Analysis of Riparian Forest and Floodplain Quality in the Yellow Creek Watershed Using the Qualitative Habitat Evaluation Index

By

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ABSTRACT

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The Yellow Creek watershed, located in northeast Ohio, covers an area of approximately 32,330 acres. Local environmental groups are concerned about the degradation of water quality due to land development. The three main objectives of this study were: delineation of the riparian condition using aerial photographs; construction of a geographical information system (GIS) database; and field evaluation of the Qualitative Habitat Evaluation Index (QHEI).

The evaluation of streams throughout the Yellow Creek watershed indicates severe deterioration of riparian forest. The average riparian width score using the QHEI procedure was 1.53 out of 4.0 (in the "moderate" range). Of the 62 streams analyzed, 10 have an average riparian width less than 10 m. The average floodplain condition of the 4 lakes and 17 streams was poor. The results confirmed the non-attainment status of the Yellow Creek watershed for warm water habitat criteria set by the Ohio EPA.

GIS maps were analyzed in order to devise a sampling network for field examination and future water quality monitoring. Full QHEI evaluations were conducted on 14 field sites. For these sites, the average QHEI score was 44.2 out of 100, indicating that the habitat is in poor condition. The field evaluations were also compared to the aerial delineation, and served to corroborate the aerial delineation method.

ACKNOWLEDGMENTS

I would like to thank Dr. Scott Martin for his time, guidance and red ink with this project. This project would not have been possible without the counsel of Dr. Martin. I am also grateful for the time that Dr. Shakir Husain and Dr. Irfan Khan put forth by serving on my defense committee. I would also like to extend my appreciation to Brian Logan from EDATA for providing the aerial photographs from Mahoning County.

DEDICATION

I would like to thank God for the gifts he has provided me: my loving and supportive wife, family and friends.

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Chapter 1

INTRODUCTION

1.1 Background Information

1.1.1 Location of Yellow Creek Watershed

The Yellow Creek Watershed, shown in Figure 1, originates in Columbiana County but lies mostly within Mahoning County. Both counties are located in Northeast Ohio.

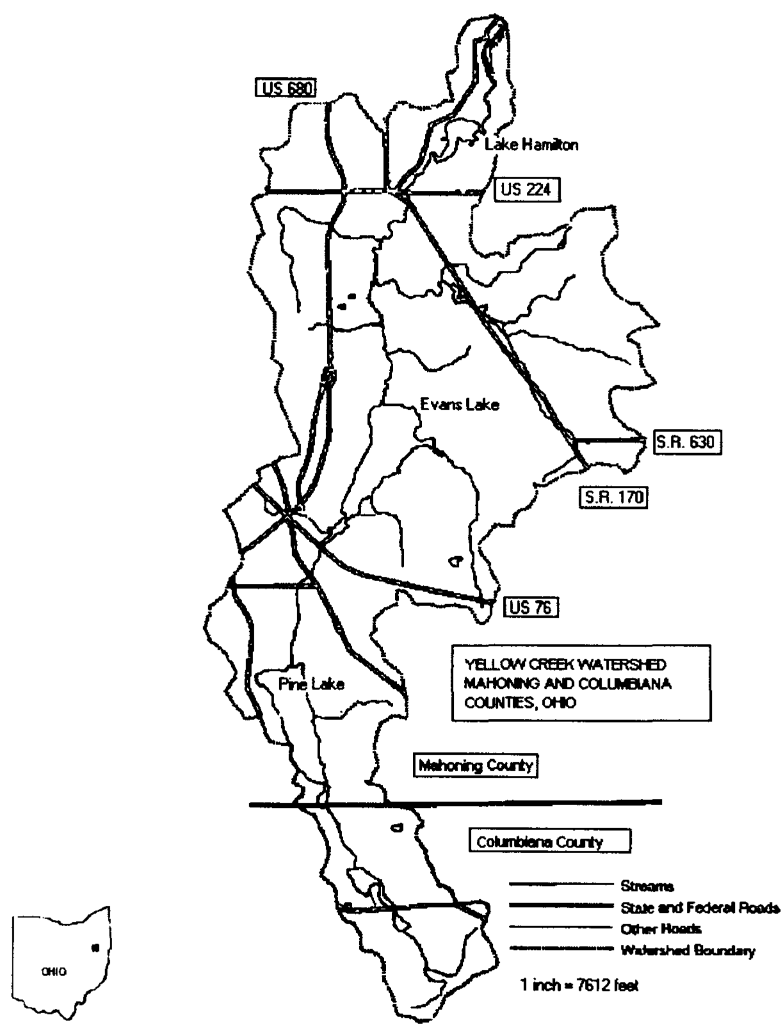

Figure 1: Yellow Creek Watershed (YSU-CUS, 1998)

1.1.2 Physical Attributes

The Yellow Creek watershed is approximately 32,330 acres (YSU-CUS, 1998). It contains one main waterway, Yellow Creek, and numerous tributaries. There are four impoundments on Yellow Creek: Lake Evans, Lake Hamilton, Pine Lake and Beaver Lake. Consumers Ohio Water Company owns Lakes Evans, Pine and Hamilton; Evans and Hamilton are used as water supplies. Consumers allows recreational fishing (for a fee) on Pine Lake, Lake Evans and Lake Hamilton.

1.1.3 Non-Attainment Status

Waterways in the U.S. are classified by the best use designation. The best use designation incorporates the potential and water quality standards of a water body. When a river does not meet the specified criteria for its use designation, it is considered in non-attainment status. The best use for Yellow Creek is aquatic habitat. The aquatic use designation contains several classifications. For the Yellow Creek Watershed, the aquatic use designation is warmwater habitat (WWH).

A 1994 water quality study of the Mahoning River Basin incorporated a point one-mile from the mouth of the Yellow Creek as one of the sampling locations (OPEA, 1996). The Ohio Environmental Protection Agency (OEPA) tested this location for attainment status. It was concluded that Yellow Creek displayed significant deviation from the ecoregion's biocriteria and is in non-attainment of WWH criteria (OEPA, 1996).

1.1.4 Nonpoint Source Pollution

Rapid development in the Yellow Creek Watershed has caused an increase in water quality problems. The urbanization of the northern portion of the watershed, coupled with extensive agricultural practices in the southern section has increased the amount of nonpoint source pollution. The pollution includes nutrients (phosphorus and nitrogen) and sediments (Korenic, 1999). The problems that have occurred due to the influx of nutrients and sediment, as well as the non-attainment status attracted the attention of the Alliance for Watershed Action and Riparian Easements (AWARE), a community-based watershed action group.

1.1.5 History of AWARE

AWARE was formed from the Lake Newport Advisory Committee in 1998. The group's constituents include concerned citizens, businesspersons, environmental professionals, and representatives from government agencies (Martin, 1998). Their prime objective is to improve the water quality in the Mill Creek and Yellow Creek Watersheds. AWARE has identified a need for better background information on the condition of the Yellow Creek Watershed.

1.1.6 Riparian Corridors

Riparian corridors are parcels of land located on both sides of rivers and streams; they act as barriers protecting the health of waterways from human land use activities. Riparian corridors are ecosystems that have a direct impact on aquatic life. Their width varies greatly depending on human activity. They offer a multitude of social, economic, and biological benefits.

Riparian corridors provide habitat for aquatic life and birds. They also lessen the damage to waterways from surface water runoff by removing suspended sediments and nutrients, while reducing the volume and velocity of runoff (Lowrance, 1998).

1.1.7 Qualitative Habitat Evaluation Index

The Qualitative Habitat Evaluation Index (QHEI) was designed as a technique to evaluate and quantify the condition of aquatic habitat in streams. It encompasses substrate composition, channel morphology, in-stream cover, riparian zones, and riffle/pool quality by assigning scores based on quality and quantity. The greater the QHEI score, the better the condition. It is used in conjunction with macro-invertebrate and fish surveys to determine the overall health of a stream. OEPA has established an overall QHEI score of 60 or greater as the attainment level for WWH criteria.

1.1.8 Need for Further Characterization of Riparian Corridors

A thorough inventory of riparian corridors in a watershed provides indispensable information. Characterization and careful monitoring of the corridor can lead to insights about human impacts on stream quality and possible remedial action. A thorough inventory of riparian corridors will lead to more effective planning and management decisions.

1.2 Objective of Study

The primary goal of this study was to examine and characterize the riparian corridor and aquatic habitat in the Yellow Creek Watershed. Based on the assumption that there is a direct relationship between the condition of the riparian corridor and the water quality of streams in the Yellow Creek Watershed, the following objectives were established:

1. Evaluate and record riparian corridor health using the QHEI procedure;
2. Create a database of riparian condition using a Geographic Information System (GIS);
3. Recommend a network of water quality sampling locations in the watershed;
4. Conduct full QHEI evaluations at several of the sampling locations.

Chapter 2

LITERATURE REVIEW

2.1 Nonpoint Source Pollution

Nonpoint source pollution is that which cannot be traced to a single source. Prime examples of nonpoint source pollution are runoff from agriculture, golf courses, residential lawns and toxic spills.

Runoff due to precipitation events from agricultural land carries organic matter (e.g., animal waste), nutrients, herbicides, pesticides, and soil. When this runoff reaches a stream, it can upset the delicate balance maintained in the aquatic ecosystem. An overload of organic matter may cause severe oxygen depletion, rendering the stream unfit for many species of fish and other aquatic organisms.

Runoff from golf courses, cropland and residential lawns also introduces fertilizers, herbicides and pesticides into the receiving streams. The introduction of toxic substances such as herbicides and pesticides can cause extreme stress on fish and other aquatic life. Organisms that are easily impacted by these stresses will die or relocate to other areas of the stream. Riparian forests act as a buffer zone between the terrestrial ecosystems and the aquatic ecosystems, helping to reduce the impact of land dwellers on aquatic life (Malanson, 1993).

2.2 Riparian Corridor Ecosystem

2.2.1 Overview of Riparian Ecosystem

The watershed ecosystem consists of several smaller systems. The terrestrial ecosystem is comprised of the land and all that dwell on it-plants, animals and smaller organisms. The aquatic ecosystem is the water and bottom sediments with all of the living organisms that inhabit it. The third system is the riparian corridor. The riparian ecosystem is very important since it acts as a buffer, or transition zone, between terrestrial and aquatic ecosystems.

There are two general classifications of riparian forests, lentic and lotic. Lentic riparian forests surround standing water such as lakes and other impoundments. A special case of a lentic riparian forest is wetlands. Lotic riparian corridors are adjacent to moving water like streams and rivers (U.S. Department of the Interior, 1994). No two riparian ecosystems are the same. Physical, geographical, climatic and biotic processes define the riparian corridor (Binford and Buchenau, 1993). Three zones of a riparian corridor are commonly defined - runoff control, managed forest, and undisturbed forest - as shown in Figure 2.

Figure 2: Schematic of Three-Zone Riparian Forest Buffer (Lowrance, 1998)

The primary function of the runoff control zone (zone 3) is to remove sediment and convert channelized flow to sheet flow (Lowrance, 1998). Channelized flow is destructive (e.g., causing soil erosion) and provides less opportunity for biological uptake of pollutants in the managed forest zone (zone 2). The removal of nutrients and other pollutants occurs in zone 2 through adsorption onto accumulated sediment, fixation and biochemical degradation, and accumulation into the biomass of the vegetation in the riparian forest. Zone 1, the undisturbed forest, performs all of the functions carried out in zone 2. However, the primary function of zone one is the protection of the stream bank (Lowrance, 1998).

Riparian forests have many ecological functions and values. They improve water quality, provide habitat for wildlife, and offer recreation for humans. Several values of riparian ecosystems are listed in Table 1.

Table 1: Values of Riparian Ecosystems (Malanson, 1993)

Economic
Reduce downstream flooding
Recharge aquifers
Surface water supply in arid regions
Support secondary productivity, e.g. for fisheries
High yields of timber
Social
Recycle nutrients
Store heavy metals and toxins
Accumulate storage for sediments
Natural heritage
Recreation
Aesthetics
Natural laboratories for teaching and research
Biological
Special habitat for some endangered or threatened species
Refuge for upland species
Corridors for species movement

Riparian ecosystems, like others ecosystems, contain both living and nonliving components. All of these components interact through a complex network of physical, chemical, and biological processes, providing the benefits listed above.

2.2.2 Physical Processes

Two key physical processes occurring in healthy riparian forests are water retention and shading. Grass, shrubs, trees and other vegetation as well as litter from leaves and decaying plant life slow runoff as it passes through the riparian forest (Binford and Buchenau, 1993). Runoff moves through the riparian buffer in many fine streams (sheet flow). The litter on the riparian floor acts as a sponge, retaining water as it passes through and trapping sediments contained in the runoff. The reduction in velocity enhances infiltration, allowing more water to seep into the soil. The riparian forest also reduces the damage when flooding of a river occurs. During a flood, water is retained by the riparian corridor and released at a slower rate. This increases the duration of the runoff and decreases the peak flow of the hydrograph (Malanson, 1993). Increased infiltration coupled with a wide riparian canopy provides shading that reduces water temperature. Colder waters can hold more dissolved oxygen, leading to a greater capacity to degrade organic material and sustain aquatic life (Binford and Buchenau, 1993). The root systems of trees that line rivers also provide support to the stream bank, preventing excessive erosion. In addition, fallen trees and limbs provide habitat for aquatic life offering protection from predators and spawning areas.

Lower order streams are affected more by the riparian corridor condition than higher order streams. The lower order streams lack the depth and water volume of higher order streams, and are therefore more susceptible to solar radiation. A decrease in riparian vegetation in headwaters results in poorer water quality downstream (e.g., warmer temperatures, lower dissolved oxygen, higher nutrient and suspended solids concentrations).

2.2.3 Chemical and Biological Processes

There are six important elements that comprise 95% of all living biomass- carbon, hydrogen, oxygen, nitrogen, phosphorus and sulfur (Binford and Buchenau, 1993). Nutrients cycle between living and nonliving matter. In order for nutrients to be utilized by plant life they must be converted to their mineral form (Binford and Buchenau, 1993). Biotic processes at work in riparian corridors are either aerobic or anaerobic and include nitrification, denitrification, and uptake of nutrients by plant life. Nitrification, the conversion of ammonia (NH_3) to nitrate (NO_3^-) by soil bacteria, occurs under aerobic conditions. The removal of nitrogen by microorganisms, denitrification ($NO_3^- \rightarrow N_2$), occurs under anaerobic conditions. These processes contribute to the removal of nitrogen from runoff entering the riparian corridor (Binford and Buchenau, 1993). Uptake by plants occurs when nutrients are utilized from the soil to promote vegetative growth. The vegetation and soil in a healthy riparian forest can remove up to 99% of the total phosphorous and anywhere from 10 to 60% of the total nitrogen (Binford and Buchenau, 1993). The overall capacity of a riparian forest to remove nutrients depends on its width, vegetation, and slope. A smaller slope translates to a lower velocity of runoff. This, along with a greater width of riparian corridor, contributes to a longer period of contact between runoff water and riparian vegetation, increasing the possibility of nutrient removal.

The decomposing leaf and vegetative litter act as a source for carbon in the riparian forest and adjacent stream. Carbon entering the stream acts as a food source for invertebrates. The vegetative litter also acts to trap contaminants such as herbicides, providing a greater chance for biological uptake and adsorption.

2.2.4 Channelization and Impoundment of Streams

Certain physical changes to a stream channel can alter flow patterns. Channelization is the straightening and deepening of a stream to increase its hydraulic capacity. In addition, dams and impoundments may be constructed along a stream for flood storage, water source or recreation.

The alteration of flow effects the spatial dynamics of the river, often leading to a decrease in sinuosity. This usually leads to a decrease in the width of riparian corridor (Malanson, 1993). Severe channelization leads to discontinuity in the riparian ecosystem. Discontinuous riparian corridors limit the quality of habitat for wildlife, removal of nutrients and sediment, groundwater recharge and the shade provided to keep the stream cool in summer. Channelization leads to an overall reduction in river length, possibly also decreasing the length of the riparian corridor (Binford and Buchenau, 1993). An increase in downstream flooding and bank erosion is likely due to the increased hydraulic capacity of channelized streams. Channelization allows land development closer to the stream. This increases the flux of contaminants into a reduced riparian zone, thereby increasing the loading of contaminants to the stream.

2.3 Laws and Regulations

2.3.1 Wild and Scenic Rivers Act 1968

The importance of wildlife and river conservation in America was stressed in 1968 when Congress passed the Wild and Scenic Rivers Act (WSRA). This established the leading national policy for the general protection of America's waterways (Bureau of Reclamation, 1999). The WSRA set guidelines and definitions for three basic categories. It was designed to protect wild rivers, scenic rivers, and those used for recreation.

Wild rivers were defined as being free from impoundments, accessible by trail only, with unpolluted water and undeveloped shorelines. Scenic rivers must also be free from impoundments, yet their shorelines are mostly undeveloped and access can be by roadway. Recreational rivers are those rivers that are readily accessible and have developed shorelines (National Park Service, 1999). Development of the land adjacent to wild and scenic rivers is allowed only if it is not damaging to the free flow of the river or the resources that the river provides.

