Biological and Water Quality Study of the Vermilion River, Old Woman Creek, Chappel Creek, Sugar Creek, and Select Lake Erie Tributaries 2002

Ashland, Huron, Erie, Richland and Lorain Counties

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NOTICE TO USERS

Ohio EPA incorporated biological criteria into the Ohio Water Quality Standards (WQS; Ohio Administrative Code 3745-1) regulations in February 1990 (effective May 1990). These criteria consist of numeric values for the Index of Biotic Integrity (IBI) and Modified Index of Well-Being (MIwb), both of which are based on fish assemblage data, and the Invertebrate Community Index (ICI), which is based on macroinvertebrate assemblage data. Criteria for each index are specified for each of Ohio's five ecoregions (as described by Omernik 1987), and are further organized by organism group, index, site type, and aquatic life use designation. These criteria, along with the existing chemical and whole effluent toxicity evaluation methods and criteria, figure prominently in the monitoring and assessment of Ohio's surface water resources.

The following documents support the use of biological criteria by outlining the rationale for using biological information, the methods by which the biocriteria were derived and calculated, the field methods by which sampling must be conducted, and the process for evaluating results:

Ohio Environmental Protection Agency. 1987a. Biological criteria for the protection of aquatic life: Volume I. The role of biological data in water quality assessment. Div. Water Qual. Monit. & Assess., Surface Water Section, Columbus, Ohio.

Ohio Environmental Protection Agency. 1987b. Biological criteria for the protection of aquatic life: Volume II. Users manual for biological field assessment of Ohio surface waters. Div. Water Qual. Monit. & Assess., Surface Water Section, Columbus, Ohio.

Ohio Environmental Protection Agency. 1989b. Addendum to Biological criteria for the protection of aquatic life: Volume II. Users manual for biological field assessment of Ohio surface waters. Div. Water Qual. Plan. & Assess., Ecol. Assess. Sect., Columbus, Ohio.

Ohio Environmental Protection Agency. 1989c. Biological criteria for the protection of aquatic life: Volume III. Standardized biological field sampling and laboratory methods for assessing fish and macroinvertebrate communities. Div. Water Quality Plan. & Assess., Ecol. Assess. Sect., Columbus, Ohio.

Ohio Environmental Protection Agency. 1990. The use of biological criteria in the Ohio EPA surface water monitoring and assessment program. Div. Water Qual. Plan. & Assess., Ecol. Assess. Sect., Columbus, Ohio.

Rankin, E.T. 1989. The qualitative habitat evaluation index (QHEI): rationale, methods, and application. Div. Water Qual. Plan. & Assess., Ecol. Assess. Sect., Columbus, Ohio.

Since the publication of the preceding guidance documents, the following new publications by the Ohio EPA have become available. These publications should also be consulted as they represent the latest information and analyses used by the Ohio EPA to implement the biological criteria.

DeShon, J.D. 1995. Development and application of the invertebrate community index (ICI), pp. 217-243. in W.S. Davis and T. Simon (eds.). Biological Assessment and Criteria: Tools for Risk-based Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

Rankin, E. T. 1995. The use of habitat assessments in water resource management programs, pp. 181-208. in W. Davis and T. Simon (eds.). Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

Yoder, C.O. and E.T. Rankin. 1995. Biological criteria program development and implementation in Ohio, pp. 109-144. in W. Davis and T. Simon (eds.). Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

Yoder, C.O. and E.T. Rankin. 1995. Biological response signatures and the area of degradation value: new tools for interpreting multimetric data, pp. 263-286. in W. Davis and T. Simon (eds.). Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

Yoder, C.O. 1995. Policy issues and management applications for biological criteria, pp. 327-344. in W. Davis and T. Simon (eds.). Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

Yoder, C.O. and E.T. Rankin. 1995. The role of biological criteria in water quality monitoring, assessment, and regulation. Environmental Regulation in Ohio: How to Cope With the Regulatory Jungle. Inst. of Business Law, Santa Monica, CA. 54 pp.

These documents and this report may be obtained by writing to:

Ohio EPA, Division of Surface Water
Ecological Assessment Section
4675 Homer Ohio Lane
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Copies of this report are located on the Ohio EPA internet web page (www.epa.state.oh.us/dsw/document_index/psdindx.html) or may be available on CD from:

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FOREWORD

What is a Biological and Water Quality Survey?

