetative protection and streambank stability ($\tau = 0.3891$; $p < 0.001$) (**Table 19**). These results suggest that bank vegetative protection had the greatest influence on streambank stability at the high-gradient stream locations; therefore, improvements to the streambank vegetation should improve the stability of the streambanks. For the high-gradient streams that there was a statistically significant relationship between epifaunal/substrate cover, velocity/depth regimes, channel flow status, channel alteration, and bank vegetative protection, and riparian vegetative zone width ($\tau \neq 0$; $p < 0.05$); the strongest relationship was between channel alteration and riparian vegetative zone width ($\tau = 0.3311$; $p < 0.001$) (**Table 20**). These results suggest that alterations to the stream channel had the greatest influence on the riparian vegetative zone width at the high-gradient stream locations; therefore, the riparian vegetative zone width could be improved by restoring those stream locations with alterations.

For the low-gradient streams, there was a statistically significant relationship between epifaunal/ substrate cover, channel alteration, and bank vegetation protection, and riparian vegetative zone width ($\tau \neq 0$; $p < 0.05$); the strongest relationship was between epifaunal/ substrate cover and riparian vegetative zone width ($\tau = 0.5054$; $p < 0.05$) (**Table 21**). These results suggest that riparian vegetative zone width had the greatest influence on epifaunal/ substrate cover at the low-gradient stream locations; therefore, improvements to the riparian vegetative zone width should result in improvements to the epifaunal/ substrate cover. For the low-gradient streams, there was a statistically significant relationship between bank vegetative protection and bank stability ($\tau = 0.6918$; $p < 0.001$) (**Table 22**). These results suggest that bank vegetative protection had the greatest influence on streambank stability at the low-gradient stream locations; therefore, improvements to the streambank vegetation should improve the stability of the streambanks.

5.0 Summary and Conclusions

The quality of stream habitat is an important component in assessing the overall health of the stream and its ability to support aquatic life. Of the 36 streams assessed for total habitat condition, one was optimal, 27 were suboptimal, eight were marginal, and none of the streams were poor. When assessing the sampling locations individually, 32 sites were optimal, 223 sites were suboptimal, 45 sites were marginal, and only one site was poor. These results suggest that while marginal and poor habitat conditions do exist, the majority of sites are in suboptimal or optimal condition.

There was no significant difference in the presence of fish between the high-gradient stream sites rated as optimal (75.0%) versus the sites rated as marginal or poor (66.7%); however, it is important to note that the streams were only assessed visually for the presence of fish. In summer 2011, a fishery assessment will be conducted on a subset of the sampling sites using the index of biotic integrity methodology to better characterize the fishery. The presence of fish was significantly reduced at sites with degraded epifaunal/substrate cover, reduced velocity/ depth regimes, and reduced riparian vegetative zone width. The presence of macroinvertebrates was found to be significantly reduced at the high-gradient stream sites rated as marginal or poor (74.4%) versus sites rated as optimal (90.6%). In addition, the presence of macroinvertebrates was significantly reduced at sites with degraded epifaunal/substrate cover, increased embeddedness, and reduced velocity/depth regimes. Restoration of the riparian zone at sites where fish and/or macroinvetebrates were absent should help improve the epifaunal/substrate cover for biota as well as reduce the embeddedness.

An assessment of the relationship between the individual parameters and total habitat score revealed that, for both low- and high-gradient streams, the strongest relationship was between epifaunal/substrate cover and total habitat score. This suggests that epifaunal/substrate cover has the largest influence on the total habitat score in comparison to the other habitat parameters. Also, as previously mentioned, stream sites with degraded epifaunal/substrate cover had a reduced presence of fish and macroinvertebrates. Improvements to the available epifaunal and substrate cover are critical to promoting a healthy fishery. Pierce *et al*. (2006) suggest that there is a trend toward higher recaptures of stocked trout occurring in Pennsylvania waters with higher epifaunal scores.

An assessment of the relationship between the individual parameters and bank stability, for both low- and high-gradient streams, revealed that the strongest relationship was between bank vegetative protection and bank stability. As the bank vegetation was degraded, the stability of the streambank was negatively impacted. This result is expected as streambank vegetation is critical in stabilizing banks. An assessment of the relationship between the individual parameters and riparian vegetative zone width revealed the strongest relationship for high-gradient streams was between channel alteration and riparian vegetative zone width. The strongest relationship for low-gradient streams was between epifuanal/ substrate cover and riparian vegetative zone width. It is not surprising that channel alteration had the largest influence on the riparian width because alteration of a stream (e.g. bridges and road crossings) results in the reduction of the riparian buffer width. In addition, it is not unexpected that as the riparian zone is impacted, the epifaunal and substrate cover is negatively impacted.

In conclusion, this study suggests that few stream locations within the Pennsylvania Lake Erie watershed are in poor condition; the presence of macroinvertebrates was strongly influenced by the total habitat rating and epifaunal/substrate cover; the presence of fish was strongly influenced by the epifaunal/

substrate cover; epifaunal/substrate cover had the greatest influence on the total habitat score; bank vegetation had the greatest influence on streambank stability; channel alteration had the strongest impact on riparian vegetative zone width of high-gradient streams; and impairment to the riparian vegetative zone on low-gradient streams had the greatest impact on epifaunal/substrate cover.

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APPENDIX A: FORMS

Form A: Pennsylvania Lake Erie Watershed Assessment Data Form (High Gradient Stream)

Site Data

Stream/Watershed: ______________________ Site Name: ______________________

Researcher Name(s): ______________________

Latitude: ______________________ Longitude: ______________________

Date/Time: ______________________ Weather: ______________________

Stream Temp: ______________________ Air Temp: ______________________

Stream Width: ______________________ Water Depth: ______________________

Watershed/Stream Assessment Data

Land Use (%)

Forest ______________________ Commercial ______________________

Agricultural ______________________ Industrial ______________________

Residential ______________________ Other: ______________________

Water Appearance

Clear: ______________________

Turbid: ______________________

Streambank Stability

Stable: ______________________

Eroding: ______________________

Pipe(s) Present

Type: ______________________

Discharging: ______________________

Water intake: ______________________

Not present: ______________________

Livestock Use

Access to stream: ______________________

No access to stream: ______________________

Not present: ______________________

Biology

Fish Present: ______________________

Macros Present: ______________________

Fish Impediments: ______________________

Invasive Species

Present: ______________________

Not present: ______________________

Type(s): ______________________

Riparian Buffer

Protected: ______________________

Impaired: ______________________

Width: ______________________

Wetland(s)

Present: ______________________

Impaired: ______________________

Not present: ______________________

Notes:

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Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
1. **Epifaunal Substrate/Available Cover**	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. **Embeddedness**	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. **Velocity/Depth Regimes**	All 4 velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). (slow is < 0.3 m/s, deep is > 0.5 m)	Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity / depth regime (usually slow-deep).
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. **Sediment Deposition**	Little or no enlargement of islands or point bars and less than 5% (< 20% for low-gradient streams) of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% (20-50% for low-gradient) of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% (50-80% for low-gradient) of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% (80% for low-gradient) of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. **Channel Flow Status**	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills > 75% of the available channel; or < 25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
6. **Channel Alteration**	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yrs.) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. In stream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. **Frequency of Riffles (or bends)**	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream < 7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of > 25.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. **Bank Stability (score each bank)** Note: determine left or right side by facing downstream.	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. < 5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. **Bank Vegetative Protection** (score each bank)	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, under story shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. **Riparian Vegetative Zone Width** (score each bank riparian zone)	Width of riparian zone > 18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone < 6 meters; little or no riparian vegetation due to human activities.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

HABITAT SCORES	VALUE
OPTIMAL	160 – 200
SUB-OPTIMAL	110 – 159
MARGINAL	60 – 109
POOR	< 60

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Form B: Pennsylvania Lake Erie Watershed Assessment Data Form (Low Gradient Stream)

Site Data

Stream/Watershed: ______________________ Site Name: ______________________

Researcher Name(s): ______________________

Latitude: ______________________ Longitude: ______________________

Date/Time: ______________________ Weather: ______________________

Stream Temp: ______________________ Air Temp: ______________________

Stream Width: ______________________ Water Depth: ______________________

Watershed/Stream Assessment Data

Land Use (%)

Forest ______________________ Commercial ______________________

Agricultural ______________________ Industrial ______________________

Residential ______________________ Other: ______________________

Water Appearance

Clear: ______________________

Turbid: ______________________

Streambank Stability

Stable: ______________________

Eroding: ______________________

Pipe(s) Present

Type: ______________________

Discharging: ______________________

Water intake: ______________________

Not present: ______________________

Livestock Use

Access to stream: ______________________

No access to stream: ______________________

Not present: ______________________

Biology

Fish Present: ______________________

Macros Present: ______________________

Fish Impediments: ______________________

Invasive Species

Present: ______________________

Not present: ______________________

Type(s): ______________________

Riparian Buffer

Protected: ______________________

Impaired: ______________________

Width: ______________________

Wetland(s)

Present: ______________________

Impaired: ______________________

Not present: ______________________

Notes:

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Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
1. Epifaunal Substrate/Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	30-50% mix of stable habitat; well suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% <20% for low-gradient streams) of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% (20-50% for low-gradient) of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% (50-80% for low-gradient) of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% (80% for low-gradient) of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yrs.) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. In stream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.	The bends in the stream increase the stream length 2 to 3 times longer than if it was in a straight line.	The bends in the stream increase the stream length 2 to 1 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Bank Vegetative Protection (score each bank) Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, under story shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

HABITAT SCORES	VALUE
OPTIMAL	160 – 200
SUB-OPTIMAL	110 – 159
MARGINAL	60 – 109
POOR	< 60

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APPENDIX B: TABLES

Table 1. Pennsylvania Lake Erie stream habitat assessment locations

Stream	Site	Latitude	Longitude	Gradient*	Date Sampled
Conneaut Creek	COC 1	41.9007	-80.42867	H	10/5/2010
Conneaut Creek	COC 2	41.89063	-80.45797	H	10/5/2010
Conneaut Creek	COC 3	41.88696	-80.40878	L	10/5/2010
Conneaut Creek	COC 4	41.86748	-80.47095	H	10/5/2010
Conneaut Creek	COC 5	41.84633	-80.50137	H	10/5/2010
Conneaut Creek	COC 6	41.82674	-80.44875	H	10/5/2010
Conneaut Creek	COC 7	41.80807	-80.49126	H	10/5/2010
Conneaut Creek	COC 8	41.86261	-80.47589	H	10/6/2010
Conneaut Creek	COC 9	41.86119	-80.47697	H	10/6/2010
Conneaut Creek	COC 10	41.86412	-80.47437	L	10/6/2010
Conneaut Creek	COC 11	41.84556	-80.47516	H	10/6/2010
Conneaut Creek	COC 12	41.84469	-80.47061	H	10/6/2010
Conneaut Creek	COC 13	41.82752	-80.49145	L	10/11/2010
Conneaut Creek	COC 14	41.81571	-80.48795	L	10/11/2010
Conneaut Creek	COC 15	41.81818	-80.51059	L	10/11/2010
Conneaut Creek	COC 16	41.81807	-80.507	L	10/11/2010
Conneaut Creek	COC 17	41.83648	-80.44799	L	10/11/2010
Conneaut Creek	COC 18	41.91824	-80.47126	H	10/12/2010
Conneaut Creek	COC 19	41.80786	-80.51337	L	10/12/2010
Conneaut Creek	COC 20	41.80793	-80.50028	L	10/12/2010
Conneaut Creek	COC 21	41.80788	-80.50662	L	10/12/2010
Conneaut Creek	COC 22	41.7878	-80.49442	L	10/12/2010
Conneaut Creek	COC 23	41.78748	-80.46864	L	10/12/2010
Conneaut Creek	COC 24	41.80246	-80.46432	L	10/12/2010
Conneaut Creek	COC 25	41.81602	-80.38705	H	10/12/2010
Conneaut Creek	COC 26	41.68502	-80.34061	H	10/19/2010
Conneaut Creek	COC 27	41.66967	-80.35116	H	10/19/2010
Conneaut Creek	COC 28	41.66549	-80.37201	H	10/19/2010
Conneaut Creek	COC 29	41.69126	-80.33813	H	10/19/2010
Conneaut Creek	COC 30	41.70498	-80.35133	H	10/19/2010
Conneaut Creek	COC 32	41.7151	-80.35091	H	10/19/2010
Conneaut Creek	COC 33	41.71782	-80.3485	H	10/19/2010
Conneaut Creek	COC 34	41.72921	-80.35656	H	10/19/2010
Conneaut Creek	COC 35	41.75674	-80.3702	H	10/19/2010
Conneaut Creek	COC 36	41.77415	-80.3809	H	10/19/2010
Conneaut Creek	COC 37	41.75927	-80.39077	H	10/22/2010
Conneaut Creek	COC 38	41.76504	-80.3764	H	10/22/2010
Conneaut Creek	COC 39	41.80057	-80.37814	H	10/22/2010
Conneaut Creek	COC 40	41.75724	-80.41114	H	10/22/2010
Conneaut Creek	COC 41	41.81701	-80.44688	L	10/22/2010
Conneaut Creek	COC 42	41.81722	-80.4684	L	10/22/2010
Conneaut Creek	COC 43	41.83636	-80.4267	H	10/22/2010
Conneaut Creek	COC 44	41.84082	-80.41846	H	10/22/2010
Conneaut Creek	COC 45	41.83884	-80.40298	H	10/22/2010

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Table 1 (*continued*). *Pennsylvania Lake Erie stream habitat assessment locations*

Stream	Site	Latitude	Longitude	Gradient*	Date Sampled
Conneaut Creek	COC 46	41.85572	-80.3051	H	10/25/2010
Conneaut Creek	COC 47	41.88434	-80.30177	H	10/25/2010
Conneaut Creek	COC 48	41.87012	-80.30511	H	10/25/2010
Conneaut Creek	COC 49	41.87098	-80.32938	H	10/25/2010
Conneaut Creek	COC 50	41.88924	-80.33749	H	10/25/2010
Conneaut Creek	COC 51	41.89011	-80.3417	H	10/25/2010
Conneaut Creek	COC 52	41.90046	-80.34898	H	10/25/2010
Conneaut Creek	COC 53	41.89817	-80.36231	H	10/25/2010
Conneaut Creek	COC 54	41.90646	-80.35325	H	10/25/2010
Conneaut Creek	COC 55	41.90457	-80.34782	H	10/25/2010
Conneaut Creek	COC 56	41.85301	-80.40199	H	10/26/2010
Conneaut Creek	COC 57	41.86065	-80.37036	H	10/26/2010
Conneaut Creek	COC 58	41.86961	-80.40203	H	10/26/2010
Conneaut Creek	COC 59	41.89005	-80.36594	H	10/26/2010
Ashtabula Creek	AC 1	41.89051	-80.46542	L	9/27/2010
Ashtabula Creek	AC 2	41.89817	-80.47295	L	9/27/2010
Ashtabula Creek	AC 3	41.8887	-80.5194	L	9/27/2010
Ashtabula Creek	AC 4	41.89325	-80.50257	L	9/27/2010
Ashtabula Creek	AC 5	41.89002	-80.50253	L	9/27/2010
Turkey Creek	TC 1	41.96155	-80.5194	H	8/3/2010
Turkey Creek	TC 2	41.96375	-80.49351	H	8/3/2010
Turkey Creek	TC 3	41.94592	-80.51182	L	8/3/2010
Turkey Creek	TC 4	41.94545	-80.48049	L	8/3/2010
Trib 62702	T702 1	41.9855	-80.49798	H	9/29/2010
Trib 62702	T702 2	41.97726	-80.49343	L	9/29/2010
Raccoon Creek	RC 1	41.98904	-80.48046	H	8/3/2010
Raccoon Creek	RC 2	41.96566	-80.45988	H	8/6/2010
Raccoon Creek	RC 3	41.97826	-80.46344	H	8/6/2010
Raccoon Creek	RC 4	41.94508	-80.44772	H	8/6/2010
Raccoon Creek	RC 5	41.93751	-80.42813	H	8/6/2010
Raccoon Creek	RC 6	41.95565	-80.45944	H	8/6/2010
Raccoon Creek	RC 7	41.96378	-80.45567	H	8/6/2010
Trib 62687	T687 1	41.99591	-80.46169	H	8/20/2010
Trib 62684	T684 1	41.99729	-80.45737	H	8/3/2010
Trib 62680	T680 1	42.00101	-80.43825	H	8/3/2010
Crooked Creek	CRC 1	42.00539	-80.43757	H	8/20/2010
Crooked Creek	CRC 2	42.00251	-80.43121	H	8/20/2010
Crooked Creek	CRC 3	42.00347	-80.43079	H	8/20/2010
Crooked Creek	CRC 4	41.98629	-80.40664	H	8/20/2010
Crooked Creek	CRC 5	41.97823	-80.38799	H	8/20/2010
Crooked Creek	CRC 6	41.97272	-80.38718	H	8/20/2010
Crooked Creek	CRC 7	41.97306	-80.3889	H	8/20/2010
Crooked Creek	CRC 8	41.96397	-80.39172	H	8/20/2010
Crooked Creek	CRC 9	41.94497	-80.36803	H	8/20/2010

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Table 1 (*continued*). *Pennsylvania Lake Erie stream habitat assessment locations*

Stream	Site	Latitude	Longitude	Gradient*	Date Sampled
Crooked Creek	CRC 10	41.94927	-80.36002	H	8/20/2010
Crooked Creek	CRC 11	41.99395	-80.41938	H	9/24/2010
Crooked Creek	CRC 12	41.98124	-80.39869	H	9/24/2010
Crooked Creek	CRC 13	41.98153	-80.39899	H	9/24/2010
Crooked Creek	CRC 14	41.98089	-80.39913	H	9/24/2010
Crooked Creek	CRC 15	41.96451	-80.41016	H	9/24/2010
Crooked Creek	CRC 16	41.96903	-80.40627	H	9/24/2010
Crooked Creek	CRC 17	41.95165	-80.35875	H	9/24/2010
Crooked Creek	CRC 18	41.97666	-80.39995	H	9/27/2010
Crooked Creek	CRC 19	41.95896	-80.36468	H	9/27/2010
Duck Run	DR 1	42.00512	-80.39331	H	6/21/2010
Duck Run	DR 2	42.0145	-80.39871	H	9/29/2010
Duck Run	DR 3	42.00607	-80.38776	L	9/29/2010
Duck Run	DR 4	41.99665	-80.38792	L	9/29/2010
Elk Creek	EC 1	42.00681	-80.35405	H	8/31/2010
Elk Creek	EC 2	41.99094	-80.35329	H	8/31/2010
Elk Creek	EC 3	41.9808	-80.31077	H	8/31/2010
Elk Creek	EC 4	41.97477	-80.30923	H	8/31/2010
Elk Creek	EC 5	42.00716	-80.36122	H	9/8/2010
Elk Creek	EC 6	41.99129	-80.3185	H	9/8/2010
Elk Creek	EC 7	41.99123	-80.32023	H	9/8/2010
Elk Creek	EC 8	41.99279	-80.291	H	9/8/2010
Elk Creek	EC 9	41.99915	-80.268	H	9/8/2010
Elk Creek	EC 10	42.01739	-80.36769	H	9/8/2010
Elk Creek	EC 11	42.00817	-80.24203	H	9/8/2010
Elk Creek	EC 12	41.94781	-80.31399	H	9/13/2010
Elk Creek	EC 13	41.94583	-80.31591	H	9/13/2010
Elk Creek	EC 14	41.95857	-80.28643	H	9/13/2010
Elk Creek	EC 15	41.9606	-80.28327	H	9/13/2010
Elk Creek	EC 16	41.94506	-80.27861	H	9/13/2010
Elk Creek	EC 17	41.94574	-80.28205	H	9/13/2010
Elk Creek	EC 18	41.94486	-80.28156	H	9/13/2010
Elk Creek	EC 19	41.90384	-80.28516	H	9/13/2010
Elk Creek	EC 20	41.93079	-80.24454	H	9/13/2010
Elk Creek	EC 21	41.94342	-80.22485	H	9/13/2010
Elk Creek	EC 22	41.99443	-80.21646	H	9/13/2010
Elk Creek	EC 23	42.00412	-80.20228	H	9/14/2010
Elk Creek	EC 24	41.98842	-80.20156	H	9/14/2010
Elk Creek	EC 25	41.98008	-80.20448	H	9/14/2010
Elk Creek	EC 26	41.95956	-80.20779	H	9/14/2010
Elk Creek	EC 27	41.93483	-80.19749	H	9/14/2010
Elk Creek	EC 28	41.94422	-80.18532	H	9/14/2010
Elk Creek	EC 29	41.98419	-80.18374	H	9/14/2010
Elk Creek	EC 30	42.00257	-80.17429	H	9/14/2010

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Table 1 (*continued*). *Pennsylvania Lake Erie stream habitat assessment locations*

Stream	Site	Latitude	Longitude	Gradient*	Date Sampled
Elk Creek	EC 31	41.99747	-80.16711	H	9/15/2010
Elk Creek	EC 32	41.98947	-80.16417	H	9/15/2010
Elk Creek	EC 33	41.94502	-80.16022	H	9/15/2010
Elk Creek	EC 34	41.95984	-80.14268	H	9/15/2010
Elk Creek	EC 35	41.98354	-80.15631	H	9/15/2010
Elk Creek	EC 36	41.99929	-80.15453	H	9/15/2010
Elk Creek	EC 37	41.99692	-80.15005	H	9/17/2010
Elk Creek	EC 38	41.98023	-80.14375	H	9/17/2010
Elk Creek	EC 39	41.98042	-80.14436	H	9/17/2010
Elk Creek	EC 40	41.96695	-80.11619	H	9/17/2010
Elk Creek	EC 41	41.96725	-80.11388	H	9/17/2010
Elk Creek	EC 42	41.97645	-80.10052	H	9/17/2010
Elk Creek	EC 43	41.98909	-80.11771	H	9/17/2010
Elk Creek	EC 44	42.00135	-80.13977	H	9/20/2010
Elk Creek	EC 45	42.00586	-80.12683	H	9/20/2010
Elk Creek	EC 46	42.00778	-80.12208	H	9/20/2010
Elk Creek	EC 47	42.00889	-80.12505	H	9/20/2010
Elk Creek	EC 48	42.00882	-80.11624	H	9/20/2010
Elk Creek	EC 49	42.02868	-80.10444	H	9/20/2010
Elk Creek	EC 50	42.00882	-80.10213	H	9/20/2010
Elk Creek	EC 51	42.00864	-80.10355	H	9/20/2010
Elk Creek	EC 52	41.99883	-80.06188	H	9/20/2010
Elk Creek	EC 53	41.99874	-80.06108	H	9/20/2010
Elk Creek	EC 54	41.98906	-80.06483	H	9/20/2010
Elk Creek	EC 55	41.97895	-80.0509	H	9/20/2010
Elk Creek	EC 56	41.97894	-80.24535	H	10/11/2010
Trib 62490	T490 1	42.02914	-80.35629	H	9/8/2010
Godfrey Run	GFR 1	42.01788	-80.32259	H	6/18/2010
Godfrey Run	GFR 2	42.01462	-80.31979	L	6/18/2010
Godfrey Run	GFR 3	42.00879	-80.31027	H	6/18/2010
Godfrey Run	GFR 4	42.00879	-80.30561	L	6/18/2010
Godfrey Run	GFR 5	42.01668	-80.28143	L	6/21/2010
Godfrey Run	GFR 6	42.04038	-80.31335	H	8/30/2010
Godfrey Run	GFR 7	42.03674	-80.30619	H	8/30/2010
Godfrey Run	GFR 8	42.02179	-80.32173	H	8/30/2010
Trib 62484	T84 1	42.04375	-80.29369	H	6/21/2010
Trib 62483	T83 1	42.04956	-80.28651	H	6/21/2010
Trout Run	TR 1	42.0569	-80.27181	H	8/26/2010
Trout Run	TR 2	42.04532	-80.27135	H	8/26/2010
Trout Run	TR 3	42.04219	-80.27196	H	8/26/2010
Trout Run	TR 4	42.03128	-80.2764	H	8/26/2010
Trout Run	TR 5	42.02905	-80.258	H	8/26/2010
Trib 62476	T76 1	42.05935	-80.26143	H	6/16/2010
Walnut Creek	WC 1	42.0742	-80.2355	H	8/10/2010

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Table 1 (*continued*). *Pennsylvania Lake Erie stream habitat assessment locations*

Stream	Site	Latitude	Longitude	Gradient*	Date Sampled
Walnut Creek	WC 2	42.04842	-80.22081	H	8/10/2010
Walnut Creek	WC 3	42.0495	-80.16557	H	8/10/2010
Walnut Creek	WC 4	42.04741	-80.16476	H	8/10/2010
Walnut Creek	WC 5	42.03705	-80.16156	H	8/16/2010
Walnut Creek	WC 6	42.02675	-80.1557	H	8/16/2010
Walnut Creek	WC 7	42.02648	-80.17207	H	8/16/2010
Walnut Creek	WC 8	42.03552	-80.22019	H	8/16/2010
Walnut Creek	WC 9	42.03756	-80.20387	H	8/16/2010
Walnut Creek	WC 10	42.04627	-80.17331	H	8/16/2010
Walnut Creek	WC 11	42.03271	-80.14478	H	8/17/2010
Walnut Creek	WC 12	42.05557	-80.14298	H	8/17/2010
Walnut Creek	WC 13	42.04448	-80.13495	H	8/17/2010
Walnut Creek	WC 14	42.03724	-80.11945	H	8/17/2010
Walnut Creek	WC 15	42.07317	-80.09709	H	8/17/2010
Walnut Creek	WC 16	42.06646	-80.10931	H	9/7/2010
Walnut Creek	WC 17	42.04872	-80.0697	H	9/7/2010
Walnut Creek	WC 18	42.04694	-80.02038	H	9/7/2010
Walnut Creek	WC 19	42.06137	-80.0265	H	9/7/2010
Walnut Creek	WC 20	42.06895	-80.03852	H	9/7/2010
Walnut Creek	WC 21	42.06571	-80.05997	H	9/7/2010
Trib 62436	T36 1	42.07227	-80.21869	H	6/16/2010
Trib 62436	T36 2	42.07601	-80.21976	H	6/16/2010
Trib 62436	T36 3	42.07953	-80.21789	H	6/16/2010
Wilkins Run	WR 1	42.08214	-80.20335	H	5/21/2010
Wilkins Run	WR 2	42.07928	-80.18929	H	5/21/2010
Wilkins Run	WR 3	42.07788	-80.19332	H	5/21/2010
Shorehaven	SH 1	42.10168	-80.16983	H	10/5/2010
Marshall Run	MR 1	42.10651	-80.16515	H	6/10/2010
Marshall Run	MR 2	42.09936	-80.16118	H	6/10/2010
Marshall Run	MR 3	42.10035	-80.15629	H	6/10/2010
Marshall Run	MR 4	42.09889	-80.15446	H	6/10/2010
Motch Run	MTR 1	42.13782	-80.04981	H	6/29/2010
Motch Run	MTR 2	42.1182	-80.03191	H	6/29/2010
Motch Run	MTR 3	42.12291	-80.03722	H	6/29/2010
Cemetery Run	CR 1	42.14973	-80.04969	H	6/29/2010
McDannel Run	MDR 1	42.15335	-80.04117	H	6/29/2010
McDannel Run	MDR 2	42.14518	-80.03677	H	6/29/2010
Fourmile Creek	4M 1	42.15895	-80.02853	H	6/30/2010
Fourmile Creek	4M 2	42.15306	-80.0226	H	6/30/2010
Fourmile Creek	4M 3	42.14665	-80.01527	H	6/30/2010
Fourmile Creek	4M 4	42.14257	-80.01054	H	6/30/2010
Fourmile Creek	4M 5	42.13441	-80.00568	H	7/6/2010
Fourmile Creek	4M 6	42.12413	-79.99638	H	7/6/2010
Fourmile Creek	4M 7	42.08771	-79.98139	H	7/6/2010

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Table 1 (*continued*). *Pennsylvania Lake Erie stream habitat assessment locations*

Stream	Site	Latitude	Longitude	Gradient*	Date Sampled
Fourmile Creek	4M 8	42.12088	-79.9911	H	9/22/2010
Fourmile Creek	4M 9	42.12004	-79.99134	H	9/22/2010
Fourmile Creek	4M 10	42.11512	-79.97881	H	9/22/2010
Fourmile Creek	4M 11	42.10488	-79.97875	H	9/22/2010
Fourmile Creek	4M 12	42.09969	-79.98826	H	9/22/2010
Fourmile Creek	4M 13	42.07416	-79.96769	H	9/22/2010
Fivemile Creek	5M 0	42.16502	-80.01316	H	7/7/2010
Fivemile Creek	5M 1	42.16187	-80.01151	H	7/7/2010
Fivemile Creek	5M 2	42.1533	-80.00096	H	7/7/2010
Fivemile Creek	5M 3	42.14795	-79.9989	H	7/7/2010
Fivemile Creek	5M 4	42.14478	-79.99332	H	7/7/2010
Sixmile Creek	6M 0	42.18023	-79.98488	H	7/13/2010
Sixmile Creek	6M 1	42.15937	-79.98045	H	7/7/2010
Sixmile Creek	6M 2	42.17522	-79.98613	H	7/7/2010
Sixmile Creek	6M 3	42.17835	-79.98508	H	7/13/2010
Sixmile Creek	6M 4	42.17139	-79.98632	H	7/13/2010
Sixmile Creek	6M 5	42.11652	-79.9129	H	7/13/2010
Sixmile Creek	6M 6	42.14956	-79.96557	H	10/13/2010
Sixmile Creek	6M 7	42.15406	-79.97815	H	10/13/2010
Sixmile Creek	6M 8	42.14782	-79.97904	H	10/13/2010
Sixmile Creek	6M 9	42.13526	-79.95032	H	10/13/2010
Sixmile Creek	6M 10	42.12268	-79.92215	H	10/13/2010
Sixmile Creek	6M 11	42.11619	-79.92445	H	10/13/2010
Sixmile Creek	6M 12	42.11627	-79.95587	H	10/13/2010
Sixmile Creek	6M 13	42.0867	-79.9137	H	10/13/2010
Sixmile Creek	6M 14	42.07043	-79.91182	H	10/13/2010
Sixmile Creek	6M 15	42.07319	-79.90019	H	10/13/2010
Sixmile Creek	6M 16	42.08863	-79.90274	H	10/13/2010
Sixmile Creek	6M 17	42.08878	-79.90266	H	10/13/2010
Sixmile Creek	6M 18	42.10263	-79.91051	H	10/13/2010
Sevenmile Creek	7M 1	42.18245	-79.98018	H	7/19/2010
Sevenmile Creek	7M 2	42.1653	-79.96082	H	7/19/2010
Sevenmile Creek	7M 3	42.18002	-79.95557	H	7/19/2010
Sevenmile Creek	7M 4	42.18322	-79.94749	H	7/19/2010
Sevenmile Creek	7M 5	42.17577	-79.93747	H	7/19/2010
Sevenmile Creek	7M 6	42.1698	-79.95026	H	7/19/2010
Sevenmile Creek	7M 7	42.16858	-79.92771	H	7/26/2010
Sevenmile Creek	7M 8	42.16091	-79.92972	H	7/26/2010
Sevenmile Creek	7M 9	42.16117	-79.92796	H	7/26/2010
Sevenmile Creek	7M 10	42.16319	-79.93961	H	7/26/2010
Sevenmile Creek	7M 11	42.15123	-79.93951	H	7/26/2010
Sevenmile Creek	7M 12	42.13892	-79.91985	H	7/26/2010
Eightmile Creek	8M 1	42.19117	-79.96172	H	7/26/2010
Eightmile Creek	8M 2	42.19498	-79.93093	H	7/26/2010

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Table 1 (*continued*). *Pennsylvania Lake Erie stream habitat assessment locations*

Stream	Site	Latitude	Longitude	Gradient*	Date Sampled
Eightmile Creek	8M 3	42.1873	-79.93176	H	7/26/2010
Eightmile Creek	8M 4	42.18029	-79.9192	H	7/26/2010
Eightmile Creek	8M 5	42.18058	-79.91015	H	7/26/2010
Eightmile Creek	8M 6	42.18294	-79.90369	H	7/26/2010
Eightmile Creek	8M 7	42.17284	-79.91924	H	7/26/2010
Eightmile Creek	8M 8	42.16358	-79.90261	H	7/27/2010
Eightmile Creek	8M 9	42.15645	-79.90276	H	7/27/2010
Eightmile Creek	8M 10	42.16626	-79.89503	H	10/21/2010
Eightmile Creek	8M 11	42.15109	-79.89602	H	10/21/2010
Eightmile Creek	8M 12	42.15122	-79.89644	H	10/21/2010
Twelvemile Creek	12M 1	42.21086	-79.91481	H	7/27/2010
Twelvemile Creek	12M 2	42.19706	-79.90988	H	7/27/2010
Twelvemile Creek	12M 3	42.17944	-79.89531	H	7/27/2010
Twelvemile Creek	12M 4	42.18855	-79.87259	H	7/27/2010
Twelvemile Creek	12M 5	42.15134	-79.84201	H	7/27/2010
Twelvemile Creek	12M 6	42.20081	-79.87325	H	10/15/2010
Twelvemile Creek	12M 7	42.18889	-79.86735	H	10/15/2010
Twelvemile Creek	12M 8	42.17647	-79.86579	H	10/15/2010
Twelvemile Creek	12M 9	42.18454	-79.88049	H	10/15/2010
Twelvemile Creek	12M 10	42.18254	-79.88646	H	10/15/2010
Twelvemile Creek	12M 11	42.16943	-79.88525	H	10/15/2010
Twelvemile Creek	12M 12	42.15495	-79.87043	H	10/15/2010
Twelvemile Creek	12M 13	42.16368	-79.84266	H	10/21/2010
Twelvemile Creek	12M 14	42.17321	-79.84246	H	10/21/2010
Sixteenmile Creek	16M 1	42.2406	-79.83153	H	6/2/2010
Sixteenmile Creek	16M 2	42.23348	-79.83584	H	6/2/2010
Sixteenmile Creek	16M 3	42.2108	-79.8523	H	6/2/2010
Sixteenmile Creek	16M 4	42.22513	-79.84218	H	8/24/2010
Sixteenmile Creek	16M 5	42.21455	-79.82856	H	8/24/2010
Sixteenmile Creek	16M 6	42.20716	-79.85521	H	8/24/2010
Sixteenmile Creek	16M 7	42.19653	-79.84772	H	8/24/2010
Sixteenmile Creek	16M 8	42.20514	-79.83469	H	8/24/2010
Sixteenmile Creek	16M 9	42.19093	-79.79639	H	8/24/2010
Sixteenmile Creek	16M 10	42.18123	-79.78477	H	8/24/2010
Sixteenmile Creek	16M 11	42.18001	-79.78602	H	8/24/2010
Sixteenmile Creek	16M 12	42.20745	-79.83802	H	8/24/2010
Sixteenmile Creek	16M 13	42.15512	-79.79919	H	10/21/2010
Sixteenmile Creek	16M 14	42.16288	-79.7961	H	10/21/2010
Sixteenmile Creek	16M 15	42.17576	-79.82065	H	10/21/2010
Sixteenmile Creek	16M 16	42.19764	-79.84206	H	10/21/2010
Orchard Beach Run	OBR 1	42.23989	-79.8271	H	6/9/2010
Orchard Beach Run	OBR 2	42.23597	-79.82578	H	6/9/2010
Orchard Beach Run	OBR 3	42.23597	-79.82664	H	6/9/2010
Orchard Beach Run	OBR 4	42.23036	-79.82176	H	6/9/2010

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Table 1 (*continued*). *Pennsylvania Lake Erie stream habitat assessment locations*

Stream	Site	Latitude	Longitude	Gradient*	Date Sampled
Orchard Beach Run	OBR 5	42.21485	-79.81623	H	6/9/2010
Woodmere Beach Run	WBR 1	42.21501	-79.79321	H	6/9/2010
Woodmere Beach Run	WBR 2	42.2138	-79.78416	H	6/9/2010
Woodmere Beach Run	WBR 3	42.23618	-79.8078	H	6/9/2010
Peck Run	PR 1	42.24112	-79.79488	H	6/14/2010
Peck Run	PR 2	42.23138	-79.78434	H	6/14/2010
Peck Run	PR 3	42.22179	-79.7743	H	6/14/2010
Peck Run	PR 4	42.21673	-79.7713	H	6/14/2010
Peck Run	PR 5	42.22451	-79.77156	H	6/14/2010
Trib 62254	T54 1	42.25891	-79.79134	H	6/14/2010
Trib 62255	T55 1	42.25761	-79.79386	H	6/14/2010
Twentymile Creek	20M 1	42.26113	-79.78286	H	6/14/2010