2.3.2 Clean Water Act

The Clean Water Act (CWA) of 1972 provided more precise definitions of pollutants and limits on their discharge into streams and rivers. Section 305(b) of the Clean Water Act requires biannual surveying of the fishable and swimmable waters by the states (Lowrance, 1998). The CWA limits the amount and type of pollution from point sources through the National Pollutant Discharge Elimination System (NPDES) permitting. NPDES permits typically place limits on point source discharges of such pollutants as nutrients, suspended solids, organic matter and bacteria into receiving waters. Regulatory agencies use a waste load allocation process based on the mass balance approach to set discharge limits.

2.3.3 Warm Water Habitat

The water quality standards in Ohio contain several aquatic use designations established by the CWA. The use designation consists of two basic elements: the potential of a water body to support certain species and the water quality standards designed to protect those species. There are four types of use designation: aquatic life habitat, water supply, recreation and state water resource (OEPA, 1999). The aquatic life habitat contains several sub-classifications - exceptional warm water habitat, warm water habitat, modified warm water habitat, cold water habitat, limited resource water, and nuisance prevention. The nuisance prevention and the limited warm water habitat classifications are currently being phased out of use (OEPA, 1999). Recreational use designations include bathing water, primary and secondary contact recreation. Primary contact designation applies to water suitable for full body contact, swimming and canoeing. Partial body contact, wading, is the secondary contact designation. The water supply classifications include industrial, agriculture and public water supply.

The WWH designation is typical of the Erie and Ontario Lake Plains ecoregion. WWH is defined as a system capable of supporting and maintaining a balanced, integrated, adaptive community of aquatic life and benthic organisms (USEPA, 1999). Non-attainment of the WWH criteria is an indication that the biological integrity needs to be restored. Table 2 summarizes the WWH guidelines.

Table 2: Partial List of WWH Guidelines (OEPA, 1995)

Parameter	Limit
Ammonia-N*	
maximum	1.1 - 13.0 mg/L
30 day average	0.1 - 13.0 mg/L
Dissolved Oxygen*	
minimum at any time	4.0 mg/L
minimum 24-hour average	5.0 mg/L
Dissolved Solids*	
maximum 30 day average	1500 mg/L**
Iron*	
30 day average	1.0 mg/L
pH*	6.5 - 9.0
Polynuclear Aromatic Hydrocarbons (PAHs)*	
Human Health 30 day average	0.00031 mg/L
Index of Biotic Integrity (IBI) fish	
Wading	38
Boat	40
Headwater	40
Modified Index of Well Being (ModIWB) fish	
Wading	7.9
Boat	8.7
Invertebrate Community Index (ICI) macroinvertebrates	34
Qualitative Habitat Evaluation Index (QHEI)	61

* denotes measured outside of mixing zone

** denotes equivalent 25°C specific conductance value is 2400μΩ

2.4 Qualitative Habitat Evaluation Index (QHEI)

2.4.1 General Description of QHEI

The QHEI empirically measures the quality of a river habitat and its ability to support aquatic life. The QHEI is not an all-encompassing parameter. It was designed to assess the physical characteristics that effect fish communities (OEPA, 1989). The constraints that the QHEI was developed under were the ease of use with moderate field verification, the inclusion of factors that effect fish communities and reproduction of results by different personnel. The QHEI is based on six attributes that were determined to be interrelated and affect the fish communities in streams. The QHEI focuses on macro-scale properties of a stream such as sinuosity and pool development rather than the current velocity and depth of the stream (OEPA, 1989).

2.4.2 Metrics of QHEI

There are seven metrics which comprise the QHEI. The total possible score is 100 for each area assessed. The higher scores are typical of streams that exhibit diversity in aquatic life and other biological indices. Table 3 contains a summary of the different metrics and the associated scores. Tables 4 and 5 summarize guidelines for the interpretation of QHEI scores.

Table 3: Metrics of the QHEI (OPEA, 1989)

Substrate			**20 pts.**
	1) Type	0-20	
	2) Quality	-5-3	
Instream Cover			**20 pts.**
	1) Type	0-9	
	2) Amount	1-11	
Channel Quality			**20 pts.**
	1) Sinuosity	1-4	
	2) Development	1-7	
	3) Channelization	1-6	
	4) Stability	1-3	
Riparian/Erosion			**10**
	1) Width	0-4	
	2) Flood Plain Quality	0-3	
	3) Bank Erosion	1-3	
Pool Rifle			**20 pts.**
	1) Max Depth	0-6	
	2) --		
	3) Current Available	-2-4	
	4) Pool Morphology	0-2	
	5) Riffle/Run Depth	0-4	
	6) Riffle Substrate Stab.	0-2	
	7) Riffle Embeddedness	-1-2	
Drainage Area		**not**	**Included**
Gradient			**0-10 pts**
Total Score			**0-100**

Table 4: Habitat Categories for Ranges of QHEI (OEPA, 1989)

QHEI	**Habitat Quality**
0-40	Very Poor
41-50	Poor
51-60	Fair
61-70	Good
71-80	Very Good
81-90	Excellent
91-100	Extraordinary

Table 5: Interpretation of the QHEI (CSU, 1999)

Score	Meaning
> 60	Stream segment suitable for Warmwater Habitat without impairment
45-60	Stream segment may meet Warmwater Habitat, but may show a level of impairment
32-45	Stream Segment meets modified Warmwater Habitat
< 32	Stream Segment may be suitable for Modified Warmwater Habitat

2.4.3 Riparian Metric

The riparian metric focuses on the stream bank and the quality of the flood plain vegetation. The scoring system for the riparian corridor includes the width of the riparian corridor, predominant vegetation, land use, and condition of the stream bank, with the maximum score being 10 (see Table 3 for scores). The right and left banks (looking downstream) are scored individually, and the average of both banks is used to score the section delineated (OEPA, 1989).

The width of the streamside vegetation is one of the indices accounted for in the riparian metric of the QHEI. The wider the riparian forest the greater the score. Wide riparian zones provide greater protection from nonpoint source pollution and better aquatic habitat. More than one classification for each bank can be accommodated during delineation of each segment. The score for each segment is then the average of all classifications. Table 6 shows the scores based on width for the riparian metric.

Table 6: Riparian Width Scoring (OEPA, 1989)

Classification	Width	Score
Wide	> 50 m	4
Moderate	10-50 m	3
Narrow	5-10 m	2
Very Narrow	< 5 m	1
None	0 m	0

The flood plain quality focuses on the area immediately outside the riparian corridor or 100 feet from the stream, whichever is greater (OEPA, 1989). It accounts for the vegetation and the use of the land. The land use is classified in one of four categories: conservation or tillage, urban or industrial, open pasture/row crops, or mining and construction. As with the width of the riparian corridor, both banks are rated and more than one classification for the flood plain may be checked. The average is then taken to obtain the overall score of the area delineated. The scoring system for floodplain quality is shown in Table 7.

Table 7: Riparian Floodplain Quality Scoring (OEPA, 1989)

Vegetation	Score
Forest / Swamp	3
Shrub / Old Field	2
Residential, Park, New Field	1
Fenced Pasture	1
Conservation Tillage	1
Urban or Industrial	0
Open Pasture/Row Crops	0
Mining / Construction	0

Bank erosion is the final component of the riparian metric. The rating used in the QHEI for the streambanks is from Platts. There are five possible classifications of bank erosion and three scores. Little or no erosion receives a score of three. No erosion of streambanks applies to those reaches that have not been altered by water flow or animals. Slightly altered streambanks are those that have undergone less than 25% stress. Streambanks that have been moderately altered from the natural state are those with less than 50% of the original streambank under stress or alteration (OEPA, 1989). Heavy erosion of a streambank refers to major alterations along the stream. It is characterized by over 50% of the streambank being false, degraded, or altered (OEPA, 1989). Severe erosion of a streambank is classified by the OEPA as those reaches have less than 25% of the original bank in a stable condition. The QHEI scoring for erosion of streambanks is summarized in Table 8.

Table 8: Streambank Erosion Scoring (OEPA, 1989)

Classification	Score
None / Little	3
Moderate	2
Heavy / Severe	1

2.5 Water Quality in Yellow Creek

Several previous studies on water quality have been performed on Yellow Creek. The two main water quality problems of the Yellow Creek Watershed are nutrients and sedimentation (Martin, 1999). The nutrients of greatest concern are phosphorus and nitrogen. The nutrients can come from combined sewer overflows, leaking septic systems, and agricultural runoff.

An in-depth study was performed on Lake Hamilton by Dr. Lauren Schroeder and others from the Youngstown State University Biology department. The study was performed for Consumers Ohio Water Company. The results of the study indicated elevated levels of phosphorus, 50 to 200 μg/L (Martin, 1999). Nitrate concentrations in Lake Hamilton are also elevated. The levels of NH_3-N in Lake Hamilton are often above 200 mg/L (Korenic, 1999). Elevated levels of phosphorus and nitrate cause accelerated eutrophication of lakes, characterized by heavy algal growth, oxygen depletion, and occasional fish kills. In 1992, nutrient studies were performed by a graduate student from Youngstown State University (Abbas, 1992). Extensive water samples were collected from Lake Hamilton and analyzed for soluble reactive phosphorus, total soluble phosphorus, nitrate, ammonia and chlorophyll a. Abbas concluded that Lake Hamilton displayed a eutrophic status by utilizing Vollenweider's loading plot (Abbas, 1992). The total phosphorus loading was estimated at 2524 kg/Yr, and it was estimated that a 60% reduction is needed to reduce the trophic status to mesotrophic (Abbas, 1992).

Testing performed by the Ohio EPA near the mouth of Yellow Creek in 1994 found the stream to be in non-attainment status of the warm water habitat criteria (OEPA, 1996). Although the QHEI score showed adequate habitat, the reach sampled was in non-attainment. The results of the sampling results are shown in Table 9.

Table 9: Aquatic Life Use Attainment Status for the Mouth of Yellow Creek (OEPA, 1996)

River Mile	IBI	Mod Iwb	ICI	QHEI	WWH Status
1.0	22	5.3	Good	65.5	non-attainment

A summary of water quality issues was presented to AWARE by Korenic and Martin. A discussion of problems was held in the Summer-Fall of 1998 as part of a watershed planning process. The prioritized list of the problems in the Yellow Creek Watershed developed by AWARE is presented in Table 10.

Table 10: Prioritized Problems in the Yellow Creek Watershed (Korenic, 1999)

North	South
Degraded Habitat	Degraded Habitat/Nutrients (tie)
Sediments	Sediments
Other NPS	Other NPS
Nutrients	Mine Drainage
Low Dissolved Oxygen	Low Dissolved Oxygen
Pathogenic Organisms	Invasive Species
Invasive Species	Pathogenic Organisms
Flooding	Flooding
Mine Drainage	

Due to the elevated nutrient loading to Lake Hamilton, excessive algal growth occurs. The decomposition of algae depletes dissolved oxygen (D.O.) faster than it can be returned to the water column. Severe D.O. depletion results in the formation of hydrogen sulfide (HS) in the hypolimnion of Lake Hamilton during the summer months (Korenic, 1999).

Chapter 3

METHODS AND PROCEDURES

3.1 Riparian and Floodplain Evaluation

In order to evaluate the riparian and floodplain condition of the Yellow Creek watershed, two types of maps were used: USGS (United States Geological Survey) 7.5-minute topographical maps and blue-line aerial photographs. The USGS maps were used as a guide for referencing the general location of streams in the Yellow Creek Watershed. The aerial photographs of the Yellow Creek Watershed were used for the riparian and floodplain delineation.

In order to distinguish between the different streams that flow into Yellow Creek, an alphabetical/numerical designation was developed. Starting with the southern portion of the watershed, direct tributaries to Yellow Creek were given a designation of YCx (where x = A, B, C…) provided the stream name was unknown. The process continued until all streams were given a designation. For streams that flowed directly into lakes, a numerical process was used. Starting from the southern section of the lake, the first stream was given the numerical value of 1(e.g., Pine Lake 1, PL1). For secondary tributaries that flowed into the main tributary streams, additional alphabetical and/or numerical designations were added. Two tributary stream names were known - Burgess Run and Drake's Run. The tributaries that flow into these streams were named using the first letters of the stream name followed by a number (e.g., DR1, DR2…; BR1, BR2,…). Figure 3 displays the designations of all streams in the Yellow Creek Watershed.

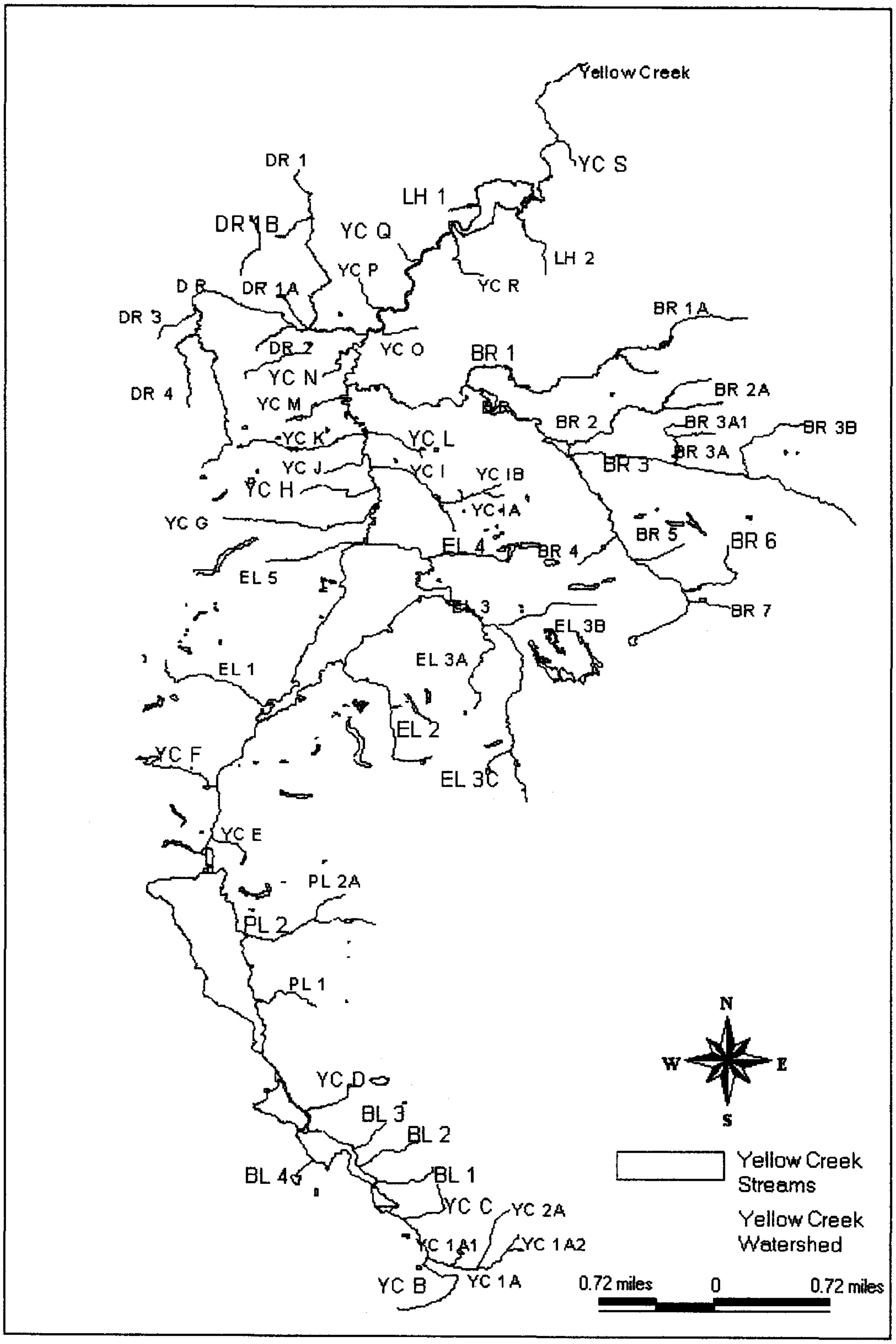

Figure 3: Stream Names for the Yellow Creek Watershed (modified USGS 1:24000 DLGS, 1998)

Each stream was the divided into 600 ft increments using aerial photographs. Aerocon Photogrammetric Services, Inc. of Willoughby Ohio developed the aerial photographs, obtained from EDATA (Eastgate Development and Transportation Agency), in spring 1996. The approximate scale was 1 in = 400 ft. Aerial photographs of the portion of the Yellow Creek watershed that lies in Columbiana County were purchased from the Columbiana County Engineer's office. Photogrammetric Services, Inc. in Reynoldsburg, Ohio flew them in March of 1983. The approximate scale was 1 in = 330 ft.