A biological and water quality survey, or "biosurvey", is an interdisciplinary monitoring effort coordinated on a waterbody specific or watershed scale. This effort may involve a relatively simple setting focusing on one or two small streams, one or two principal stressors, and a handful of sampling sites or a much more complex effort including entire drainage basins, multiple and overlapping stressors, and tens of sites. Each year Ohio EPA conducts biosurveys in 4-5 watersheds study areas with an aggregate total of 250-300 sampling sites.

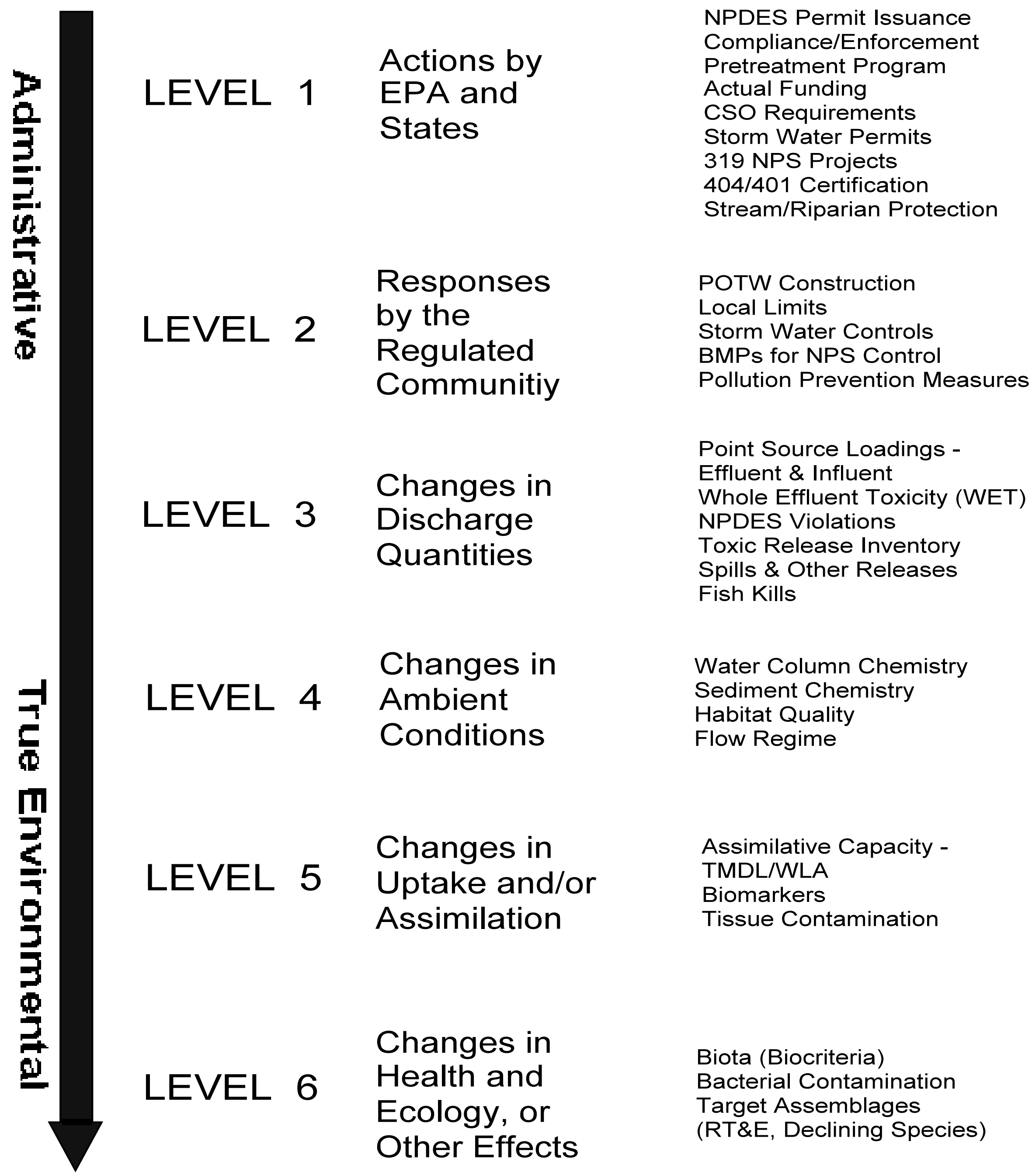
The Ohio EPA employs biological, chemical, and physical monitoring and assessment techniques in biosurveys in order to meet three major objectives: 1) determine the extent to which use designations assigned in the Ohio Water Quality Standards (WQS) are either attained or not attained; 2) determine if use designations assigned to a given water body are appropriate and attainable; and 3) determine if any changes in key ambient biological, chemical, or physical indicators have taken place over time, particularly before and after the implementation of point source pollution controls or best management practices. The data gathered by a biosurvey is processed, evaluated, and synthesized in a biological and water quality report. Each biological and water quality study contains a summary of major findings and recommendations for revisions to WQS, future monitoring needs, or other actions which may be needed to resolve existing impairment of designated uses. While the principal focus of a biosurvey is on the status of aquatic life uses, the status of other uses such as recreation and water supply, as well as human health concerns, are also addressed.