* The gradient of the stream was classifed as either High (H) or Low (L) gradient

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Table 2. High gradient stream habitat assessment parameters (Barbour *et al. 1999)*

Habitat	Condition Category			
Parameter	**Optimal**	**Suboptimal**	**Marginal**	**Poor**
1. Epifaunal Substrate/ Available Cover	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Embeddedness	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Velocity/Depth Regime	All 4 velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). (slow is <0.3 m/s, deep is >0.5m)	Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity/depth regime (usually slow-deep).
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% (<20% for low-gradient streams) of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% (20-50% for low-gradient) of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% (50-80% for low-gradient) of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% (80% for low-gradient) of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yrs.) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. In stream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Frequency of Riffles (or bends)	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE _____ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE _____ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Bank Vegetative Protection (score each bank**)**	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, under story shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE _____ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE _____ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone**)**	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE _____ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE _____ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

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Table 3. Low gradient stream habitat assessment parameters (Barbour *et al. 1999)*

Habitat Parameter	Condition Category: Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	30-50% mix of stable habitat; well suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Pool Substrate Characteri-zation	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% <20% for low-gradient streams) of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% (20-50% for low-gradient) of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% (50-80% for low-gradient) of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% (80% for low-gradient) of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yrs.) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. In stream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.	The bends in the stream increase the stream length 2 to 3 times longer than if it was in a straight line.	The bends in the stream increase the stream length 2 to 1 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60 -100% of bank has erosional scars.
SCORE _____ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE _____ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Bank Vegetative Protection (score each bank)	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, under story shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE _____ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE _____ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE _____ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE _____ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

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Table 4. Mean epifaunal/substrate cover scores for Pennsylvania Lake Erie streams

Stream	No. of Sites	Mean Epifaunal Score	Std. Deviation	Rank	Mean Rating
Twentymile Creek	1	18.0	0.00	1	Optimal
Raccoon Creek	7	16.3	2.86	2	Optimal
Trib 62680	1	16.0	0.00	3	Optimal
Fourmile Creek	12	15.6	3.45	4	Suboptimal/Optimal
Trout Run	5	15.4	3.20	5	Suboptimal/Optimal
Twelvemile Creek	14	15.4	3.39	5	Suboptimal/Optimal
Woodmere Beach Run	3	15.0	0.82	7	Suboptimal
Sixmile Creek	19	14.8	3.43	8	Suboptimal
Elk Creek	56	14.2	3.92	9	Suboptimal
Sixteenmile Creek	15	14.2	4.29	9	Suboptimal
Conneaut Creek	54	14.0	3.43	11	Suboptimal
Trib 62476	1	14.0	0.00	11	Suboptimal
Eightmile Creek	12	13.7	3.04	13	Suboptimal
Peck Run	4	13.5	2.60	14	Suboptimal
Godfrey Run	5	13.4	4.22	15	Suboptimal
Marshall Run	4	13.3	4.87	16	Suboptimal
McDannel Run	2	13.0	2.00	17	Suboptimal
Crooked Creek	18	12.9	3.39	18	Suboptimal
Orchard Beach Run	4	12.3	3.70	19	Suboptimal
Trib 62684	1	12.0	0.00	20	Suboptimal
Trib 62484	1	12.0	0.00	20	Suboptimal
Motch Run	3	11.7	2.49	22	Suboptimal
Sevenmile Creek	12	10.8	4.34	23	Marginal/Suboptimal
Turkey Creek	4	10.5	5.20	24	Marginal/Suboptimal
Fivemile Creek	5	10.4	2.42	25	Marginal/Suboptimal
Ashtabula Creek	1	10.0	0.00	26	Marginal
Trib 62254	1	10.0	0.00	26	Marginal
Walnut Creek	19	9.9	3.35	28	Marginal
Trib 62436	3	8.0	2.83	29	Marginal
Wilkins Run	2	7.5	2.50	30	Marginal
Duck Run	4	6.8	4.65	31	Marginal
Trib 62490	1	6.0	0.00	32	Marginal
Trib 62483	1	6.0	0.00	32	Marginal
Shorehaven	1	6.0	0.00	32	Marginal
Cemetery Run	1	5.0	0.00	35	Poor
Trib 62255	1	5.0	0.00	35	Poor

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Table 5. Mean embeddedness scores for Pennsylvania Lake Erie streams

Stream	No. of Sites	Mean Embeddedness Score	Std. Deviation	Rank	Mean Rating
Ashtabula Creek	ND	ND	ND	ND	ND
Twentymile Creek	1	19.0	0.00	1	Optimal
Cemetery Run	1	18.0	0.00	2	Optimal
McDannel Run	2	17.5	1.50	3	Optimal
Fourmile Creek	12	17.2	2.54	4	Optimal
Orchard Beach Run	4	17.0	3.46	5	Optimal
Woodmere Beach Run	3	16.3	1.25	6	Optimal
Sixmile Creek	19	15.9	3.25	7	Suboptimal/Optimal
Twelvemile Creek	14	15.9	2.07	7	Suboptimal/Optimal
Eightmile Creek	12	14.8	3.56	9	Suboptimal
Sixteenmile Creek	15	14.6	3.16	10	Suboptimal
Trib 62254	1	14.0	0.00	11	Suboptimal
Peck Run	4	13.3	3.49	12	Suboptimal
Elk Creek	56	12.9	4.50	13	Suboptimal
Conneaut Creek	41	11.9	3.53	14	Suboptimal
Sevenmile Creek	12	11.7	5.33	15	Suboptimal
Godfrey Run	5	10.6	2.50	16	Marginal/Suboptimal
Fivemile Creek	5	10.6	3.26	16	Marginal/Suboptimal
Trout Run	5	10.4	3.61	18	Marginal/Suboptimal
Walnut Creek	19	10.4	2.91	18	Marginal/Suboptimal
Marshall Run	4	10.3	4.26	20	Marginal/Suboptimal
Motch Run	3	10.3	4.64	20	Marginal/Suboptimal
Shorehaven	1	10.0	0.00	22	Marginal
Duck Run	2	9.5	3.50	23	Marginal
Crooked Creek	18	9.2	2.97	24	Marginal
Trib 62684	1	9.0	0.00	25	Marginal
Wilkins Run	2	8.5	1.50	26	Marginal
Turkey Creek	2	8.0	2.00	27	Marginal
Trib 62476	1	8.0	0.00	27	Marginal
Trib 62255	1	8.0	0.00	27	Marginal
Raccoon Creek	7	7.6	1.92	30	Marginal
Trib 62680	1	5.0	0.00	31	Poor
Trib 62490	1	5.0	0.00	31	Poor
Trib 62484	1	5.0	0.00	31	Poor
Trib 62483	1	5.0	0.00	31	Poor
Trib 62436	3	4.7	1.25	35	Poor

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Table 6. Mean velocity/depth regime scores for Pennsylvania Lake Erie streams

Stream	No. of Sites	Mean Velocity Score	Std. Deviation	Rank	Mean Rating
Ashtabula Creek	ND	ND	ND	ND	ND
Twentymile Creek	1	19.0	0.00	1	Optimal
Fourmile Creek	12	17.6	2.81	2	Optimal
Sixmile Creek	19	15.7	3.97	3	Suboptimal/Optimal
Trout Run	5	15.0	3.29	4	Suboptimal
McDannel Run	2	15.0	0.00	4	Suboptimal
Sixteenmile Creek	15	14.9	3.28	6	Suboptimal
Twelvemile Creek	14	14.3	4.08	7	Suboptimal
Woodmere Beach Run	3	14.3	0.47	7	Suboptimal
Conneaut Creek	41	14.0	3.81	9	Suboptimal
Trib 62490	1	14.0	0.00	9	Suboptimal
Raccoon Creek	7	13.9	1.88	11	Suboptimal
Godfrey Run	5	13.8	2.64	12	Suboptimal
Elk Creek	56	13.2	4.64	13	Suboptimal
Peck Run	4	12.8	4.49	14	Suboptimal
Crooked Creek	18	12.7	2.90	15	Suboptimal
Eightmile Creek	12	12.5	3.59	16	Suboptimal
Duck Run	2	12.0	1.00	17	Suboptimal
Sevenmile Creek	12	11.8	4.10	18	Suboptimal
Motch Run	3	11.7	2.62	19	Suboptimal
Turkey Creek	2	11.5	1.50	20	Suboptimal
Marshall Run	4	11.5	3.57	20	Suboptimal
Fivemile Creek	5	11.4	5.00	22	Suboptimal
Shorehaven	1	10.0	0.00	23	Marginal
Walnut Creek	19	9.4	2.82	24	Marginal
Wilkins Run	2	9.0	0.00	25	Marginal
Trib 62484	1	8.0	0.00	26	Marginal
Trib 62476	1	8.0	0.00	26	Marginal
Trib 62680	1	7.0	0.00	28	Marginal
Cemetery Run	1	7.0	0.00	28	Marginal
Trib 62684	1	6.0	0.00	30	Marginal
Trib 62436	3	5.7	0.47	31	Poor/Marginal
Orchard Beach Run	4	5.5	1.50	32	Poor/Marginal
Trib 62254	1	5.0	0.00	33	Poor
Trib 62255	1	5.0	0.00	33	Poor
Trib 62483	1	4.0	0.00	35	Poor

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Table 7. Mean sediment deposition scores for Pennsylvania Lake Erie streams

Stream	No. of Sites	Mean Deposition Score	Std. Deviation	Rank	Mean Rating
Cemetery Run	1	20.0	0.00	1	Optimal
Orchard Beach Run	4	17.3	1.92	2	Optimal
McDannel Run	2	16.0	0.00	3	Optimal
Trib 62254	1	16.0	0.00	3	Optimal
Woodmere Beach Run	3	14.0	3.27	5	Suboptimal
Conneaut Creek	54	13.9	2.86	6	Suboptimal
Godfrey Run	8	13.8	2.12	7	Suboptimal
Twelvemile Creek	14	13.7	5.08	8	Suboptimal
Fivemile Creek	5	13.4	2.42	9	Suboptimal
Sixmile Creek	19	13.4	3.45	9	Suboptimal
Shorehaven	1	13.0	0.00	11	Suboptimal
Peck Run	4	12.8	3.96	12	Suboptimal
Eightmile Creek	12	12.7	4.15	13	Suboptimal
Sixteenmile Creek	15	12.5	1.78	14	Suboptimal
Ashtabula Creek	1	12.0	0.00	15	Suboptimal
Elk Creek	56	11.7	3.56	16	Suboptimal
Fourmile Creek	12	11.7	4.70	16	Suboptimal
Marshall Run	4	11.5	3.50	18	Suboptimal
Turkey Creek	4	10.8	2.99	19	Marginal/Suboptimal
Sevenmile Creek	12	10.6	4.25	20	Marginal/Suboptimal
Wilkins Run	2	10.5	0.50	21	Marginal/Suboptimal
Trout Run	5	10.4	3.77	22	Marginal/Suboptimal
Crooked Creek	18	10.3	2.67	23	Marginal/Suboptimal
Trib 62484	1	10.0	0.00	24	Marginal
Trib 62255	1	10.0	0.00	24	Marginal
Twentymile Creek	1	10.0	0.00	24	Marginal
Duck Run	4	9.8	4.65	27	Marginal
Motch Run	3	9.3	2.05	28	Marginal
Walnut Creek	19	9.2	2.88	29	Marginal
Raccoon Creek	7	9.1	2.75	30	Marginal
Trib 62684	1	5.0	0.00	31	Poor
Trib 62680	1	5.0	0.00	31	Poor
Trib 62490	1	5.0	0.00	31	Poor
Trib 62483	1	5.0	0.00	31	Poor
Trib 62436	3	5.0	0.00	31	Poor
Trib 62476	1	2.0	0.00	36	Poor

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Table 8. Mean channel flow status scores for Pennsylvania Lake Erie streams

Stream	No. of Sites	Mean Flow Score	Std. Deviation	Rank	Mean Rating
Orchard Beach Run	4	18.3	0.43	1	Optimal
Shorehaven	1	16.0	0.00	2	Optimal
Ashtabula Creek	1	15.0	0.00	3	Suboptimal
Trib 62476	1	15.0	0.00	3	Suboptimal
Trib 62254	1	15.0	0.00	3	Suboptimal
Godfrey Run	8	14.9	1.96	6	Suboptimal
Conneaut Creek	54	14.8	4.04	7	Suboptimal
Trout Run	5	14.2	1.60	8	Suboptimal
Twelvemile Creek	14	14.1	4.95	9	Suboptimal
Trib 62484	1	14.0	0.00	10	Suboptimal
Twentymile Creek	1	14.0	0.00	10	Suboptimal
Eightmile Creek	12	13.9	2.96	12	Suboptimal
Woodmere Beach Run	3	13.7	1.89	13	Suboptimal
Marshall Run	4	13.5	2.60	14	Suboptimal
Sevenmile Creek	12	13.4	2.81	15	Suboptimal
Sixteenmile Creek	15	13.4	3.93	15	Suboptimal
Turkey Creek	4	12.5	3.00	17	Suboptimal
Wilkins Run	2	12.5	2.50	17	Suboptimal
Sixmile Creek	19	12.1	3.35	19	Suboptimal
Cemetery Run	1	12.0	0.00	20	Suboptimal
Peck Run	4	12.0	3.47	20	Suboptimal
Crooked Creek	18	11.2	3.04	22	Suboptimal
Walnut Creek	19	11.2	3.76	22	Suboptimal
Trib 62255	1	11.0	0.00	24	Suboptimal
Elk Creek	56	10.4	3.86	25	Marginal/Suboptimal
Raccoon Creek	7	9.6	2.38	26	Marginal
McDannel Run	2	9.5	0.50	27	Marginal
Fourmile Creek	12	8.8	2.30	28	Marginal
Duck Run	4	8.5	5.20	29	Marginal
Trib 62436	3	8.3	0.47	30	Marginal
Trib 62680	1	8.0	0.00	31	Marginal
Fivemile Creek	5	7.8	4.58	32	Marginal
Trib 62684	1	7.0	0.00	33	Marginal
Trib 62483	1	7.0	0.00	33	Marginal
Motch Run	3	7.0	1.41	33	Marginal
Trib 62490	1	6.0	0.00	36	Marginal

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Table 9. Mean channel alteration scores for Pennsylvania Lake Erie streams

Stream	No. of Sites	Mean Alteration Score	Std. Deviation	Rank	Mean Rating
Trib 62684	1	20.0	0.00	1	Optimal
Trib 62476	1	20.0	0.00	1	Optimal
Twentymile Creek	1	19.0	0.00	3	Optimal
McDannel Run	2	16.5	1.50	4	Optimal
Trib 62490	1	16.0	0.00	5	Optimal
Sixmile Creek	19	15.9	2.28	6	Suboptimal/Optimal
Crooked Creek	18	15.7	2.19	7	Suboptimal/Optimal
Raccoon Creek	7	15.6	1.84	8	Suboptimal/Optimal
Marshall Run	4	15.3	2.49	9	Suboptimal/Optimal
Woodmere Beach Run	3	15.3	0.47	9	Suboptimal/Optimal
Eightmile Creek	12	15.1	2.22	11	Suboptimal/Optimal
Twelvemile Creek	14	15.1	2.28	11	Suboptimal/Optimal
Trib 62680	1	15.0	0.00	13	Suboptimal
Trib 62484	1	15.0	0.00	13	Suboptimal
Trib 62483	1	15.0	0.00	13	Suboptimal
Cemetery Run	1	15.0	0.00	13	Suboptimal
Trib 62254	1	15.0	0.00	13	Suboptimal
Elk Creek	56	14.8	2.04	18	Suboptimal
Fourmile Creek	12	14.8	3.44	18	Suboptimal
Conneaut Creek	54	14.6	2.20	20	Suboptimal
Peck Run	4	14.5	2.50	21	Suboptimal
Turkey Creek	4	14.3	4.35	22	Suboptimal
Wilkins Run	2	14.0	1.00	23	Suboptimal
Godfrey Run	8	13.8	2.96	24	Suboptimal
Orchard Beach Run	4	13.8	0.43	24	Suboptimal
Walnut Creek	19	13.3	2.41	26	Suboptimal
Sevenmile Creek	12	13.3	2.55	26	Suboptimal
Fivemile Creek	5	13.2	3.66	28	Suboptimal
Ashtabula Creek	1	13.0	0.00	29	Suboptimal
Trib 62436	3	13.0	5.35	29	Suboptimal
Motch Run	3	13.0	2.16	29	Suboptimal
Sixteenmile Creek	15	12.7	4.34	32	Suboptimal
Trout Run	5	12.0	2.53	33	Suboptimal
Shorehaven	1	10.0	0.00	34	Marginal
Trib 62255	1	10.0	0.00	34	Marginal
Duck Run	4	9.8	4.65	36	Marginal

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Table 10. Mean frequency of riffles scores for Pennsylvania Lake Erie streams

Stream	No. of Sites	Mean Riffle Score	Std. Deviation	Rank	Mean Rating
Ashtabula Creek	ND	ND	ND	ND	ND
Cemetery Run	1	19.0	0.00	1	Optimal
Twelvemile Creek	14	18.3	1.30	2	Optimal
Orchard Beach Run	4	18.3	1.30	2	Optimal
Trib 62476	1	18.0	0.00	4	Optimal
Peck Run	4	18.0	0.71	4	Optimal
Twentymile Creek	1	18.0	0.00	4	Optimal
Fourmile Creek	12	17.8	1.72	7	Optimal
Woodmere Beach Run	3	17.3	1.25	8	Optimal
Eightmile Creek	12	17.2	2.15	9	Optimal
Sixmile Creek	19	16.9	4.44	10	Optimal
McDannel Run	2	16.5	2.50	11	Optimal
Sixteenmile Creek	15	16.1	4.64	12	Optimal
Trib 62490	1	16.0	0.00	13	Optimal
Shorehaven	1	16.0	0.00	13	Optimal
Trib 62254	1	16.0	0.00	13	Optimal
Trib 62255	1	16.0	0.00	13	Optimal
Wilkins Run	2	15.5	0.50	17	Suboptimal/Optimal
Sevenmile Creek	12	15.1	5.38	18	Suboptimal/Optimal
Trib 62484	1	15.0	0.00	19	Suboptimal
Godfrey Run	5	14.6	4.50	20	Suboptimal
Marshall Run	4	14.5	3.20	21	Suboptimal
Duck Run	2	14.0	2.00	22	Suboptimal
Elk Creek	56	13.7	4.95	23	Suboptimal
Crooked Creek	18	13.4	3.59	24	Suboptimal
Raccoon Creek	7	13.3	4.30	25	Suboptimal
Motch Run	3	13.3	4.64	25	Suboptimal
Conneaut Creek	41	12.8	4.38	27	Suboptimal
Trout Run	5	12.0	3.74	28	Suboptimal
Trib 62680	1	11.0	0.00	29	Suboptimal
Walnut Creek	19	10.7	3.21	30	Marginal/Suboptimal
Trib 62436	3	10.3	5.44	31	Marginal/Suboptimal
Trib 62684	1	10.0	0.00	32	Marginal
Fivemile Creek	5	9.6	7.06	33	Marginal
Trib 62483	1	8.0	0.00	34	Marginal
Turkey Creek	2	7.0	1.00	35	Marginal

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Table 11. Mean bank stability scores for Pennsylvania Lake Erie streams

Stream	No. of Sites	Mean Stability Score	Std. Deviation	Rank	Mean Rating
Orchard Beach Run	4	18.8	1.29	1	Optimal
Trib 62490	1	18.0	0.00	2	Optimal
Cemetery Run	1	18.0	0.00	2	Optimal
Trib 62254	1	18.0	0.00	2	Optimal
Trib 62255	1	18.0	0.00	2	Optimal
Twelvemile Creek	14	16.6	3.40	6	Optimal
Twentymile Creek	1	16.0	0.00	7	Optimal
Godfrey Run	8	15.8	4.83	8	Suboptimal/Optimal
Sixmile Creek	19	15.7	3.45	9	Suboptimal/Optimal
Conneaut Creek	54	15.6	3.06	10	Suboptimal/Optimal
Elk Creek	56	15.1	3.38	11	Suboptimal/Optimal
Walnut Creek	19	15.1	3.71	11	Suboptimal/Optimal
Trib 62680	1	15.0	0.00	13	Suboptimal
Sixteenmile Creek	15	14.9	3.23	14	Suboptimal
Sevenmile Creek	12	14.7	3.42	15	Suboptimal
Ashtabula Creek	1	14.0	0.00	16	Suboptimal
Wilkins Run	2	14.0	4.00	16	Suboptimal
Trout Run	5	13.8	0.00	18	Suboptimal
Fourmile Creek	12	13.8	3.97	18	Suboptimal
Duck Run	4	13.5	4.12	20	Suboptimal
Fivemile Creek	5	13.2	5.15	21	Suboptimal
Crooked Creek	18	12.8	3.64	22	Suboptimal
Marshall Run	4	12.5	4.39	23	Suboptimal
Turkey Creek	4	12.3	4.57	24	Suboptimal
Woodmere Beach Run	3	12.3	2.05	24	Suboptimal
Trib 62484	1	12.0	0.00	26	Suboptimal
McDannel Run	2	12.0	2.00	26	Suboptimal
Raccoon Creek	7	11.9	4.39	28	Suboptimal
Trib 62436	3	11.3	1.89	29	Suboptimal
Trib 62684	1	11.0	0.00	30	Suboptimal
Peck Run	4	11.0	5.39	30	Suboptimal
Eightmile Creek	12	10.4	4.09	32	Marginal/Suboptimal
Trib 62476	1	10.0	0.00	33	Marginal
Shorehaven	1	10.0	0.00	33	Marginal
Trib 62483	1	8.0	0.00	35	Marginal
Motch Run	3	4.7	0.94	36	Poor

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Table 12. Mean bank vegetative protection scores for Pennsylvania Lake Erie streams

Stream	No. of Sites	Mean Vegetation Score	Std. Deviation	Rank	Mean Rating
Ashtabula Creek	1	18.0	0.00	1	Optimal
Trib 62684	1	18.0	0.00	1	Optimal
Trib 62680	1	18.0	0.00	1	Optimal
Trib 62490	1	18.0	0.00	1	Optimal
Trib 62484	1	18.0	0.00	1	Optimal
Trib 62483	1	18.0	0.00	1	Optimal
Cemetery Run	1	18.0	0.00	1	Optimal
Twentymile Creek	1	18.0	0.00	1	Optimal
Twelvemile Creek	14	17.9	2.45	9	Optimal
Raccoon Creek	7	16.7	2.12	10	Optimal
Conneaut Creek	54	16.4	2.98	11	Optimal
Orchard Beach Run	4	16.3	1.79	12	Optimal
Trib 62476	1	16.0	0.00	13	Optimal
Wilkins Run	2	16.0	2.00	13	Optimal
Trib 62254	1	16.0	0.00	13	Optimal
Elk Creek	56	15.7	3.51	16	Suboptimal/Optimal
Walnut Creek	19	15.5	2.87	17	Suboptimal/Optimal
Sixmile Creek	19	14.9	4.43	18	Suboptimal
Sevenmile Creek	12	14.8	4.64	19	Suboptimal
Crooked Creek	18	14.7	4.48	20	Suboptimal
Fivemile Creek	5	14.4	2.33	21	Suboptimal
Peck Run	4	14.0	5.83	22	Suboptimal
Duck Run	4	13.8	3.86	23	Suboptimal
Fourmile Creek	12	13.4	4.23	24	Suboptimal
Eightmile Creek	12	12.8	5.15	25	Suboptimal
Trout Run	5	12.6	3.98	26	Suboptimal
Godfrey Run	8	12.3	6.54	27	Suboptimal
Marshall Run	4	12.3	5.45	27	Suboptimal
Sixteenmile Creek	15	12.3	4.36	27	Suboptimal
McDannel Run	2	11.5	2.50	30	Suboptimal
Turkey Creek	4	11.3	6.60	31	Suboptimal
Trib 62436	3	10.0	6.53	32	Marginal
Woodmere Beach Run	3	9.0	4.08	33	Marginal
Motch Run	3	8.7	5.25	34	Marginal
Shorehaven	1	8.0	0.00	35	Marginal
Trib 62255	1	6.0	0.00	36	Poor

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Table 13. Mean riparian vegetative zone width scores for Pennsylvania Lake Erie streams

Stream	No. of Sites	Mean Riparian Score	Std. Deviation	Rank	Mean Rating
Trib 62476	1	20.0	0.00	1	Optimal
Ashtabula Creek	1	18.0	0.00	2	Optimal
Raccoon Creek	7	18.0	2.62	2	Optimal
Trib 62490	1	18.0	0.00	2	Optimal
Trib 62483	1	18.0	0.00	2	Optimal
Twentymile Creek	1	18.0	0.00	2	Optimal
Wilkins Run	2	17.0	2.00	7	Optimal
Crooked Creek	18	15.5	4.48	8	Suboptimal/Optimal
Conneaut Creek	54	14.3	5.49	9	Suboptimal
Fourmile Creek	12	13.8	5.08	10	Suboptimal
Sixmile Creek	19	13.6	4.07	11	Suboptimal
Walnut Creek	19	13.5	4.64	12	Suboptimal
Trib 62684	1	12.0	0.00	13	Suboptimal
Orchard Beach Run	4	11.8	5.49	14	Suboptimal
Elk Creek	56	11.2	5.85	15	Suboptimal
Woodmere Beach Run	3	11.0	4.97	16	Suboptimal
Trib 62436	3	10.3	6.55	17	Marginal/Suboptimal
Turkey Creek	4	10.0	8.49	18	Marginal
Trout Run	5	10.0	5.90	18	Marginal
Peck Run	4	9.5	4.50	20	Marginal
Twelvemile Creek	14	9.4	4.34	21	Marginal
Motch Run	3	9.3	7.59	22	Marginal
Trib 62484	1	9.0	0.00	23	Marginal
Sixteenmile Creek	15	9.0	6.22	23	Marginal
McDannel Run	2	8.5	5.50	25	Marginal
Duck Run	4	8.3	5.06	26	Marginal
Trib 62680	1	8.0	0.00	27	Marginal
Eightmile Creek	12	8.0	5.40	27	Marginal
Godfrey Run	8	7.6	6.74	29	Marginal
Fivemile Creek	5	6.2	6.01	30	Marginal
Marshall Run	4	6.0	4.06	31	Marginal
Sevenmile Creek	12	5.2	3.48	32	Poor/Marginal
Cemetery Run	1	4.0	0.00	33	Poor
Trib 62254	1	4.0	0.00	33	Poor
Trib 62255	1	4.0	0.00	33	Poor
Shorehaven	1	3.0	0.00	36	Poor

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Table 14. Habitat data for the Pennsylvania Lake Erie high-gradient stream sites

	Habitat Parameter Scores																		
Stream	Site	Epi	Emb	Vel	Dep	Ch Fl	Ch Alt	Riffle	L-Stab	R-Stab	T-Stab	L-Veg	R-Veg	T-Veg	L-Rip	R-Rip	T-Rip	T-Hab	Rating
Conneaut Creek	COC 2	10	10	7	15	15	15	11	9	9	18	9	9	18	10	7	17	136	Suboptimal
Conneaut Creek	COC 4	14	15	10	16	17	14	11	9	9	18	9	9	18	10	10	20	153	Suboptimal
Conneaut Creek	COC 5	11	10	10	16	16	15	11	9	9	18	9	9	18	9	2	11	136	Suboptimal
Conneaut Creek	COC 6	11	10	5	16	16	14	6	9	9	18	9	9	18	10	10	20	134	Suboptimal
Conneaut Creek	COC 7	15	15	15	16	19	19	14	9	9	18	9	9	18	9	9	18	167	Optimal
Conneaut Creek	COC 8	14	18	13	18	18	20	19	9	9	18	9	9	18	10	10	20	176	Optimal
Conneaut Creek	COC 9	18	18	18	18	16	18	18	9	9	18	9	9	18	10	10	20	180	Optimal
Conneaut Creek	COC 11	15	16	15	17	18	19	19	9	9	18	9	9	18	9	9	18	173	Optimal
Conneaut Creek	COC 12	15	15	15	16	18	18	15	9	9	18	9	9	18	9	9	18	161	Optimal
Conneaut Creek	COC 18	18	16	16	16	16	16	16	9	9	18	9	9	18	5	9	14	164	Optimal
Conneaut Creek	COC 25	16	12	16	11	13	13	10	6	6	12	7	7	14	5	8	13	130	Suboptimal
Conneaut Creek	COC 26	11	5	11	11	18	14	13	9	9	18	9	9	18	10	10	20	139	Suboptimal
Conneaut Creek	COC 28	11	14	8	11	15	11	7	6	9	15	9	9	18	5	8	13	123	Suboptimal
Conneaut Creek	COC 29	12	5	6	15	19	9	7	9	9	18	9	9	18	8	8	16	125	Suboptimal
Conneaut Creek	COC 30	12	13	11	16	19	14	11	9	9	18	9	9	18	2	4	6	138	Suboptimal
Conneaut Creek	COC 32	11	6	8	16	19	15	7	9	9	18	9	9	18	8	9	17	135	Suboptimal
Conneaut Creek	COC 33	10	10	12	11	16	15	11	8	5	13	9	9	18	9	9	18	134	Suboptimal
Conneaut Creek	COC 34	13	6	10	15	18	15	10	9	9	18	9	9	18	7	7	14	137	Suboptimal
Conneaut Creek	COC 35	15	12	15	16	19	15	17	9	9	18	9	9	18	3	3	6	151	Suboptimal
Conneaut Creek	COC 36	16	10	10	16	19	15	10	5	7	12	9	9	18	9	9	18	144	Suboptimal
Conneaut Creek	COC 37	16	15	16	15	14	15	16	5	5	10	9	9	18	10	10	20	152	Suboptimal
Conneaut Creek	COC 38	15	10	15	11	15	15	10	7	7	14	9	9	18	6	6	12	135	Suboptimal
Conneaut Creek	COC 39	15	7	18	7	16	15	16	7	8	15	7	10	17	6	5	11	137	Suboptimal
Conneaut Creek	COC 40	16	12	15	10	9	15	17	5	3	8	5	6	11	6	8	14	127	Suboptimal
Conneaut Creek	COC 43	20	13	20	14	10	13	18	7	7	14	6	6	12	10	10	20	154	Suboptimal
Conneaut Creek	COC 44	18	14	18	14	15	15	19	8	8	16	9	6	15	10	10	20	164	Optimal
Conneaut Creek	COC 45	17	15	20	16	15	15	15	7	7	14	9	9	18	10	5	15	160	Optimal
Conneaut Creek	COC 46	8	9	14	10	19	15	8	9	7	16	9	8	17	2	2	4	120	Suboptimal
Conneaut Creek	COC 47	15	14	15	19	18	15	15	9	7	16	9	8	17	4	4	8	152	Suboptimal
Conneaut Creek	COC 48	17	10	14	13	9	15	13	7	3	10	6	5	11	10	10	20	132	Suboptimal
Conneaut Creek	COC 49	16	11	15	12	15	15	8	9	9	18	9	7	16	8	8	16	142	Suboptimal
Conneaut Creek	COC 50	15	16	16	14	9	14	19	6	6	12	7	7	14	2	2	4	133	Suboptimal
Conneaut Creek	COC 51	16	15	18	12	9	15	19	8	10	18	8	9	17	9	9	18	157	Suboptimal
Conneaut Creek	COC 52	17	16	19	14	9	11	15	9	3	12	9	3	12	8	5	13	136	Suboptimal
Conneaut Creek	COC 53	16	14	18	18	18	15	8	8	7	15	9	9	18	10	10	20	160	Optimal
Conneaut Creek	COC 54	18	7	16	12	16	15	6	10	8	18	9	9	18	10	10	20	148	Suboptimal
Conneaut Creek	COC 55	12	7	15	12	15	15	5	9	3	12	9	3	12	2	1	3	108	Marginal
Conneaut Creek	COC 56	13	8	14	8	7	11	6	7	4	11	5	4	9	8	8	16	103	Marginal
Conneaut Creek	COC 57	15	14	15	14	9	10	15	3	5	8	7	5	12	2	1	3	115	Suboptimal
Conneaut Creek	COC 58	19	12	20	11	9	14	15	8	6	14	7	7	14	9	6	15	143	Suboptimal
Conneaut Creek	COC 59	16	12	14	14	7	10	18	7	6	13	8	7	15	2	1	3	122	Suboptimal
Turkey Creek	TC 1	15	6	13	8	9	20	8	2	5	7	2	8	10	10	10	20	116	Suboptimal
Turkey Creek	TC 2	15	10	10	10	15	10	6	9	9	18	10	10	20	5	9	14	128	Suboptimal
Raccoon Creek	RC 1	17	8	15	10	10	15	10	7	7	14	9	9	18	10	2	12	129	Suboptimal
Raccoon Creek	RC 2	17	6	15	14	9	14	16	9	2	11	9	6	15	10	10	20	137	Suboptimal
Raccoon Creek	RC 3	19	11	15	10	8	15	18	7	7	14	9	9	18	9	9	18	146	Suboptimal
Raccoon Creek	RC 4	19	9	12	9	9	15	6	3	3	6	7	7	14	10	9	18	118	Suboptimal
Raccoon Creek	RC 5	17	8	15	10	9	15	15	8	9	17	9	10	19	10	10	20	145	Suboptimal
Raccoon Creek	RC 6	15	6	10	6	7	20	10	3	2	5	9	5	14	10	10	20	113	Suboptimal
Raccoon Creek	RC 7	10	5	15	5	15	15	18	7	9	16	9	10	19	10	8	18	136	Suboptimal
Trib 62684	T684 1	12	9	6	5	7	20	10	9	2	11	10	8	18	3	9	12	110	Suboptimal
Trib 62680	T680 1	16	5	7	5	8	15	11	6	9	15	9	9	18	4	4	8	108	Marginal
Crooked Creek	CRC 1	15	8	14	6	8	11	6	10	9	19	4	5	9	2	2	4	100	Marginal

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Table 14 (*continued).* *Habitat data for the Pennsylvania Lake Erie high-gradient stream sites*