The 600 ft increments were measured on the aerial photographs using a piece of paper and a pencil. For the 1 in = 400 ft aerials, a 1.5in. long section of paper was used. For the 1 in = 330 ft photographs, a 1.82 in section was used. Once a 600 ft segment was marked, it was given a number associated with the stream. Two templates were made from plexiglas, one for the 1in : 400 ft aerials (shown in Figure 4) and one for the 1 in : 330 ft aerials. The template dimensions were scaled so that it would cover 600 ft along the stream with a width of 200 ft on each side. For the 1 in : 400 ft photos, the inner dimensions were 1.5 in long by 1 in wide, with outer dimensions of 2 in long by 1.5 in wide. Holes were drilled on the top and bottom edges. Strings were then threaded through the holes. There was one string along the centerline, one string that corresponded to 10 meters from centerline and one string which corresponded to 50 meters from the centerline. These are the widths evaluated for the riparian metric of the QHEI.

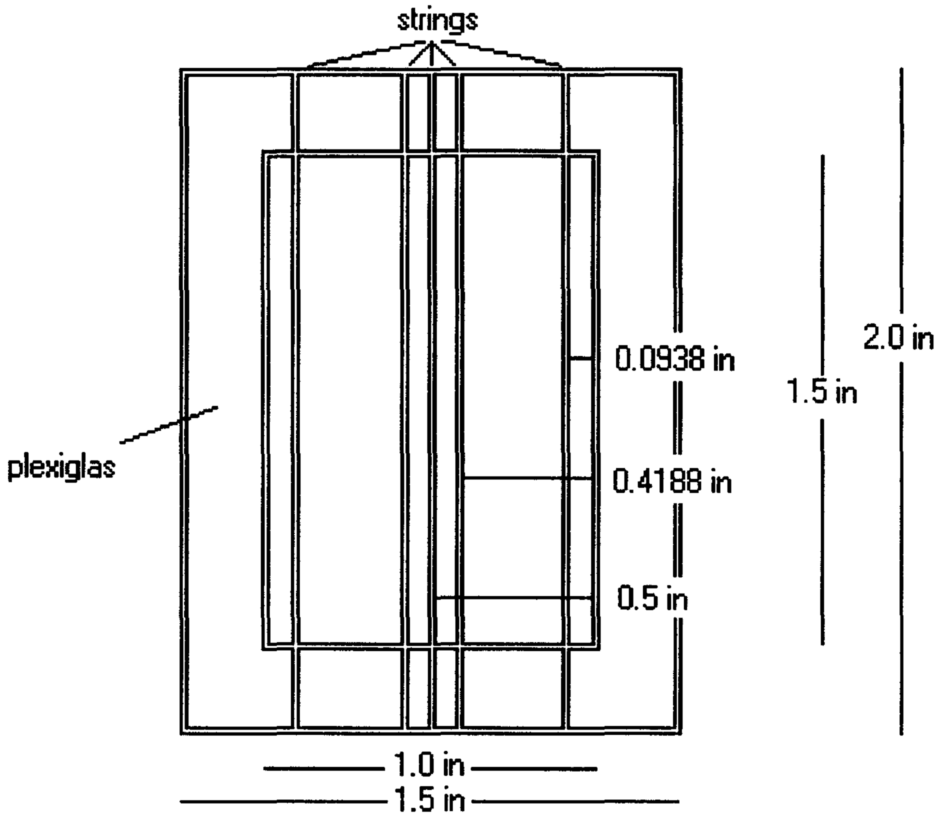

Figure 4: Schematic of Template used on 1 in : 400 ft Aerial Photographs

Once all streams were divided into 600-ft. segments, the appropriate template was placed over each section. The centerline was placed on the edge of the stream when there was significant width to the stream. Two hundred feet was examined on each side of the stream and scored using the riparian metric from the QHEI (see Tables 6 and 7). Two hundred feet on both sides of the streams was used as a standard (Pritchard, 1999).

The first feature examined was the width of the vegetation. Using the lines on the template as a guide, the appropriate box was checked on a score sheet for each side of each section. If there was more than one width of vegetation with a significant length, all applicable boxes were checked. Significant length was considered to be at least 100 feet.

All of the boxes that were checked for the left and right side of the section were added and averaged for a riparian width score. An example is shown in Table 11.

Table 11: Example Scoring of Riparian Width

Segment	wide_left	wide_right	mod_left	mod_right	narr_left	narr_right	vnarr_left	vnarr_right	none_left	none_right	ripar_sub
6	4	4		3							3.70

For segment 6, shown in Table 11, both the right and left side displayed a riparian width of 50 meters or greater. The right side of the stream also had a section along the river that was between 10 and 50 meters. Therefore, the wide boxes were marked for both the left and right sides, and the moderate box was checked for the right side. The sum of the boxes checked was 11. Dividing the sum by the number of boxes checked, for segment 6: it was three, gave a score of 3.70 for the riparian width score.

Once the riparian width was scored, the flood plain quality was then inventoried. The evaluation of the floodplain quality was approached in the same way as riparian width. The template was placed over the region being examined, and the floodplain qualities were recorded for 200-ft. on both sides of the segment. All occurrences in the floodplain were marked on the score sheet and averaged to obtain the floodplain quality subtotal. An example of a floodplain score is shown in Table 12.

Table 12: Example Scoring for Floodplain Quality

Segment	forr left	forr right	shru left	shru right	past left	past right	res left	res right	crop left	crop right	till left	till right	urb left	urb right	mine left	mine right	flood sub
6	3	3	2							1							2.30

The riparian width and floodplain scores were then added to obtain the overall score of the riparian metric excluding the stream bank erosion. The maximum possible scores are 4.0 for riparian width and 3.0 for the floodplain quality. This makes the total possible score for each section 7.0.

After all sections were scored, all the information recorded by hand was entered into an Excel spreadsheet. The spreadsheet was then saved as a database file. The database file was then imported into Arcview to be used for the generation of maps and as an information base.

3.2 GIS

The GIS software used, ArcView, was developed by Environmental Systems Research Institute, Inc. (ESRI). Starting with digital line graphs (DLGs) from the United States Geological Survey (USGS), the streams in the Yellow Creek watershed were modified to account for inaccuracies. Some of the streams on the DLGs were too long, too short or not present. Since the aerial photographs were considered more accurate than the 7.5-minute USGS quadrangle maps, stream lengths were extended, shortened, or added when necessary to make the DLG maps consistent with the aerial photographs.

When using ArcView, it is required that certain fields in an attribute table be unique, such as a name or identification number. Other attributes, such as polygon shapes, do not have to be unique. Streams were divided in the same way as with aerial photographs using the ArcView breaking tool. Each segment was given a unique segment number. The ArcView measure tool and road attributes were used to transfer segment boundaries as accurately as possible from the aerial photographs to ArcView.

Some of the stream sinuosity was lost due to inaccuracies from digitizing. This led to smaller stream lengths when using the ArcView measure tool. The stream segment numbers served as identification for the information recorded in the database file. The stream segment numbers ranged from 1 to 679, and included the four major lakes.

A reference line was drawn down the middle of the lakes. A line drawn perpendicular to the centerline was then drawn to segment the floodplain surrounding the lakes. This was done as an approximation. The actual length along the perimeter of the lake is much longer.

Once the stream was segmented, the segment field in the DLG attribute table was then linked to the dbase file that contained all of the information (riparian width and floodplain quality rankings) from the aerial photo delineation. A separate database file was also created containing stream segment numbers and the appropriate stream names. Using the stream segment as a common field, this file was linked to the DLG attribute table.

3.3 QHEI

The full QHEI evaluation was performed on 14 sites throughout the Yellow Creek watershed. Six metrics were examined at each location: substrate quality, instream cover, channel morphology, riparian zone, pool/glide and riffle/run quality. The seventh metric (gradient) was computed through the use of USGS 7.5-minute topographical maps. At each site, a reach was examined by walking up and down the stream noting and recording the various attributes associated with the QHEI score sheet (see Table 3).

Three sites were used as test locations to check the consistency of field QHEI procedures. Score sheets from the 1994 Ohio EPA survey of the Mahoning River Basin were obtained for the Mill Creek and Yellow Creek watersheds and served as verification of proper procedures. Two of the sites selected for comparison were located in the Mill Creek Watershed; the remaining site was in the Yellow Creek Watershed. The results from the Ohio EPA survey of 1994 and the field ratings obtained in this study are compared in Table 13.

Table 13: QHEI Results from OEPA and Trial Sampling

Metric	**Mill Creek R.M. 1.5**		**Mill Creek R.M. 7.7**		**Yellow Creek R.M. 1.0**	
	OEPA	Field	OEPA	Field	OEPA	Field
Substrate	19.5	17	2.5	1	16.5	16
Instream Cover	11	15	6	11	12	10
Morphology	16.5	16	7	11.5	16	14
Riparian	10	9.7	9	9.5	7	8.5
Pool/Glide	8	7	6	5	6	8
Riffle/Run	4	4	2	0	4	4
Gradient	4	4	4	4	4	4
Total	**73**	**72.7**	**36.5**	**42**	**65.5**	**64.5**

Results for sampling test sites were reasonably consistent with the Ohio EPA surveys except for two metrics for Mill Creek river mile 7.7. The instream and channel morphology metrics displayed the largest deviation from Ohio EPA results. The discrepancy of the instream metric results from differences in interpreting the amount of overhead vegetation. The Ohio EPA rated this location as sparse. This rating carries a score of 3.0. The rating that the same location received as a test site was moderate. The moderate score is a 7.0, leading to a difference of 4.0. The difference in channel morphology rating is related to the amount of channelization. The Ohio EPA rated the area as recovering, with a score of 3.0. When sampled, the same site displayed no channelization and received a score of 6.0. The sum of these two differences accounts for the major deviation at this site. The other two sites displayed no significant deviation in total QHEI scoring.

The substrate metric involves inventory of the substrate type and quality. Extra points are given to a stream segment that contains 5 or more different substrates in significant quantities. The origin of the substrate was also accounted for in the scoring of this metric. The larger the substrate particles, the higher the score. The embeddedness of substrate was determined by examining the degree to which larger particles were buried by smaller particles. The substrate quality was determined by examining the amount of silt stirred up in removing substrate from the streambed.

The instream cover metric is a measure of diversity of habitat in the stream channel. By examining the composition of the stream cover, points are assigned for woody debris, undercut banks and other features that make good spots for propagation of aquatic species. A subjective portion of this metric is the amount of overhead cover. This refers to the percentage of the stream channel covered by overhead vegetation. The instream cover metric is very sensitive to this rating.

The channel morphology metric accounts for sinuosity, development, channelization and stability. The development of the stream was determined by examining the flow patterns and shape of the streambed (i.e. riffle/pool system). If riffles are absent or accompanied by sand and fine gravel, it is considered a poor system. Conversely, excellent development refers to pools with a depth greater than 1 meter and deep riffles. The stability was determined by examining the erosion potential and stream banks. A channel with low stability is comprised of fine substrate particles with riffles that change direction often. This type of stream bank yields a high bed load that moves downstream.

The first portion of the riparian metric was the width of vegetation. The width was estimated by pacing a perpendicular path from the stream to the edge of the riparian vegetation. More vegetation correlated to a greater riparian score. Floodplain quality was evaluated by observing the land use within 50 m of the stream on either side, and marking the appropriate box on the QHEI score sheet. Since all sampling locations were located near bridges and roads, all of the sampling locations had urban boxes marked in the floodplain scoring. There was only one location (Poland Forest) that did not have the urban boxes marked. The bank erosion was an inventory of the condition of the banks (none, moderate, severe).

The pool/glide and riffle/run quality metric stresses the quality of habitats provided by developed pools, glides and/or riffles and runs. The rating is based on depth and width of pools and riffles. Points are deducted for destructive (torrential) and very slow moving (intermittent and interstitial) currents.

The gradient metric was performed using USGS 7.5-minute topographical maps. The stream gradient was calculated by measuring the distance from the first contour line immediately upstream of the sample location to the first contour line downstream and dividing by the drop in elevation. If the contour lines are closely spaced, the QHEI manual recommends a minimum distance of 1 mile. The stream gradient was calculated in ft/mi.

Chapter 4

RESULTS

4.1 General Results

The evaluation of riparian and floodplain quality in the Yellow Creek watershed from the aerial photographs yielded 679 segments along 62 individual streams and the 4 major lakes. The total length of all streams and lakes in the Yellow Creek Watershed totals approximately 77.16 miles. The distance measured for the lakes was along the centerline.

4.1.1 Riparian and Floodplain Evaluation

The degree to which the riparian forests have diminished due to human activity is difficult to approximate. However, it is important that an effort be made to track such changes. The data from this study were used to obtain an estimate of total riparian forest acreage in the Yellow Creek watershed.

Assuming that there is a linear relationship between the score received for the width of the riparian forest and the actual width of vegetation, approximations can be made for the average width of vegetation in each section. Using the widths and scores set by the QHEI procedure, and letting the width ranges and scores operate as boundary conditions, Figure 5 was constructed.

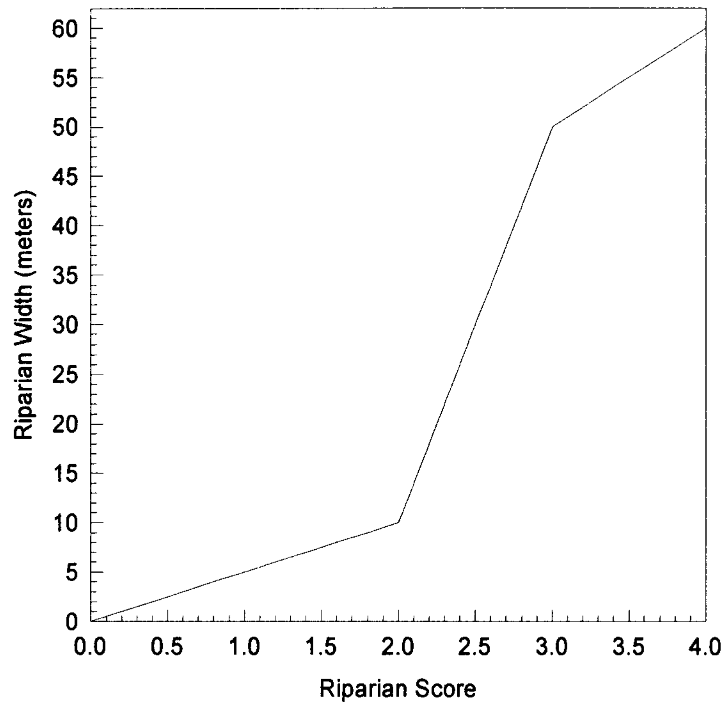

Figure 5: Assumed Relationship between Riparian Width and Riparian Score

Using Figure 5 as a correlation between riparian width score and actual width of riparian forest, the total acreage of riparian forest was calculated using the following formula:

$$Area = C * \frac{L * W}{Ac}$$

Where: Area ≡ acres

L ≡ length of segment in feet = 600 ft

W ≡ width of riparian zone in meters (taken from Figure 5)

Ac ≡ 43560 ft^2/acre

C ≡ conversion factor = 3.25 ft/m

The total area of riparian zone was then summed over the number of transects. In order to account for both sides of the stream, the total was multiplied by 2.

$$A_t = 2 * \sum_{i=1}^{n} (Area)_i$$

Where: A_t ≡ total area of stream riparian zone

$(Area)_i$ ≡ individual transect area

n ≡ number of transects per stream

The resulting total area for the riparian corridors is presented in Table 14.

The sum for all streams in the Yellow Creek Watershed yielded a total riparian zone of approximately 2,070 acres. The average score for riparian width in the Yellow Creek watershed is (1.53 out of 4.0). The average width of riparian corridor that scored a 4 was at least 60 meters. Assuming that this is what the width should ideally be leads to an overall total of 3,682 acres, including the buffer surrounding the four lakes in the watershed. The current riparian acreage is 43.8% below this projection. This reduction can be attributed to development and farming practices that have encroached upon the riparian zone. An increase in riparian width of 1 meter on each side throughout the watershed would result in an approximate increase of 60 acres of riparian forest, 30 acres per side. This would increase the average riparian width score from 1.53 to 1.55. An increase of 10 m per side would yield 600 additional acres of riparian forest. The average score would then increase to 3.13.

Table 14: Total Riparian Area for Streams in the Yellow Creek Watershed

Stream Name	Total Riparian Area (acres)	Stream Name	Total Riparian Area (acres)
Yellow Creek(YC)	388.2	YCM	17.3
YCB	14.1	Burgess Run(BR)	109.7
YC1a	37.6	BR1	91.8
YC1a1	5.2	BR1a	19.7
YC1a2	0.9	BR2	43.3
YC2a	36.6	BR2a	26.2
YCC	17.9	BR3	78.4
BL1	7	BR3a	19.9
BL2	15.1	BR3a1	6.3
BL3	9	BR3b	5.8
BL4	1.1	BR4	14.3
YCD	1.6	BR5	15.6
PL1	17	BR6	18
PL2	17.9	BR7	0.9
PL2a	2.7	YCN	16.3
YCE	6.7	Drakes Run (DR)	120.7
YCF	9.6	DR1	46.1
EL1	28.6	DR1a	1.8
EL2	46.6	DR1b	0.9
EL3	88.7	DR2	35.9
EL3a	37.7	DR3	32.5
EL3b	21.4	DR4	46.4
EL3c	6.1	YCO	6.3
EL4	28.7	YCP	9.8
EL5	18.8	YCQ	1.4
YCG	46.7	YCR	8.6
YCH	27.6	LH1	1.1
YCI	58.3	LH2	19
YCIa	12.2	YCS	14
YCIb	6.8	Lake Hamilton	28.9
YCK	37.5	Evans Lake	45.2
YCJ	20.8	Pine Lake	55.6
YCL	11.8	Beaver Lake	25.5

Further examination of Table 14 reveals that ten streams have an average riparian corridor width less than 10 meters per side. Analysis of the floodplain quality shows 45% of the streams with less than 10 meters of riparian buffer contained agricultural practices. Areas that have undergone urbanization ("urban sprawl") accounted for the remaining 55%. The results are shown in Table 15.

Table 15: Streams With Less than 10 Meters of Riparian Buffer

Stream Name	Avg. Width per Side (meters)	Surrounding Floodplain Activities
BR7	3.27	Urbanization
YC1a2	4.90	Agriculture
DR1b	4.90	Urbanization
YCD	5.81	Agriculture
BL4	5.99	Agriculture
LH1	5.99	Urbanization
DR1a	6.53	Urbanization
PL2a	7.35	Agriculture
YCQ	7.62	Urbanization
BR3b	7.90	Agriculture/urbanization

Using the QHEI ranges, riparian widths less than 10 meters fall into one of three categories: none, very narrow and narrow. The types of problems associated with reduction in riparian corridor in urban areas differ from those in agricultural areas. Both areas introduce serious problems to the streams' quality and the possible well being of aquatic life. High nutrient loading and suspended solids are the primary issues in floodplains that contain agricultural practices. Lawn chemicals (fertilizers and herbicides), oil, road salt, and trash are primary pollutants in urbanized areas.

4.2 GIS Evaluation

A geographical information system (GIS) was constructed using the database built from the aerial photo delineation. Upon completion of the data entry, three maps were developed using ArcView software in order to help visualize the condition of Yellow Creek Watershed. These maps show riparian score, floodplain score and the sum of the two. To develop the GIS database, the attribute table that accompanied the USGS DLGs was first modified to represent the individual stream segments that were analyzed. A segment number field was added to the attribute table. The segment field in the modified

USGS attribute table was linked to the segment field in the database built from the aerial photograph delineation. Once the two fields were linked, segment information about the riparian width, floodplain, and total scores could be graphically represented. The graphical displays were useful in identifying areas of concern and developing a network of sampling stations for future study.

4.2.1 Riparian Scoring Results

The headwaters of any watershed are the most susceptible to human impact. The Yellow Creek Watershed is no exception. The majority of the riparian corridors that have had detrimental impact in the Yellow Creek Watershed are located around the headwaters (see Figure 6).

Rapid development in Boardman and Poland townships has not been without its costs. Riparian forests have been steadily decreasing due to recent growth. The riparian forests along the intermittent streams that flow into Drake's Run have been severely impacted by urbanization. Two of the streams that flow into Drake's Run have a riparian buffer less than 10 meters wide. With heavy traffic in this area, large amounts of pollutants can enter the streams. Salt applied to roads in the winter months, coupled with runoff from melting snow, can be major source of pollution. Oils, grease, antifreeze and trash also contribute to the pollution that the streams may receive from paved roads throughout the year. Without a good riparian buffer, these pollutants can enter the stream with little biological uptake, thereby increasing the severity of damage to the aquatic life.

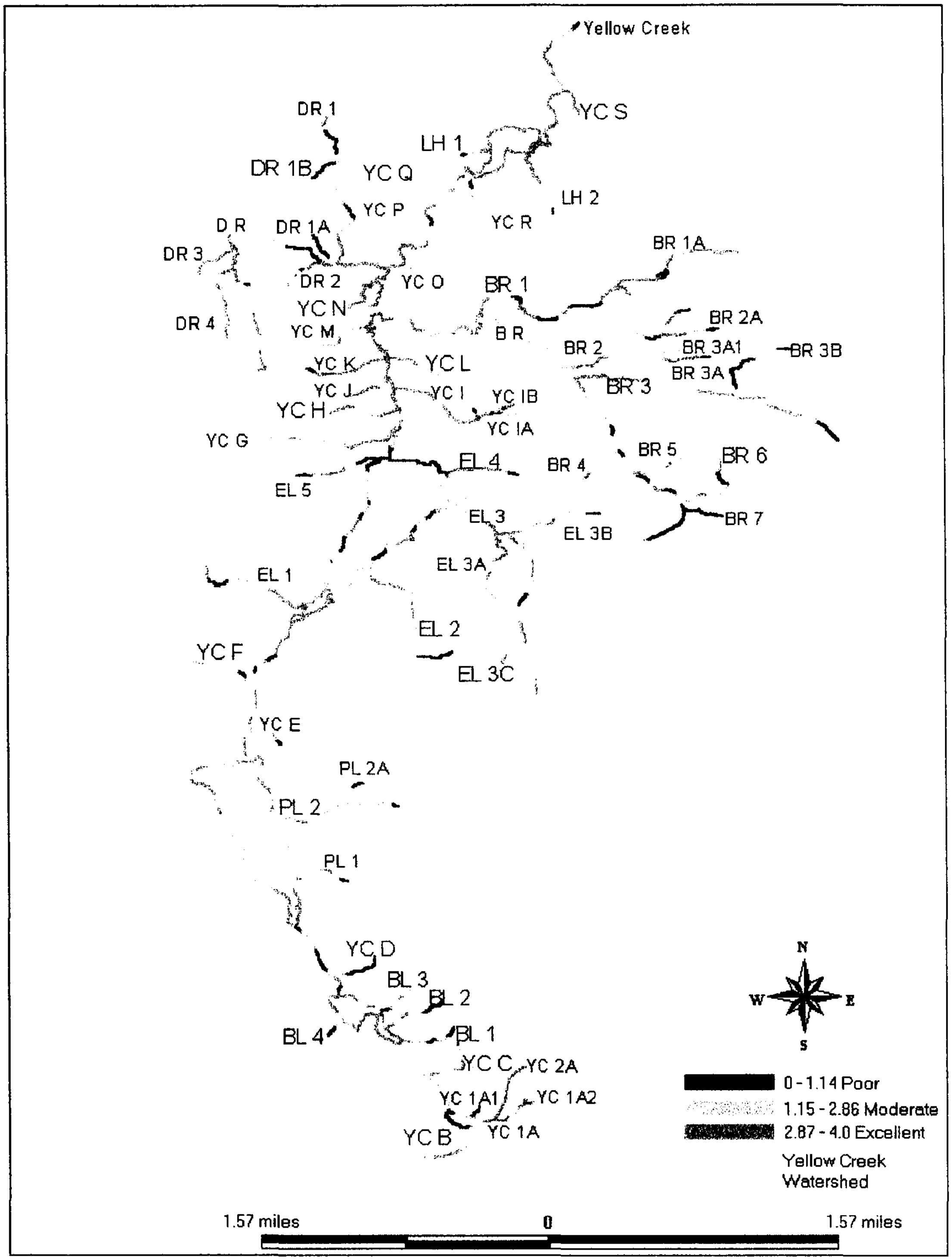

Figure 6: Riparian Width Scoring of QHEI (modified USGS DLGS, 1998)

Evans Lake has a unique issue uncommon with the rest of the watershed. Inactive strip mines located on the eastern and western sides of the lake allow acid drainage to enter the headwaters surrounding the lake. Diminished riparian forests adjacent to these streams are not effective in reducing the pollutants from the abandoned strip mines. The agricultural practices south of Evans Lake have left narrow riparian buffers, leading to possible high nutrient and suspended solids loading.

4.2.2 Floodplain Scoring Results

There are several areas in the Yellow Creek Watershed that have a poor floodplain score. The map which shows the Floodplain Scoring for Yellow Creek Watershed is presented in Figure 7.

The average condition of the Yellow Creek Watershed floodplain is in the moderate range, with a mean score of 1.24 (out of 3.0). On average, the condition of the floodplain for all four lakes scored in the poor range. This can be attributed to the development that commonly occurs around lakes. There were 21 streams and lakes that scored in the poor range, which translates to 31.8% of all streams inventoried. For the streams and lakes that scored less than 1.0 on average, there is a combination of residential, urban and/or agricultural practices. Table 16 shows a complete listing of all streams and lakes that scored in the poor range.

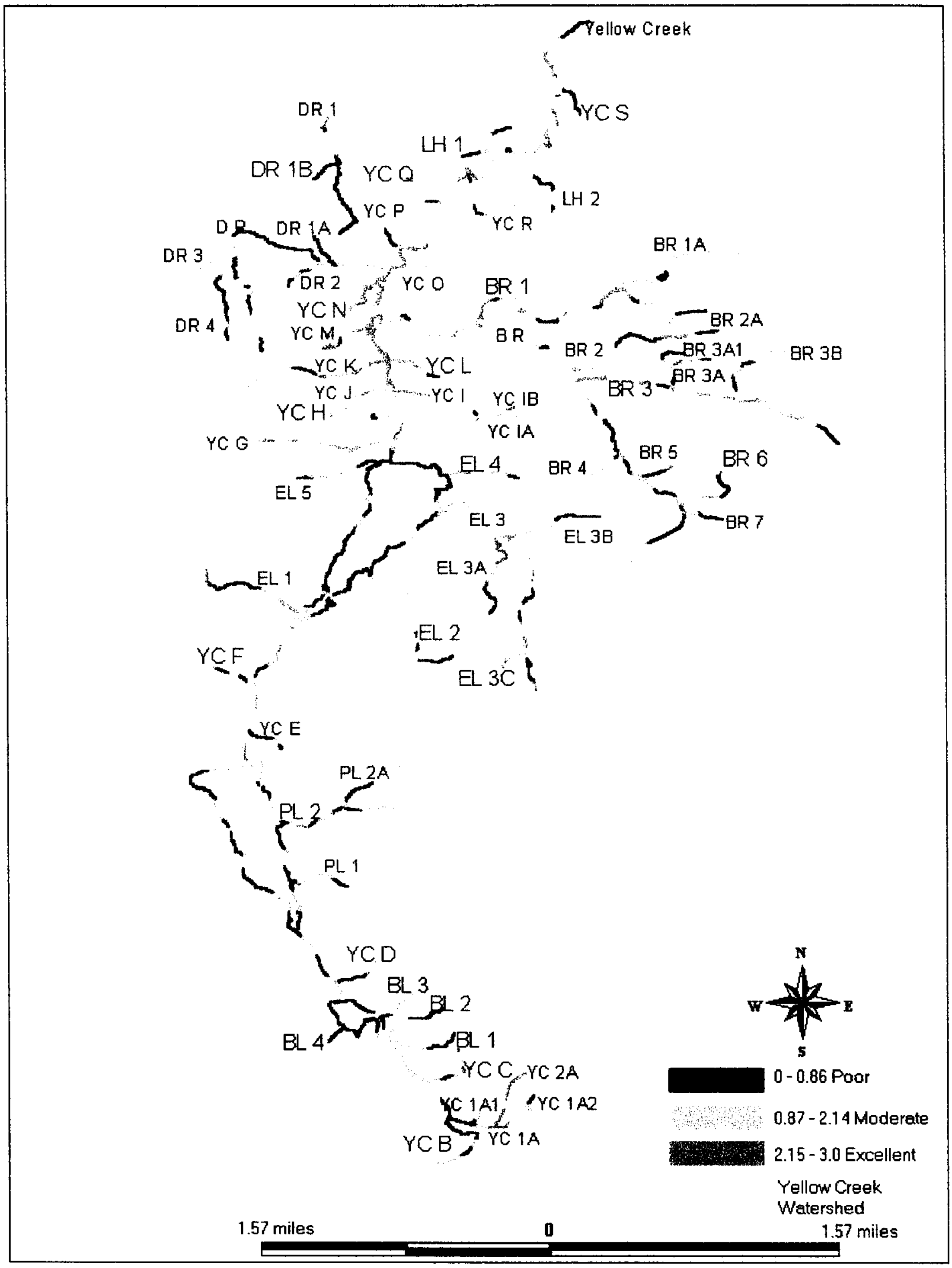

Figure 7: Floodplain Quality Scoring of QHEI (modified USGS DLGS, 1998)

Table 16: Streams Ranking in the Poor Range for Floodplain Quality

Stream Name	Segment Range	Avg. Floodplain Score
YC1a1	121-122	0.00
PL2a	175-178	0.23
BL4	154-155	0.38
BL2	144-149	0.42
BL1	139-143	0.50
BR3a1	480-482	0.50
DR1a	571-573	0.50
DR1b	574-575	0.50
Beaver Lake	674-679	0.56
YCB	101-109	0.61
YCP	605-608	0.63
Pine Lake	655-673	0.67
Evans Lake	636-654	0.69
DR4	592-601	0.73
DR2	576-585	0.75
LH1	617-618	0.75
LH2	619-626	0.78
L. Hamilton	630-635	0.78
YCS	627-629	0.80
YCR	611-616	0.83
YCQ	609-610	0.85

Of the remaining streams, 63.6% scored in the moderate range, and 4.5% in the excellent range. Table 17 is a listing of the three streams in the Yellow Creek Watershed that received an average score in the excellent range.

Table 17: Streams Ranking in the Excellent Range for Floodplain Quality

Stream Name	Segment Range	Avg. Floodplain Score
YCIb	318-320	2.33
YC2a	125-131	2.64
YCN	513-515	3.00

Of the three streams presented in Table 17, YC2a is the only stream with a significant number of segments.

4.2.3 Floodplain and Riparian Scoring Results

Figure 8 shows the sum of Floodplain and Riparian scores of the QHEI riparian metric within Yellow Creek watershed. The average condition of the floodplain quality and riparian width, with a mean score of 3.95 (out of 7.0), is in the moderate range.

The degradation of the riparian corridor in the southern portion of the watershed is primarily attributed to agricultural practices, while urban sprawl is the primary reason for a lack of riparian forest in the northern portion of Yellow Creek Watershed.

The appeal of lakeside homes has severely diminished the QHEI score on all four lakes in the watershed. The ranking of the lakes, from worst to best condition of the surrounding riparian forest and floodplain, is: Evans Lake, Pine Lake, Lake Hamilton and Beaver Lake. The poor to moderate condition of the floodplain and riparian zone around the lakes can be primarily attributed to land development.

Burgess Run should be of great concern. It drains more than 20% of the watershed. The general condition of the floodplain and riparian buffer is poor to moderate, with intermittent sections that are excellent. Three of the ten worst streams in the watershed drain into Burgess Run (see Table 15).

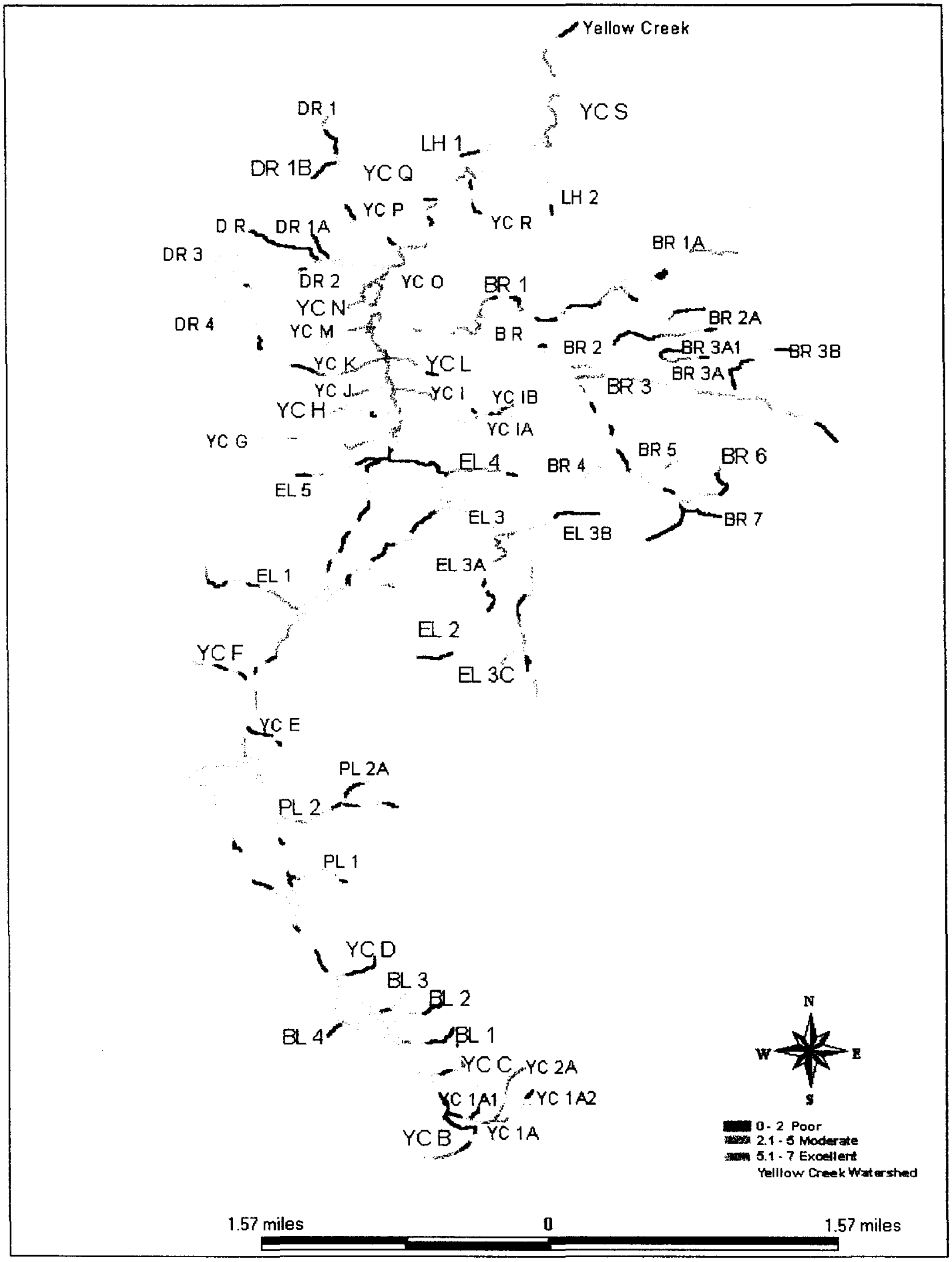

Figure 8: Sum of Floodplain and Riparian Sections of QHEI Riparian Metric (modified USGS DGLS, 1998)

Drake's Run drains approximately 12% of the watershed. Even though two of the most severely degraded streams drain into Drake's Run, the stream passes through a heavily forested area (Poland Forest) prior to its confluence with Yellow Creek.