		Habitat Parameter Scores																	
Stream	Site	Epi	Emb	Vel	Dep	Ch Fl	Ch Alt	Riffle	L-Stab	R-Stab	T-Stab	L-Veg	R-Veg	T-Veg	L-Rip	R-Rip	T-Rip	T-Hab	Rating
Crooked Creek	CRC 2	7	5	14	6	16	15	19	4	4	8	9	9	18	10	3	13	121	Suboptimal
Crooked Creek	CRC 3	10	10	10	14	15	15	16	9	7	16	2	2	4	2	2	4	114	Suboptimal
Crooked Creek	CRC 4	19	10	15	8	8	20	14	7	2	9	9	9	18	10	10	20	141	Suboptimal
Crooked Creek	CRC 5	8	2	5	10	15	15	10	9	9	18	10	10	20	5	8	13	116	Suboptimal
Crooked Creek	CRC 6	18	6	15	9	8	18	15	3	5	8	9	9	18	10	9	19	134	Suboptimal
Crooked Creek	CRC 7	16	13	10	11	8	20	15	9	8	17	10	10	20	9	8	17	147	Suboptimal
Crooked Creek	CRC 8	15	8	13	10	8	15	9	7	7	14	10	10	20	7	7	14	126	Suboptimal
Crooked Creek	CRC 9	15	8	9	10	13	15	6	2	7	9	3	8	11	8	10	18	114	Suboptimal
Crooked Creek	CRC 10	14	7	10	6	7	14	11	9	9	18	9	9	18	8	8	16	121	Suboptimal
Crooked Creek	CRC 11	16	13	16	15	15	15	16	6	8	14	8	8	16	8	9	17	153	Suboptimal
Crooked Creek	CRC 12	10	10	11	10	10	15	12	5	5	10	5	5	10	9	7	16	114	Suboptimal
Crooked Creek	CRC 13	14	13	16	15	14	17	16	8	6	14	8	8	16	9	9	18	153	Suboptimal
Crooked Creek	CRC 14	15	12	15	11	10	15	16	7	6	13	7	7	14	9	9	18	139	Suboptimal
Crooked Creek	CRC 16	11	7	14	12	14	15	16	7	7	14	8	8	16	9	9	18	137	Suboptimal
Crooked Creek	CRC 17	10	11	13	12	9	16	16	5	4	9	5	5	10	9	9	18	124	Suboptimal
Crooked Creek	CRC 18	10	10	13	11	13	18	16	5	5	10	8	8	16	9	9	18	124	Suboptimal
Crooked Creek	CRC 19	10	12	16	10	10	13	13	6	4	10	6	4	10	9	9	18	122	Suboptimal
Duck Run	DR 1	11	6	11	8	10	10	12	5	5	10	5	6	11	2	2	4	93	Marginal
Duck Run	DR 2	10	13	13	10	10	16	16	5	5	10	5	5	10	5	9	14	122	Suboptimal
Elk Creek	EC 1	16	6	19	10	8	15	15	10	9	19	10	8	18	10	8	18	134	Suboptimal
Elk Creek	EC 2	5	5	9	5	9	14	8	10	10	20	2	10	12	2	1	3	90	Marginal
Elk Creek	EC 3	13	5	19	7	8	15	8	9	8	17	10	9	19	9	9	18	129	Suboptimal
Elk Creek	EC 4	9	7	11	7	6	11	10	7	3	10	10	5	15	2	3	5	91	Marginal
Elk Creek	EC 5	8	10	10	16	16	15	16	8	9	17	9	9	18	9	9	18	144	Suboptimal
Elk Creek	EC 6	10	9	12	9	10	16	15	9	9	18	9	9	18	9	9	18	135	Suboptimal
Elk Creek	EC 7	12	8	10	8	10	16	16	9	9	18	9	9	18	5	9	14	130	Suboptimal
Elk Creek	EC 8	5	14	8	11	10	16	17	8	8	16	9	9	18	9	9	18	133	Suboptimal
Elk Creek	EC 9	9	6	11	15	19	15	6	9	9	18	9	9	18	1	4	5	122	Suboptimal
Elk Creek	EC 10	12	16	15	15	16	16	13	5	9	14	9	9	18	9	9	18	153	Suboptimal
Elk Creek	EC 11	6	5	6	10	16	15	4	9	9	18	9	9	18	9	2	11	109	Marginal
Elk Creek	EC 12	10	10	9	10	7	20	10	4	7	11	6	8	14	9	9	18	119	Suboptimal
Elk Creek	EC 13	14	13	7	11	6	15	5	9	7	16	8	10	18	9	4	13	118	Suboptimal
Elk Creek	EC 14	16	10	14	10	6	15	10	9	9	18	9	8	17	10	10	20	136	Suboptimal
Elk Creek	EC 15	13	13	15	10	8	15	14	9	9	18	5	9	14	10	6	16	136	Suboptimal
Elk Creek	EC 16	14	16	15	10	7	13	17	8	7	15	6	8	14	8	6	14	135	Suboptimal
Elk Creek	EC 17	14	15	15	10	7	19	11	9	9	18	9	9	19	8	10	18	145	Suboptimal
Elk Creek	EC 18	10	10	10	11	8	15	15	9	8	17	9	8	17	10	10	20	117	Suboptimal
Elk Creek	EC 19	10	15	3	15	5	15	3	10	10	20	10	10	20	9	8	17	123	Suboptimal
Elk Creek	EC 20	15	14	7	10	5	15	5	5	5	10	3	5	8	9	9	18	107	Marginal
Elk Creek	EC 21	13	13	12	11	6	13	9	5	2	7	8	5	13	2	2	4	101	Marginal
Elk Creek	EC 22	15	13	19	7	10	19	17	9	6	15	9	6	15	10	3	13	143	Suboptimal
Elk Creek	EC 23	15	14	19	8	10	10	17	9	9	18	7	8	15	7	2	9	135	Suboptimal
Elk Creek	EC 24	17	14	17	16	11	14	16	7	5	12	7	5	12	2	2	4	133	Suboptimal
Elk Creek	EC 25	17	19	18	17	9	15	18	9	9	18	7	9	16	10	10	20	167	Optimal
Elk Creek	EC 26	16	9	10	9	8	15	7	6	6	12	6	6	12	8	8	16	114	Suboptimal
Elk Creek	EC 27	11	8	7	8	7	15	5	5	7	12	5	8	13	6	7	13	99	Marginal
Elk Creek	EC 28	14	8	6	10	12	17	5	9	9	18	9	9	18	2	2	4	112	Suboptimal
Elk Creek	EC 29	14	13	10	10	8	15	14	5	4	9	5	6	11	6	1	7	111	Suboptimal
Elk Creek	EC 30	15	6	16	6	11	15	15	5	9	14	4	9	13	3	4	7	118	Suboptimal
Elk Creek	EC 31	15	6	18	6	10	8	10	8	9	17	4	9	13	3	2	5	108	Marginal
Elk Creek	EC 32	18	14	13	10	8	15	16	6	6	12	7	8	15	4	8	12	133	Suboptimal
Elk Creek	EC 33	16	10	5	10	5	15	5	9	9	18	8	9	17	10	10	20	121	Suboptimal
Elk Creek	EC 34	19	7	18	10	9	15	19	6	9	15	8	10	18	4	4	8	138	Suboptimal
Elk Creek	EC 35	7	8	10	10	11	11	13	6	2	8	2	2	4	2	2	4	86	Marginal
Elk Creek	EC 36	18	9	17	9	15	15	10	8	10	18	10	10	20	2	2	4	135	Suboptimal

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Table 14 (*continued). Habitat data for the Pennsylvania Lake Erie high-gradient stream sites*

	Habitat Parameter Scores																		
Stream	Site	Epi	Emb	Vel	Dep	Ch Fl	Ch Alt	Riffle	L-Stab	R-Stab	T-Stab	L-Veg	R-Veg	T-Veg	L-Rip	R-Rip	T-Rip	T-Hab	Rating
Elk Creek	EC 37	18	17	19	10	15	15	18	7	7	14	10	8	18	4	2	6	150	Suboptimal
Elk Creek	EC 38	18	18	15	14	10	12	19	4	5	9	3	3	6	1	2	3	124	Suboptimal
Elk Creek	EC 39	13	20	8	20	19	19	19	8	8	16	8	9	17	8	2	10	158	Suboptimal
Elk Creek	EC 40	20	18	18	16	8	15	19	8	6	14	6	6	12	8	8	16	156	Suboptimal
Elk Creek	EC 41	19	19	10	18	18	15	19	8	8	16	10	10	20	2	7	9	163	Optimal
Elk Creek	EC 42	20	19	18	15	16	15	17	7	10	17	6	10	16	4	4	8	161	Optimal
Elk Creek	EC 43	20	19	20	15	15	15	20	8	6	14	7	7	14	10	10	20	172	Optimal
Elk Creek	EC 44	13	18	5	11	7	10	15	5	8	13	4	8	12	1	2	3	107	Marginal
Elk Creek	EC 45	15	18	17	13	9	14	17	10	9	19	10	10	20	2	2	4	146	Suboptimal
Elk Creek	EC 46	18	18	20	17	19	14	20	7	3	10	9	9	18	3	1	4	158	Suboptimal
Elk Creek	EC 47	16	17	14	17	15	15	19	6	10	16	9	10	19	2	2	4	152	Suboptimal
Elk Creek	EC 48	16	16	14	15	12	15	14	6	9	15	8	10	18	1	2	3	138	Suboptimal
Elk Creek	EC 49	15	18	10	19	7	15	18	10	10	20	10	10	20	9	5	14	156	Suboptimal
Elk Creek	EC 50	20	18	15	13	8	15	18	4	4	8	8	7	15	8	3	11	141	Suboptimal
Elk Creek	EC 51	20	15	20	14	10	15	18	4	9	13	6	10	16	2	5	7	148	Suboptimal
Elk Creek	EC 52	19	16	20	15	9	15	19	8	10	18	8	10	18	3	10	13	162	Optimal
Elk Creek	EC 53	15	12	10	10	10	14	19	7	8	15	8	8	16	2	10	12	133	Suboptimal
Elk Creek	EC 54	13	17	13	14	10	15	13	5	9	14	8	9	17	2	2	4	130	Suboptimal
Elk Creek	EC 55	18	15	16	15	15	15	18	9	9	18	10	10	20	6	8	14	164	Optimal
Elk Creek	EC 56	10	16	15	8	15	16	16	9	9	18	5	5	10	5	5	10	134	Suboptimal
Trib 62490	T490 1	6	5	14	5	6	16	16	9	9	18	9	9	18	9	9	18	122	Suboptimal
Godfrey Run	GFR 1	11	8	14	17	18	17	13	6	8	14	6	6	12	1	1	2	126	Suboptimal
Godfrey Run	GFR3	10	8	14	13	15	13	7	6	6	12	5	5	10	2	2	4	106	Marginal
Godfrey Run	GFR 6	18	14	15	12	15	15	20	2	4	6	2	2	4	9	9	18	137	Suboptimal
Godfrey Run	GFR 7	18	13	17	14	14	14	18	9	9	18	10	10	20	9	2	11	157	Suboptimal
Godfrey Run	GFR 8	10	10	9	12	15	7	15	10	10	20	0	10	10	1	2	3	111	Suboptimal
Trib 62484	T84 1	10	5	8	10	14	15	15	5	7	12	8	10	18	2	7	9	116	Suboptimal
Trib 62483	T83 1	6	5	4	5	7	15	8	4	4	8	9	9	18	8	10	18	94	Marginal
Trout Run	TR 1	14	6	19	5	15	10	14	8	8	16	9	5	14	3	1	4	117	Suboptimal
Trout Run	TR 2	19	14	15	12	11	11	16	3	4	7	3	5	8	7	3	10	123	Suboptimal
Trout Run	TR 3	18	13	16	15	15	15	13	7	9	16	9	9	18	9	6	15	154	Suboptimal
Trout Run	TR 4	16	13	16	13	15	15	12	4	8	12	7	8	15	9	9	18	145	Suboptimal
Trout Run	TR 5	10	6	9	7	15	9	5	9	9	18	6	2	8	2	1	3	90	Marginal
Trib 62476	T76 1	14	8	8	2	15	20	18	5	5	10	8	8	16	10	10	20	131	Suboptimal
Walnut Creek	WC 1	10	13	11	11	11	13	13	8	8	16	7	7	14	9	3	12	124	Suboptimal
Walnut Creek	WC 2	10	10	10	5	8	16	16	5	5	10	5	5	10	10	10	20	115	Suboptimal
Walnut Creek	WC 3	8	9	8	12	10	13	11	6	4	10	6	5	11	9	6	15	107	Marginal
Walnut Creek	WC 4	7	9	9	7	6	16	16	9	9	18	9	9	18	9	9	18	124	Suboptimal
Walnut Creek	WC 5	10	12	11	10	10	15	11	5	8	13	6	6	12	9	9	18	122	Suboptimal
Walnut Creek	WC 6	8	9	8	11	7	16	9	7	7	14	9	9	18	9	9	18	118	Suboptimal
Walnut Creek	WC 7	13	15	10	13	15	14	10	8	8	16	9	8	17	9	7	16	129	Suboptimal
Walnut Creek	WC 8	10	12	11	11	14	8	11	8	8	16	9	9	18	2	6	8	119	Suboptimal
Walnut Creek	WC 9	3	2	2	5	18	13	2	8	8	16	8	8	16	9	3	12	89	Marginal
Walnut Creek	WC 10	10	9	10	10	11	10	13	2	2	4	5	5	10	2	2	4	91	Marginal
Walnut Creek	WC 12	10	10	11	10	11	13	10	8	8	16	7	8	15	5	5	10	116	Suboptimal
Walnut Creek	WC 13	10	15	11	11	11	13	12	9	9	18	9	9	18	9	9	18	137	Suboptimal
Walnut Creek	WC 15	10	8	10	10	10	8	10	6	6	12	7	6	13	5	5	10	101	Marginal
Walnut Creek	WC 16	12	11	10	8	16	16	13	9	10	19	9	9	18	9	9	18	141	Suboptimal
Walnut Creek	WC 17	3	14	2	2	2	14	6	9	9	18	9	9	18	5	3	8	87	Marginal
Walnut Creek	WC 18	16	12	13	9	13	16	7	9	9	18	9	9	18	9	9	18	140	Suboptimal
Walnut Creek	WC 19	17	10	12	6	10	14	13	9	9	18	9	9	18	7	9	16	134	Suboptimal
Walnut Creek	WC 20	10	8	9	12	15	12	11	9	7	16	9	7	16	7	2	9	118	Suboptimal
Walnut Creek	WC 21	11	10	11	12	15	13	10	9	9	18	9	8	17	6	2	8	125	Suboptimal
Trib 62436	T36 1	4	3	6	5	9	6	6	5	5	10	1	1	2	1	1	2	53	Poor
Trib 62436	T36 2	10	5	6	5	8	14	7	5	5	10	5	5	10	2	9	11	86	Marginal

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Table 14 (*continued)*. *Habitat data for the Pennsylvania Lake Erie high-gradient stream sites*

		Habitat Parameter Scores																	
Stream	Site	Epi	Emb	Vel	Dep	Ch Fl	Ch Alt	Riffle	L-Stab	R-Stab	T-Stab	L-Veg	R-Veg	T-Veg	L-Rip	R-Rip	T-Rip	T-Hab	Rating
Trib 62436	T36 3	10	6	5	5	8	19	18	7	7	14	9	9	18	8	10	18	121	Suboptimal
Wilkins Run	WR 1	5	7	7	10	15	13	16	9	9	18	9	9	18	7	8	15	124	Suboptimal
Wilkins Run	WR 2	10	10	11	11	10	15	15	5	5	10	7	7	14	9	9	19	124	Suboptimal
Shorehave	SH 1	6	10	10	13	16	10	16	5	5	10	4	4	8	2	1	3	102	Marginal
Marshall Run	MR 1	18	15	15	14	15	13	17	8	7	15	7	8	15	5	2	7	144	Suboptimal
Marshall Run	MR 2	18	14	15	15	15	19	18	8	8	16	7	10	17	3	9	12	159	Suboptimal
Marshall Run	MR 3	7	6	9	11	15	13	13	4	1	5	2	1	3	1	1	1	84	Marginal
Marshall Run	MR 4	10	6	7	6	9	16	10	7	7	14	7	7	14	2	2	4	96	Marginal
Motch Run	MTR 1	15	4	8	7	9	10	7	3	3	6	8	8	16	1	2	3	85	Marginal
Motch Run	MTR 2	11	15	14	9	6	15	15	2	2	4	3	3	6	10	10	20	115	Suboptimal
Motch Run	MTR 3	9	12	13	12	6	14	18	2	2	4	2	2	4	4	1	5	97	Marginal
Cemetery Run	CR 1	5	18	7	20	12	15	19	9	9	18	9	9	18	2	2	4	136	Suboptimal
McDannel Run	MDR 1	15	19	15	16	9	18	19	7	7	14	7	7	14	9	5	14	153	Suboptimal
McDannel Run	MDR 2	11	16	15	16	10	15	14	2	8	10	1	8	9	1	2	3	119	Suboptimal
Fourmile Creek	4M 1	16	13	19	17	15	19	16	8	9	17	8	9	17	3	8	11	160	Optimal
Fourmile Creek	4M 2	19	19	19	3	8	15	19	3	8	11	7	9	16	2	9	11	140	Suboptimal
Fourmile Creek	4M 3	15	18	19	8	9	6	15	8	8	16	1	6	7	1	3	4	117	Suboptimal
Fourmile Creek	4M 5	15	14	16	6	7	11	16	6	6	12	8	8	16	4	4	8	121	Suboptimal
Fourmile Creek	4M 6	6	15	16	9	8	15	17	4	4	8	3	3	6	9	9	18	118	Suboptimal
Fourmile Creek	4M 7	16	19	15	14	9	15	20	5	5	10	8	8	16	10	2	12	146	Suboptimal
Fourmile Creek	4M 8	20	20	20	15	7	17	20	4	4	8	7	7	14	10	10	20	161	Optimal
Fourmile Creek	4M 9	16	20	20	18	10	20	20	10	10	20	4	4	8	10	10	20	172	Optimal
Fourmile Creek	4M 10	19	19	18	10	7	14	19	9	9	18	8	8	16	10	10	20	160	Optimal
Fourmile Creek	4M 11	13	13	10	9	6	15	16	8	4	12	5	5	10	6	6	12	116	Suboptimal
Fourmile Creek	4M 12	16	18	20	13	9	15	18	9	9	18	10	9	19	8	3	11	157	Suboptimal
Fourmile Creek	4M 13	16	18	19	18	11	15	18	8	8	16	8	8	16	9	9	18	165	Optimal
Fivemile Creek	5M 0	10	9	17	9	8	18	14	3	3	6	7	7	14	10	8	18	123	Suboptimal
Fivemile Creek	5M 1	12	14	15	14	10	15	16	4	4	8	8	8	16	4	1	5	125	Suboptimal
Fivemile Creek	5M 2	13	13	14	16	15	10	16	8	8	16	6	6	12	1	1	2	127	Suboptimal
Fivemile Creek	5M 3	6	5	7	13	2	8	1	9	9	18	6	6	12	1	1	2	74	Marginal
Fivemile Creek	5M 4	11	12	4	15	4	15	1	9	9	18	9	9	18	2	2	4	102	Marginal
Sixmile Creek	6M 0	14	18	14	10	10	15	8	10	9	19	8	2	10	9	9	18	136	Suboptimal
Sixmile Creek	6M 1	15	16	16	10	12	18	18	2	5	7	5	5	10	2	9	11	133	Suboptimal
Sixmile Creek	6M 2	15	6	19	10	7	15	16	9	9	18	6	6	12	8	2	10	128	Suboptimal
Sixmile Creek	6M 3	11	19	19	6	7	20	20	10	10	20	2	5	7	10	9	19	148	Suboptimal
Sixmile Creek	6M 4	12	17	18	8	10	20	18	9	9	18	5	3	8	2	4	6	135	Suboptimal
Sixmile Creek	6M 5	15	16	13	16	15	15	20	10	8	18	10	10	20	10	8	18	166	Optimal
Sixmile Creek	6M 6	18	15	14	13	14	20	17	6	8	14	9	9	18	8	10	18	161	Optimal
Sixmile Creek	6M 7	18	19	20	15	15	15	20	9	9	18	10	6	16	9	9	18	174	Optimal
Sixmile Creek	6M 8	16	13	17	15	14	15	18	6	6	12	10	10	20	4	4	8	148	Suboptimal
Sixmile Creek	6M 9	17	18	15	14	15	15	19	6	6	12	9	9	18	7	7	14	150	Suboptimal
Sixmile Creek	6M 10	16	18	19	9	8	15	20	6	9	15	8	8	16	8	8	16	152	Suboptimal
Sixmile Creek	6M 11	14	12	16	14	14	15	17	9	9	18	8	9	17	9	3	12	149	Suboptimal
Sixmile Creek	6M 12	16	18	20	17	15	15	20	8	8	16	9	9	18	8	8	16	171	Optimal
Sixmile Creek	6M 13	9	16	10	14	11	15	16	9	7	16	9	9	18	3	3	6	131	Suboptimal
Sixmile Creek	6M 14	16	13	10	17	16	15	16	9	9	18	10	10	20	5	5	10	151	Suboptimal
Sixmile Creek	6M 15	5	13	5	19	5	11	2	10	10	20	10	10	20	8	8	16	116	Suboptimal
Sixmile Creek	6M 16	16	19	15	15	16	15	18	3	10	13	4	8	12	5	9	14	153	Suboptimal
Sixmile Creek	6M 17	18	18	19	15	11	15	19	4	6	10	4	4	8	8	8	16	149	Suboptimal
Sixmile Creek	6M 18	20	19	20	17	15	19	20	7	9	16	8	8	16	10	2	12	174	Optimal
Sevenmile Creek	7M 1	7	8	19	9	9	15	19	8	8	16	9	9	18	2	2	4	124	Suboptimal
Sevenmile Creek	7M 2	5	5	6	7	10	13	3	7	9	16	9	9	18	2	2	4	87	Marginal
Sevenmile Creek	7M 3	6	5	13	6	15	8	14	10	10	20	2	2	4	1	1	2	93	Marginal
Sevenmile Creek	7M 4	14	5	14	5	15	15	13	3	5	8	6	9	15	10	2	12	116	Suboptimal
Sevenmile Creek	7M 5	13	13	9	7	15	15	19	9	9	18	10	10	20	2	2	4	133	Suboptimal

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Table 14 (*continued). Habitat data for the Pennsylvania Lake Erie high-gradient stream sites*

		Habitat Parameter Scores																	
Stream	Site	Epi	Emb	Vel	Dep	Ch Fl	Ch Alt	Riffle	L-Stab	R-Stab	T-Stab	L-Veg	R-Veg	T-Veg	L-Rip	R-Rip	T-Rip	T-Hab	Rating
Sevenmile Creek	7M 6	6	5	5	5	7	10	5	9	7	16	7	9	16	1	1	2	77	Marginal
Sevenmile Creek	7M 7	16	18	14	15	15	15	19	5	8	13	5	8	13	2	2	4	127	Suboptimal
Sevenmile Creek	7M 8	15	16	14	13	15	15	19	8	8	16	9	9	18	2	1	3	144	Suboptimal
Sevenmile Creek	7M 9	10	16	13	15	15	15	18	4	7	11	5	8	13	2	2	4	120	Suboptimal
Sevenmile Creek	7M 10	7	15	8	16	15	9	15	7	7	14	3	4	7	1	1	2	108	Marginal
Sevenmile Creek	7M 11	18	18	17	15	15	15	18	9	9	18	9	9	18	5	5	10	162	Optimal
Sevenmile Creek	7M 12	13	16	10	14	15	14	19	6	4	10	9	8	17	10	1	11	126	Suboptimal
Eightmile Creek	8M 1	6	19	17	10	15	20	15	5	5	10	5	5	10	3	9	12	134	Suboptimal
Eightmile Creek	8M 2	16	6	13	5	15	14	15	4	3	7	6	4	10	9	9	18	119	Suboptimal
Eightmile Creek	8M 3	15	16	15	15	15	15	15	2	8	10	2	9	11	1	2	3	130	Suboptimal
Eightmile Creek	8M 4	14	15	10	15	15	12	17	3	3	6	1	1	2	1	1	2	108	Marginal
Eightmile Creek	8M 5	12	16	10	17	15	15	16	9	9	18	9	9	18	2	2	4	126	Suboptimal
Eightmile Creek	8M 6	12	10	9	18	14	13	15	9	9	18	9	9	18	2	2	4	131	Suboptimal
Eightmile Creek	8M 7	15	13	5	15	15	15	19	3	8	11	9	9	18	2	2	4	130	Suboptimal
Eightmile Creek	8M 8	16	18	10	7	8	15	20	3	5	8	9	9	18	5	5	10	130	Suboptimal
Eightmile Creek	8M 9	16	17	14	7	7	15	15	3	3	6	9	9	18	10	5	15	130	Suboptimal
Eightmile Creek	8M 10	13	18	14	13	16	15	19	3	3	6	3	3	6	1	1	2	122	Suboptimal
Eightmile Creek	8M 11	18	14	18	14	15	19	20	6	7	13	7	6	13	7	7	14	158	Suboptimal
Eightmile Creek	8M 12	11	16	15	16	17	13	20	4	8	12	4	8	12	3	5	8	140	Suboptimal
Twelvemile Creek	12M 1	19	11	19	7	9	20	13	8	5	13	9	9	18	2	7	9	138	Suboptimal
Twelvemile Creek	12M 2	16	15	19	10	11	19	16	8	8	16	9	9	18	2	8	10	150	Suboptimal
Twelvemile Creek	12M 3	18	15	15	10	10	15	19	9	8	17	10	10	20	2	9	11	150	Suboptimal
Twelvemile Creek	12M 4	16	16	15	7	7	15	19	5	9	14	9	9	18	4	2	6	133	Suboptimal
Twelvemile Creek	12M 5	18	13	15	10	7	15	14	9	5	14	8	7	15	9	10	19	140	Suboptimal
Twelvemile Creek	12M 6	10	18	15	19	19	11	20	10	10	20	10	10	20	2	1	3	155	Suboptimal
Twelvemile Creek	12M 7	10	14	14	19	19	15	19	10	10	20	9	10	19	2	4	6	155	Suboptimal
Twelvemile Creek	12M 8	18	19	18	6	8	11	20	5	3	8	7	4	11	10	5	15	134	Suboptimal
Twelvemile Creek	12M 9	12	17	7	19	19	15	19	10	10	20	10	10	20	2	2	4	152	Suboptimal
Twelvemile Creek	12M 10	18	17	15	18	18	15	19	8	7	15	8	8	16	7	4	11	162	Optimal
Twelvemile Creek	12M 11	18	18	18	12	15	15	20	9	8	17	9	9	18	4	3	7	158	Suboptimal
Twelvemile Creek	12M 12	17	16	15	18	18	15	20	10	9	19	9	8	17	3	8	11	166	Optimal
Twelvemile Creek	12M 13	16	17	10	18	18	15	20	9	10	19	10	10	20	3	3	6	159	Suboptimal
Twelvemile Creek	12M 14	9	16	5	19	20	15	18	10	10	20	10	10	20	5	9	14	156	Suboptimal
Sixteen Mile Creek	16M 1	8	13	15	11	11	9	16	9	9	18	9	2	11	8	2	10	122	Suboptimal
Sixteen Mile Creek	16M 3	7	16	13	13	17	17	17	9	2	11	9	2	11	9	4	13	135	Suboptimal
Sixteen Mile Creek	16M 4	16	18	18	11	15	6	20	10	10	20	4	4	8	2	2	4	136	Suboptimal
Sixteen Mile Creek	16M 5	15	11	10	13	19	7	6	9	9	18	8	10	18	1	2	3	120	Suboptimal
Sixteen Mile Creek	16M 6	18	13	14	14	15	15	16	7	8	15	8	8	16	2	2	4	140	Suboptimal
Sixteen Mile Creek	16M 7	6	7	11	11	9	4	15	9	9	18	1	1	2	1	1	2	85	Marginal
Sixteen Mile Creek	16M 8	16	15	19	10	9	10	13	7	7	14	5	5	10	2	2	4	120	Suboptimal
Sixteen Mile Creek	16M 9	20	19	20	12	14	20	19	9	9	18	9	9	18	10	8	18	160	Optimal
Sixteen Mile Creek	16M 10	16	16	10	11	5	15	5	7	9	16	9	9	18	10	9	19	131	Suboptimal
Sixteen Mile Creek	16M 11	13	10	13	14	8	15	16	3	5	8	6	6	12	4	2	6	115	Suboptimal
Sixteen Mile Creek	16M 12	16	16	15	15	16	15	19	7	10	17	6	10	16	2	2	4	133	Suboptimal
Sixteen Mile Creek	16M 13	19	15	19	10	14	15	20	8	5	13	5	5	10	8	10	18	153	Suboptimal
Sixteen Mile Creek	16M 14	15	16	19	14	15	15	20	4	7	11	5	9	14	2	6	8	147	Suboptimal
Sixteen Mile Creek	16M 15	18	18	13	16	16	13	20	4	9	13	6	6	12	8	10	18	157	Suboptimal
Sixteen Mile Creek	16M 16	10	16	14	12	18	15	19	7	7	14	4	4	8	2	2	4	130	Suboptimal
Orchard Beach Run	OBR 1	15	19	5	18	18	13	19	10	10	20	9	9	18	10	9	19	164	Optimal
Orchard Beach Run	OBR 2	13	19	5	18	18	14	19	10	10	20	9	6	15	5	5	10	151	Suboptimal
Orchard Beach Run	OBR 4	15	19	8	19	19	14	19	9	8	17	9	9	18	7	7	14	162	Optimal
Orchard Beach Run	OBR 5	6	11	4	14	18	14	16	9	9	18	7	7	14	2	2	4	119	Suboptimal
Woodmere Beach Run	WBR 1	15	15	15	10	11	15	16	5	5	10	2	7	9	5	10	15	131	Suboptimal
Woodmere Beach Run	WBR 2	16	16	14	14	15	16	17	6	6	12	7	7	14	9	5	14	148	Suboptimal
Woodmere Beach Run	WBR 3	14	18	14	18	15	15	19	7	8	15	2	2	4	2	2	4	136	Suboptimal

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Table 14 (*continued*). *Habitat data for the Pennsylvania Lake Erie high-gradient stream sites*

	Habitat Parameter Scores																	
Stream	Site	Epi	Emb	Vel	Dep	Ch Fl	Ch Alt	Riffle	L-Stab	R-Stab	T-Stab	L-Veg	R-Veg	T-Veg	L-Rip	R-Rip	T-Rip	T-Hab	Rating
Peck Run	PR 1	16	9	15	16	18	18	19	9	9	18	9	9	18	5	6	11	158	Suboptimal
Peck Run	PR 2	12	11	16	6	10	11	18	4	4	8	9	9	18	8	8	16	126	Suboptimal
Peck Run	PR 3	10	18	5	15	10	15	18	2	2	4	2	2	4	2	2	4	103	Marginal
Peck Run	PR 5	16	15	15	14	10	14	17	5	9	14	8	8	16	2	5	7	138	Suboptimal
Trib 62254	T54 1	10	14	5	16	15	15	16	9	9	18	8	8	16	2	2	4	129	Suboptimal
Trib 62255	T55 1	5	8	5	10	11	10	16	9	9	18	1	5	6	2	2	4	93	Marginal
Twentymile Creek	20M 1	18	19	19	10	14	19	18	8	8	16	9	9	18	8	10	18	169	Optimal

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Table 15. Habitat data for the Pennsylvania Lake Erie low-gradient stream sites

	Habitat Parameter Scores																		
Stream	Site	Epi	Subst	Var	Dep	Ch Fl	Ch Alt	Ch Sin	L-Stab	R-Stab	T-Stab	L-Veg	R-Veg	T-Veg	L-Rip	R-Rip	T-Rip	T-Hab	Rating
Conneaut Creek	COC 13	18	17	16	15	15	15	6	9	9	18	9	9	18	9	9	18	156	Suboptimal
Conneaut Creek	COC 14	7	10	10	11	10	19	19	5	5	10	7	7	14	9	9	18	128	Suboptimal
Conneaut Creek	COC 15	13	13	13	13	18	15	6	9	9	18	9	9	18	9	9	18	145	Suboptimal
Conneaut Creek	COC 16	16	15	13	13	15	15	12	9	9	18	9	9	18	9	9	18	153	Suboptimal
Conneaut Creek	COC 17	13	15	10	18	18	15	5	9	9	18	9	9	18	8	9	17	147	Suboptimal
Conneaut Creek	COC 19	10	11	11	16	15	15	10	9	9	18	9	9	18	7	9	16	140	Suboptimal
Conneaut Creek	COC 20	2	2	2	16	2	13	5	9	9	18	9	9	18	2	2	4	82	Marginal
Conneaut Creek	COC 21	13	13	13	10	10	13	10	5	8	13	2	2	4	2	4	6	105	Marginal
Conneaut Creek	COC 22	18	15	11	11	16	16	13	9	9	18	9	9	18	9	9	18	139	Suboptimal
Conneaut Creek	COC 23	13	13	14	16	18	15	5	9	9	18	9	9	18	7	7	14	144	Suboptimal
Conneaut Creek	COC 24	13	13	13	11	16	11	10	9	9	18	9	9	18	2	4	6	129	Suboptimal
Conneaut Creek	COC 41	7	6	10	9	18	15	8	9	9	18	10	10	20	10	3	13	124	Suboptimal
Conneaut Creek	COC 42	16	18	16	18	19	15	15	7	7	14	8	8	16	9	3	12	159	Suboptimal
Ashtabula Creek	AC 5	10	10	6	12	15	13	10	7	7	14	9	9	18	9	9	18	126	Suboptimal
Turkey Creek	TC 3	6	6	6	10	11	15	6	2	9	11	3	8	11	2	2	4	76	Marginal
Turkey Creek	TC 4	6	11	8	15	15	12	11	8	5	13	2	2	4	1	1	2	97	Marginal
Duck Run	DR 3	1	6	5	5	13	5	5	8	8	16	8	8	16	2	2	4	76	Marginal
Duck Run	DR 4	5	1	0	16	1	8	5	9	9	18	9	9	18	2	9	11	83	Marginal
Godfrey Run	GFR 2	12	9	5	12	16	15	6	10	10	20	10	10	20	9	8	17	132	Suboptimal
Godfrey Run	GFR 4	5	13	8	17	15	14	7	9	9	18	2	2	4	1	1	2	103	Marginal
Godfrey Run	GFR 5	9	14	5	13	11	15	6	9	9	18	9	9	18	2	2	4	113	Suboptimal

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Table 16. Mean total habitat scores for Pennsylvania Lake Erie streams

Stream	No. of Sites	Mean Habitat Score	Std. Deviation	Rank	Mean Habitat Rating
Twentymile Creek	1	169.0	0.00	1	Optimal
Twelvemile Creek	14	150.6	10.07	2	Suboptimal
Orchard Beach Run	4	149.0	18.01	3	Suboptimal
Sixmile Creek	19	148.7	15.68	4	Suboptimal
Fourmile Creek	12	144.4	20.27	5	Suboptimal
Conneaut Creek	54	140.5	18.97	6	Suboptimal
Woodmere Beach Run	3	138.3	7.13	7	Suboptimal
Cemetery Run	1	136.0	0.00	8	Suboptimal
McDannel Run	2	136.0	17.00	9	Suboptimal
Elk Creek	56	132.4	20.54	10	Suboptimal
Sixteenmile Creek	15	132.3	18.36	11	Suboptimal
Raccoon Creek	7	132.0	11.78	12	Suboptimal
Peck Run	4	131.3	19.92	13	Suboptimal
Trib 62476	1	131.0	0.00	14	Suboptimal
Eightmile Creek	12	129.8	11.49	15	Suboptimal
Trib 62254	1	129.0	0.00	16	Suboptimal
Crooked Creek	18	127.8	14.34	17	Suboptimal
Ashtabula Creek	1	126.0	0.00	18	Suboptimal
Trout Run	5	125.8	22.49	19	Suboptimal
Wilkins Run	2	124.0	0.00	20	Suboptimal
Godfrey Run	8	123.1	18.42	21	Suboptimal
Trib 62490	1	122.0	0.00	22	Suboptimal
Marshall Run	4	120.8	31.49	23	Suboptimal
Sevenmile Creek	12	118.1	23.08	24	Suboptimal
Walnut Creek	19	117.7	15.96	25	Suboptimal
Trib 62484	1	116.0	0.00	26	Suboptimal
Fivemile Creek	5	110.2	20.21	27	Suboptimal
Trib 62684	1	110.0	0.00	28	Suboptimal
Trib 62680	1	108.0	0.00	29	Marginal
Turkey Creek	4	104.3	22.75	30	Marginal
Shorehaven	1	102.0	0.00	31	Marginal
Motch Run	3	99.0	12.23	32	Marginal
Trib 62483	1	94.0	0.00	33	Marginal
Duck Run	4	93.5	20.24	34	Marginal
Trib 62255	1	93.0	0.00	35	Marginal
Trib 62436	3	86.7	27.76	36	Marginal

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Table 17. Relationship of individual parameters to total habitat score (high-gradient streams)

Parameter	Kendall tau coefficient (τ)	p-value
Epifuanal/substrate cover	0.4666	0.00
Embeddedness	0.4604	0.00
Velociy/depth regimes	0.4163	0.00
Sediment deposition	0.4111	0.00
Channel flow status	0.2807	0.00
Channel alteration	0.3068	0.00
Frequency of riffles	0.4467	0.00
Bank stability	0.2416	1.1465E-08
Bank vegetation protection	0.3072	0.00
Riparian vegetative zone width	0.2737	0.00

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Table 18. Relationship of individual parameters to total habitat score (low-gradient streams)

Parameter	Kendall tau coefficient (τ)	p-value
Epifuanal/substrate cover	0.7300	8.3135E-06
Pool substrate	0.6190	0.0002
Pool variability	0.6108	0.0002
Sediment deposition	0.2930	0.0769
Channel flow status	0.5150	0.0021
Channel alteration	0.4320	0.0126
Channel sinuosity	0.2193	0.1957
Bank stability	0.2366	0.1859
Bank vegetation protection	0.2464	0.1664
Riparian vegetative zone width	0.5275	0.0015

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Table 19. Relationship of individual parameters to bank stability (high-gradient streams)

Parameter	Kendall tau coefficient (τ)	p-value
Epifuanal/substrate cover	-0.0521	0.2349
Embeddedness	0.0436	0.3162
Velocity/depth regimes	-0.0461	0.2915
Sediment deposition	*0.1823*	*2.9511E-05*
Channel flow status	*0.1994*	*6.0797E-06*
Channel alteration	-0.0130	0.7779
Frequency of riffles	-0.0861	0.8443
Bank vegetation protection	*0.3891*	*0.0000*
Riparian vegetative zone width	0.0023	0.9586

Italicized results are statistically significant ($p < 0.05$)

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Table 20. Relationship of individual parameters to riparian vegetative zone width (high-gradient streams)

Parameter	Kendall tau coefficient (τ)	p-value
Epifuanal/substrate cover	*0.1695*	*9.1314E-05*
Embeddedness	0.0076	0.8610
Velocity/depth regimes	*0.1030*	*0.0170*
Sediment deposition	-0.0455	0.2926
Channel flow status	*-0.1065*	*0.0145*
Channel alteration	*0.3311*	*0.0000*
Frequency of riffles	-0.0083	0.8481
Bank vegetation protection	*0.1398*	*0.0015*
Bank stability	0.0023	0.9586