4.3 QHEI Sampling Locations

As a verification of the map delineation performed, fourteen field sites were chosen throughout the watershed for complete QHEI evaluation. These sites are also recommended to serve as a sampling network for future water quality monitoring of the Yellow Creek Watershed. The fourteen sites that were chosen are listed in Table 18 and illustrated in Figure 9.

Table 18: QHEI Evaluation Sites in the Yellow Creek Watershed

Sampling Number	Stream Name	Location
1	Yellow Creek	Catherine St. Bridge
2	Yellow Creek	Rt. 170 by Poland Library
3	Yellow Creek	Walker Mill Rd.
4	Yellow Creek	Western Reserve Rd.
5	Yellow Creek	Rt. 165
6	YC1a	Macklin Rd
7	PL2	Beaver Springfield Rd.
8	EL2	Middletown and Springfield Rd.
9	EL3	Beard Rd.
10	Burgess Run	Walker Mill Rd.
11	Burgess Run	Arrell Rd. and Rt. 170
12	BR3	Arrell Rd.
13	Drakes Run	College St.
14	Drakes Run	South Ave.

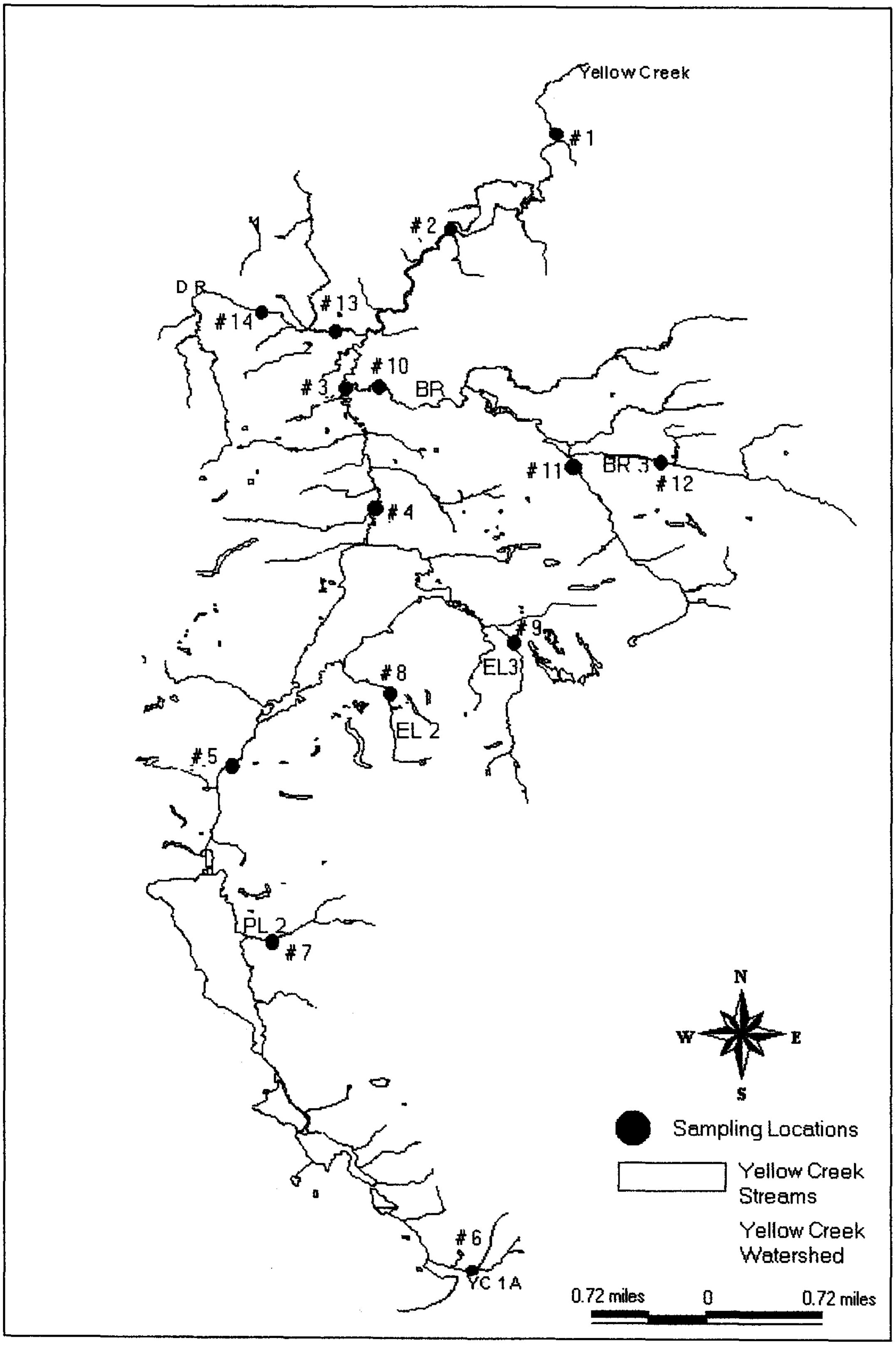

Figure 9: QHEI Sampling Locations (modified USGS DGLS, 1998)

The sampling sites for Yellow Creek were chosen in order to determine where problem areas exist. The sampling site near Catherine Street Bridge in Struthers was selected because it was used in 1994 by the Ohio EPA and served as a verification for the QHEI scoring in this study. It also can provide critical data about the amount of pollutants flowing from Yellow Creek to the Mahoning River. In order to estimate the pollutant loading to Lake Hamilton from the rest of the watershed, the sampling site by the Poland Library was selected. The Walker Mill Road site on Yellow Creek was selected since it is just upstream of the confluence with Burgess Run. This site allows monitoring of nutrients and suspended solids prior to inputs from the major tributary that drains approximately 20% of the watershed. The sampling locations north of Evans Lake on Western Reserve Road and south of the lake on Route 165 will allow tracking of the baseline quality of water entering and leaving the lake. Two sites, EL2 and EL3, were also selected on tributaries that flow into Evans Lake. They were selected because of inactive strip mines located in the floodplain. A sampling site on Pine Lake 2 was selected to monitor the effects of a heavily farmed floodplain. The site on Macklin Road was chosen because it is located at the origin of Yellow Creek. It will provide information on the variation in water quality as Yellow Creek travels though the watershed. The two sites on Drake's Run were selected to evaluate the changes in the stream as it passes from a heavily urbanized area through a heavily forested area. Drake's Run is also of importance because, along with its tributaries, it drains a substantial portion of the watershed. The three sites located on Burgess Run and one of its tributaries were chosen because of the wide variation in land use that the stream undergoes from the headwaters to the confluence with Yellow Creek.

The results of the QHEI field examinations are listed in Table 19. Individual metric scores are presented for each sampling site.

Table 19: QHEI Metric Scores for Sampling Sites

Site #	Substrate Total	Instream Cover Total	Channel Morphology Total	Riparian Zone Total	Pool/Glide Total	Gradient Total	Riffle/Run Total
1	16.0	10.0	14.0	8.5	8.0	4.0	4.0
2	9.0	5.0	13.0	5.0	6.0	4.0	4.0
3	5.0	11.0	13.0	7.5	5.0	0.0	8.0
4	0.0	2.0	12.0	8.5	2.0	1.0	4.0
5	2.0	6.0	4.0	5.5	4.0	0.0	8.0
6	3.0	9.0	12.0	6.2	3.0	0.0	8.0
7	1.0	11.0	14.0	5.9	5.0	0.0	2.0
8	17.0	2.0	14.0	3.5	6.0	4.0	4.0
9	6.0	12.0	12.5	7.5	7.0	0.0	4.0
10	13.0	11.0	11.5	7.0	9.0	0.0	6.0
11	3.0	6.0	11.0	4.5	2.0	0.0	8.0
12	9.0	6.0	13.0	4.3	3.0	0.0	8.0
13	13.5	10.0	12.0	9.0	4.0	2.0	6.0
14	12.5	3.0	4.0	1.5	3.0	0.0	4.0

Using Table 19, the overall results for the field QHEI examinations have been complied in Table 20.

Table 20: QHEI Results for Yellow Creek Sampling Network

Sampling Number	Stream Name	QHEI Score
1	Yellow Creek	64.5
2	Yellow Creek	46.0
3	Yellow Creek	49.5
4	Yellow Creek	29.5
5	Yellow Creek	29.5
6	YC1a	41.2
7	PL2	38.9
8	EL2	50.5
9	EL3	49.0
10	Burgess Run	57.5
11	Burgess Run	34.5
12	BR3	43.3
13	Drakes Run	56.5
14	Drakes Run	28.0

The relationship of QHEI score to the overall habitat quality and the distribution of scores for the 14 sampling sites are presented in Table 21.

Table 21: Distribution of QHEI Ratings for Sampling Sites in the Yellow Creek Watershed

QHEI Score	Habitat Quality	# of Sites
0-40	Very Poor	5
41-50	Poor	5
51-60	Fair	3
61-70	Good	1
71-80	Very Good	0
81-90	Excellent	0
91-100	Extraordinary	0

Habitat quality ranged from very poor to good. The average QHEI score for all of the sampling sites is 44.2 (out of 100), placing the overall condition of habitat at the sites sampled in the poor category. The trend in the condition of sampling locations is fair habitat downstream near the confluence with other streams. As the stream continues to the headwaters, there is a decrease in the score received through the QHEI method. A possible reason is that as streams combine, they are more susceptible to flooding, and thereby less attractive to farming and development. The results indicate that there is an urgent need for both preservation and restoration of aquatic habitat in the Yellow Creek watershed.

4.4 Comparison of Field and Aerial Evaluations

Two facets of the field QHEI were compared to the aerial evaluation of the Yellow Creek watershed - riparian width and floodplain quality. The evaluation serves as a verification of the aerial procedure, and points out the inaccuracy that stems from aerial photographs.

Segment locations for the field evaluations were determined by looking at the aerial photographs and the USGS topographical maps. Using roads shown on the USGS maps as reference points, the selected sampling sites were located on aerial photographs, and the appropriate segment numbers were identified. The aerial segments and the corresponding field sampling sites are listed in Table 22.

Table 22: Aerial Transect / QHEI Sampling Locations

Sampling #	Stream	Segment
1	Yellow Creek	8
2	Yellow Creek	29
3	Yellow Creek	51
4	Yellow Creek	66
5	Yellow Creek	76
6	YC1a	9
7	PL2	3
8	EL2	6
9	EL3	12
10	Burgess Run	6
11	Burgess Run	24
12	BR3	9
13	Drakes Run	5
14	Drakes Run	11

The comparison of the field and aerial data is presented in Table 23.

Table 23: Field and Aerial Data for Sampling Locations

	Field Evaluation		Aerial Evaluation				
Sample #	Riparian Score	Floodplain Score	Riparian Score	Floodplain Score	Riparian Difference	Floodplain Difference	Total Difference
1	4	1.5	3.7	2.3	-0.3	0.8	0.5
2	1.5	0.5	1	1	-0.5	0.5	0
3	4	1.5	4	1.5	0	0	0
4	4	1.5	3	2.3	-1	0.8	-0.2
5	2	0.5	1	1	-1	0.5	-0.5
6	2.5	0.7	2.5	1.3	0	0.6	0.6
7	2.5	0.4	1.5	1	-1	0.6	-0.4
8	0	0.5	2.2	2	2.2	1.5	3.7
9	4	1.5	3.5	1.5	-0.5	0	-0.5
10	3	1	3	1	0	0	0
11	0.5	1	1.8	0.3	1.3	-0.7	0.6
12	1	0.3	2	0.5	1	0.2	1.2
13	4	3	4	3	0	0	0
14	0	0.5	1	0.5	1	0	1

Based on the comparisons made in Table 22, site 8 has the biggest discrepancy. This sampling location was at an intersection, and the stream, EL2, ran directly through a yard at the intersection. The yard, mowed up to the edges of the stream, left no riparian vegetation. The length of the segment surveyed in the field for this site (and the remaining sites) was approximately 100 to 200 ft. Upstream and downstream of field site #8 is riparian forest. This vegetation was not accounted for during the field sampling. The map delineation was in 600 ft increments, and therefore accounted for the surrounding vegetation. While evaluating the field sites, it was difficult to determine where the corresponding aerial transects began and ended. Deviations at the other sites can be accounted for through the same reasoning. The combination of low resolution in the aerial photographs and differences in area surveyed account for differences in scoring.

4.5 Limitations of this Study

There were two primary limitations to this study- the age of aerial photographs used and the number of field verifications. The photos for the portion of Yellow Creek Watershed that lies in Columbiana County were from 1983. The changes that may have occurred over the past 16 years could alter the findings for the Yellow Creek Watershed in Columbiana County. In addition, although the aerial photographs for Mahoning County are only 5 years old, rapid development in the Boardman and Poland area could have changed riparian conditions for the northern portion of the watershed.

The limitation of the field verification lies in the number of sampling sites. More extensive site verification is needed in order to validate map delineation.

CHAPTER 5

SUMMARY, CONCLUSIONS and RECOMMENDATIONS

5.1 Summary

The analysis of the riparian forest and floodplain condition in the Yellow Creek watershed was accomplished through the use of aerial photographs and GIS software. Full QHEI evaluations were done at 14 sites, serving to validate the aerial delineation and posing as suggested water quality monitoring stations.

5.2 Conclusions

The riparian forest in the Yellow Creek watershed has undergone a variety of changes. The results from those changes yielded an average QHEI score of 1.53, approximately 7 meters. The floodplain quality has also experienced changes. The average QHEI floodplain score was 1.24. Both of the average scores for riparian corridor and floodplain quality are in the moderate range.

Of the 62 streams and 4 lakes that were mapped, 10 have an average riparian forest of less than 10 m wide. The majority of the surrounding floodplain activities are urban and residential practices. The headwaters of all of the streams mapped suffered from a diminished riparian forest. In general, the farther downstream the better the riparian condition.

5.3 Recommendations

In order to maintain the present "quality" of aquatic habitat in the Yellow Creek watershed, it is recommended that the riparian forest currently intact be preserved. To do this will involve a collaborative effort between environmental groups, political leaders, businesspersons, and landowners. This effort should incorporate all riparian buffers, especially those surrounding present and future construction sites (residential and industrial), as well as farmland. Halting the reduction of the riparian corridor will limit further damage to stream quality. Permits issued for new construction projects should incorporate limitations on the clearing of undeveloped properties; for example, requiring a minimum width of 30 meters of healthy riparian corridor.

The long-term recommendation is a four-prong approach. This system includes selected regions for a full riparian restoration, heightened pubic awareness, periodic monitoring of riparian widths and continuous water quality monitoring. Using the most current aerial photographs and field verification, the changes in riparian widths can be observed.

An attainable long-term goal for Yellow Creek Watershed would be an average increase of 3 m in all riparian forest. The increase would generate approximately 190 additional acres of riparian forest throughout the watershed. This would also reduce the streams that have a riparian forest of less than 10 meters by 30%. For five specific areas, a more aggressive approach is needed.

There are five primary areas that have a severely degraded riparian corridor - the headwaters of Burgess Run and Drakes Run, Burgess Run 7, Burgess Run 3 and the land adjacent to Evans Lake. All areas need a drastic change in riparian forest management in

order to help limit the flow of nutrients and contaminants into Evans Lake and the headwaters of Drakes and Burgess Run. The long-term recommendation for these areas is an increase of five meters on average for both sides. The increase would reduce the percentage of riparian corridors that scored in the poor range as well as help provide habitat for migratory birds and aquatic life. The agricultural advantage of an increased riparian forest can be equated in terms of topsoil loss. Through proper management of zone 3 of a riparian corridor (see Figure 2), soil lost to runoff could be reduced.
The suggested five-meter increase should be provided through a contractual agreement with local officials and landowners or purchase.

A water-sampling program conducted over an extended period of time is needed to develop baseline data for the watershed. .Water sampling will provide valuable insight to the quantity and general location of non-point source pollution. Recommended sites are those discussed in Chapter 4. Once the primary trouble spots are identified, remedial actions can be focused on these areas.

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APPENDIX

QHEI Score Sheets for Sampling Stations

Sampling Site # 1 **Stream:** Yellow Creek

Substrate Type

				Substrate Origin		**Substrate Quality**	
bldr/slbs (10)		Gravel (7)		Limestone (1)		Silt Heavy (-2)	
Boulder (9)	x	Sand (6)		Tills (1)		Silt Moderate (-1)	
Cobble (8)	x	Bedrock (5)		Wetlands (0)		Silt Normal (0)	x
Hardpan (4)		detritus (3)		Hardpan (0)		Silt Free (1)	
Muck (2)		Artificial (0)		Sandstone (0)			
Silt (2)				Rip/Rap (0)		**Embeddedness**	
				Lacustrine (0)		Extensive (-2)	
				Shale (-1)	x	Moderate (-1)	
				Coal Fines (-2)		Normal (0)	x
						None (1)	
						Substrate Subtotal:	16

Instream Cover

Undercut Banks (1)		Pools >70cm (2)		Oxbows (1)		**Overhead Cover**	
Overhang Veg (1)	x	Rootwads (1)		Aquatic Macro (1)		>75% (11)	
Shallows (1)	x	Boulders (1)		Woody Debris (1)	x	25-75% (7)	x
Rootmats (1)						5-25% (3)	
						<5% (1)	
						Instream Subtotal:	10

Channel Morphology

Sinuosity		**Development**		**Channelization**		**Stability**	
High (4)		Excellent (7)		None (6)	x	High (3)	x
Moderate (3)		Good (5)		Recovered (4)		Moderate (2)	
Low (2)	x	Fair (3)	x	Recovering (3)		Low (1)	
None (1)		Poor (1)		Recent / None (1)			

Channel Morphology Subtotal: 14

Riparian Zone and Bank Erosion

Riparian Width		**Floodplain Quality**				**Bank Erosion**	
Wide (4)	l r	Forest (3)	l r	Tillage (1)		None (3)	l r
Moderate (3)		Shrub (2)		Urban (0)	l r	Moderate (2)	
Narrow (2)		Residential (1)		Rowcrop (0)		Heavy (1)	
Very Narrow (1)		Pasture (1)		Mining (0)			
None (0)						**Riparian Subtotal:**	8.5

Pool/Glide and Riffle Run Quality

Max Depth		**Morphology**		**Current Velocity (Pool and Riffles)**			
>1 m (6)		PW>RW (2)	x	Eddies (1)		Torrential (-1)	
0.7-1m (4)	x	PW=RW (1)		Fast (1)		Interstitial (-1)	
0.4-0.7m (2)		PW<RW (0)		Moderate (1)	x	Intermittent (-2)	
0.2-0.4m (1)		PW=pool width		Slow (1)	x		
<0.2m (0)		RW=riffle width				**Pool/Glide and Riffle Run Subtotal:**	8

Riffle/Run Depth Metric

R/R Depth		R/R Substrate		R/R Embeddedness		Run Depth	
>10 cm,Max>50(4)		Stable (2)	x	None (2)		Max>50 (2)	
>10 cm,Max<50(3)		Mod Stable (1)		Low (1)	x	Max<50 (1)	x
5-10cm (1)		Unstable (0)		Moderate (0)			
<5 cm (0)	x			Extensive (-1)			
		If No Riffle, Metric=0		**Riffle/Run Depth Subtotal:**		4	

Stream Gradient Metric

Stream Gradient (ft/mi)		
0' - 3.3'	4	
3.4' - 6.6'	6	
6.7' - 9.8'	8	
9.9' - 13.1'	10	
13.2' - 23.0'	8	
23.1' - 32.8'	6	
32.9' - 65.6'	4	X
> 65.7'	2	

Stream Gradient Subtotal: 4

QHEI TOTAL SCORE: 64.5

Sampling Site # 2 **Stream:** Yellow Creek

Substrate

Type				Substrate Origin		Substrate Quality	
bldr/slbs (10)		Gravel (7)		Limestone (1)		Silt Heavy (-2)	
Boulder (9)		Sand (6)		Tills (1)		Silt Moderate (-1)	
Cobble (8)		Bedrock (5)	xx	Wetlands (0)		Silt Normal (0)	x
Hardpan (4)		detritus (3)		Hardpan (0)		Silt Free (1)	
Muck (2)		Artificial (0)		Sandstone (0)			
Silt (2)				Rip/Rap (0)		**Embeddedness**	
				Lacustrine (0)		Extensive (-2)	
				Shale (-1)	x	Moderate (-1)	
				Coal Fines (-2)		Normal (0)	x
						None (1)	

Substrate Subtotal: 9

Instream Cover

					Overhead Cover	
Undercut Banks (1)		Pools >70cm (2)	Oxbows (1)			
Overhang Veg (1)	x	Rootwads (1)	Aquatic Macro (1)		>75% (11)	
Shallows (1)	x	Boulders (1)	Woody Debris (1)		25-75% (7)	
Rootmats (1)					5-25% (3)	x
					<5% (1)	

Instream Subtotal: 5

Channel Morphology

Sinuosity		Development		Channelization		Stability	
High (4)		Excellent (7)		None (6)	x	High (3)	x
Moderate (3)		Good (5)		Recovered (4)		Moderate (2)	
Low (2)	x	Fair (3)	x	Recovering (3)		Low (1)	
None (1)		Poor (1)	x	Recent / None (1)			

Channel Morphology Subtotal: 13

Riparian Zone and Bank Erosion

Riparian Width		Floodplain Quality				Bank Erosion	
Wide (4)		Forest (3)		Tillage (1)		None (3)	l r
Moderate (3)	r	Shrub (2)		Urban (0)	l r	Moderate (2)	
Narrow (2)		Residential (1)	l r	Rowcrop (0)		Heavy (1)	
Very Narrow (1)		Pasture (1)		Mining (0)			
None (0)	l					**Riparian Zone Subtotal:**	5

Pool/Glide and Riffle Run Quality

Max Depth		Morphology		Current Velocity (Pool and Riffles)			
>1 m (6)		PW>RW (2)	x	Eddies (1)		Torrential (-1)	
0.7-1m (4)		PW=RW (1)		Fast (1)		Interstitial (-1)	
0.4-0.7m (2)	x	PW<RW (0)		Moderate (1)	x	Intermittent (-2)	
0.2-0.4m (1)		PW=pool width		Slow (1)	x		
<0.2m (0)		RW=riffle width		**Pool/Glide and Riffle Run Subtotal:**			6

Riffle/Run Depth Metric

R/R Depth		R/R Substrate		R/R Embeddedness		Run Depth	
>10 cm,Max>50(4)		Stable (2)	x	None (2)		Max>50 (2)	
>10 cm,Max<50(3)		Mod Stable (1)		Low (1)	x	Max<50 (1)	x
5-10cm (1)		Unstable (0)		Moderate (0)			
<5 cm (0)	x			Extensive (-1)			
		If No Riffle, Metric=0		**Riffle/Run Depth Subtotal:**			4

Stream Gradient Metric

Stream Gradient (ft/mi)			
0' - 3.3'	4		
3.4' - 6.6'	6		
6.7' - 9.8'	8		
9.9' - 13.1'	10		**Stream Gradient Subtotal:** 4
13.2' - 23.0'	8		
23.1' - 32.8'	6		
32.9' - 65.6'	4	X	
> 65.7'	2		

QHEI TOTAL SCORE: 46

Sampling Site #	3			Stream:	Yellow Creek		

Substrate

Type				Substrate Origin		Substrate Quality	
bldr/slbs (10)		Gravel (7)		Limestone (1)		Silt Heavy (-2)	x
Boulder (9)		Sand (6)		Tills (1)		Silt Moderate (-1)	
Cobble (8)	x	Bedrock (5)		Wetlands (0)		Silt Normal (0)	
Hardpan (4)		detritus (3)		Hardpan (0)		Silt Free (1)	
Muck (2)		Artificial (0)		Sandstone (0)			
Silt (2)	x			Rip/Rap (0)		**Embeddedness**	
				Lacustrine (0)		Extensive (-2)	x
				Shale (-1)	x	Moderate (-1)	
				Coal Fines (-2)		Normal (0)	
						None (1)	
				Substrate Subtotal:		5	

Instream Cover

						Overhead Cover	
Undercut Banks (1)	x	Pools >70cm (2)		Oxbows (1)			
Overhang Veg (1)	x	Rootwads (1)		Aquatic Macro (1)		>75% (11)	
Shallows (1)	x	Boulders (1)		Woody Debris (1)		25-75% (7)	x
Rootmats (1)	x					5-25% (3)	
						<5% (1)	
				Instream Subtotal:		11	

Channel Morphology

Sinuosity		Development		Channelization		Stability	
High (4)		Excellent (7)		None (6)	x	High (3)	
Moderate (3)	x	Good (5)		Recovered (4)		Moderate (2)	
Low (2)		Fair (3)	x	Recovering (3)		Low (1)	x
None (1)		Poor (1)		Recent / None (1)			
				Channel Morphology Subtotal:		13	

Riparian Zone and Bank Erosion

Riparian Width		Floodplain Quality				Bank Erosion	
Wide (4)	l r	Forest (3)	l r	Tillage (1)		None (3)	
Moderate (3)		Shrub (2)		Urban (0)	l r	Moderate (2)	l r
Narrow (2)		Residential (1)		Rowcrop (0)		Heavy (1)	
Very Narrow (1)		Pasture (1)		Mining (0)			
None (0)				**Riparian Zone Subtotal:**		7.5	

Pool/Glide and Riffle Run Quality

Max Depth		Morphology		Current Velocity (Pool and Riffles)			
>1 m (6)		PW>RW (2)	x	Eddies (1)		Torrential (-1)	
0.7-1m (4)		PW=RW (1)		Fast (1)		Interstitial (-1)	
0.4-0.7m (2)	x	PW<RW (0)		Moderate (1)		Intermittent (-2)	
0.2-0.4m (1)		PW=pool width		Slow (1)	x		
<0.2m (0)		RW=riffle width		**Pool/Glide and Riffle Run Subtotal:**		5	

Riffle/Run Depth Metric

R/R Depth	**R/R Substrate**	**R/R Embeddedness**	**Run Depth**
>10 cm,Max>50(4)	Stable (2)	None (2)	Max>50 (2)
>10 cm,Max<50(3)	Mod Stable (1)	Low (1)	Max<50 (1)
5-10cm (1)	Unstable (0)	Moderate (0)	
<5 cm (0)		Extensive (-1)	
	If No Riffle, Metric=0 x	**Riffle/Run Depth Subtotal:**	0

Stream Gradient Metric

Stream Gradient (ft/mi)		
0' - 3.3'	4	
3.4' - 6.6'	6	
6.7' - 9.8'	8	X
9.9' - 13.1'	10	
13.2' - 23.0'	8	
23.1' - 32.8'	6	
32.9' - 65.6'	4	
> 65.7'	2	

Stream Gradient Subtotal: 8

QHEI TOTAL SCORE: 49.5

Sampling Site # 4 **Stream:** Yellow Creek

Substrate

Type				**Substrate Origin**		**Substrate Quality**	
bldr/slbs (10)		Gravel (7)		Limestone (1)		Silt Heavy (-2)	x
Boulder (9)		Sand (6)		Tills (1)		Silt Moderate (-1)	
Cobble (8)		Bedrock (5)		Wetlands (0)	x	Silt Normal (0)	
Hardpan (4)		detritus (3)		Hardpan (0)		Silt Free (1)	
Muck (2)	x	Artificial (0)		Sandstone (0)			
Silt (2)	x			Rip/Rap (0)		**Embeddedness**	
				Lacustrine (0)		Extensive (-2)	x
				Shale (-1)		Moderate (-1)	
				Coal Fines (-2)		Normal (0)	
						None (1)	

Substrate Subtotal: 0

Instream Cover

				Overhead Cover	
Undercut Banks (1)		Pools >70cm (2)	Oxbows (1)		
Overhang Veg (1)		Rootwads (1)	Aquatic Macro (1)	>75% (11)	
Shallows (1)	x	Boulders (1)	Woody Debris (1)	25-75% (7)	
Rootmats (1)				5-25% (3)	
				<5% (1)	x

Instream Subtotal: 2

Channel Morphology

Sinuosity		**Development**		**Channelization**		**Stability**	
High (4)		Excellent (7)		None (6)	x	High (3)	x
Moderate (3)		Good (5)		Recovered (4)		Moderate (2)	
Low (2)	x	Fair (3)		Recovering (3)		Low (1)	
None (1)		Poor (1)	x	Recent / None (1)			

Channel Morphology Subtotal: 12

Riparian Zone and Bank Erosion

Riparian Width		Floodplain Quality				Bank Erosion	
Wide (4)	l r	Forest (3)	l r	Tillage (1)		None (3)	l r
Moderate (3)		Shrub (2)		Urban (0)	l r	Moderate (2)	
Narrow (2)		Residential (1)		Rowcrop (0)		Heavy (1)	
Very Narrow (1)		Pasture (1)		Mining (0)			
None (0)				**Riparian Zone Subtotal:**		8.5	

Pool/Glide and Riffle Run Quality

Max Depth		Morphology		Current Velocity (Pool and Riffles)			
>1 m (6)		PW>RW (2)		Eddies (1)		Torrential (-1)	
0.7-1m (4)		PW=RW (1)	x	Fast (1)		Interstitial (-1)	
0.4-0.7m (2)		PW<RW (0)		Moderate (1)		Intermittent (-2)	
0.2-0.4m (1)		PW=pool width		Slow (1)	x		
<0.2m (0)	x	RW=riffle width		**Pool/Glide and Riffle Run Subtotal:**		2	

Riffle/Run Depth Metric

R/R Depth		R/R Substrate		R/R Embeddedness		Run Depth	
>10 cm,Max>50(4)		Stable (2)		None (2)		Max>50 (2)	
>10 cm,Max<50(3)		Mod Stable (1)		Low (1)		Max<50 (1)	x
5-10cm (1)		Unstable (0)	x	Moderate (0)	x		
<5 cm (0)	x			Extensive (-1)			
		If No Riffle, Metric=0		**Riffle/Run Depth Subtotal:**		1	

Stream Gradient Metric

Stream Gradient (ft/mi)				
0' - 3.3'	4			
3.4' - 6.6'	6			
6.7' - 9.8'	8			
9.9' - 13.1'	10		**Stream Gradient Subtotal:**	4
13.2' - 23.0'	8			
23.1' - 32.8'	6			
32.9' - 65.6'	4	X		
> 65.7'	2			

QHEI TOTAL SCORE: 29.5

Sampling Site # 5 **Stream:** Yellow Creek

Substrate

Type				Substrate Origin		Substrate Quality	
bldr/slbs (10)		Gravel (7)		Limestone (1)		Silt Heavy (-2)	
Boulder (9)		Sand (6)		Tills (1)		Silt Moderate (-1)	x
Cobble (8)		Bedrock (5)		Wetlands (0)		Silt Normal (0)	
Hardpan (4)		detritus (3)		Hardpan (0)		Silt Free (1)	
Muck (2)	x	Artificial (0)		Sandstone (0)	x		
Silt (2)	x			Rip/Rap (0)		**Embeddedness**	
				Lacustrine (0)		Extensive (-2)	
				Shale (-1)		Moderate (-1)	x
				Coal Fines (-2)		Normal (0)	
						None (1)	
				Substrate Subtotal:		2	

Instream Cover

Undercut Banks (1)	x	Pools >70cm (2)		Oxbows (1)		**Overhead Cover**	
Overhang Veg (1)	x	Rootwads (1)		Aquatic Macro (1)	x	>75% (11)	
Shallows (1)		Boulders (1)		Woody Debris (1)		25-75% (7)	
Rootmats (1)						5-25% (3)	x
						<5% (1)	

Instream Subtotal: 6

Channel Morphology

Sinuosity		**Development**		**Channelization**		**Stability**	
High (4)		Excellent (7)		None (6)		High (3)	
Moderate (3)		Good (5)		Recovered (4)		Moderate (2)	x
Low (2)		Fair (3)		Recovering (3)		Low (1)	
None (1)	x	Poor (1)	x	Recent / None (1)	x		

Channel Morphology Subtotal: 4

Riparian Zone and Bank Erosion

Riparian Width		**Floodplain Quality**				**Bank Erosion**	
Wide (4)		Forest (3)		Tillage (1)		None (3)	l r
Moderate (3)		Shrub (2)		Urban (0)	l r	Moderate (2)	
Narrow (2)	l r	Residential (1)	l r	Rowcrop (0)		Heavy (1)	
Very Narrow (1)		Pasture (1)		Mining (0)			
None (0)							