Italicized results are statistically significant ($p < 0.05$)

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Table 21. Relationship of individual parameters to riparian vegetative zone width (low-gradient streams)

Parameter	Kendall tau coefficient (τ)	p-value
Epifuanal/substrate cover	*0.5054*	*0.0032*
Pool substrate	0.2434	0.1615
Pool variability	0.2843	0.1001
Sediment deposition	-0.0316	0.8767
Channel flow status	0.1784	0.3157
Channel alteration	*0.4698*	*0.0092*
Channel sinuosity	0.1946	0.2726
Bank vegetation protection	*0.3918*	*0.0333*
Bank stability	0.1736	0.3575

Italicized results are statistically significant ($p < 0.05$)

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Table 22. Relationship of individual parameters to bank stability (low-gradient streams)

Parameter	Kendall tau coefficient (τ)	p-value
Epifuanal/substrate cover	0.1637	0.3799
Pool substrate	0.0949	0.6225
Pool variability	-0.0315	0.8884
Sediment deposition	0.2141	0.2471
Channel flow status	0.2780	0.1368
Channel alteration	0.0996	0.6240
Channel sinuosity	-0.3233	0.0827
Bank vegetation protection	*0.6918*	*0.0004*
Riparian vegetative zone width	0.1736	0.3575

Italicized results are statistically significant ($p < 0.05$)

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APPENDIX C: MAPS

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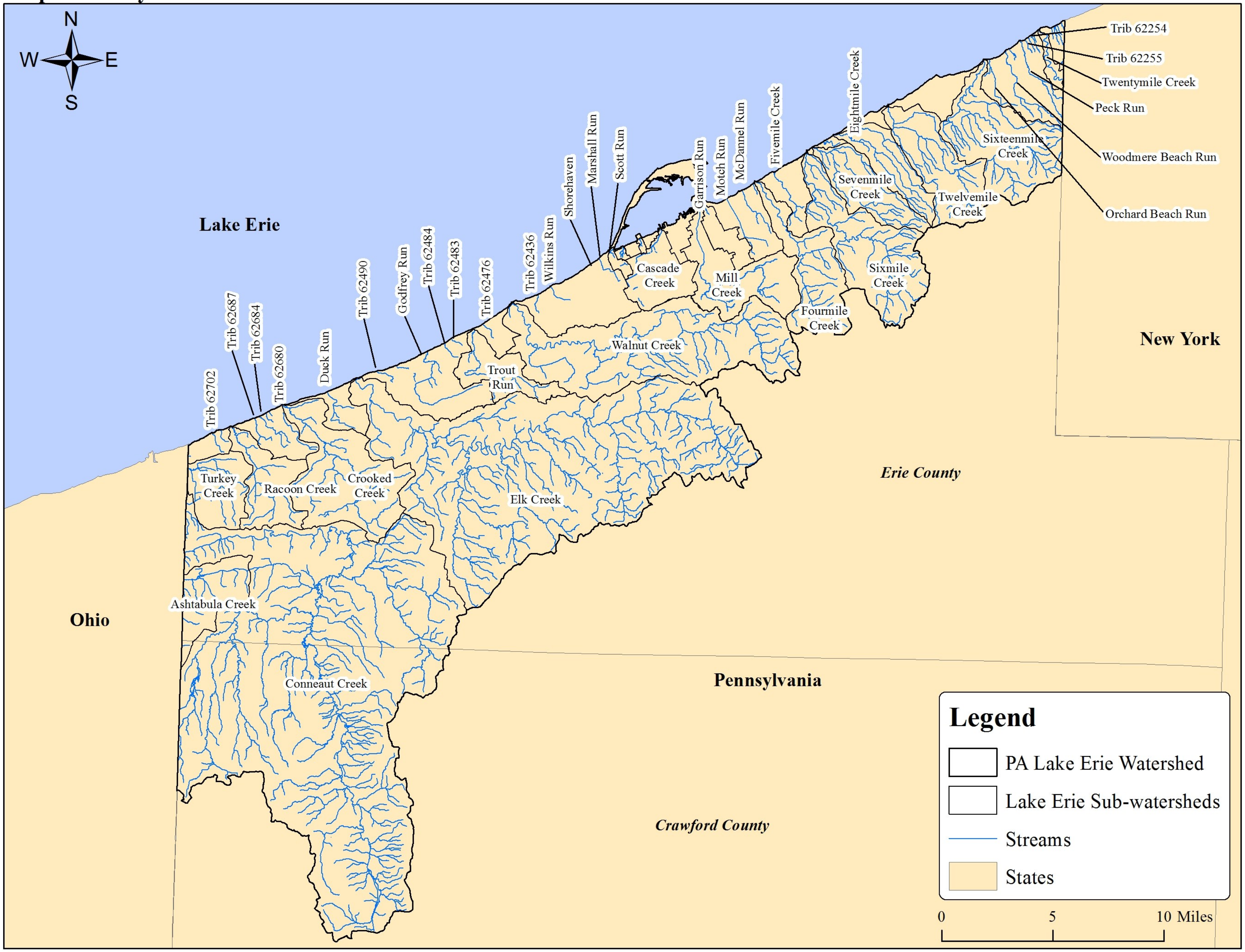
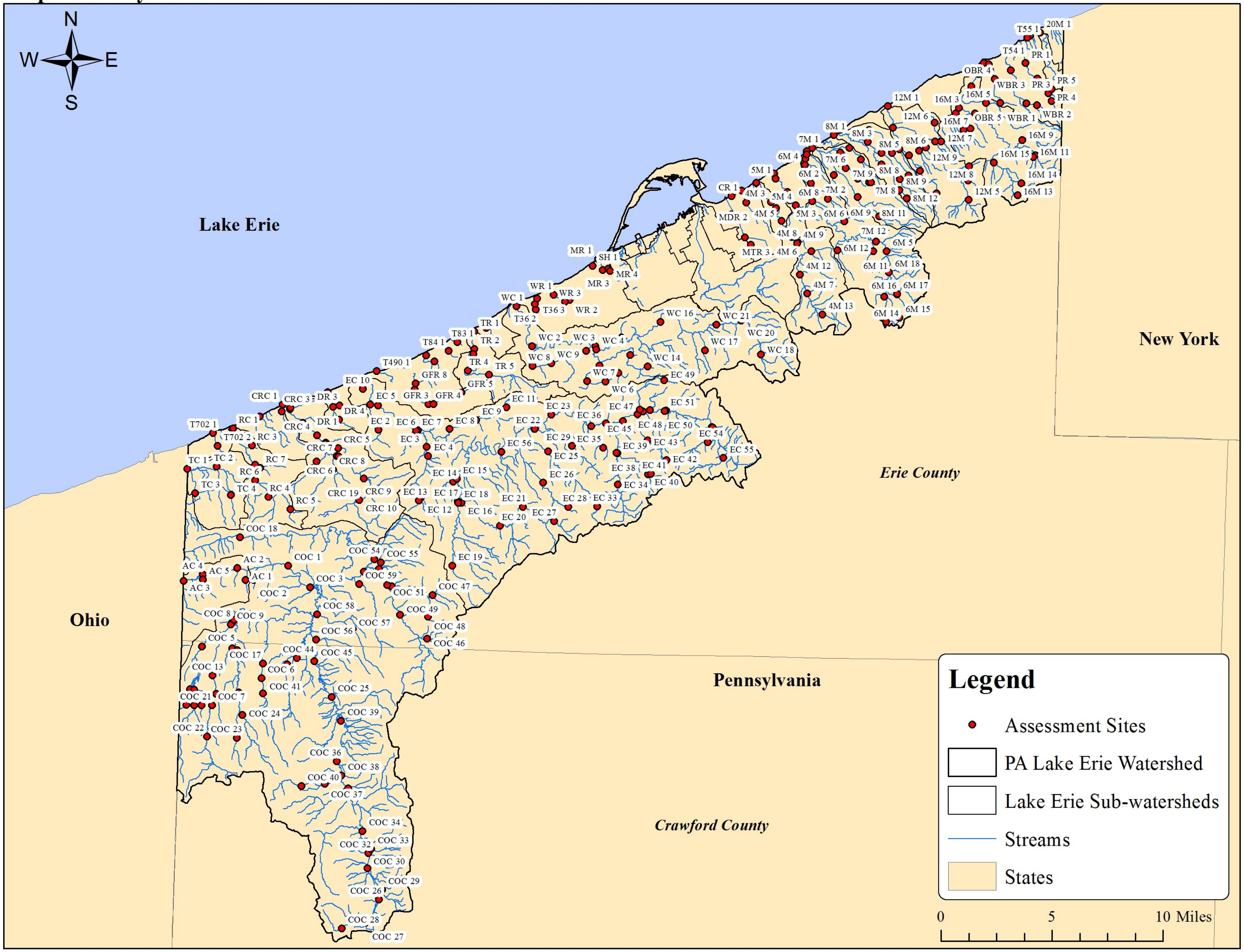
Map 1: Pennsylvania Lake Erie watershed



Map 2: Pennsylvania Lake Erie watershed assessment locations



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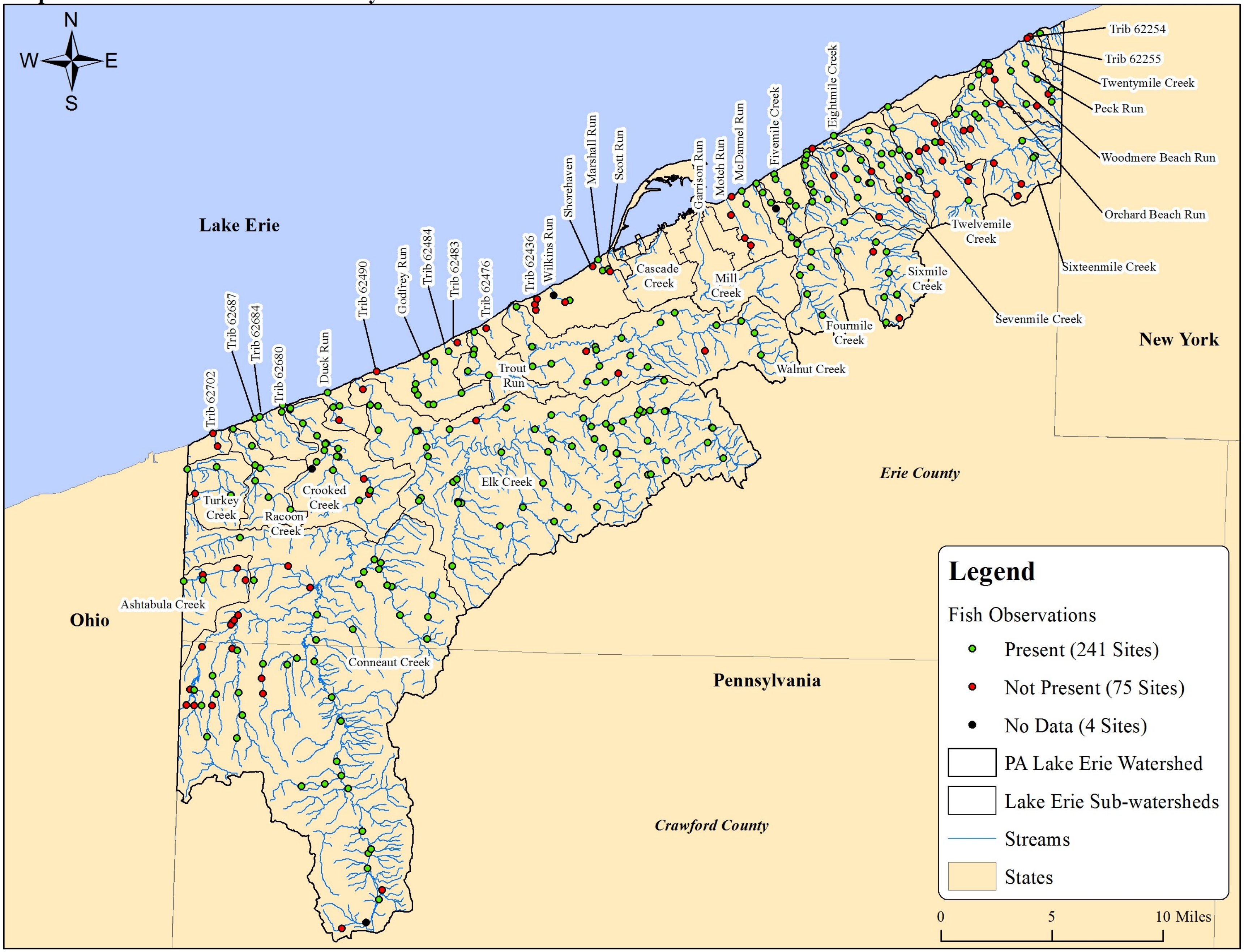
Map 3: Fish observations in the Pennsylvania Lake Erie watershed



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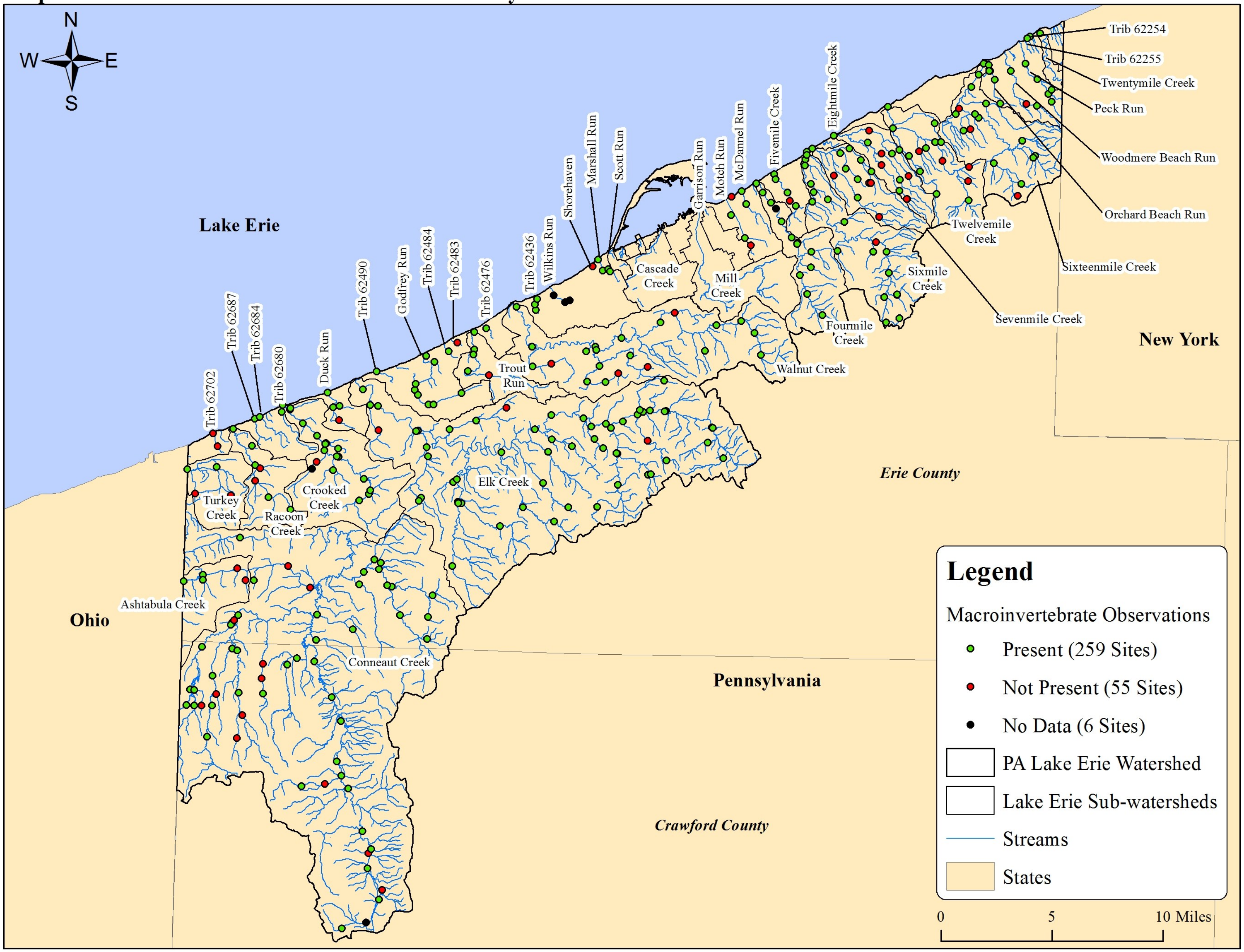
Map 4: Macroinvertebrate observations in the Pennsylvania Lake Erie watershed



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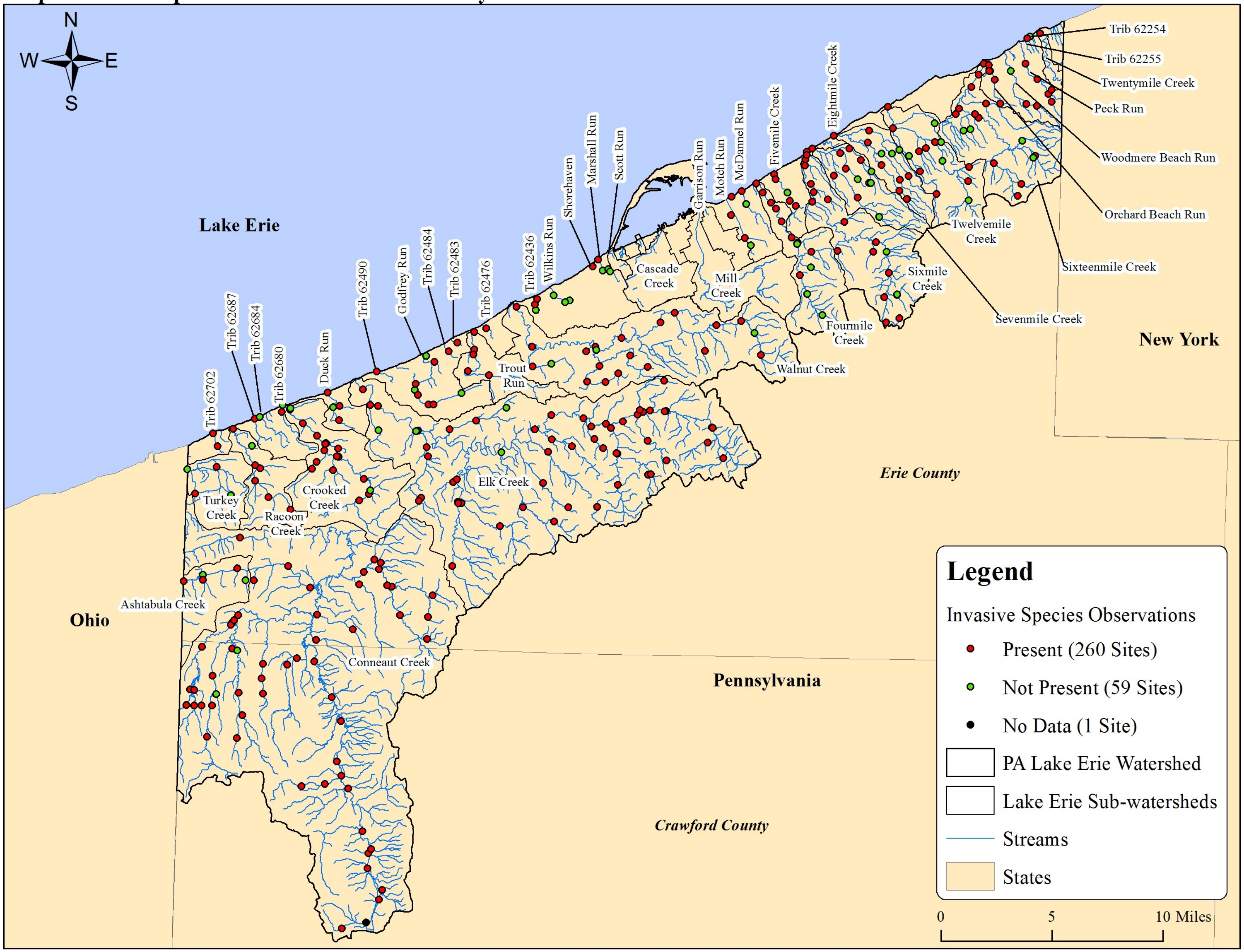
Map 5: Invasive species observations in the Pennsylvania Lake Erie watershed



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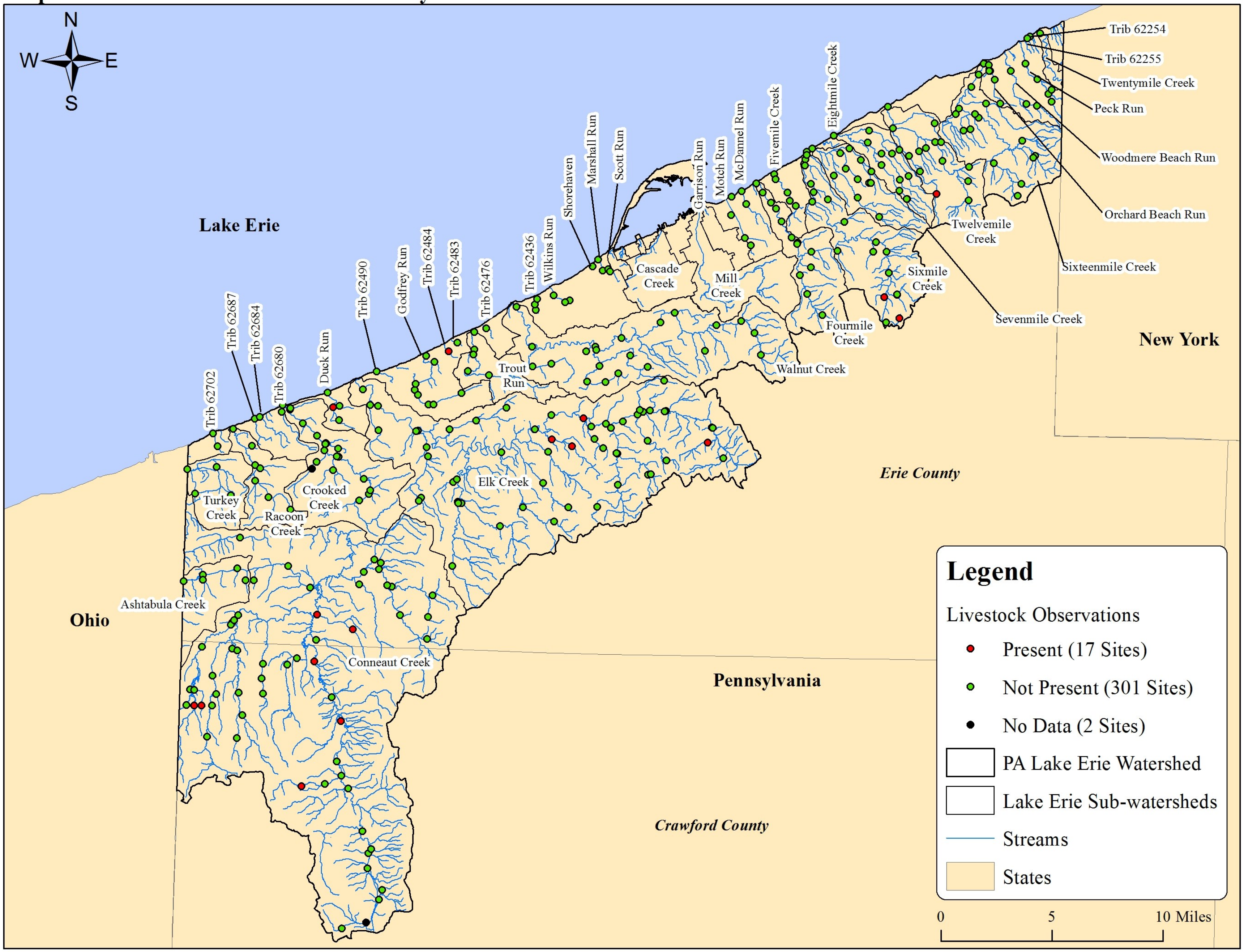
Map 6: Livestock observations in the Pennsylvania Lake Erie watershed



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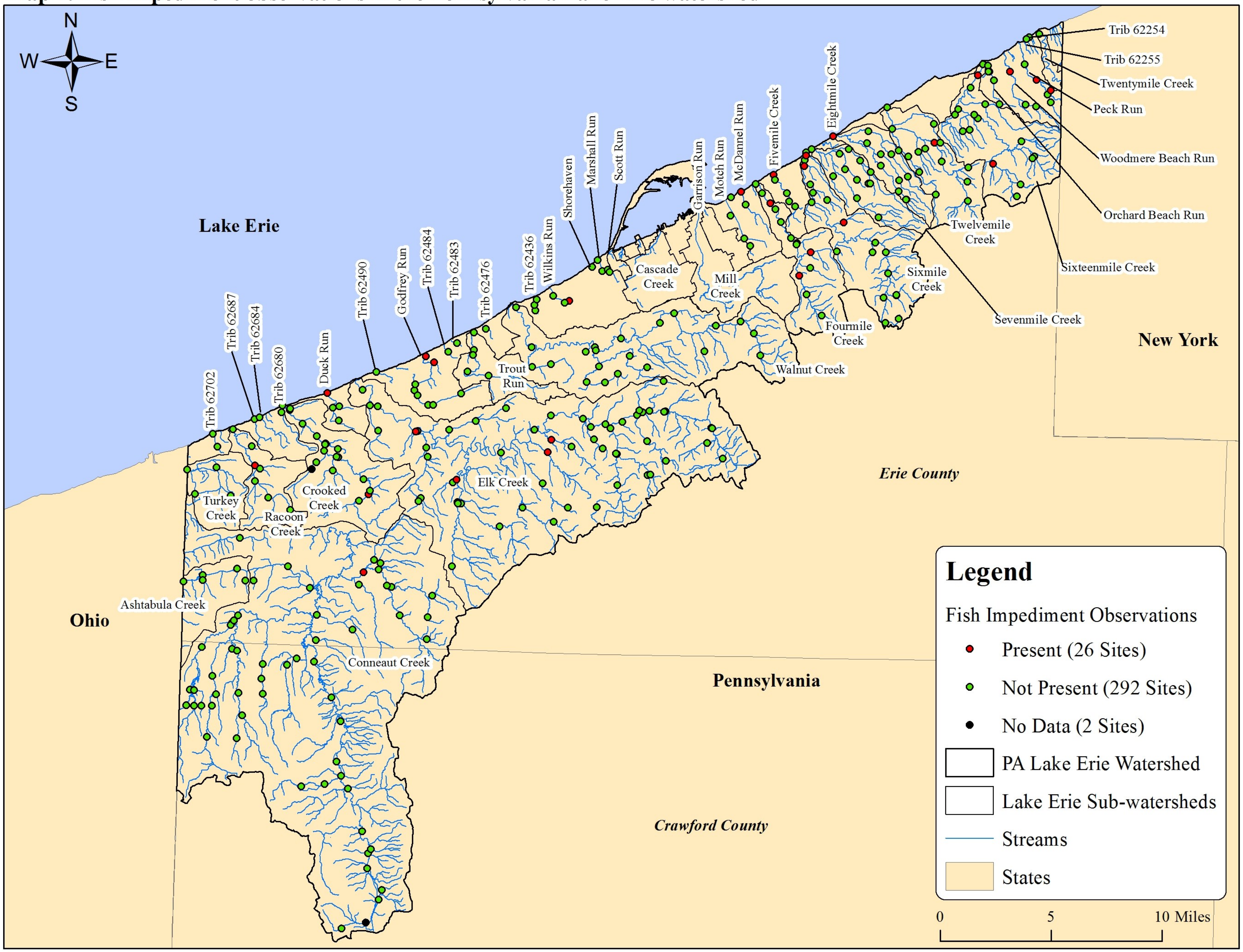
Map 7: Fish impediment observations in the Pennsylvania Lake Erie watershed



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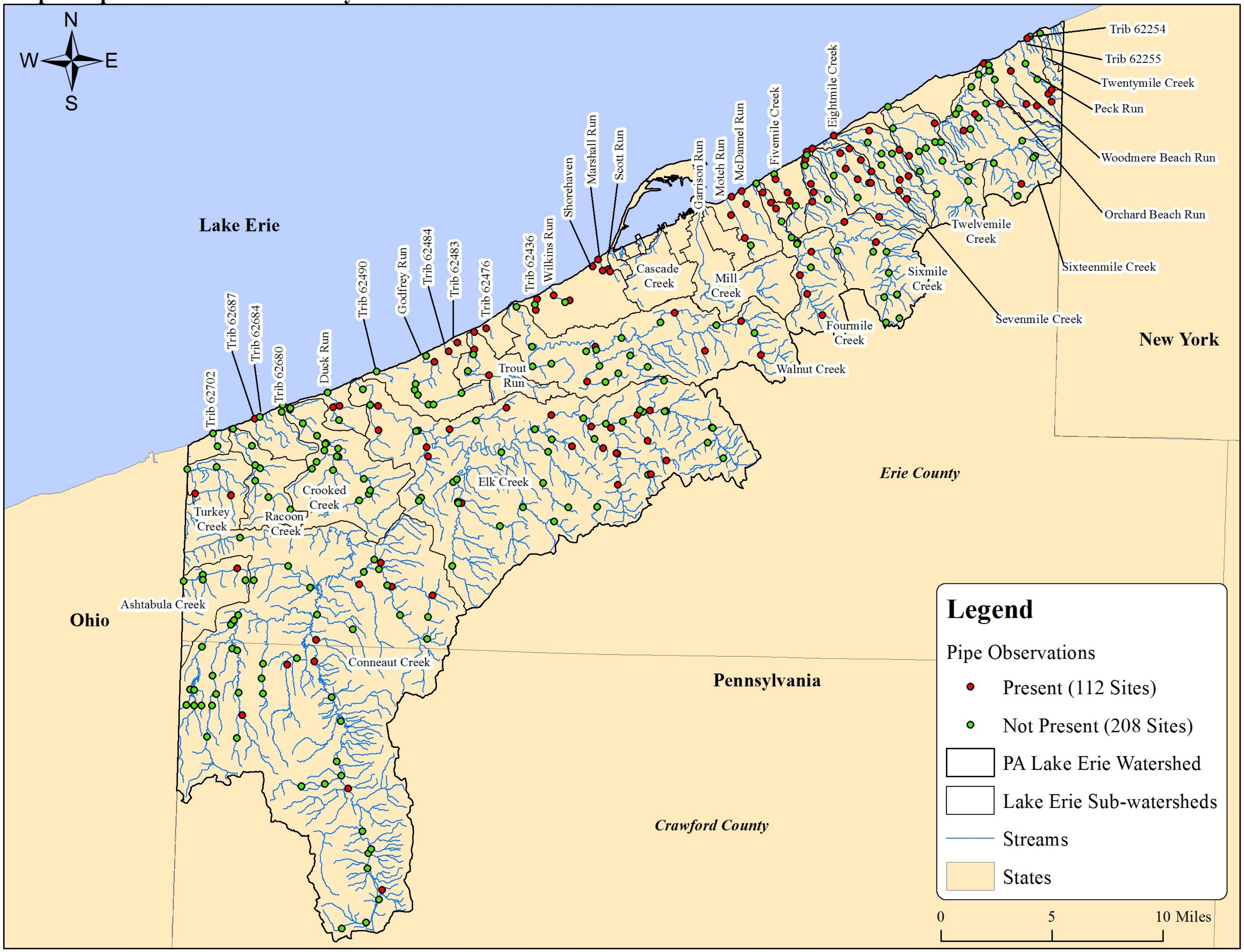
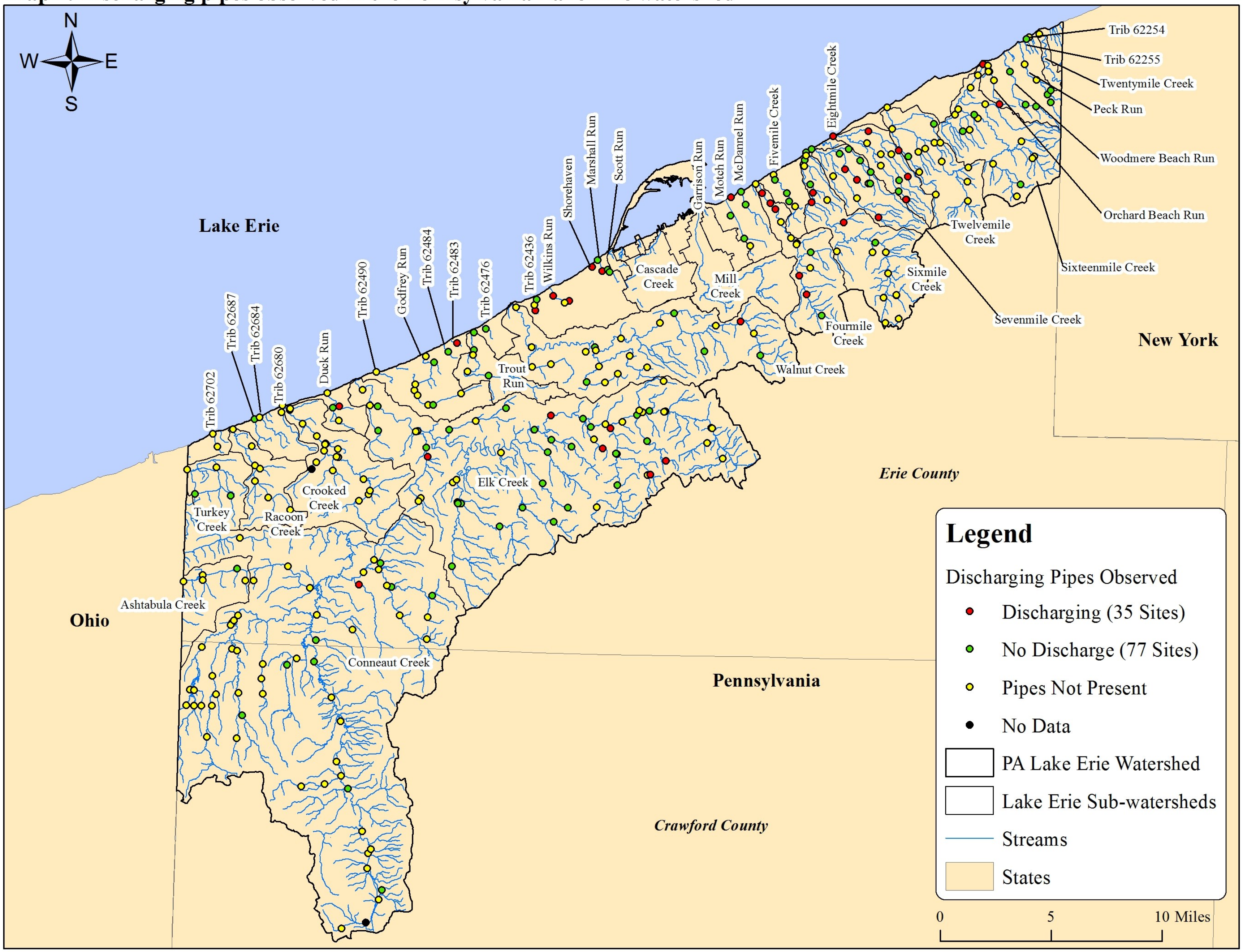
Map 8: Pipes observed in the Pennsylvania Lake Erie watershed