Riparian Zone Subtotal: 5.5

Pool/Glide and Riffle Run Quality

Max Depth		**Morphology**		**Current Velocity (Pool and Riffles)**		
>1 m (6)		PW>RW (2)	x	Eddies (1)		Torrential (-1)
0.7-1m (4)		PW=RW (1)		Fast (1)		Interstitial (-1)
0.4-0.7m (2)		PW<RW (0)		Moderate (1)		Intermittent (-2)
0.2-0.4m (1)	x	PW=pool width		Slow (1)	x	
<0.2m (0)		RW=riffle width				

Pool/Glide and Riffle Run Subtotal: 4

Riffle/Run Depth Metric

R/R Depth		**R/R Substrate**		**R/R Embeddedness**		**Run Depth**	
>10 cm,Max>50(4)		Stable (2)		None (2)		Max>50 (2)	
>10 cm,Max<50(3)		Mod Stable (1)		Low (1)		Max<50 (1)	x
5-10cm (1)		Unstable (0)	x	Moderate (0)			
<5 cm (0)	x			Extensive (-1)	x		

If No Riffle, Metric=0

Riffle/Run Depth Subtotal: 0

Stream Gradient Metric

Stream Gradient (ft/mi)		
0' - 3.3'	4	
3.4' - 6.6'	6	
6.7' - 9.8'	8	X
9.9' - 13.1'	10	
13.2' - 23.0'	8	
23.1' - 32.8'	6	
32.9' - 65.6'	4	
> 65.7'	2	

Stream Gradient Subtotal: 8

QHEI TOTAL SCORE: 29.5

Sampling Site #	**6**			**Stream:**		Yellow Creek 1a	
Substrate Type				**Substrate Origin**		**Substrate Quality**	
bldr/slbs (10)		Gravel (7)		Limestone (1)		Silt Heavy (-2)	
Boulder (9)		Sand (6)		Tills (1)		Silt Moderate (-1)	x
Cobble (8)		Bedrock (5)		Wetlands (0)		Silt Normal (0)	
Hardpan (4)		detritus (3)		Hardpan (0)		Silt Free (1)	
Muck (2)	x	Artificial (0)		Sandstone (0)	x		
Silt (2)	x			Rip/Rap (0)		**Embeddedness**	
				Lacustrine (0)		Extensive (-2)	
				Shale (-1)		Moderate (-1)	x
				Coal Fines (-2)		Normal (0)	
						None (1)	
				Substrate Subtotal:		3	
Instream Cover							
Undercut Banks (1)		Pools >70cm (2)		Oxbows (1)		**Overhead Cover**	
Overhang Veg (1)	x	Rootwads (1)		Aquatic Macro (1)		>75% (11)	
Shallows (1)		Boulders (1)		Woody Debris (1)	x	25-75% (7)	x
Rootmats (1)						5-25% (3)	
						<5% (1)	
				Instream Subtotal:		9	
Channel Morphology							
Sinuosity		**Development**		**Channelization**		**Stability**	
High (4)		Excellent (7)		None (6)	x	High (3)	x
Moderate (3)		Good (5)		Recovered (4)		Moderate (2)	
Low (2)	x	Fair (3)		Recovering (3)		Low (1)	
None (1)		Poor (1)	x	Recent / None (1)			
				Channel Morphology Subtotal:		12	
Riparian Zone and Bank Erosion							
Riparian Width		**Floodplain Quality**				**Bank Erosion**	
Wide (4)		Forest (3)		Tillage (1)		None (3)	l r
Moderate (3)	r	Shrub (2)	l r	Urban (0)	l r	Moderate (2)	
Narrow (2)	l	Residential (1)		Rowcrop (0)	l r	Heavy (1)	
Very Narrow (1)		Pasture (1)		Mining (0)			
None (0)				**Riparian Zone Subtotal:**		6.2	
Pool/Glide and Riffle Run Quality							
Max Depth		**Morphology**		**Current Velocity (Pool and Riffles)**			
>1 m (6)		PW>RW (2)	x	Eddies (1)		Torrential (-1)	
0.7-1m (4)		PW=RW (1)		Fast (1)		Interstitial (-1)	
0.4-0.7m (2)		PW<RW (0)		Moderate (1)		Intermittent (-2)	
0.2-0.4m (1)		PW=pool width		Slow (1)	x		
<0.2m (0)	x	RW=riffle width		**Pool/Glide and Riffle Run Subtotal:**		3	
Riffle/Run Depth Metric							
R/R Depth		**R/R Substrate**		**R/R Embeddedness**		**Run Depth**	
>10 cm,Max>50(4)		Stable (2)		None (2)		Max>50 (2)	
>10 cm,Max<50(3)		Mod Stable (1)		Low (1)		Max<50 (1)	
5-10cm (1)		Unstable (0)		Moderate (0)			
<5 cm (0)				Extensive (-1)			
		If No Riffle, Metric=0	x	**Riffle/Run Depth Subtotal:**		0	

Stream Gradient Metric

Stream Gradient (ft/mi)				
0' - 3.3'	4			
3.4' - 6.6'	6			
6.7' - 9.8'	8			
9.9' - 13.1'	10		**Stream Gradient Subtotal:**	8
13.2' - 23.0'	8	X		
23.1' - 32.8'	6			
32.9' - 65.6'	4			
> 65.7'	2			

QHEI TOTAL SCORE: 41.2

Sampling Site #	**7**				**Stream:**	Pine Lake 2		
Substrate Type					**Substrate Origin**		**Substrate Quality**	
bldr/slbs (10)		Gravel (7)			Limestone (1)		Silt Heavy (-2)	x
Boulder (9)		Sand (6)			Tills (1)		Silt Moderate (-1)	
Cobble (8)		Bedrock (5)			Wetlands (0)		Silt Normal (0)	
Hardpan (4)		detritus (3)			Hardpan (0)		Silt Free (1)	
Muck (2)	x	Artificial (0)			Sandstone (0)	x		
Silt (2)	x				Rip/Rap (0)		**Embeddedness**	
					Lacustrine (0)		Extensive (-2)	
					Shale (-1)		Moderate (-1)	x
					Coal Fines (-2)		Normal (0)	
							None (1)	
					Substrate Subtotal:		1	
Instream Cover								
Undercut Banks (1)	x	Pools >70cm (2)			Oxbows (1)		**Overhead Cover**	
Overhang Veg (1)	x	Rootwads (1)			Aquatic Macro (1)	x	>75% (11)	
Shallows (1)		Boulders (1)			Woody Debris (1)	x	25-75% (7)	x
Rootmats (1)							5-25% (3)	
							<5% (1)	
					Instream Subtotal:		11	
Channel Morphology								
Sinuosity		**Development**			**Channelization**		**Stability**	
High (4)		Excellent (7)			None (6)	x	High (3)	
Moderate (3)	x	Good (5)			Recovered (4)		Moderate (2)	x
Low (2)		Fair (3)		x	Recovering (3)		Low (1)	
None (1)		Poor (1)			Recent / None (1)			
					Channel Morphology Subtotal:		14	
Riparian Zone and Bank Erosion								
Riparian Width		**Floodplain Quality**					**Bank Erosion**	
Wide (4)		Forest (3)			Tillage (1)		None (3)	l r
Moderate (3)	l	Shrub (2)		l	Urban (0)	l r	Moderate (2)	
Narrow (2)	r	Residential (1)			Rowcrop (0)	r	Heavy (1)	
Very Narrow (1)		Pasture (1)			Mining (0)			
None (0)					**Riparian Zone Subtotal:**		5.9	

Pool/Glide and Riffle Run Quality

Max Depth		Morphology		Current Velocity (Pool and Riffles)			
>1 m (6)		PW>RW (2)	x	Eddies (1)		Torrential (-1)	
0.7-1m (4)		PW=RW (1)		Fast (1)		Interstitial (-1)	
0.4-0.7m (2)	x	PW<RW (0)		Moderate (1)		Intermittent (-2)	
0.2-0.4m (1)		PW=pool width		Slow (1)	x		
<0.2m (0)		RW=riffle width		**Pool/Glide and Riffle Run Subtotal:**			5

Riffle/Run Depth Metric

R/R Depth	R/R Substrate		R/R Embeddedness	Run Depth	
>10 cm,Max>50(4)	Stable (2)		None (2)	Max>50 (2)	
>10 cm,Max<50(3)	Mod Stable (1)		Low (1)	Max<50 (1)	
5-10cm (1)	Unstable (0)		Moderate (0)		
<5 cm (0)			Extensive (-1)		
	If No Riffle, Metric=0	x	**Riffle/Run Depth Subtotal:**		0

Stream Gradient Metric

Stream Gradient (ft/mi)				
0' - 3.3'	4			
3.4' - 6.6'	6			
6.7' - 9.8'	8			
9.9' - 13.1'	10		**Stream Gradient Subtotal:**	2
13.2' - 23.0'	8			
23.1' - 32.8'	6			
32.9' - 65.6'	4			
> 65.7'	2	X		

QHEI TOTAL SCORE: 38.9

Sampling Site # 8 **Stream:** Evans Lake 2

Substrate Type				Substrate Origin		Substrate Quality	
bldr/slbs (10)		Gravel (7)	x	Limestone (1)		Silt Heavy (-2)	
Boulder (9)	x	Sand (6)		Tills (1)		Silt Moderate (-1)	
Cobble (8)	x	Bedrock (5)		Wetlands (0)		Silt Normal (0)	x
Hardpan (4)		detritus (3)		Hardpan (0)		Silt Free (1)	
Muck (2)		Artificial (0)		Sandstone (0)	x		
Silt (2)				Rip/Rap (0)	x	**Embeddedness**	
				Lacustrine (0)		Extensive (-2)	
				Shale (-1)		Moderate (-1)	
				Coal Fines (-2)		Normal (0)	x
						None (1)	
				Substrate Subtotal:		17	

Instream Cover

				Overhead Cover	
Undercut Banks (1)	Pools >70cm (2)	Oxbows (1)			
Overhang Veg (1)	Rootwads (1)	Aquatic Macro (1)	x	>75% (11)	
Shallows (1)	Boulders (1)	Woody Debris (1)		25-75% (7)	
Rootmats (1)				5-25% (3)	
				<5% (1)	x
		Instream Subtotal:		2	

Channel Morphology

Sinuosity		Development		Channelization		Stability	
High (4)	x	Excellent (7)		None (6)	x	High (3)	x
Moderate (3)		Good (5)		Recovered (4)		Moderate (2)	
Low (2)		Fair (3)		Recovering (3)		Low (1)	
None (1)		Poor (1)	x	Recent / None (1)			
				Channel Morphology Subtotal:			14

Riparian Zone and Bank Erosion

Riparian Width		Floodplain Quality				Bank Erosion	
Wide (4)		Forest (3)		Tillage (1)		None (3)	l r
Moderate (3)		Shrub (2)		Urban (0)	l r	Moderate (2)	
Narrow (2)		Residential (1)	l r	Rowcrop (0)		Heavy (1)	
Very Narrow (1)		Pasture (1)		Mining (0)			
None (0)	l r			**Riparian Zone Subtotal:**			3.5

Pool/Glide and Riffle Run Quality

Max Depth		Morphology		Current Velocity (Pool and Riffles)			
>1 m (6)		PW>RW (2)	x	Eddies (1)		Torrential (-1)	
0.7-1m (4)		PW=RW (1)		Fast (1)	x	Interstitial (-1)	
0.4-0.7m (2)	x	PW<RW (0)		Moderate (1)	x	Intermittent (-2)	
0.2-0.4m (1)		PW=pool width		Slow (1)			
<0.2m (0)		RW=riffle width		**Pool/Glide and Riffle Run Subtotal:**			6

Riffle/Run Depth Metric

>10 cm,Max>50(4)		Stable (2)		None (2)		Max>50 (2)	x
>10 cm,Max<50(3)		Mod Stable (1)	x	Low (1)	x	Max<50 (1)	
5-10cm (1)		Unstable (0)		Moderate (0)			
<5 cm (0)	x			Extensive (-1)			
		If No Riffle, Metric=0		**Riffle/Run Depth Subtotal:**			4

Stream Gradient Metric

Stream Gradient (ft/mi)				
0' - 3.3'	4			
3.4' - 6.6'	6			
6.7' - 9.8'	8			
9.9' - 13.1'	10		**Stream Gradient Subtotal:**	4
13.2' - 23.0'	8			
23.1' - 32.8'	6			
32.9' - 65.6'	4	x		
> 65.7'	2			

QHEI TOTAL SCORE: 50.5

Sampling Site #	9			**Stream:**	Evans Lake 3		
Substrate Type				**Substrate Origin**		**Substrate Quality**	
bldr/slbs (10)		Gravel (7)	x	Limestone (1)		Silt Heavy (-2)	
Boulder (9)		Sand (6)		Tills (1)		Silt Moderate (-1)	x
Cobble (8)		Bedrock (5)		Wetlands (0)	x	Silt Normal (0)	
Hardpan (4)		detritus (3)		Hardpan (0)		Silt Free (1)	
Muck (2)		Artificial (0)		Sandstone (0)			
Silt (2)	x			Rip/Rap (0)		**Embeddedness**	
				Lacustrine (0)		Extensive (-2)	x
				Shale (-1)		Moderate (-1)	
				Coal Fines (-2)		Normal (0)	
						None (1)	
				Substrate Subtotal:		6	

Instream Cover							
Undercut Banks (1)	x	Pools >70cm (2)		Oxbows (1)		**Overhead Cover**	
Overhang Veg (1)	x	Rootwads (1)	x	Aquatic Macro (1)		>75% (11)	
Shallows (1)	x	Boulders (1)		Woody Debris (1)	x	25-75% (7)	x
Rootmats (1)						5-25% (3)	
						<5% (1)	
				Instream Subtotal:		12	

Channel Morphology							
Sinuosity		**Development**		**Channelization**		**Stability**	
High (4)	x	Excellent (7)		None (6)	x	High (3)	
Moderate (3)		Good (5)		Recovered (4)		Moderate (2)	x
Low (2)		Fair (3)		Recovering (3)		Low (1)	x
None (1)		Poor (1)	x	Recent / None (1)			
				Channel Morphology Subtotal:		12.5	

Riparian Zone and Bank Erosion							
Riparian Width		**Floodplain Quality**				**Bank Erosion**	
Wide (4)	l r	Forest (3)	l r	Tillage (1)		None (3)	
Moderate (3)		Shrub (2)		Urban (0)	l r	Moderate (2)	l r
Narrow (2)		Residential (1)		Rowcrop (0)		Heavy (1)	
Very Narrow (1)		Pasture (1)		Mining (0)			
None (0)				**Riparian Zone Subtotal:**		7.5	

Pool/Glide and Riffle Run Quality							
Max Depth		**Morphology**		**Current Velocity (Pool and Riffles)**			
>1 m (6)		PW>RW (2)	x	Eddies (1)		Torrential (-1)	
0.7-1m (4)	x	PW=RW (1)		Fast (1)		Interstitial (-1)	
0.4-0.7m (2)		PW<RW (0)		Moderate (1)		Intermittent (-2)	
0.2-0.4m (1)		PW=pool width		Slow (1)	x		
<0.2m (0)		RW=riffle width		**Pool/Glide and Riffle Run Subtotal:**		7	

Riffle/Run Depth Metric							
R/R Depth		**R/R Substrate**		**R/R Embeddedness**		**Run Depth**	
>10 cm,Max>50(4)		Stable (2)		None (2)		Max>50 (2)	
>10 cm,Max<50(3)		Mod Stable (1)		Low (1)		Max<50 (1)	
5-10cm (1)		Unstable (0)		Moderate (0)			
<5 cm (0)				Extensive (-1)			
	If No Riffle, Metric=0	x		**Riffle/Run Depth Subtotal:**		0	

Stream Gradient Metric

Stream Gradient (ft/mi)		
0' - 3.3'	4	
3.4' - 6.6'	6	
6.7' - 9.8'	8	
9.9' - 13.1'	10	
13.2' - 23.0'	8	
23.1' - 32.8'	6	
32.9' - 65.6'	4	x
> 65.7'	2	

Stream Gradient Subtotal: 4

QHEI TOTAL SCORE: 49

Sampling Site # **10** **Stream:** Burgess Run

Substrate Type				**Substrate Origin**		**Substrate Quality**	
bldr/slbs (10)		Gravel (7)	x	Limestone (1)		Silt Heavy (-2)	
Boulder (9)		Sand (6)		Tills (1)		Silt Moderate (-1)	
Cobble (8)	x	Bedrock (5)		Wetlands (0)		Silt Normal (0)	x
Hardpan (4)		detritus (3)		Hardpan (0)		Silt Free (1)	
Muck (2)		Artificial (0)		Sandstone (0)			
Silt (2)				Rip/Rap (0)		**Embeddedness**	
				Lacustrine (0)		Extensive (-2)	
				Shale (-1)	x	Moderate (-1)	x
				Coal Fines (-2)		Normal (0)	
						None (1)	