Map 9: Discharging pipes observed in the Pennsylvania Lake Erie watershed



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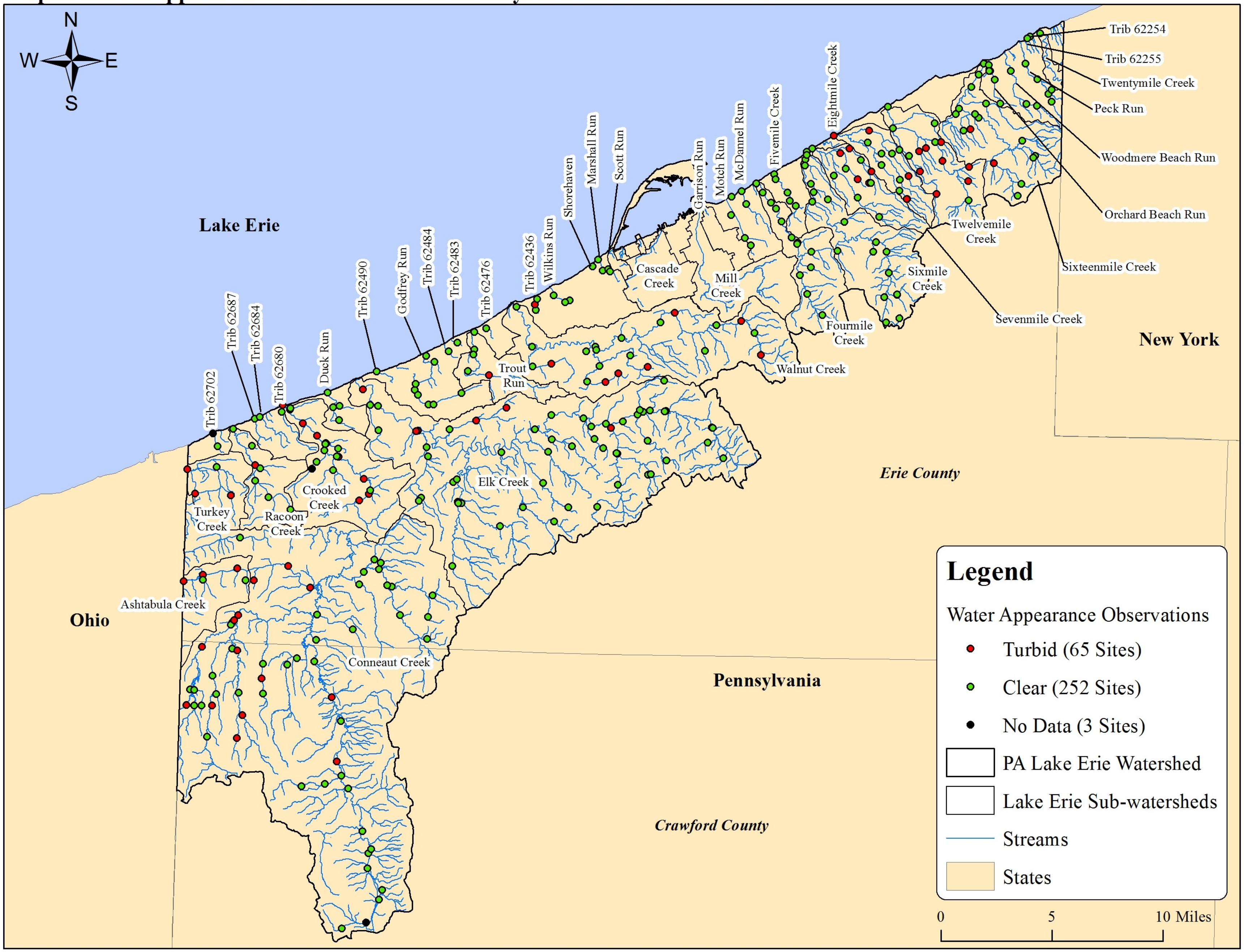
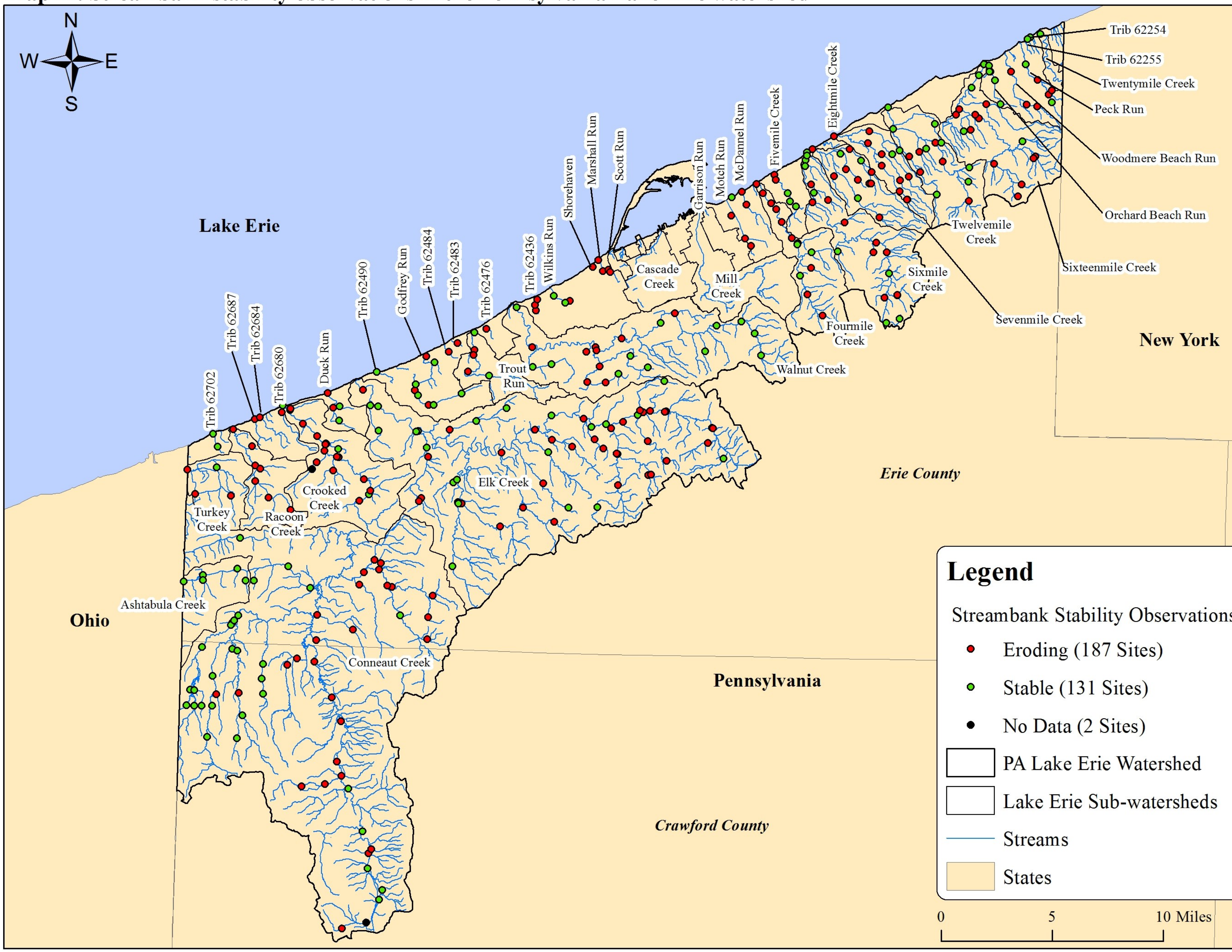
Map 10: Water appearance observations in the Pennsylvania Lake Erie watershed



Map 11: Streambank stability observations in the Pennsylvania Lake Erie watershed



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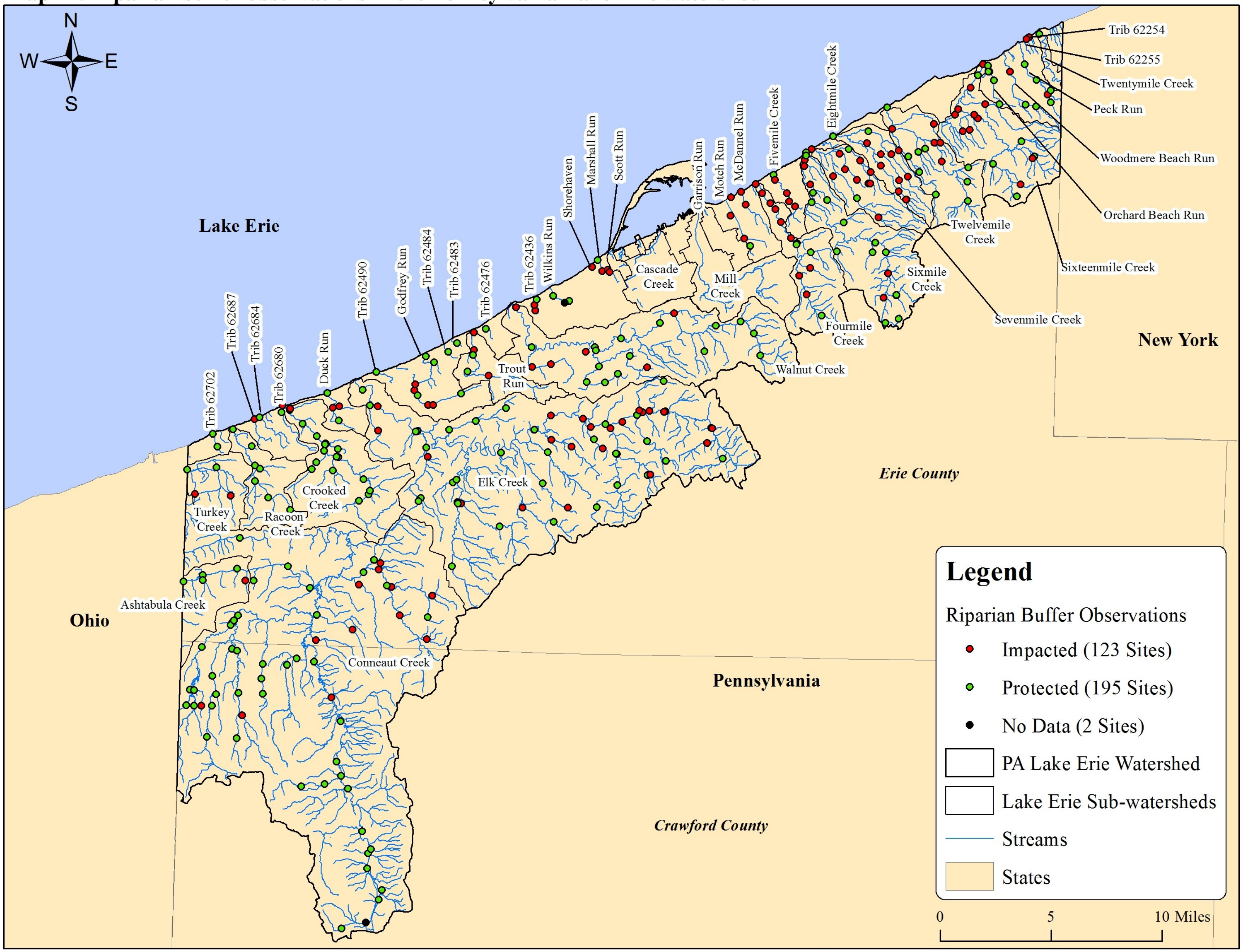
Map 12: Riparian buffer observations in the Pennsylvania Lake Erie watershed



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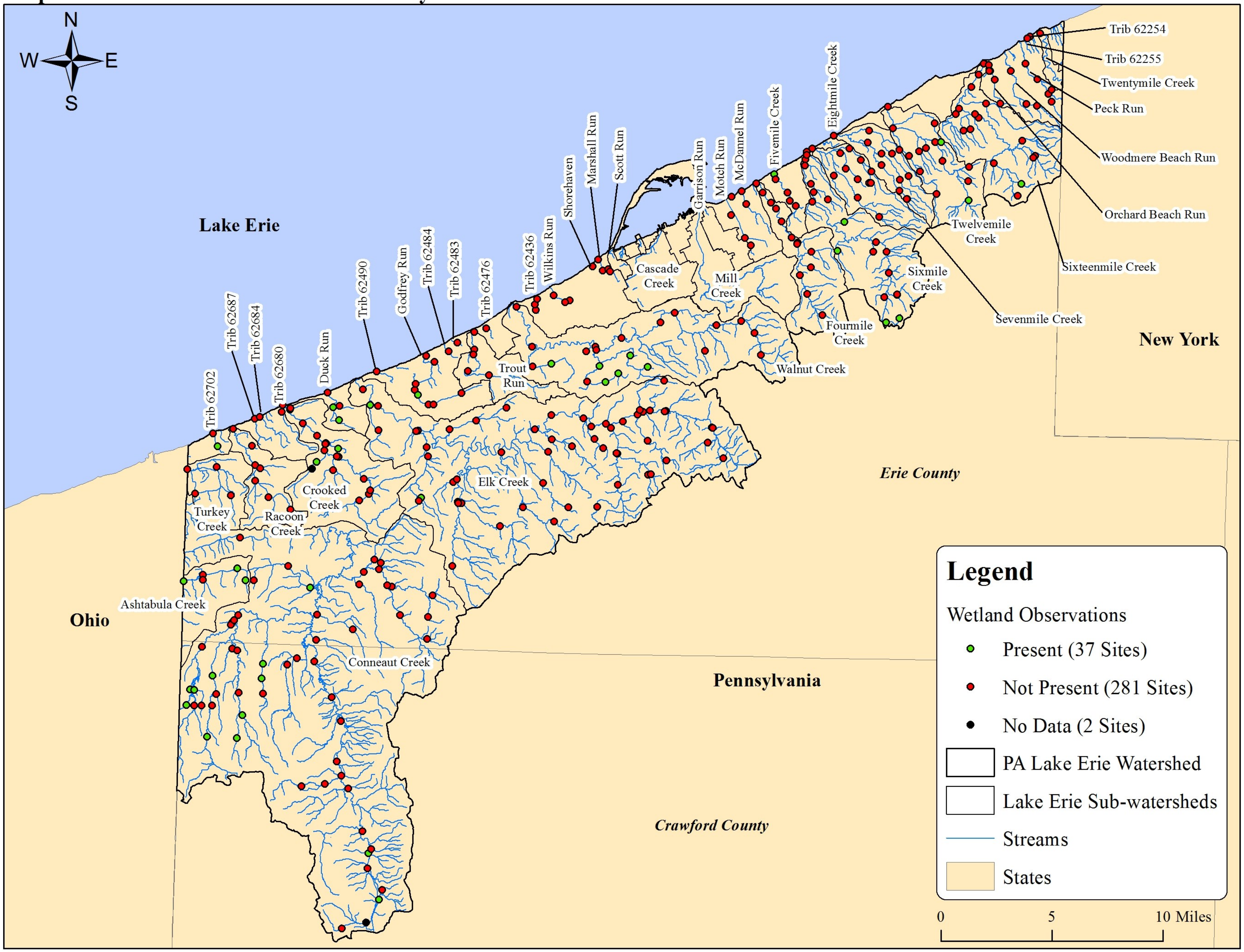
Map 13: Wetland observations in the Pennsylvania Lake Erie watershed



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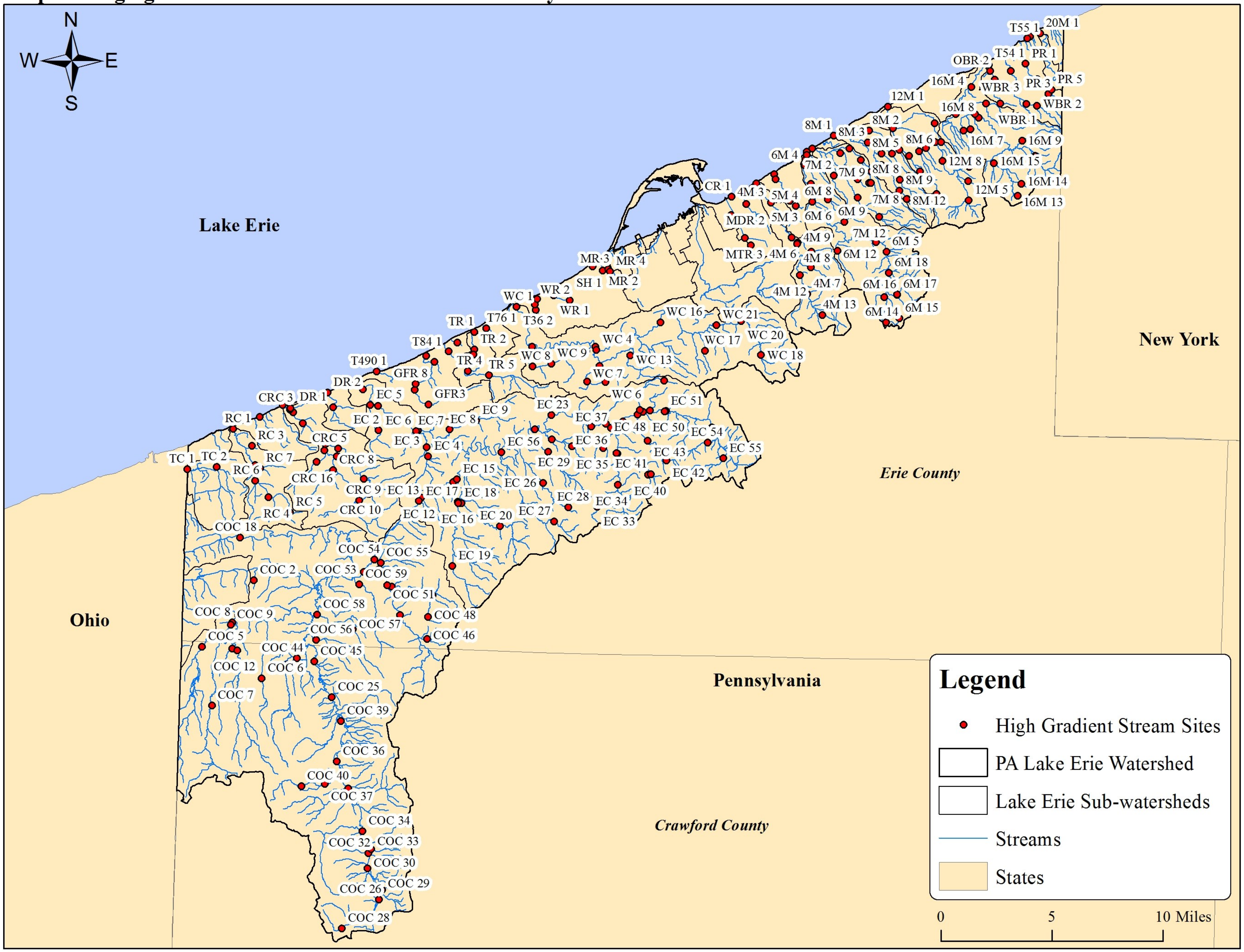
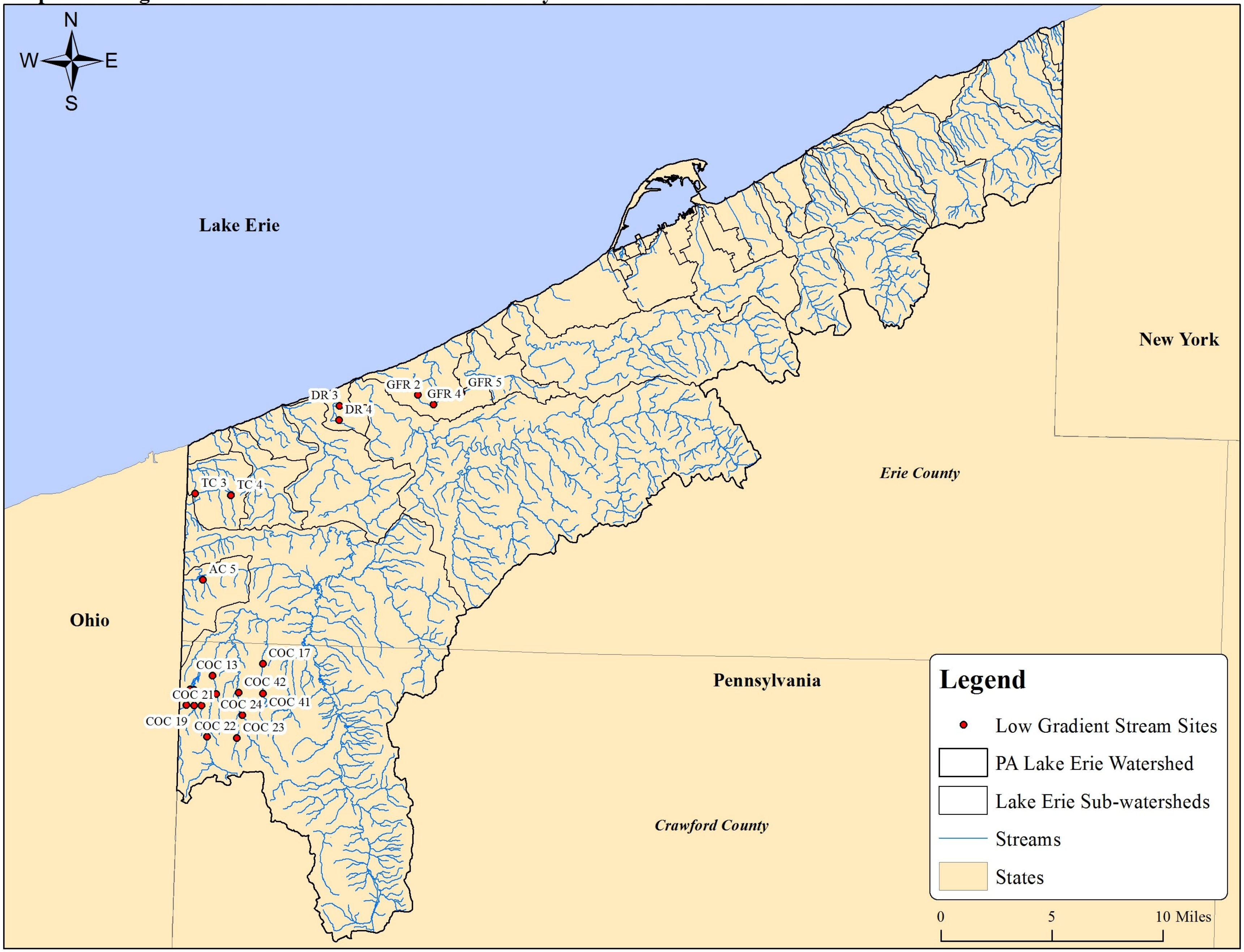
Map 14: High gradient stream sites assessed in the Pennsylvania Lake Erie watershed



Map 15: Low gradient stream sites assessed in the Pennsylvania Lake Erie watershed



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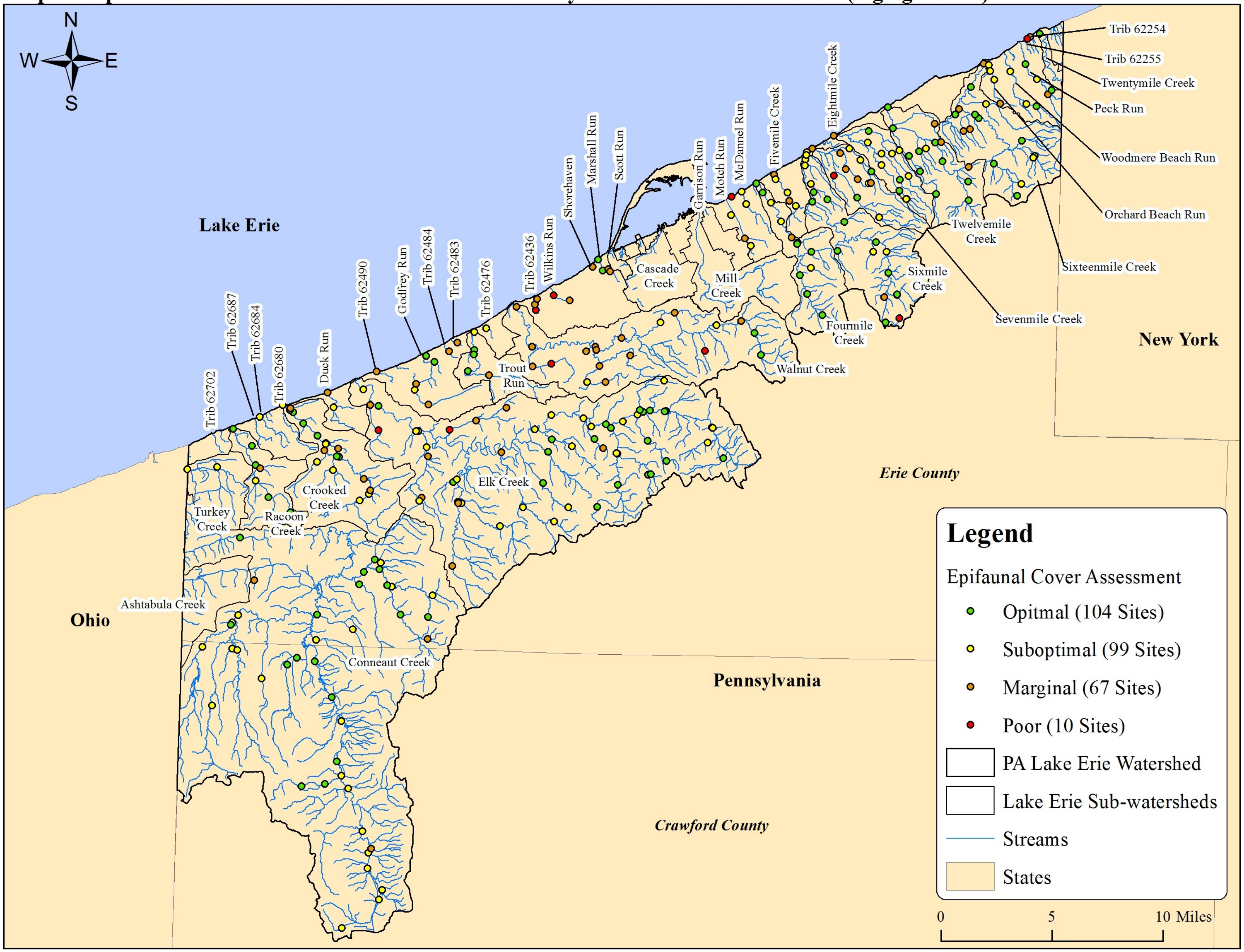
Map 16: Epifaunal/substrate cover assessment in the Pennsylvania Lake Erie watershed (high gradient)



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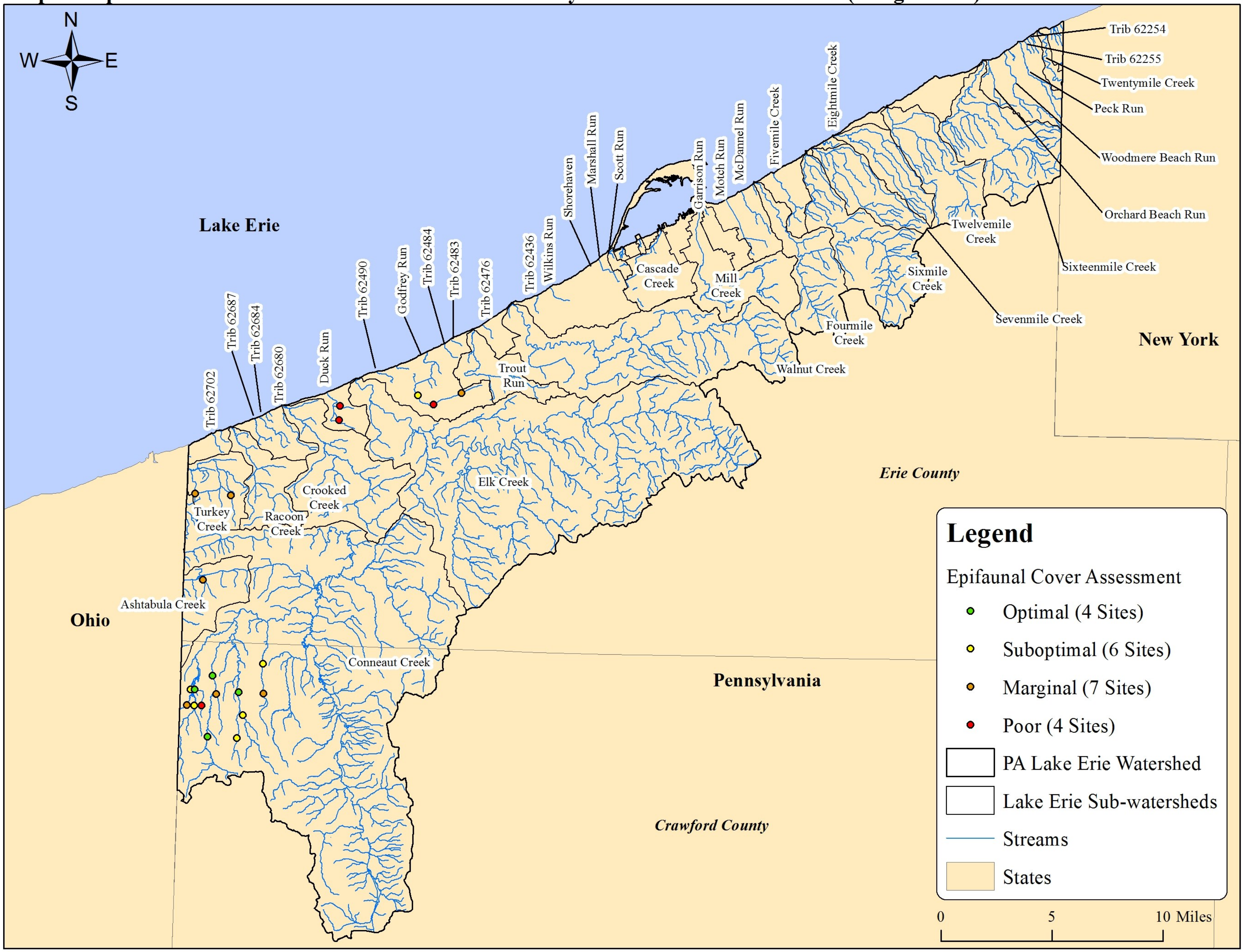
Map 17: Epifaunal/substrate cover assessment in the Pennsylvania Lake Erie watershed (low gradient)



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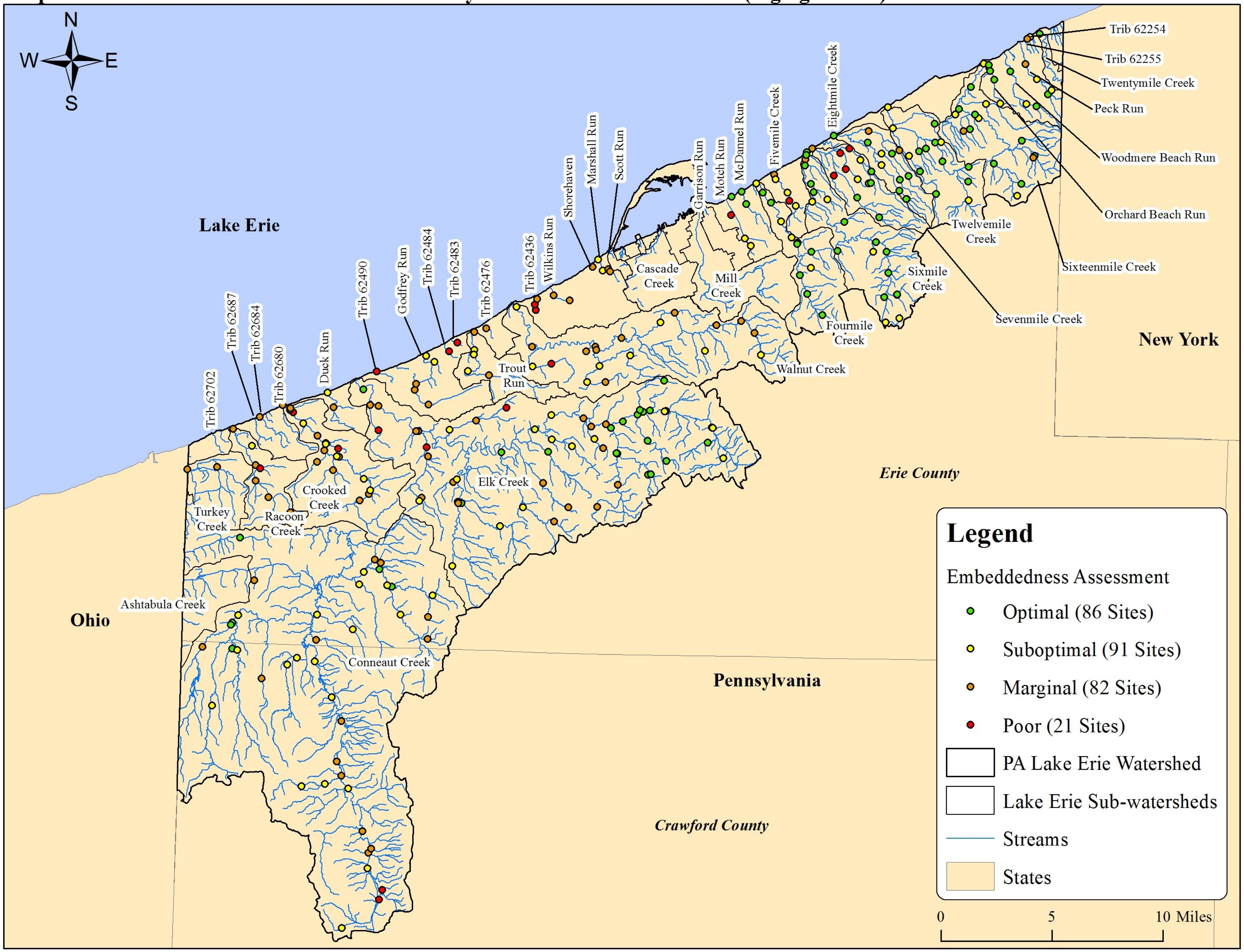
Map 18: Embeddedness assessment in the Pennsylvania Lake Erie watershed (high gradient)



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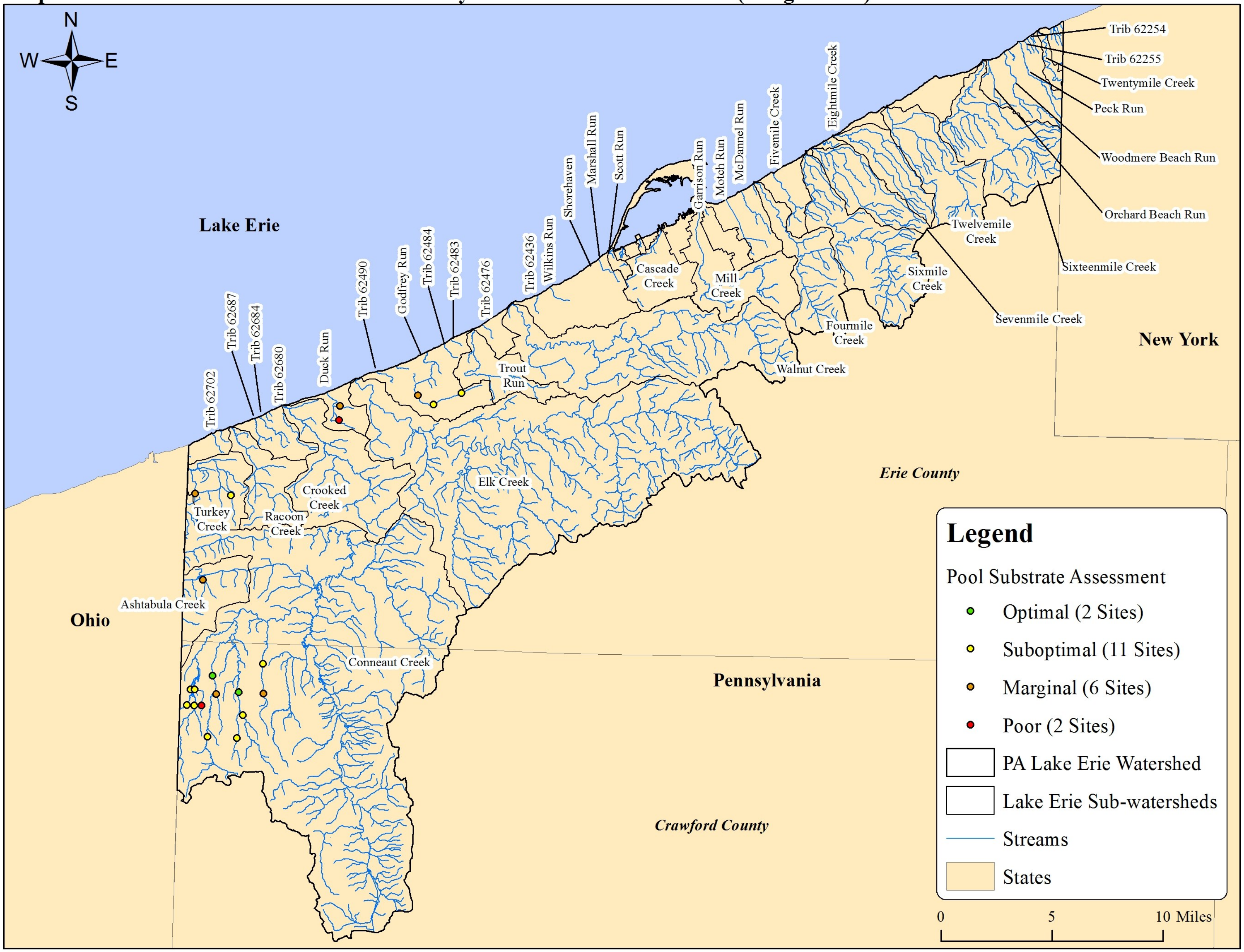
Map 19: Pool substrate assessment in the Pennsylvania Lake Erie watershed (low gradient)



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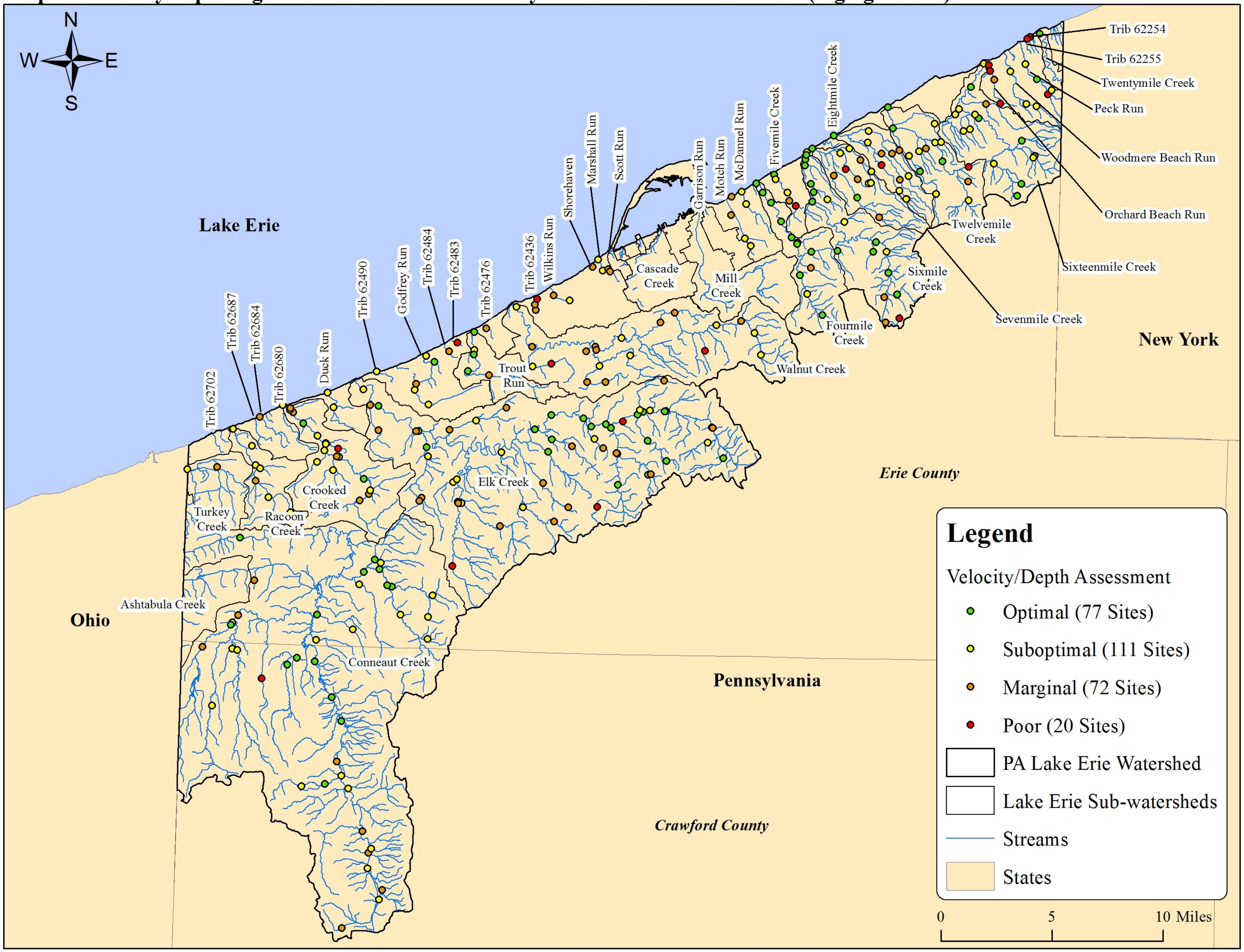
Map 20: Velocity/depth regime assessment in the Pennsylvania Lake Erie watershed (high gradient)



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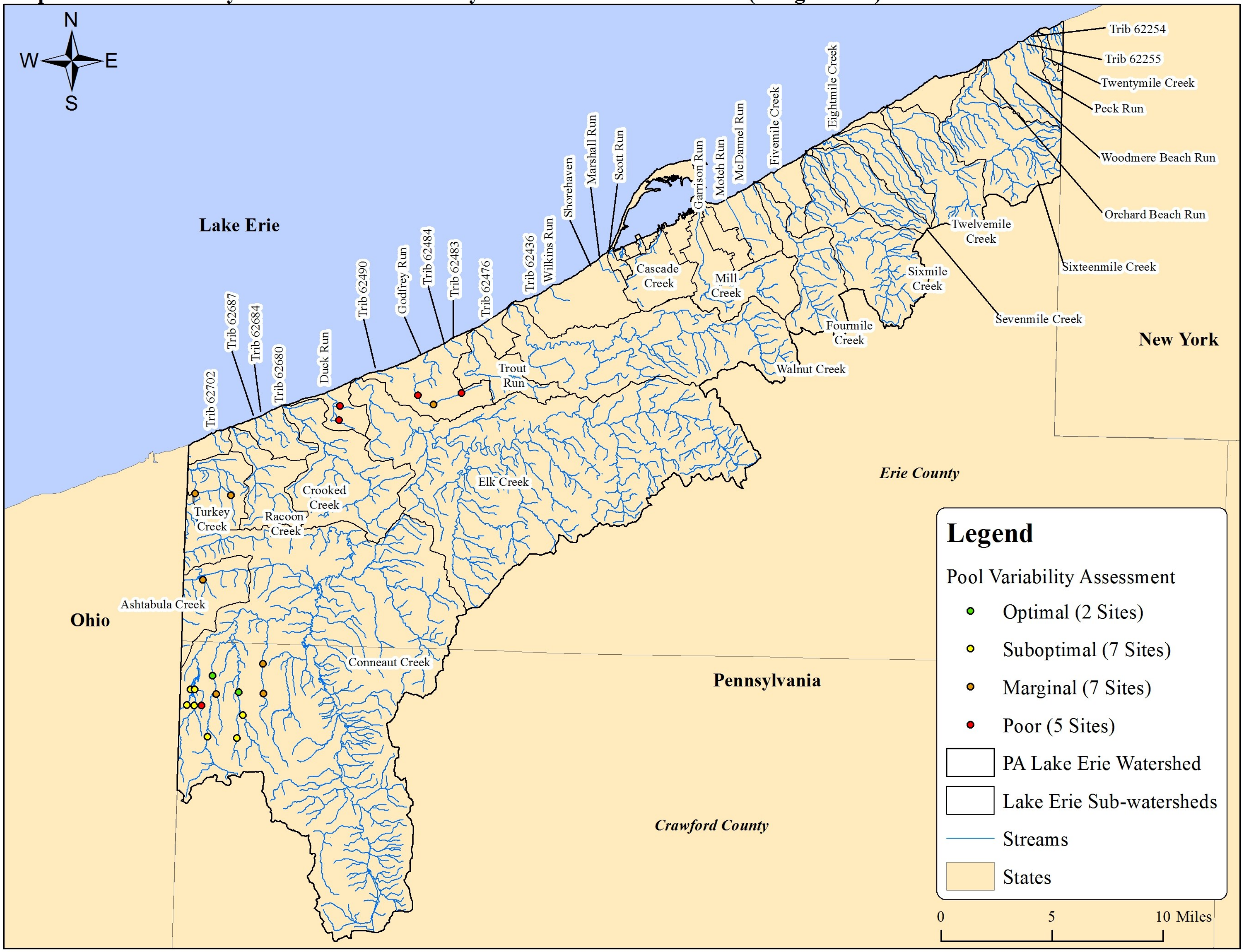
Map 21: Pool variability assessment in the Pennsylvania Lake Erie watershed (low gradient)



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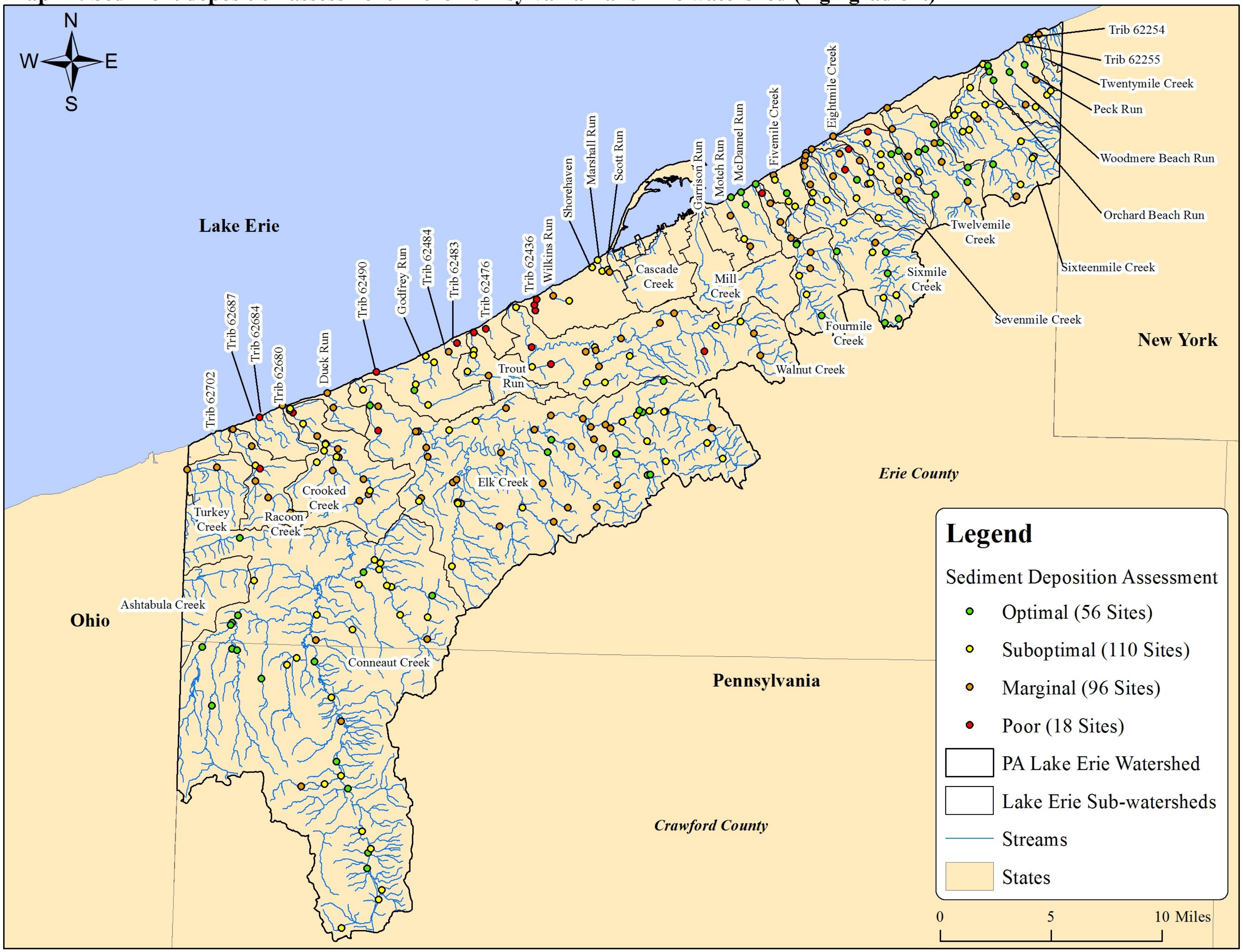
Map 22: Sediment deposition assessment in the Pennsylvania Lake Erie watershed (high gradient)



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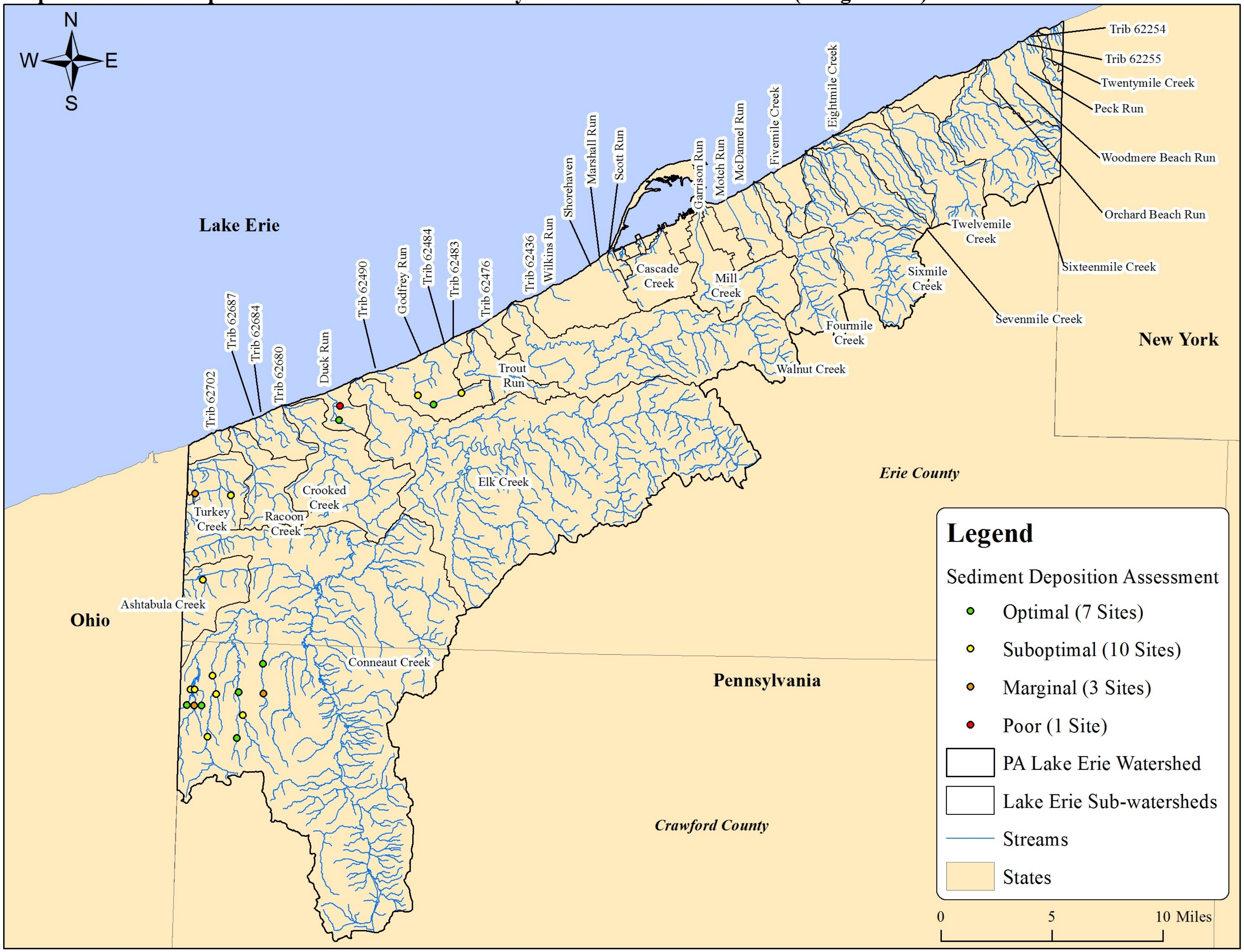
Map 23: Sediment deposition assessment in the Pennsylvania Lake Erie watershed (low gradient)



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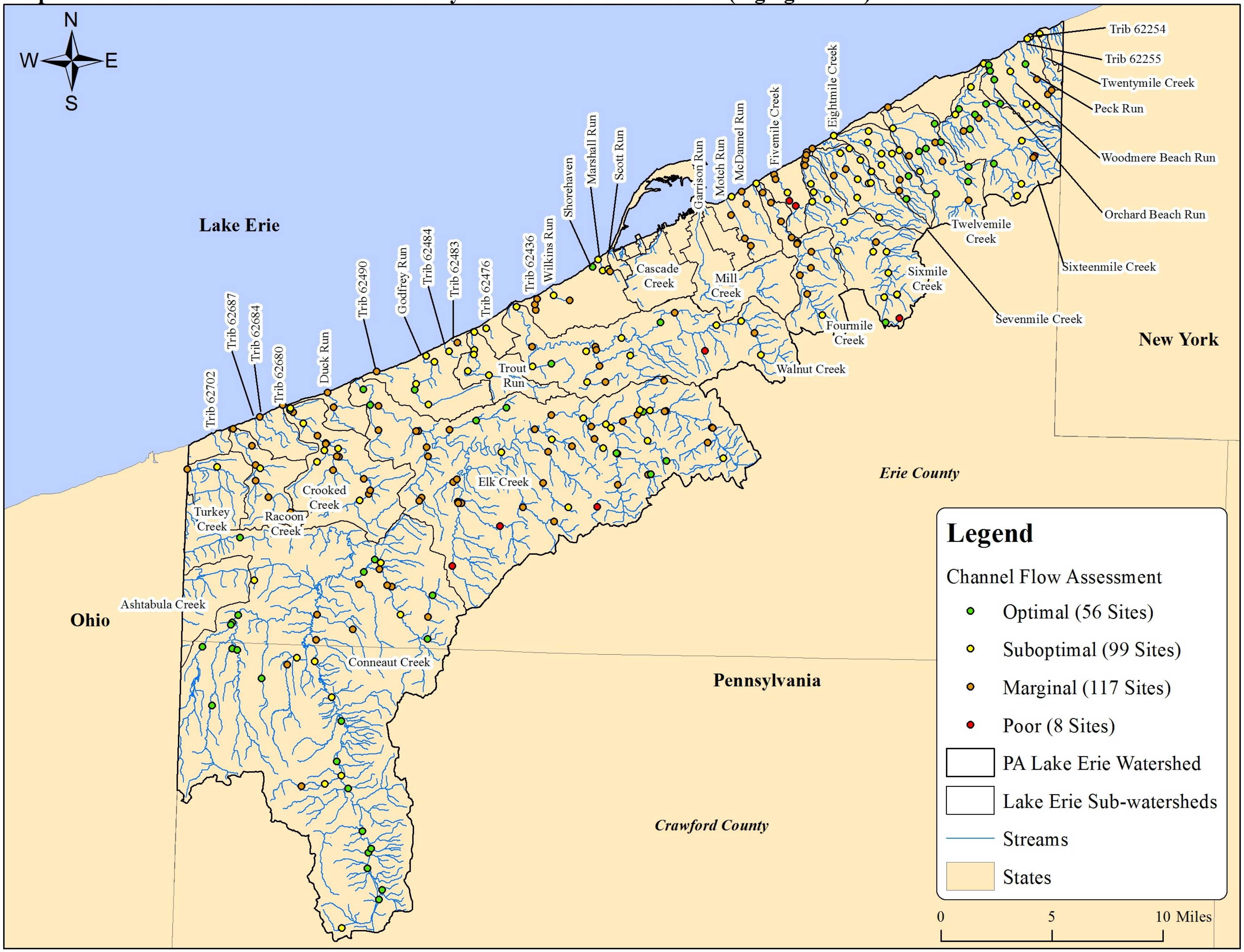
Map 24: Channel flow assessment in the Pennsylvania Lake Erie watershed (high gradient)



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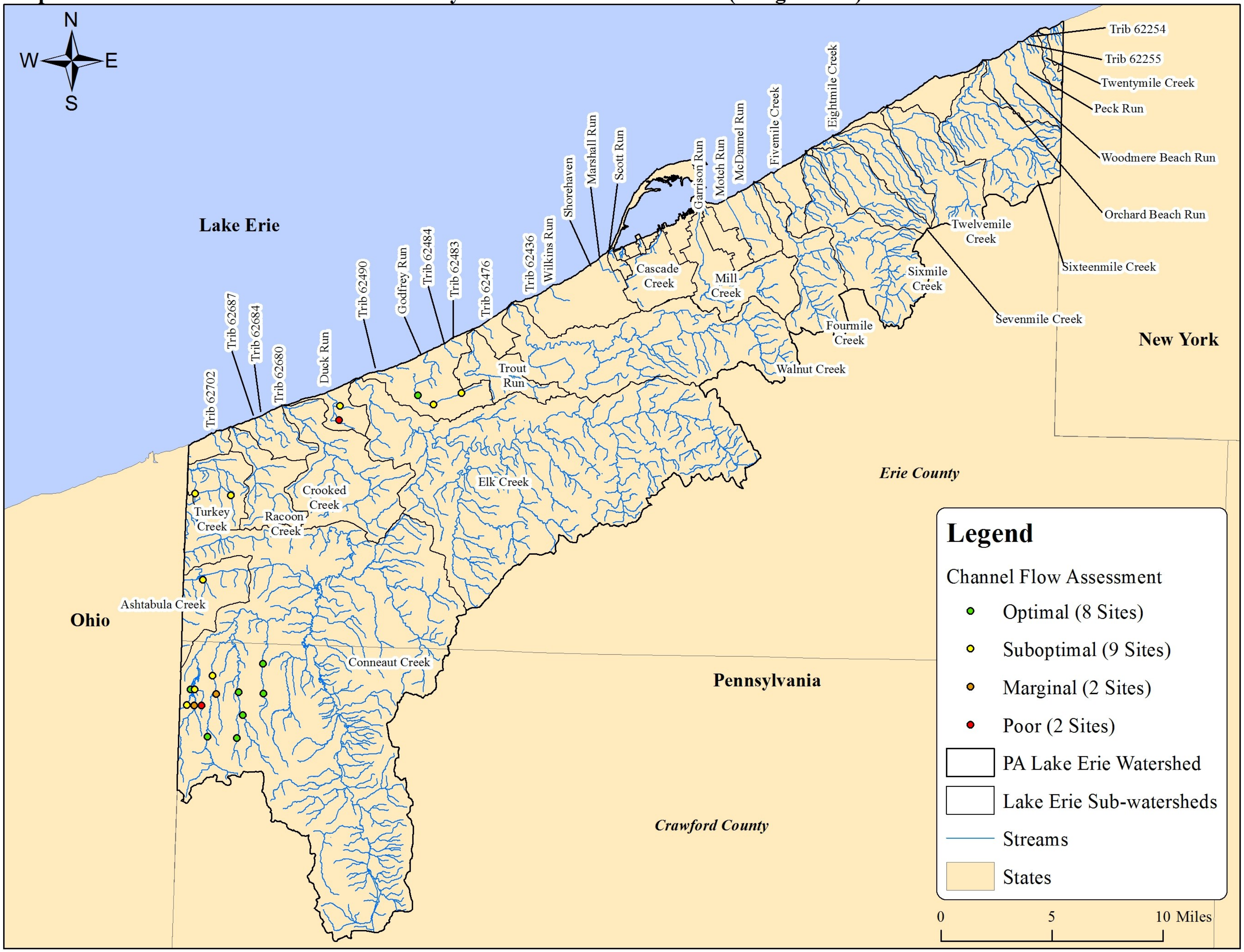
Map 25: Channel flow assessment in the Pennsylvania Lake Erie watershed (low gradient)



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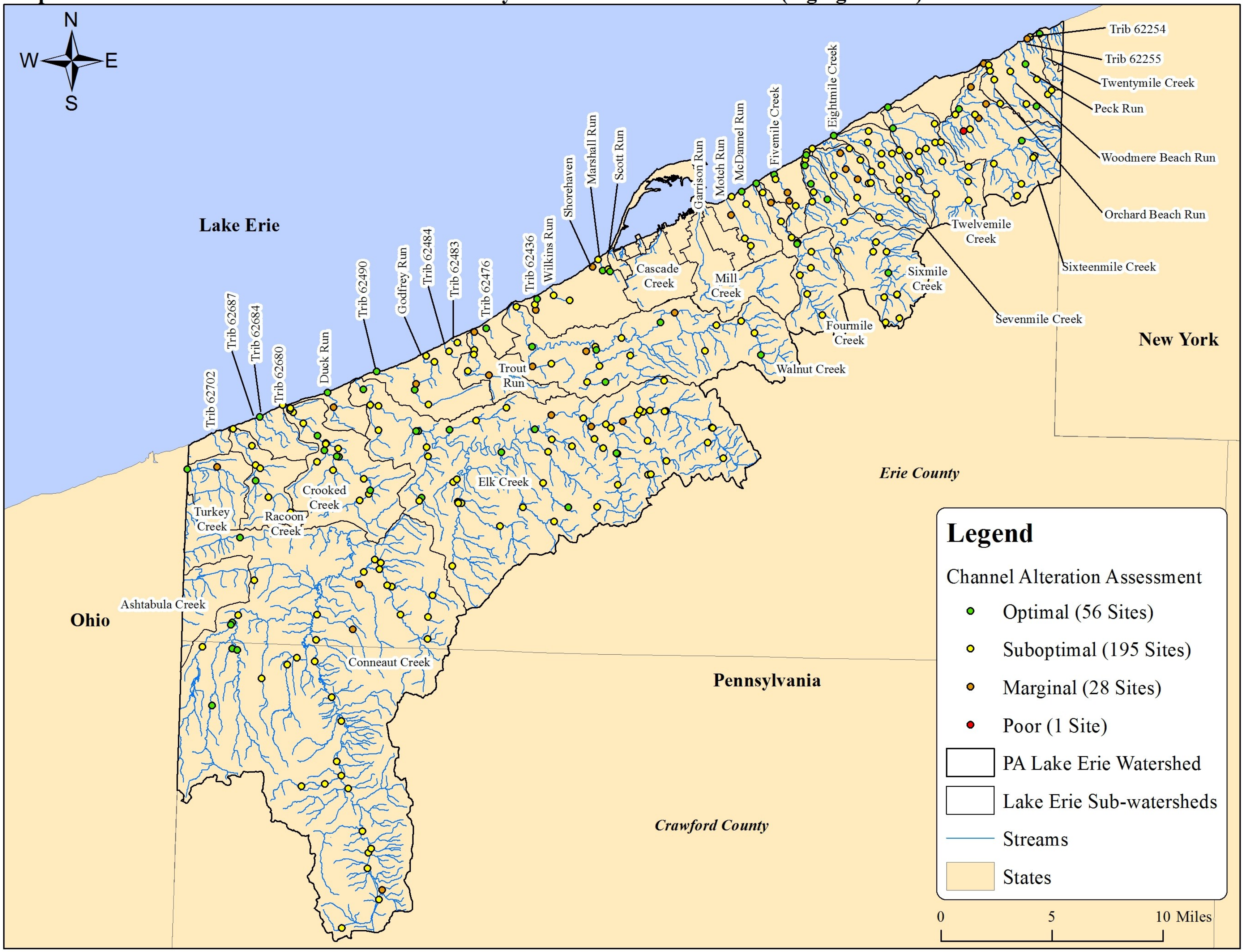
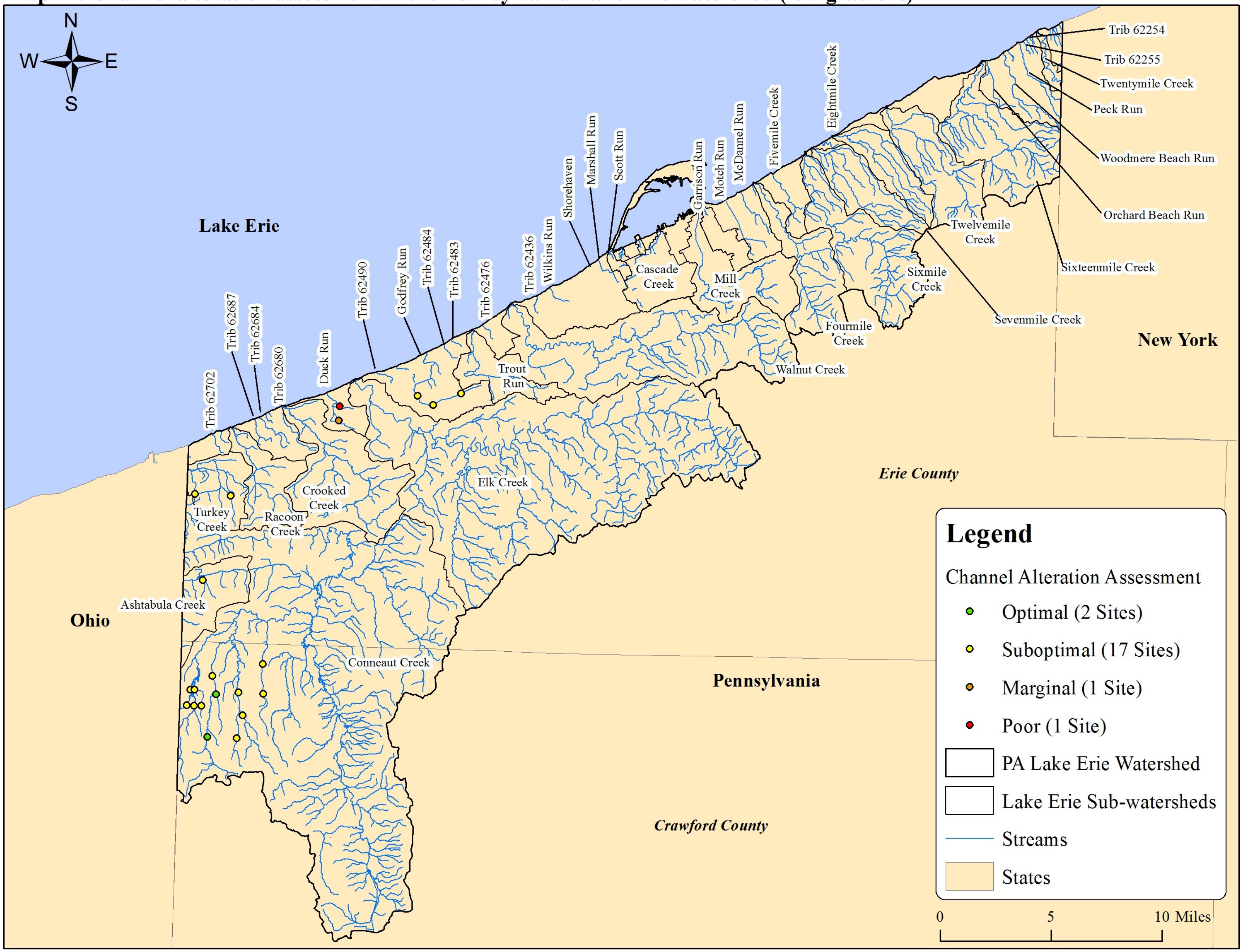
Map 26: Channel alteration assessment in the Pennsylvania Lake Erie watershed (high gradient)



Map 27: Channel alteration assessment in the Pennsylvania Lake Erie watershed (low gradient)



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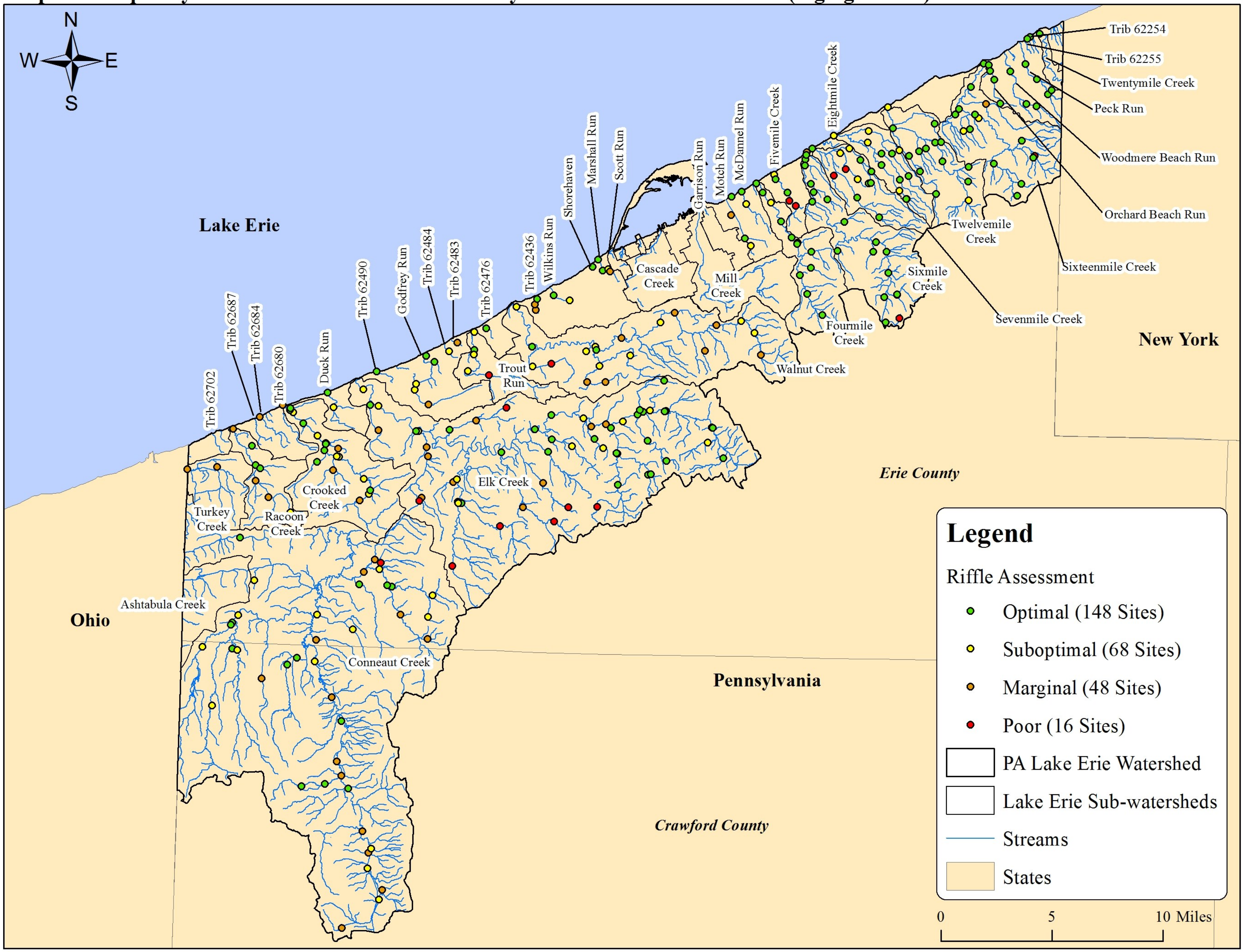
Map 28: Frequency of riffles assessment in the Pennsylvania Lake Erie watershed (high gradient)



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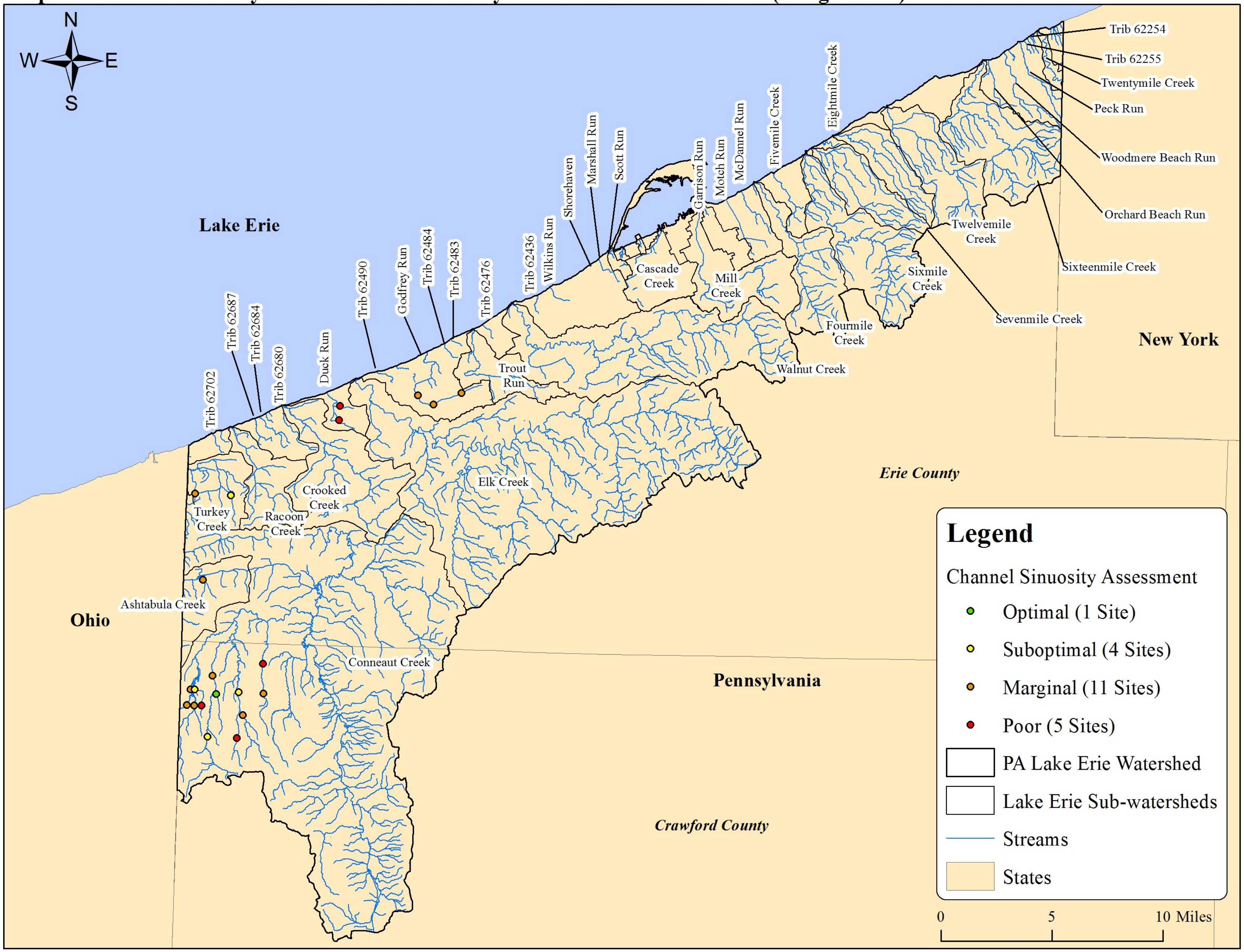
Map 29: Channel sinuosity assessment in the Pennsylvania Lake Erie watershed (low gradient)