Substrate Subtotal: 13

Instream Cover							
Undercut Banks (1)		Pools >70cm (2)		Oxbows (1)		**Overhead Cover**	
Overhang Veg (1)	x	Rootwads (1)		Aquatic Macro (1)	x	>75% (11)	
Shallows (1)	x	Boulders (1)		Woody Debris (1)		25-75% (7)	x
Rootmats (1)	x					5-25% (3)	
						<5% (1)	

Instream Subtotal: 11

Channel Morphology

Sinuosity		**Development**		**Channelization**		**Stability**	
High (4)		Excellent (7)		None (6)	x	High (3)	
Moderate (3)	x	Good (5)		Recovered (4)		Moderate (2)	
Low (2)	x	Fair (3)	x	Recovering (3)		Low (1)	x
None (1)		Poor (1)	x	Recent / None (1)			

Channel Morphology Subtotal: 11.5

Riparian Zone and Bank Erosion

Riparian Width		**Floodplain Quality**				**Bank Erosion**	
Wide (4)	l	Forest (3)	l	Tillage (1)		None (3)	l r
Moderate (3)	r	Shrub (2)		Urban (0)	l r	Moderate (2)	
Narrow (2)	r	Residential (1)	r	Rowcrop (0)		Heavy (1)	
Very Narrow (1)		Pasture (1)		Mining (0)			
None (0)							

Riparian Zone Subtotal: 7

Pool/Glide and Riffle Run Quality

Max Depth		Morphology		Current Velocity (Pool and Riffles)		
>1 m (6)	x	PW>RW (2)	x	Eddies (1)		Torrential (-1)
0.7-1m (4)		PW=RW (1)		Fast (1)		Interstitial (-1)
0.4-0.7m (2)		PW<RW (0)		Moderate (1)		Intermittent (-2)
0.2-0.4m (1)		PW=pool width		Slow (1)	x	
<0.2m (0)		RW=riffle width		**Pool/Glide and Riffle Run Subtotal:**		9

Riffle/Run Depth Metric

R/R Depth		R/R Substrate	R/R Embeddedness	Run Depth
>10 cm,Max>50(4)		Stable (2)	None (2)	Max>50 (2)
>10 cm,Max<50(3)		Mod Stable (1)	Low (1)	Max<50 (1)
5-10cm (1)		Unstable (0)	Moderate (0)	
<5 cm (0)			Extensive (-1)	
	If No Riffle, Metric=0	x	**Riffle/Run Depth Subtotal:**	0

Stream Gradient Metric

Stream Gradient (ft/mi)		
0' - 3.3'	4	
3.4' - 6.6'	6	
6.7' - 9.8'	8	
9.9' - 13.1'	10	
13.2' - 23.0'	8	
23.1' - 32.8'	6	x
32.9' - 65.6'	4	
> 65.7'	2	

Stream Gradient Subtotal: 6

QHEI TOTAL SCORE: 57.5

Sampling Site # **11** **Stream:** Burgess Run

Substrate Type				Substrate Origin		Substrate Quality	
bldr/slbs (10)		Gravel (7)	x	Limestone (1)		Silt Heavy (-2)	x
Boulder (9)		Sand (6)		Tills (1)		Silt Moderate (-1)	
Cobble (8)		Bedrock (5)		Wetlands (0)		Silt Normal (0)	
Hardpan (4)		detritus (3)		Hardpan (0)		Silt Free (1)	
Muck (2)		Artificial (0)		Sandstone (0)	x		
Silt (2)	x			Rip/Rap (0)		**Embeddedness**	
				Lacustrine (0)		Extensive (-2)	x
				Shale (-1)		Moderate (-1)	
				Coal Fines (-2)		Normal (0)	
						None (1)	

Substrate Subtotal: 3

Instream Cover

						Overhead Cover	
Undercut Banks (1)		Pools >70cm (2)		Oxbows (1)			
Overhang Veg (1)	x	Rootwads (1)		Aquatic Macro (1)	x	>75% (11)	
Shallows (1)	x	Boulders (1)		Woody Debris (1)		25-75% (7)	
Rootmats (1)						5-25% (3)	x
						<5% (1)	

Instream Subtotal: 6

Channel Morphology

Sinuosity		Development		Channelization		Stability	
High (4)		Excellent (7)		None (6)	x	High (3)	
Moderate (3)		Good (5)		Recovered (4)		Moderate (2)	
Low (2)	x	Fair (3)	x	Recovering (3)		Low (1)	x
None (1)		Poor (1)	x	Recent / None (1)			

Channel Morphology Subtotal: 11

Riparian Zone and Bank Erosion

Riparian Width		Floodplain Quality				Bank Erosion	
Wide (4)		Forest (3)		Tillage (1)		None (3)	l r
Moderate (3)		Shrub (2)	l r	Urban (0)	l r	Moderate (2)	
Narrow (2)		Residential (1)		Rowcrop (0)		Heavy (1)	
Very Narrow (1)	l	Pasture (1)		Mining (0)			
None (0)			r				

Riparian Zone Subtotal: 4.5

Pool/Glide and Riffle Run Quality

Max Depth		Morphology		Current Velocity (Pool and Riffles)		
>1 m (6)		PW>RW (2)		Eddies (1)		Torrential (-1)
0.7-1m (4)		PW=RW (1)	x	Fast (1)		Interstitial (-1)
0.4-0.7m (2)		PW<RW (0)		Moderate (1)		Intermittent (-2)
0.2-0.4m (1)		PW=pool width		Slow (1)	x	
<0.2m (0)	x	RW=riffle width				

Pool/Glide and Riffle Run Subtotal: 2

Riffle/Run Depth Metric

R/R Depth	R/R Substrate		R/R Embeddedness	Run Depth
>10 cm,Max>50(4)	Stable (2)		None (2)	Max>50 (2)
>10 cm,Max<50(3)	Mod Stable (1)		Low (1)	Max<50 (1)
5-10cm (1)	Unstable (0)		Moderate (0)	
<5 cm (0)			Extensive (-1)	
	If No Riffle, Metric=0	x		

Riffle/Run Depth Subtotal: 0

Stream Gradient Metric

Stream Gradient (ft/mi)		
0' - 3.3'	4	
3.4' - 6.6'	6	
6.7' - 9.8'	8	x
9.9' - 13.1'	10	
13.2' - 23.0'	8	
23.1' - 32.8'	6	
32.9' - 65.6'	4	
> 65.7'	2	

Stream Gradient Subtotal: 8

QHEI TOTAL SCORE: 34.5

Sampling Site #	**12**					**Stream:**	Burgess Run 3
Substrate Type				**Substrate Origin**		**Substrate Quality**	
bldr/slbs (10)		Gravel (7)	x	Limestone (1)		Silt Heavy (-2)	
Boulder (9)		Sand (6)		Tills (1)		Silt Moderate (-1)	
Cobble (8)		Bedrock (5)		Wetlands (0)		Silt Normal (0)	x
Hardpan (4)		detritus (3)		Hardpan (0)		Silt Free (1)	
Muck (2)		Artificial (0)		Sandstone (0)	x		
Silt (2)	x			Rip/Rap (0)		**Embeddedness**	
				Lacustrine (0)		Extensive (-2)	
				Shale (-1)		Moderate (-1)	
				Coal Fines (-2)		Normal (0)	x
						None (1)	
				Substrate Subtotal:		9	
Instream Cover							
Undercut Banks (1)		Pools >70cm (2)		Oxbows (1)		**Overhead Cover**	
Overhang Veg (1)	x	Rootwads (1)		Aquatic Macro (1)	x	>75% (11)	
Shallows (1)	x	Boulders (1)		Woody Debris (1)		25-75% (7)	
Rootmats (1)						5-25% (3)	x
						<5% (1)	
				Instream Subtotal:		6	
Channel Morphology							
Sinuosity		**Development**		**Channelization**		**Stability**	
High (4)		Excellent (7)		None (6)	x	High (3)	
Moderate (3)		Good (5)		Recovered (4)		Moderate (2)	x
Low (2)	x	Fair (3)	x	Recovering (3)		Low (1)	
None (1)		Poor (1)		Recent / None (1)			
				Channel Morphology Subtotal:		13	
Riparian Zone and Bank Erosion							
Riparian Width		**Floodplain Quality**				**Bank Erosion**	
Wide (4)		Forest (3)		Tillage (1)		None (3)	l r
Moderate (3)		Shrub (2)		Urban (0)	l r	Moderate (2)	
Narrow (2)		Residential (1)	l r	Rowcrop (0)	l r	Heavy (1)	
Very Narrow (1)	l r	Pasture (1)		Mining (0)			
None (0)				**Riparian Zone Subtotal:**		4.3	
Pool/Glide and Riffle Run Quality							
Max Depth		**Morphology**		**Current Velocity (Pool and Riffles)**			
>1 m (6)		PW>RW (2)	x	Eddies (1)		Torrential (-1)	
0.7-1m (4)		PW=RW (1)		Fast (1)		Interstitial (-1)	
0.4-0.7m (2)		PW<RW (0)		Moderate (1)		Intermittent (-2)	
0.2-0.4m (1)		PW=pool width		Slow (1)	x		
<0.2m (0)	x	RW=riffle width		**Pool/Glide and Riffle Run Subtotal:**		3	

Riffle/Run Depth Metric

R/R Depth		R/R Substrate		R/R Embeddedness		Run Depth	
>10 cm,Max>50(4)		Stable (2)		None (2)		Max>50 (2)	
>10 cm,Max<50(3)		Mod Stable (1)		Low (1)		Max<50 (1)	
5-10cm (1)		Unstable (0)		Moderate (0)			
<5 cm (0)				Extensive (-1)			
		If No Riffle, Metric=0	x	**Riffle/Run Depth Subtotal:**			0

Stream Gradient Metric

Stream Gradient (ft/mi)			
0' - 3.3'	4		
3.4' - 6.6'	6		
6.7' - 9.8'	8		
9.9' - 13.1'	10		
13.2' - 23.0'	8	x	
23.1' - 32.8'	6		
32.9' - 65.6'	4		
> 65.7'	2		

Stream Gradient Subtotal: 8

QHEI TOTAL SCORE: 43.3

Sampling Site # 13 **Stream:** Drake's Run

Substrate Type				Substrate Origin		Substrate Quality	
bldr/slbs (10)		Gravel (7)	x	Limestone (1)		Silt Heavy (-2)	
Boulder (9)		Sand (6)	x	Tills (1)	x	Silt Moderate (-1)	
Cobble (8)		Bedrock (5)		Wetlands (0)		Silt Normal (0)	x
Hardpan (4)		detritus (3)		Hardpan (0)		Silt Free (1)	
Muck (2)		Artificial (0)		Sandstone (0)			
Silt (2)				Rip/Rap (0)		**Embeddedness**	
				Lacustrine (0)		Extensive (-2)	
				Shale (-1)		Moderate (-1)	
				Coal Fines (-2)		Normal (0)	x
						None (1)	x

Substrate Subtotal: 13.5

Instream Cover						Overhead Cover	
Undercut Banks (1)	x	Pools >70cm (2)		Oxbows (1)		>75% (11)	
Overhang Veg (1)	x	Rootwads (1)		Aquatic Macro (1)			
Shallows (1)		Boulders (1)		Woody Debris (1)	x	25-75% (7)	x
Rootmats (1)						5-25% (3)	
						<5% (1)	

Instream Subtotal: 10

Channel Morphology

Sinuosity		Development		Channelization		Stability	
High (4)		Excellent (7)		None (6)	x	High (3)	
Moderate (3)		Good (5)		Recovered (4)		Moderate (2)	x
Low (2)	x	Fair (3)	x	Recovering (3)		Low (1)	
None (1)		Poor (1)	x	Recent / None (1)			

Channel Morphology Subtotal: 12

Riparian Zone and Bank Erosion

Riparian Width		Floodplain Quality				Bank Erosion	
Wide (4)	l r	Forest (3)	l r	Tillage (1)		None (3)	
Moderate (3)		Shrub (2)		Urban (0)		Moderate (2)	l r
Narrow (2)		Residential (1)		Rowcrop (0)	Heavy (1)		
Very Narrow (1)		Pasture (1)		Mining (0)			
None (0)							

Riparian Zone Subtotal: 9

Pool/Glide and Riffle Run Quality

Max Depth		Morphology		Current Velocity (Pool and Riffles)		
>1 m (6)		PW>RW (2)	x	Eddies (1)		Torrential (-1)
0.7-1m (4)		PW=RW (1)		Fast (1)		Interstitial (-1)
0.4-0.7m (2)		PW<RW (0)		Moderate (1)	x	Intermittent (-2)
0.2-0.4m (1)	x	PW=pool width		Slow (1)		
<0.2m (0)		RW=riffle width				

Pool/Glide and Riffle Run Subtotal: 4

Riffle/Run Depth Metric

R/R Depth		R/R Substrate		R/R Embeddedness		Run Depth	
>10 cm,Max>50(4)		Stable (2)		None (2)		Max>50 (2)	
>10 cm,Max<50(3)		Mod Stable (1)		Low (1)	x	Max<50 (1)	x
5-10cm (1)		Unstable (0)	x	Moderate (0)			
<5 cm (0)		x		Extensive (-1)			
		If No Riffle, Metric=0					

Riffle/Run Depth Subtotal: 2

Stream Gradient Metric

Stream Gradient (ft/mi)		
0' - 3.3'	4	
3.4' - 6.6'	6	
6.7' - 9.8'	8	
9.9' - 13.1'	10	
13.2' - 23.0'	8	
23.1' - 32.8'	6	x
32.9' - 65.6'	4	
> 65.7'	2	

Stream Gradient Subtotal: 6

QHEI TOTAL SCORE: 56.5

Sampling Site # 14 **Stream:** Drake's Run

Substrate Type			Substrate Origin		Substrate Quality	
bldr/slbs (10)	Gravel (7)	x	Limestone (1)		Silt Heavy (-2)	
Boulder (9)	Sand (6)	x	Tills (1)		Silt Moderate (-1)	
Cobble (8)	Bedrock (5)		Wetlands (0)		Silt Normal (0)	x
Hardpan (4)	detritus (3)		Hardpan (0)		Silt Free (1)	
Muck (2)	Artificial (0)		Sandstone (0)			
Silt (2)			Rip/Rap (0)		**Embeddedness**	
			Lacustrine (0)		Extensive (-2)	
			Shale (-1)	x	Moderate (-1)	
			Coal Fines (-2)		Normal (0)	x
					None (1)	x

Substrate Subtotal: 12.5

Instream Cover					Overhead Cover	
Undercut Banks (1)		Pools >70cm (2)	Oxbows (1)			
Overhang Veg (1)		Rootwads (1)	Aquatic Macro (1)	x	>75% (11)	
Shallows (1)	x	Boulders (1)	Woody Debris (1)		25-75% (7)	
Rootmats (1)					5-25% (3)	
					<5% (1)	x

Instream Subtotal: 3

Channel Morphology

Sinuosity		Development		Channelization		Stability	
High (4)		Excellent (7)		None (6)		High (3)	
Moderate (3)		Good (5)		Recovered (4)		Moderate (2)	
Low (2)		Fair (3)		Recovering (3)		Low (1)	x
None (1)	x	Poor (1)	x	Recent / None (1)	x		

Channel Morphology Subtotal: 4

Riparian Zone and Bank Erosion

Riparian Width		Floodplain Quality				Bank Erosion	
Wide (4)		Forest (3)		Tillage (1)		None (3)	
Moderate (3)		Shrub (2)		Urban (0)	l r	Moderate (2)	
Narrow (2)		Residential (1)	l r	Rowcrop (0)		Heavy (1)	l r
Very Narrow (1)		Pasture (1)		Mining (0)			
None (0)	l r						

Riparian Zone Subtotal: 1.5

Pool/Glide and Riffle Run Quality

Max Depth		Morphology		Current Velocity (Pool and Riffles)			
>1 m (6)		PW>RW (2)	x	Eddies (1)		Torrential (-1)	
0.7-1m (4)		PW=RW (1)		Fast (1)		Interstitial (-1)	
0.4-0.7m (2)		PW<RW (0)		Moderate (1)		Intermittent (-2)	
0.2-0.4m (1)		PW=pool width		Slow (1)	x		
<0.2m (0)	x	RW=riffle width					

Pool/Glide and Riffle Run Subtotal: 3

Riffle/Run Depth Metric

R/R Depth	R/R Substrate		R/R Embeddedness	Run Depth
>10 cm,Max>50(4)	Stable (2)		None (2)	Max>50 (2)
>10 cm,Max<50(3)	Mod Stable (1)		Low (1)	Max<50 (1)
5-10cm (1)	Unstable (0)		Moderate (0)	
<5 cm (0)			Extensive (-1)	
	If No Riffle, Metric=0	x		

Riffle/Run Depth Subtotal: 0

Stream Gradient Metric

Stream Gradient (ft/mi)		
0' - 3.3'	4	
3.4' - 6.6'	6	
6.7' - 9.8'	8	
9.9' - 13.1'	10	
13.2' - 23.0'	8	
23.1' - 32.8'	6	
32.9' - 65.6'	4	x
> 65.7'	2	

Stream Gradient Subtotal: 4

QHEI TOTAL SCORE: 28