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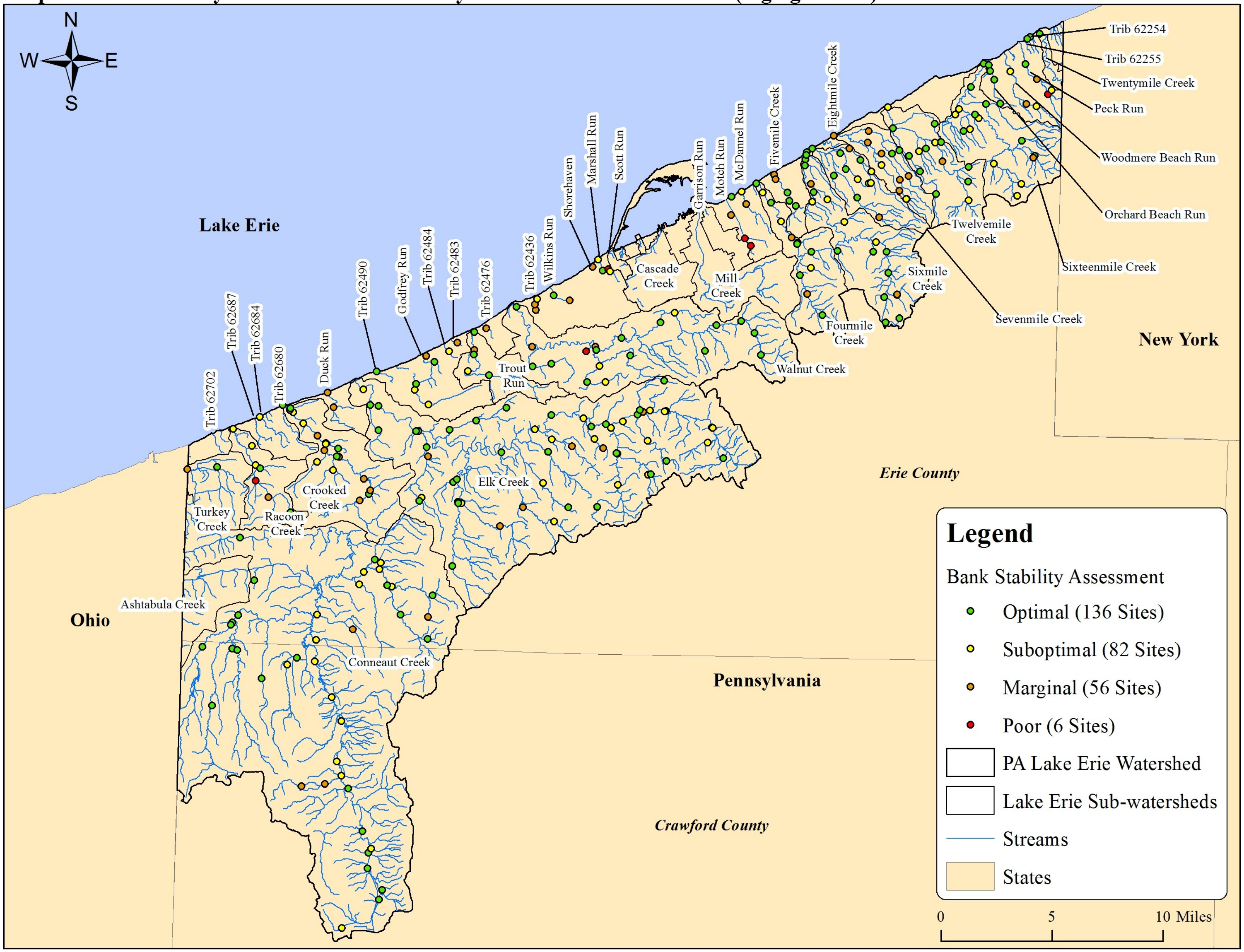
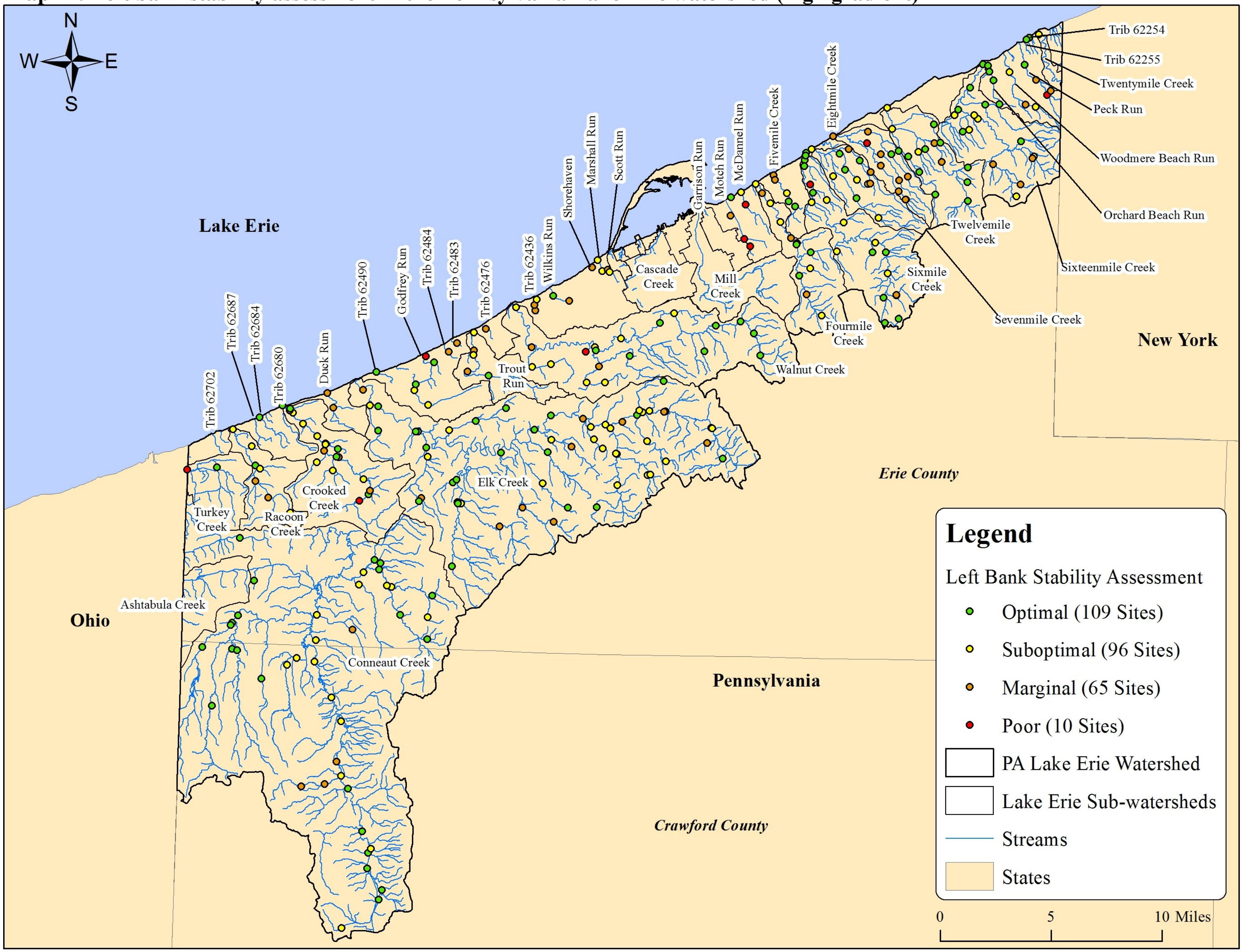
Map 30: Bank stability assessment in the Pennsylvania Lake Erie watershed (high gradient)



Map 31: Left bank stability assessment in the Pennsylvania Lake Erie watershed (high gradient)



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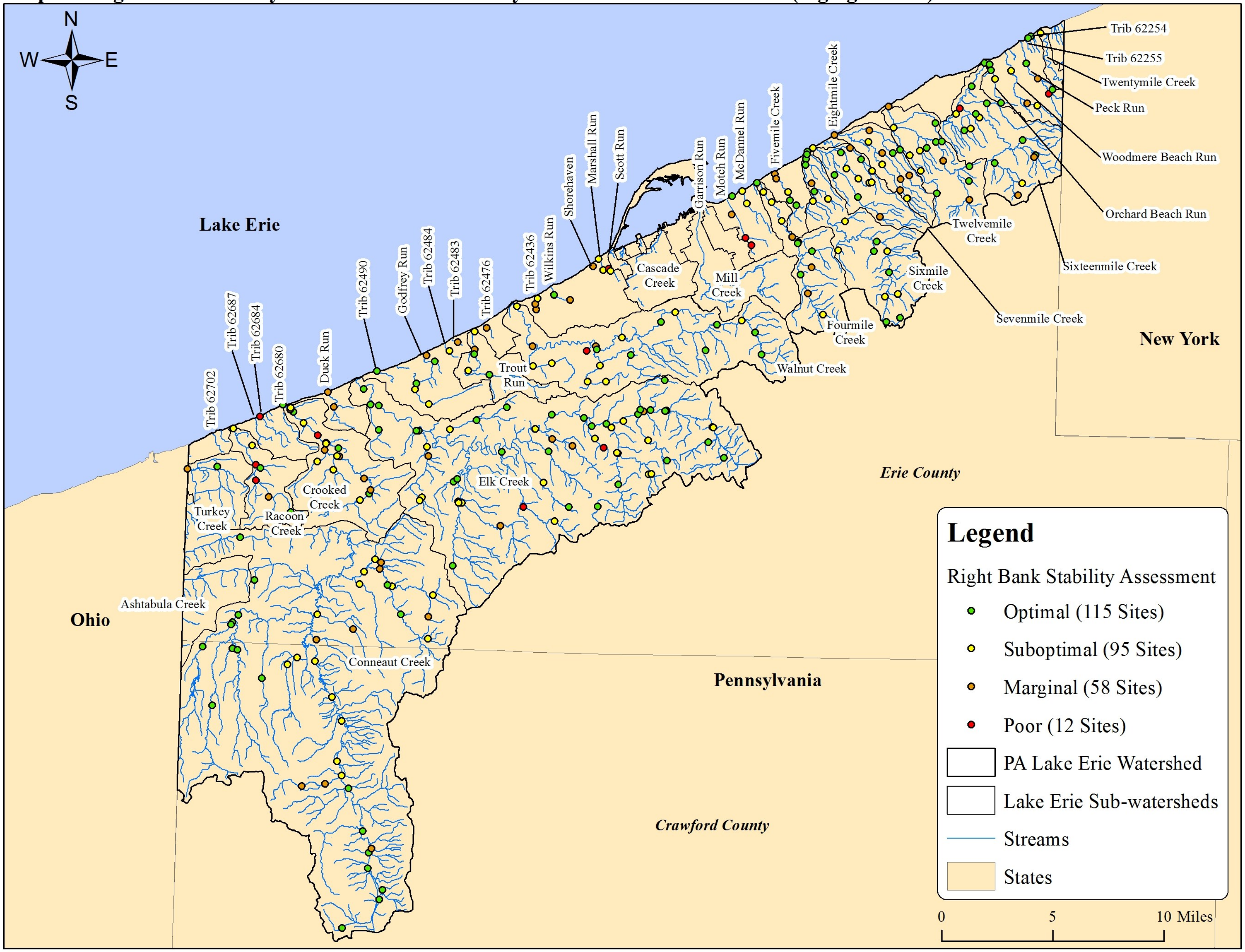
Map 32: Right bank stability assessment in the Pennsylvania Lake Erie watershed (high gradient)



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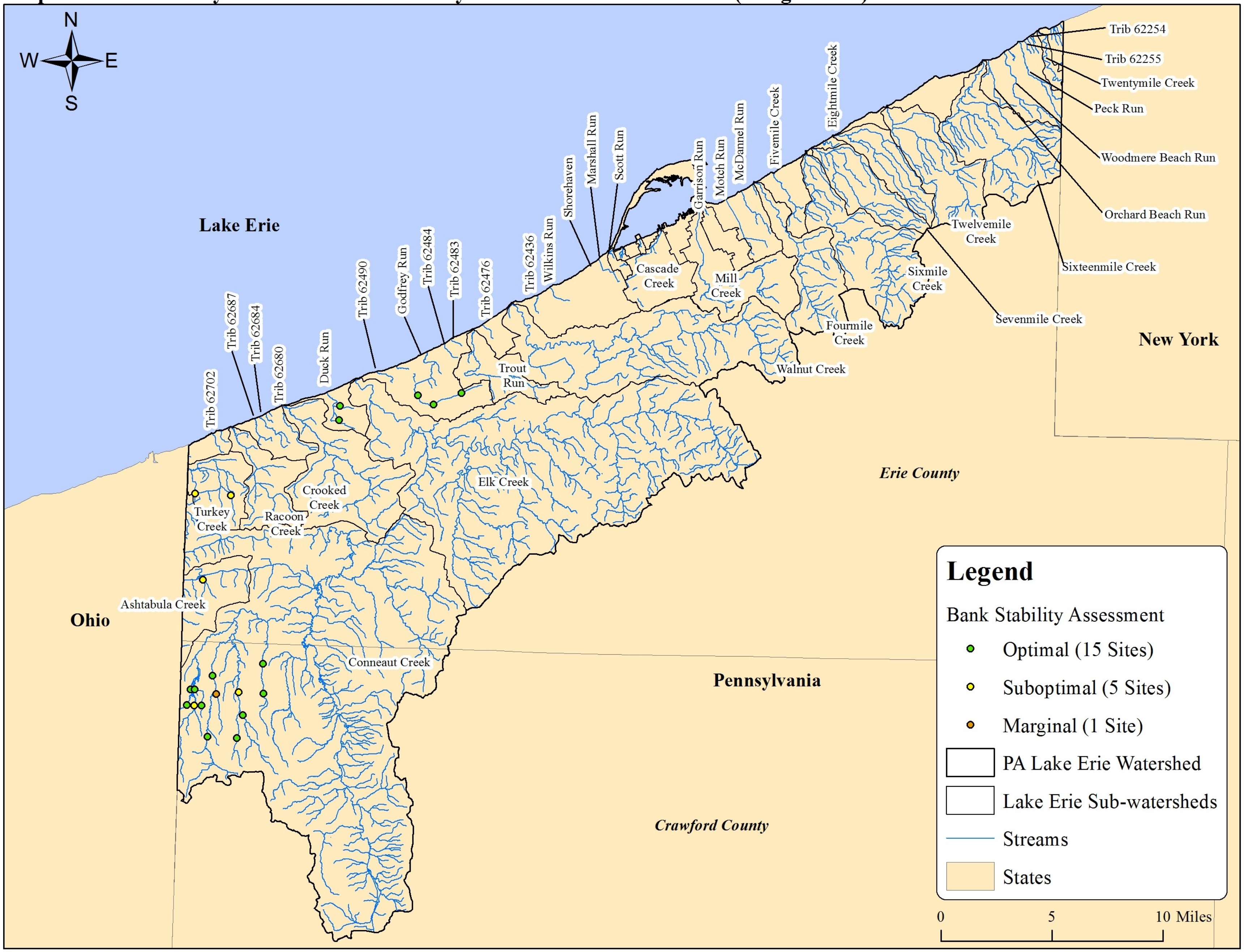
Map 33: Bank stability assessment in the Pennsylvania Lake Erie watershed (low gradient)



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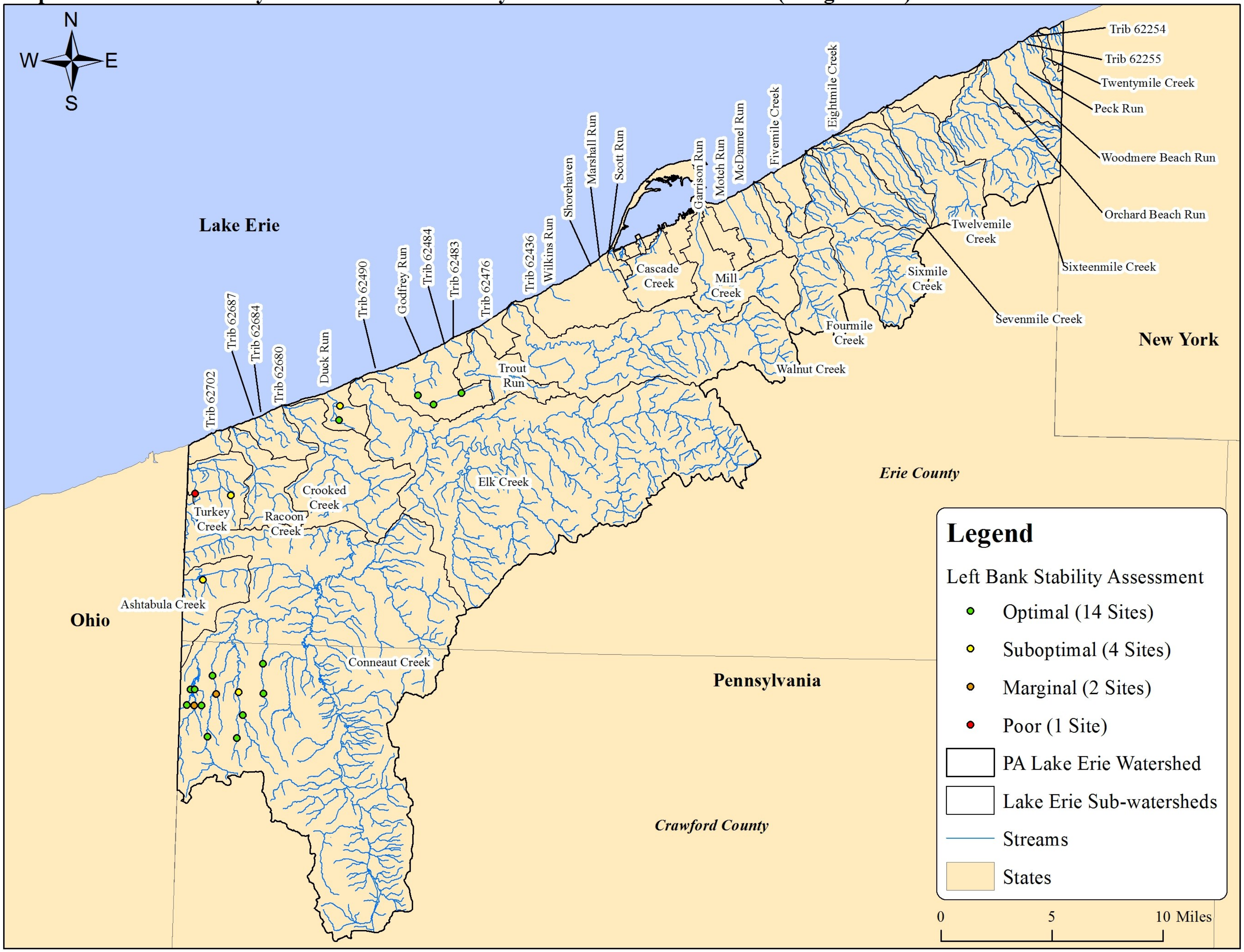
Map 34: Left bank stability assessment in the Pennsylvania Lake Erie watershed (low gradient)



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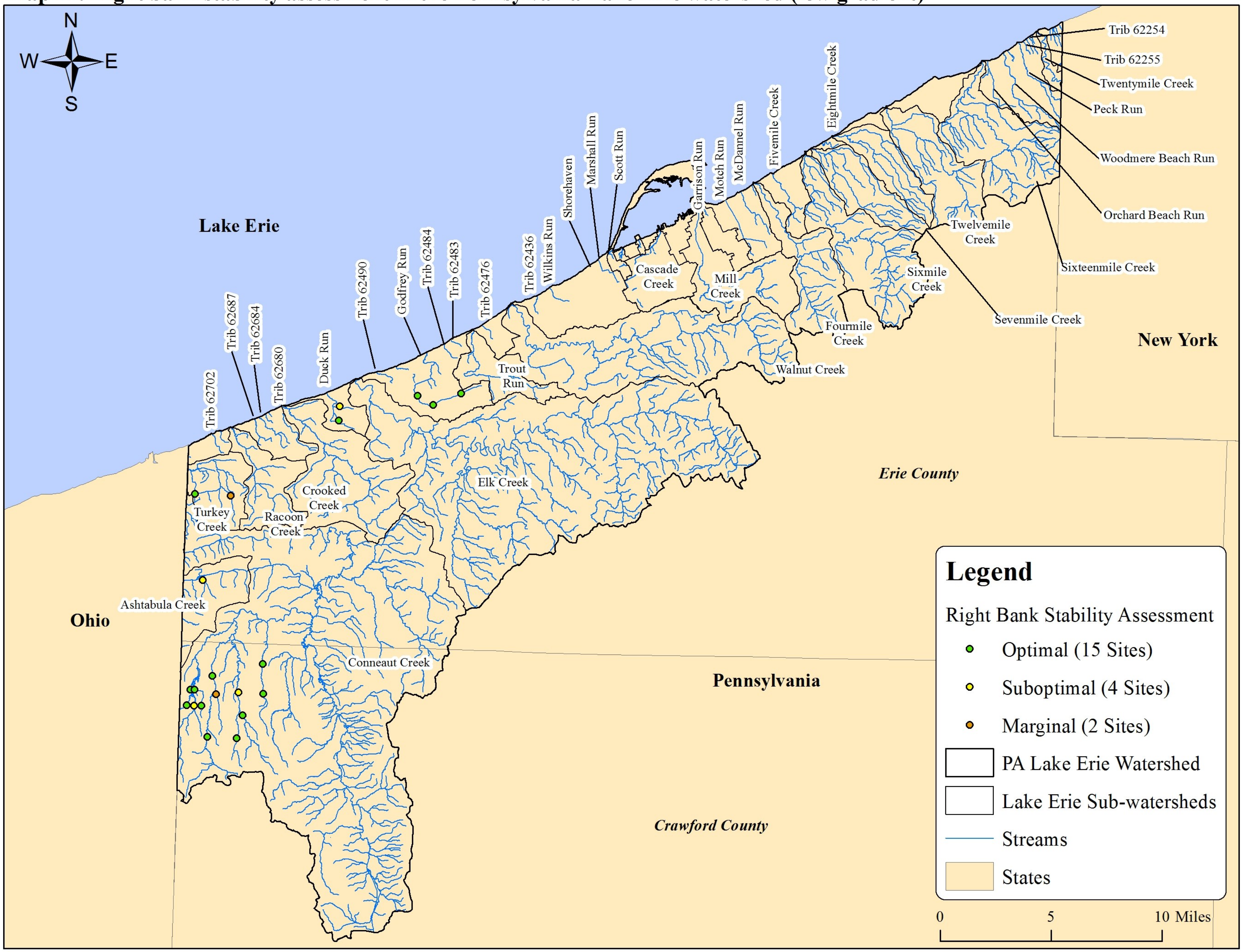
Map 35: Right bank stability assessment in the Pennsylvania Lake Erie watershed (low gradient)



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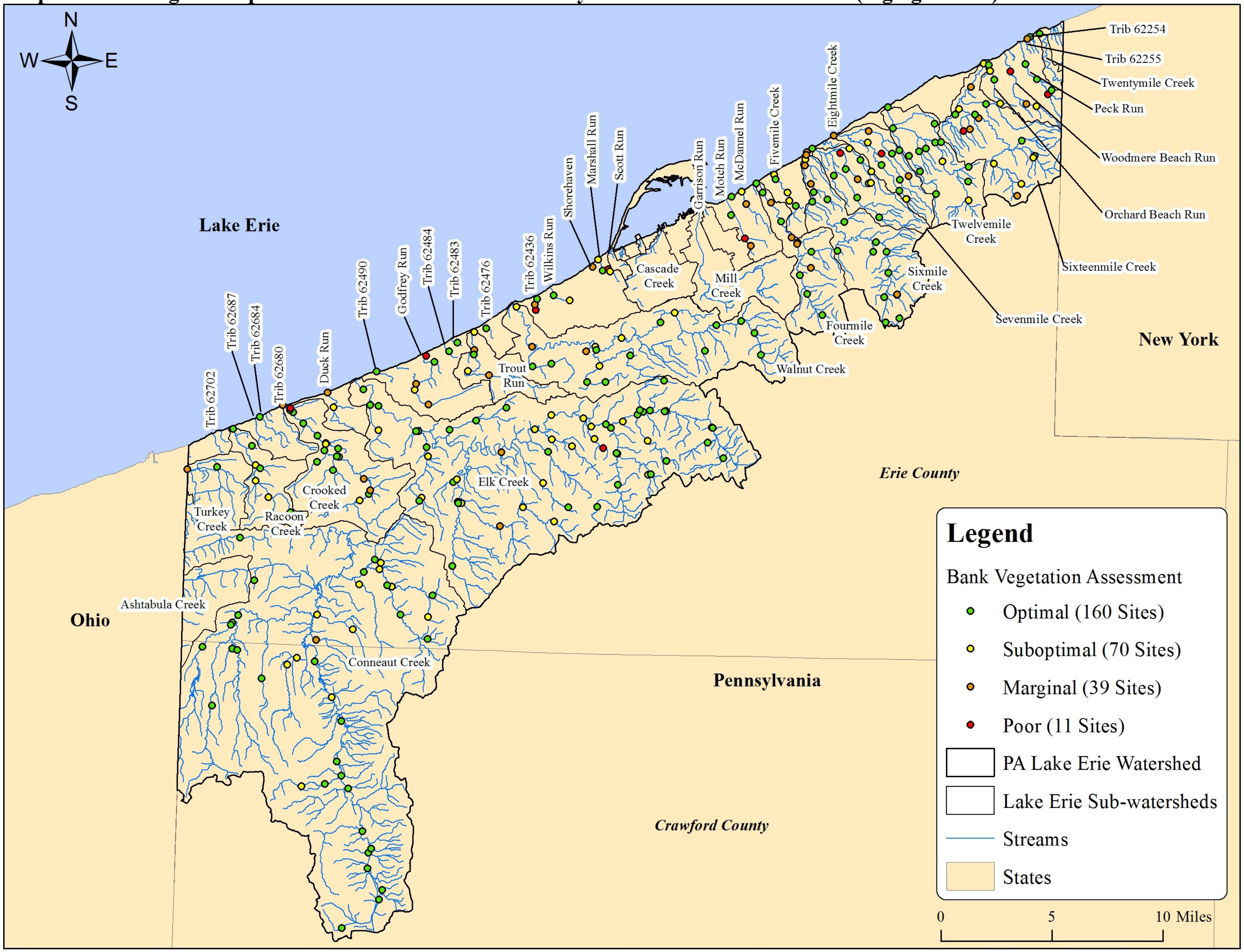
Map 36: Bank vegetative protection assessment in the Pennsylvania Lake Erie watershed (high gradient)



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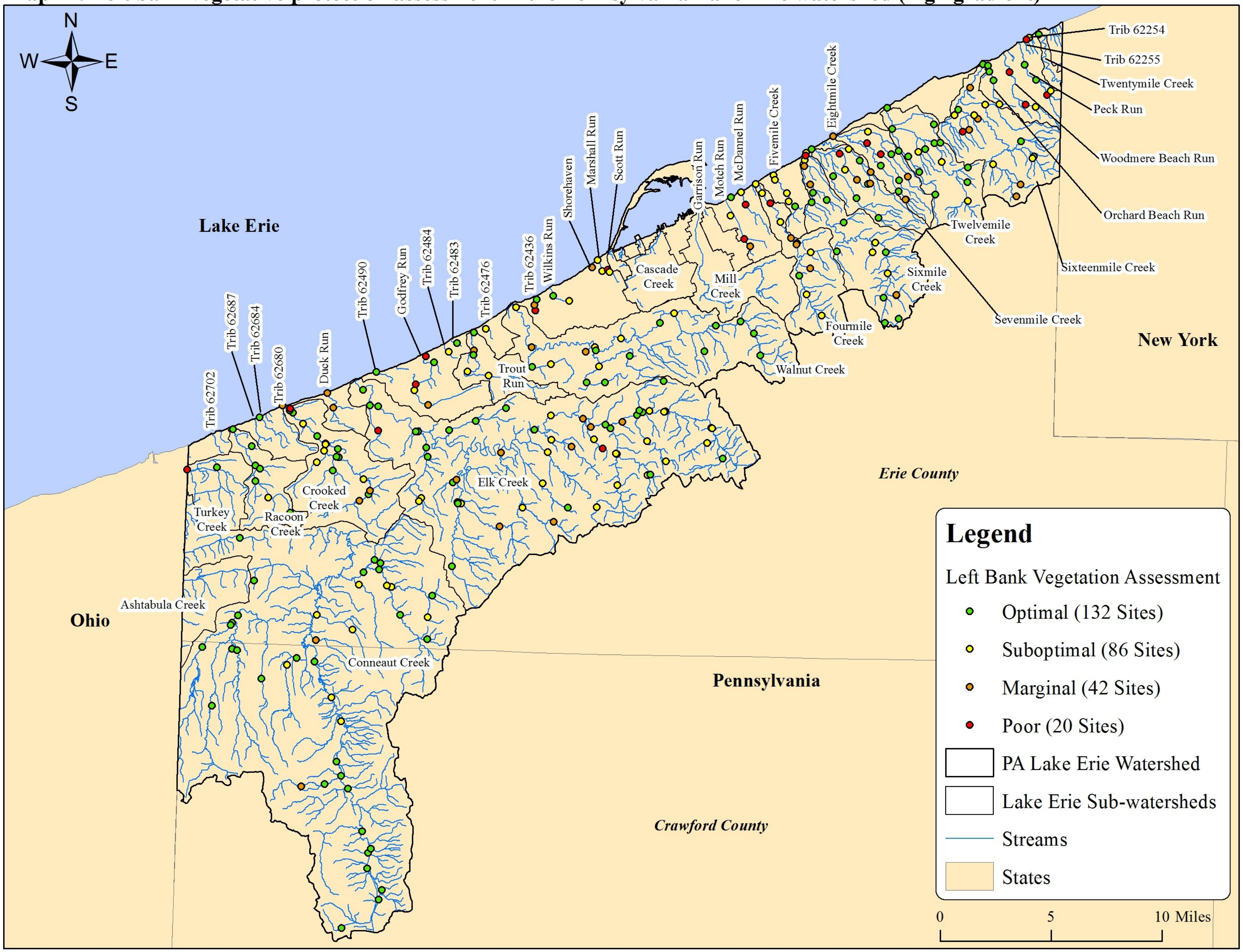
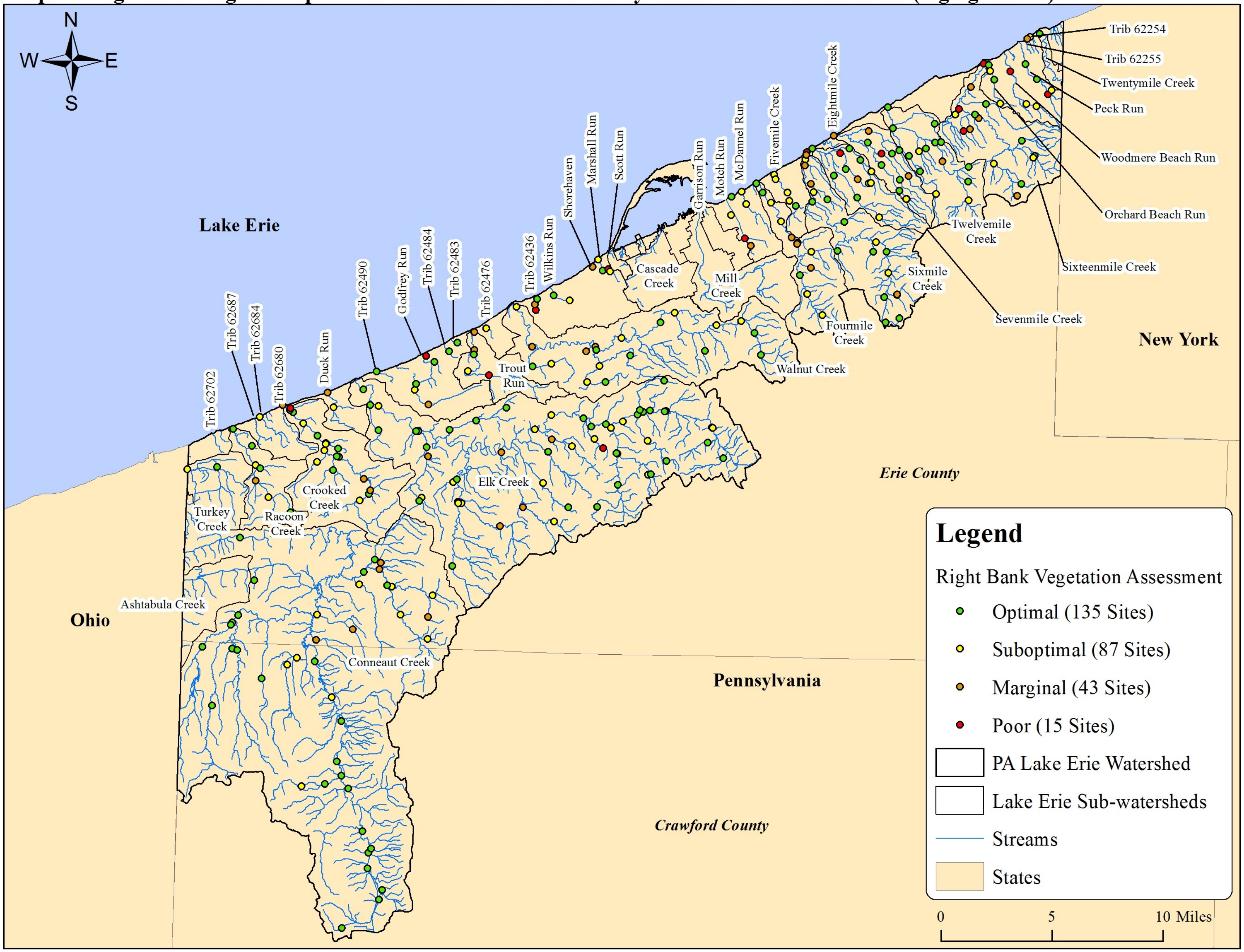
Map 37: Left bank vegetative protection assessment in the Pennsylvania Lake Erie watershed (high gradient)



Map 38: Right bank vegetative protection assessment in the Pennsylvania Lake Erie watershed (high gradient)



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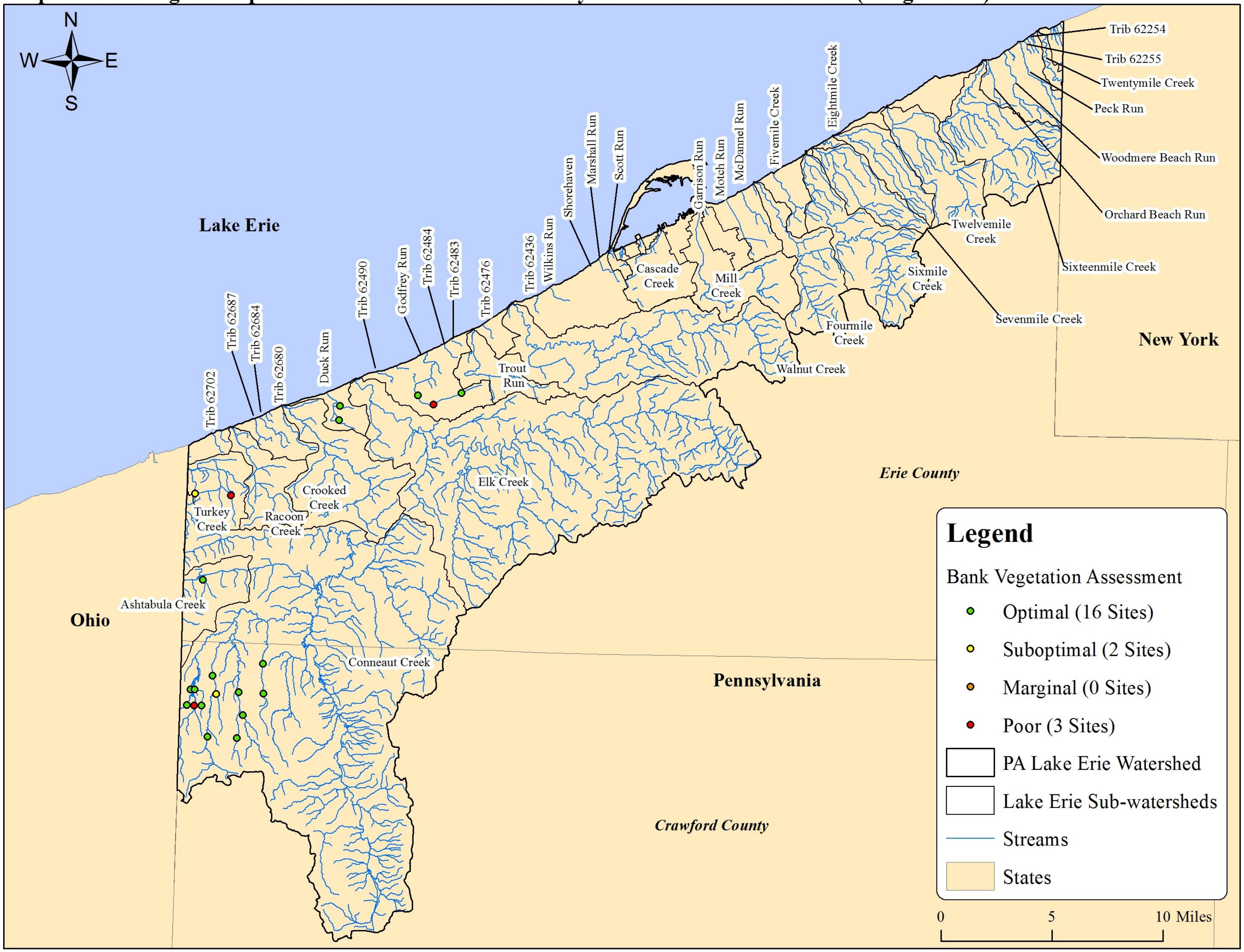
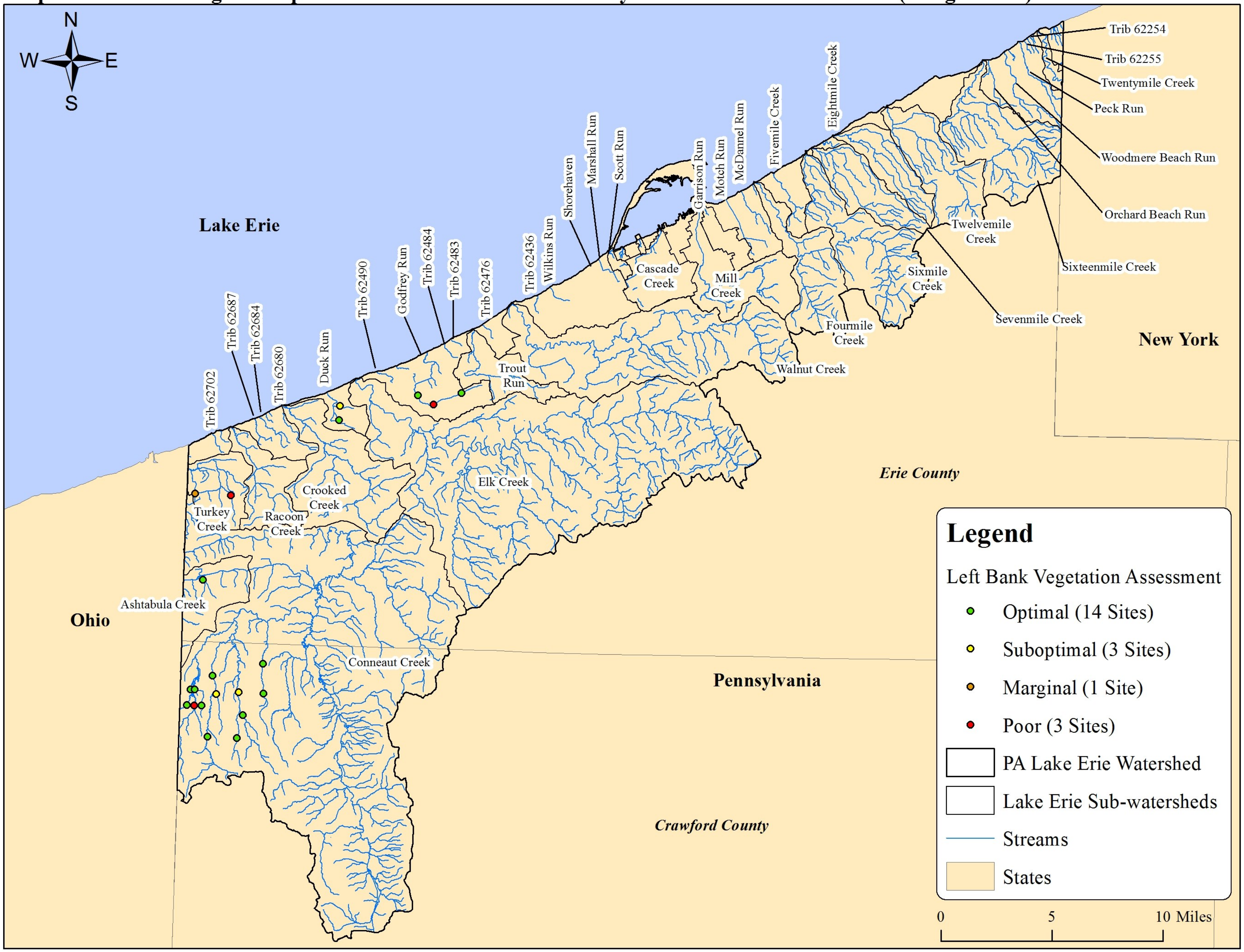
Map 39: Bank vegetative protection assessment in the Pennsylvania Lake Erie watershed (low gradient)



Map 40: Left bank vegetative protection assessment in the Pennsylvania Lake Erie watershed (low gradient)



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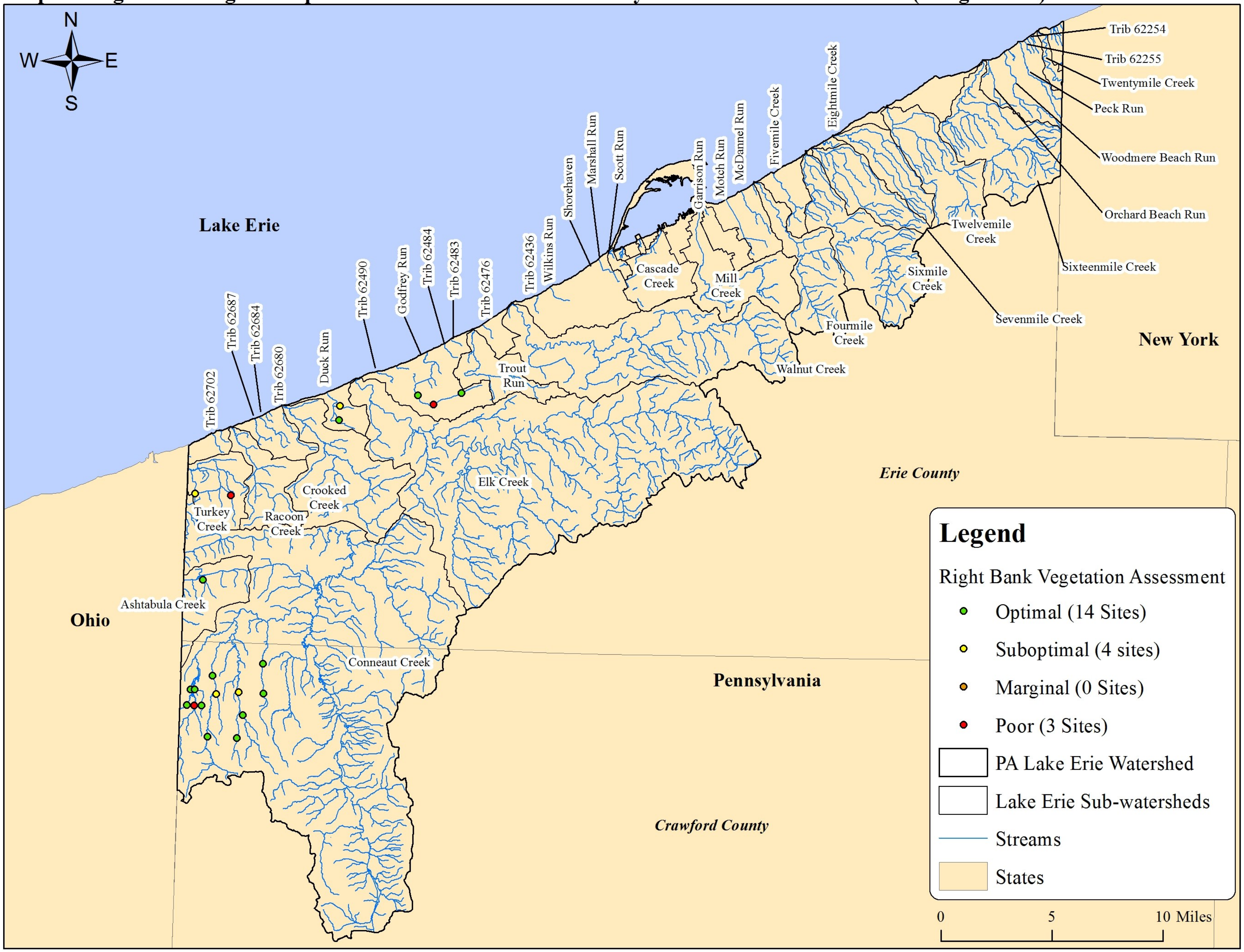
Map 41: Right bank vegetative protection assessment in the Pennsylvania Lake Erie watershed (low gradient)



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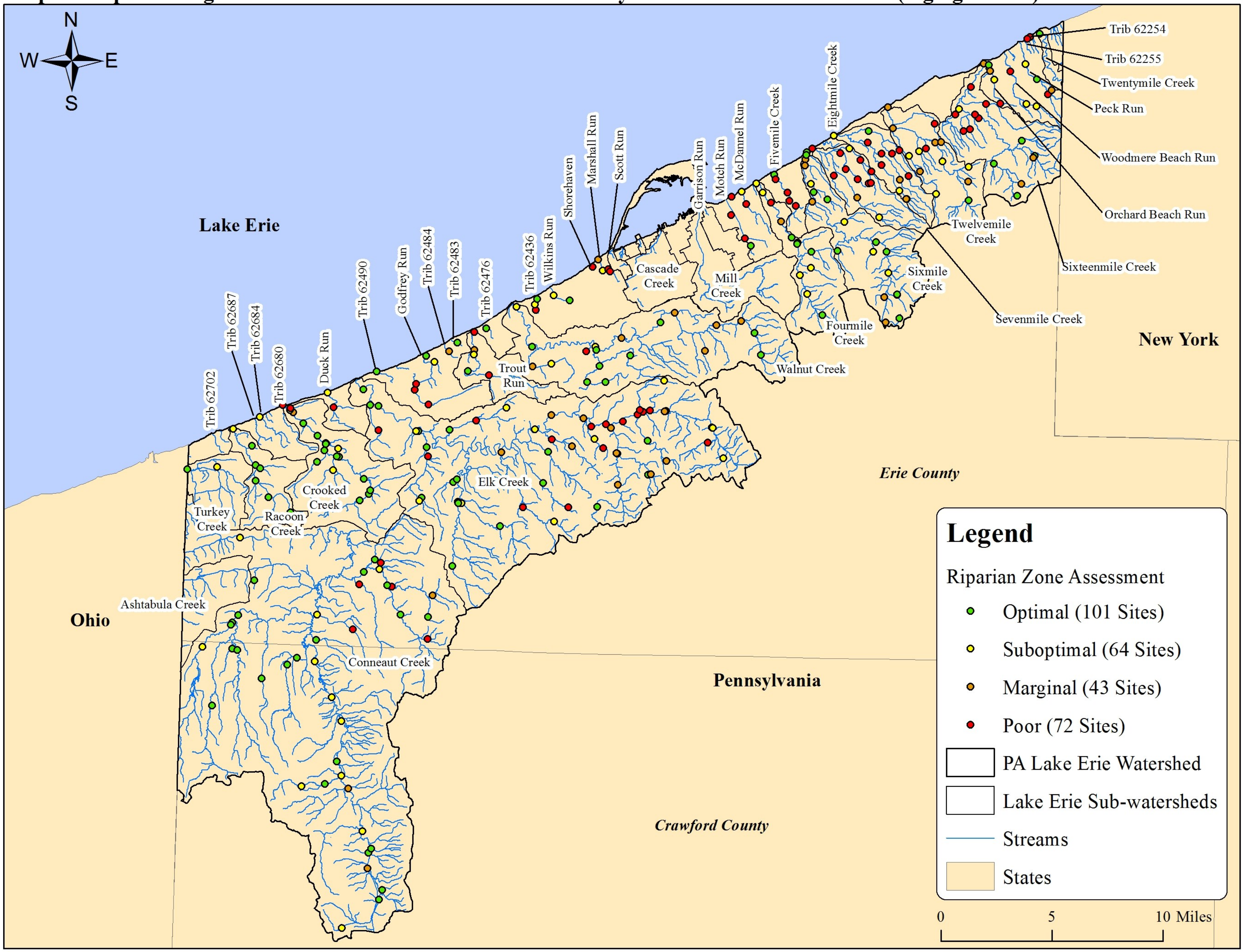
Map 42: Riparian vegetative zone width assessment in the Pennsylvania Lake Erie watershed (high gradient)



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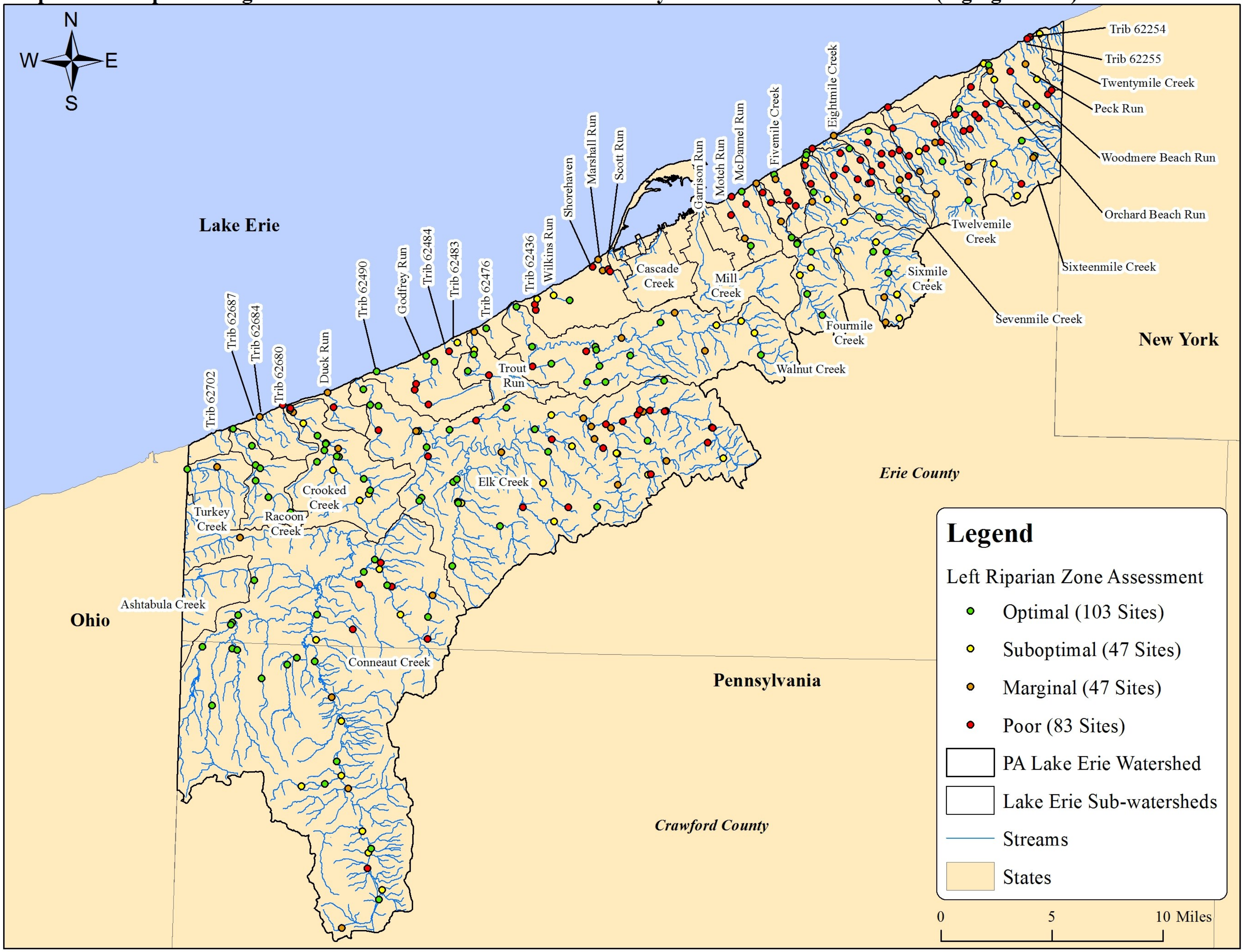
Map 43: Left riparian vegetative zone width assessment in the Pennsylvania Lake Erie watershed (high gradient)



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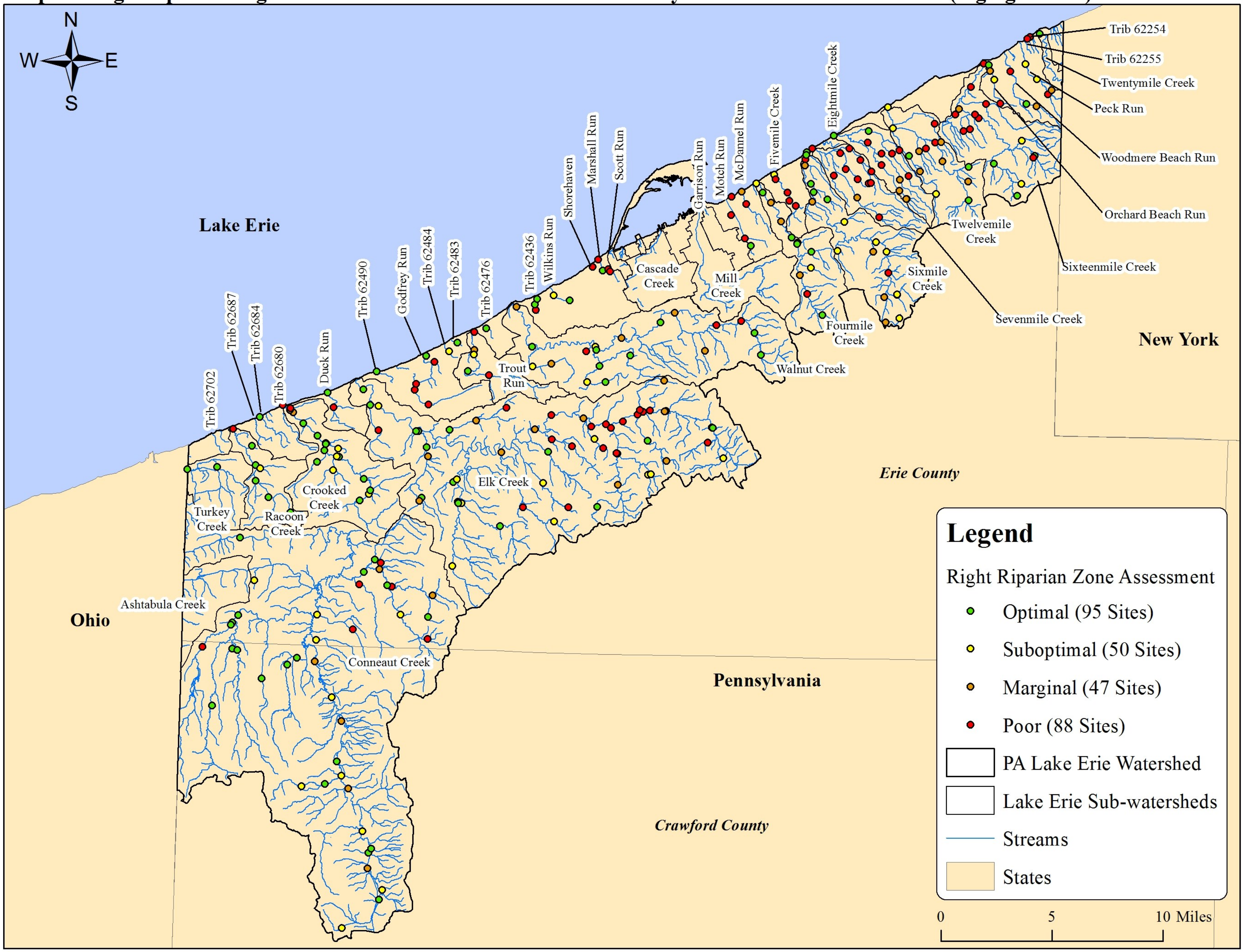
Map 44: Right riparian vegetative zone width assessment in the Pennsylvania Lake Erie watershed (high gradient)



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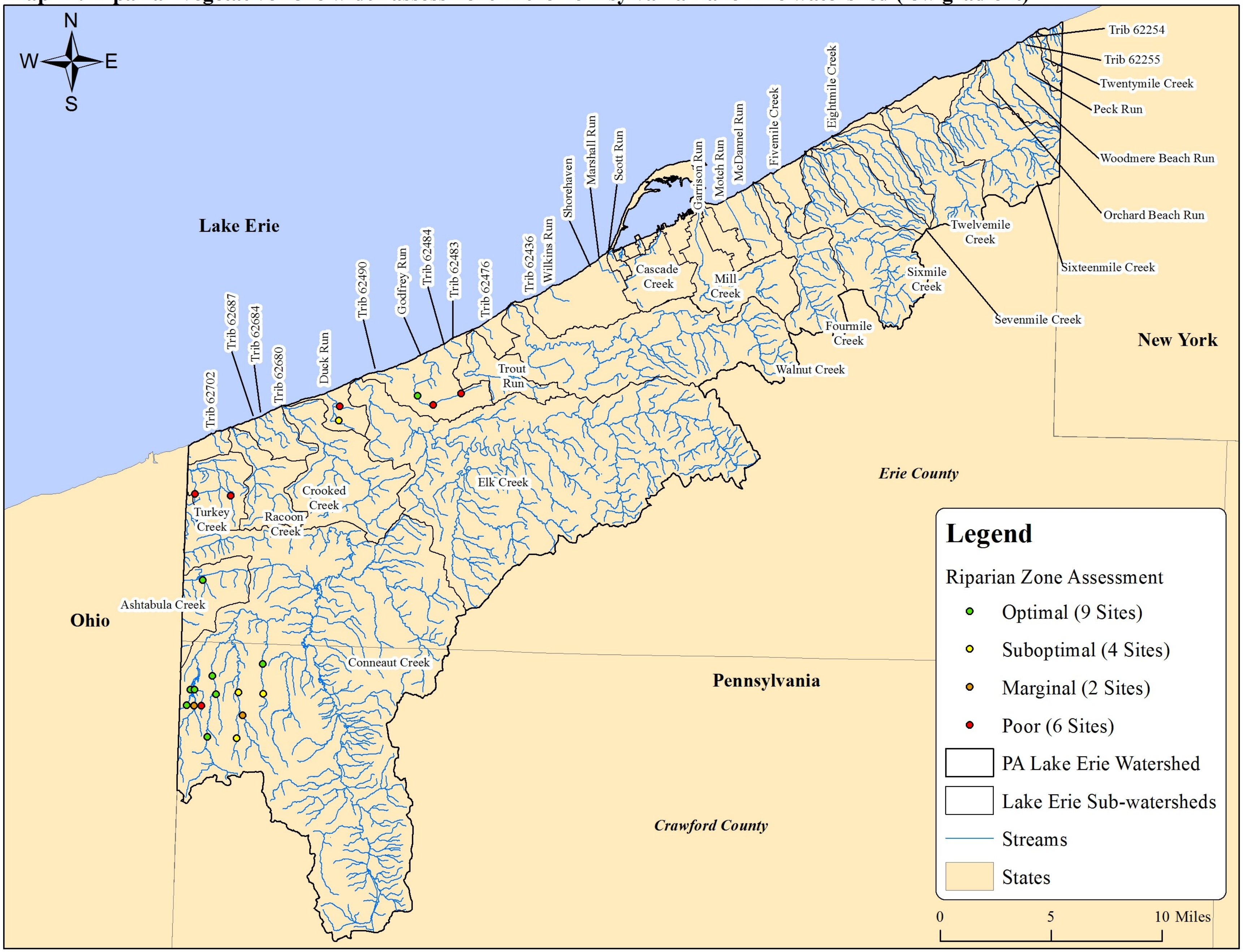
Map 45: Riparian vegetative zone width assessment in the Pennsylvania Lake Erie watershed (low gradient)



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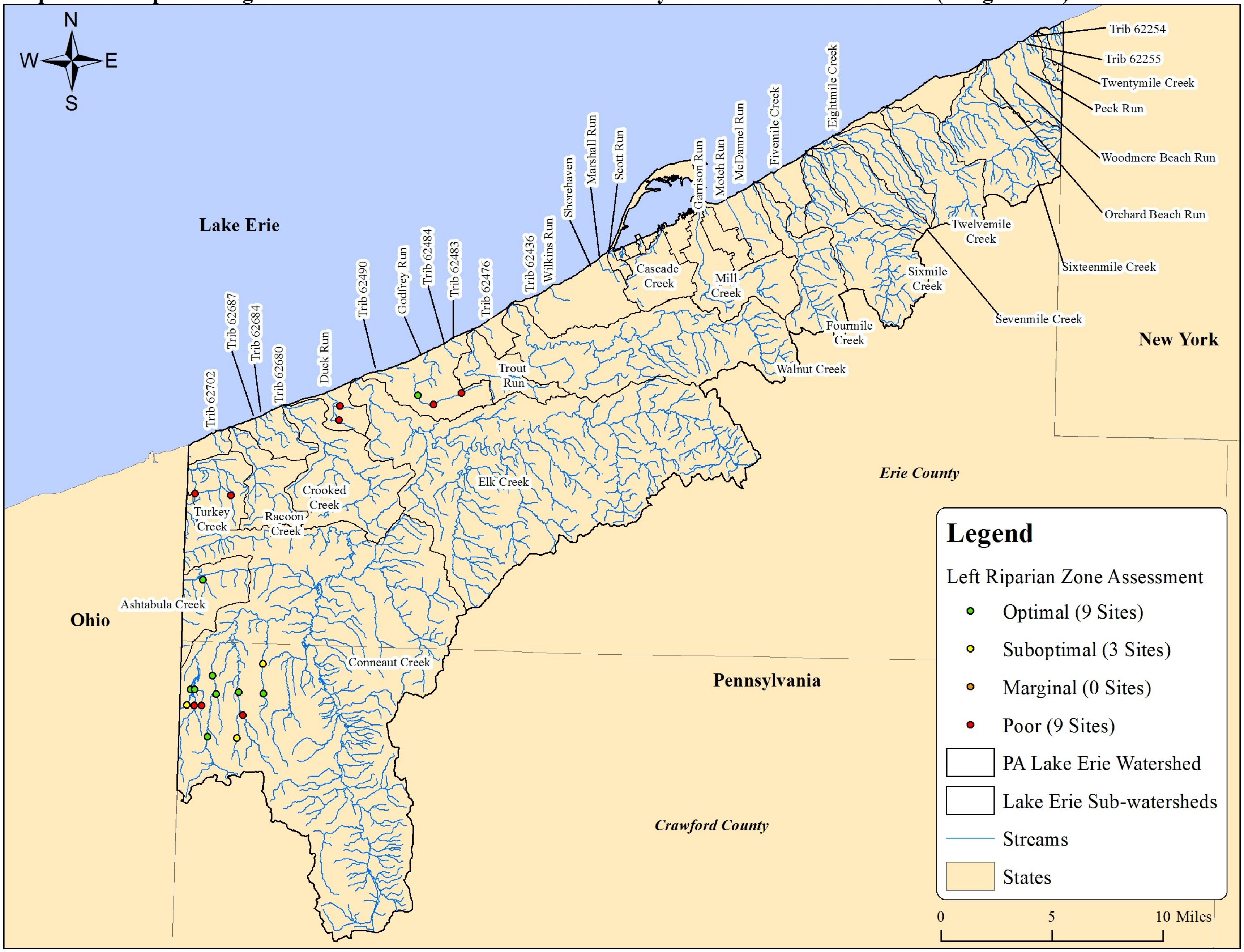
Map 46: Left riparian vegetative zone width assessment in the Pennsylvania Lake Erie watershed (low gradient)



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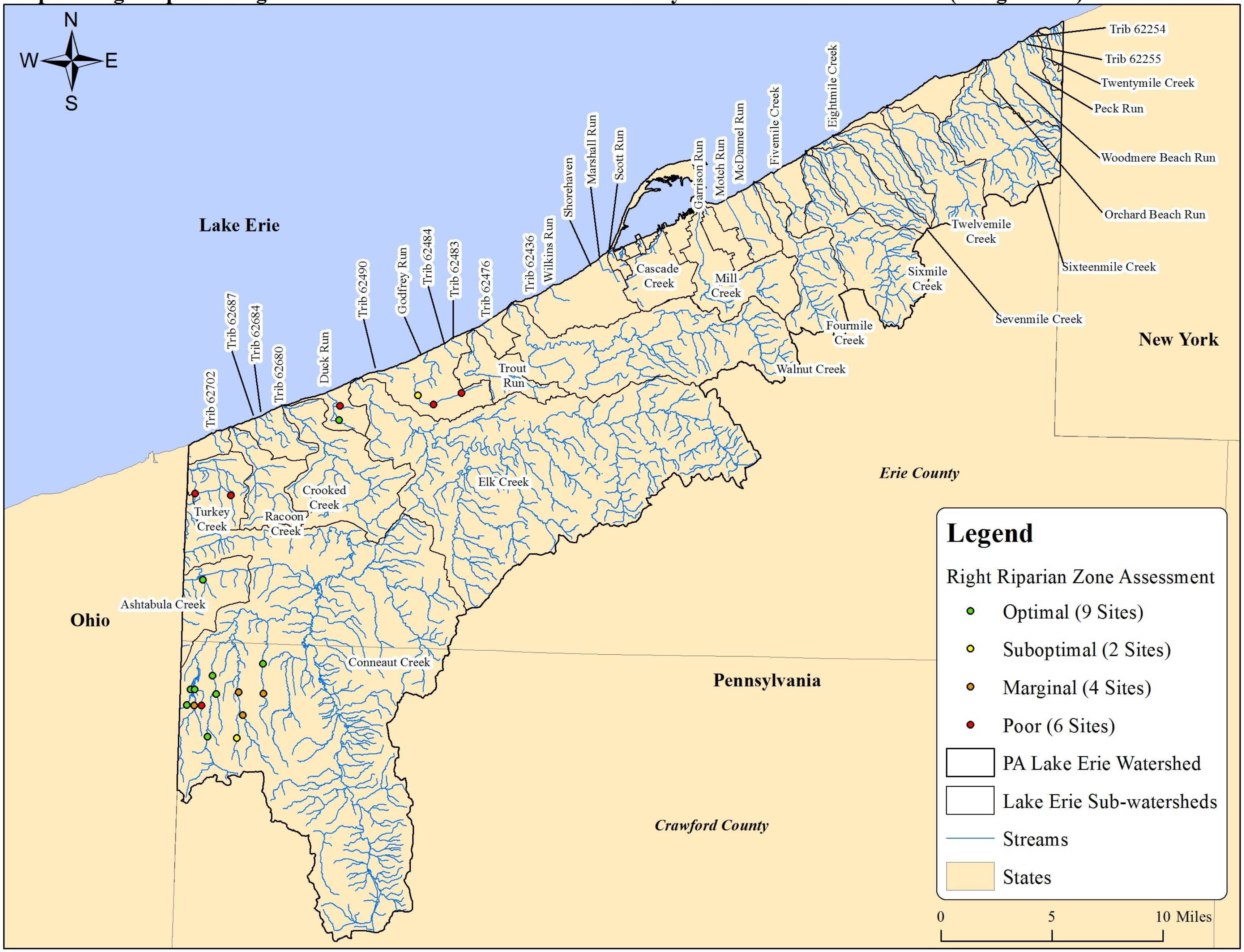
Map 47: Right riparian vegetative zone width assessment in the Pennsylvania Lake Erie watershed (low gradient)



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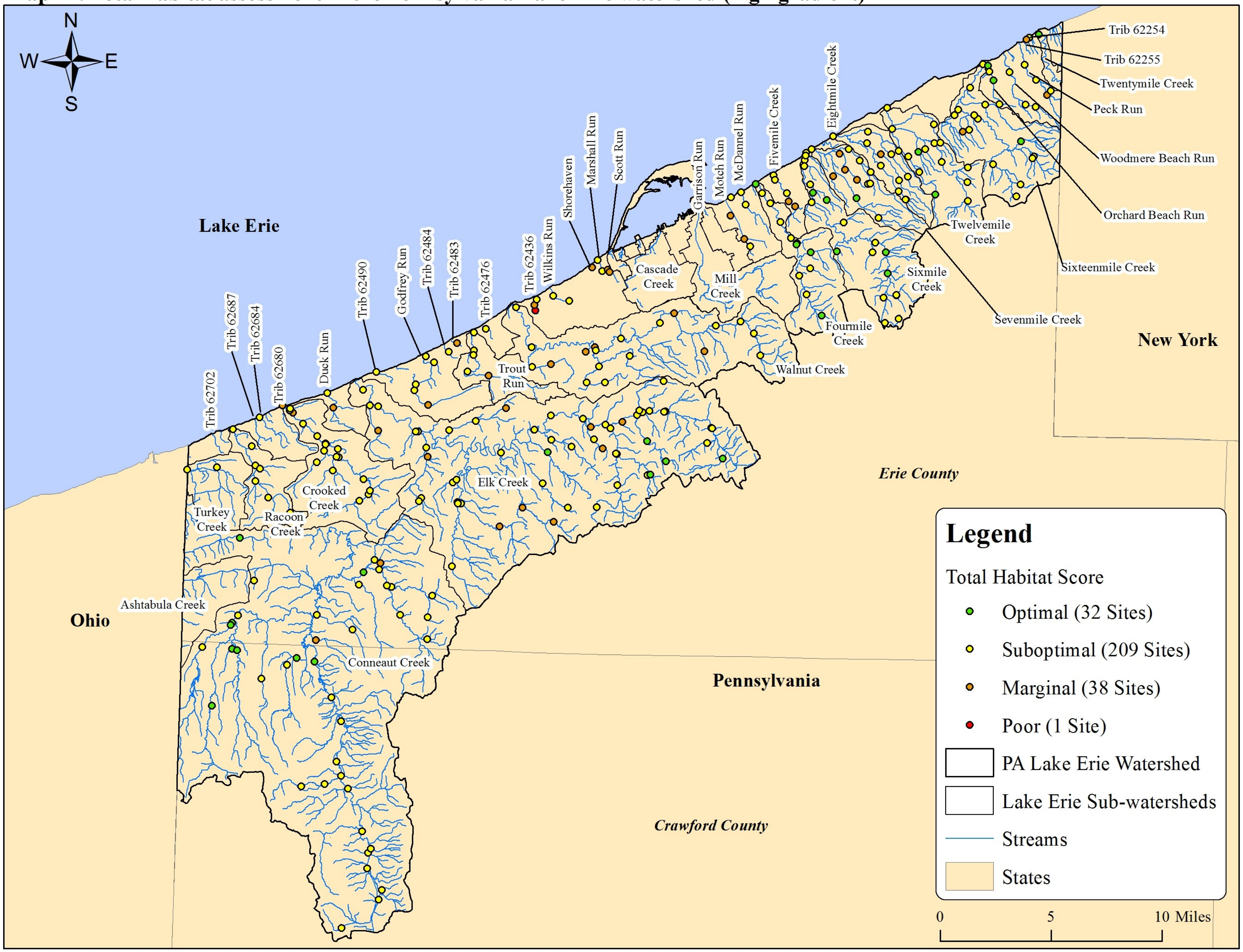
Map 48: Total habitat assessment in the Pennsylvania Lake Erie watershed (high gradient)



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Map 49: Total habitat assessment in the Pennsylvania Lake Erie watershed (low gradient)