The findings and conclusions of a biological and water quality study may factor into regulatory actions taken by Ohio EPA (*e.g.,* NPDES permits, Director's Orders, the Ohio Water Quality Standards [OAC 3745-1], Water Quality Permit Support Documents [WQPSDs]), and are eventually incorporated into State Water Quality Management Plans, the Ohio Nonpoint Source Assessment, and the biennial Integrated Water Quality Monitoring and Assessment Report (305[b] and 303[d]).

Hierarchy of Indicators

A carefully conceived ambient monitoring approach, using cost-effective indicators consisting of ecological, chemical, and toxicological measures, can ensure that all relevant pollution sources are judged objectively on the basis of environmental results. Ohio EPA relies on a tiered approach in attempting to link the results of administrative activities with true environmental measures. This integrated approach includes a hierarchical continuum from administrative to true environmental indicators (Figure1). The six "levels" of indicators include: 1) actions taken by regulatory agencies (permitting, enforcement, grants); 2) responses by the regulated community (treatment works, pollution prevention); 3) changes in discharged quantities (pollutant loadings); 4) changes in ambient conditions (water quality, habitat); 5) changes in uptake and/or assimilation (tissue contamination, biomarkers, wasteload allocation); and, 6) changes in health, ecology, or other effects (ecological condition, pathogens). In this process the results of administrative activities (levels 1 and 2) can be linked to efforts to improve water quality (levels 3, 4, and 5) which should translate into the environmental "results" (level 6). Thus, the aggregate effect of billions of dollars spent on water pollution control since the early 1970s can now be determined with quantifiable measures of environmental condition.

Superimposed on this hierarchy is the concept of stressor, exposure, and response indicators. *Stressor* indicators generally include activities which have the potential to degrade the aquatic environment such as pollutant discharges (permitted and unpermitted), land use effects, and habitat



modifications. *Exposure* indicators are those which measure the effects of stressors and can include whole effluent toxicity tests, tissue residues, and biomarkers, each of which provides evidence of biological exposure to a stressor or bioaccumulative agent. *Response* indicators are generally composite measures of the cumulative effects of stress and exposure and include the more direct measures of community and population response that are represented here by the biological indices which comprise Ohio's biological criteria. Other response indicators could include target assemblages, *i.e.,* rare, threatened, endangered, special status, and declining species or bacterial levels which serve as surrogates for the recreation uses. These indicators represent the essential technical elements for watershed-based management approaches. The key, however, is to use the different indicators *within* the roles which are most appropriate for each.

Describing the causes and sources associated with observed impairments revealed by the biological criteria and linking this with pollution sources involves an interpretation of multiple lines of evidence including water chemistry data, sediment data, habitat data, effluent data, biomonitoring results, land use data, and biological response signatures within the biological data itself. Thus the assignment of principal causes and sources of impairment represents the association of impairments (defined by response indicators) with stressor and exposure indicators. The principal reporting venue for this process on a watershed or subbasin scale is a biological and water quality report. These reports then provide the foundation for aggregated assessments such as the Integrated Water Quality Monitoring and Assessment Report (305[b] and 303[d]), the Ohio Nonpoint Source Assessment, and other technical bulletins.

Ohio Water Quality Standards: Designated Aquatic Life Use

The Ohio Water Quality Standards (WQS; Ohio Administrative Code 3745-1) consist of designated uses and chemical, physical, and biological criteria designed to represent measurable properties of the environment that are consistent with the goals specified by each use designation. Use designations consist of two broad groups, aquatic life and non-aquatic life uses. In applications of the Ohio WQS to the management of water resource issues in Ohio's rivers and streams, the aquatic life use criteria frequently result in the most stringent protection and restoration requirements, hence their emphasis in biological and water quality reports. Also, an emphasis on protecting for aquatic life generally results in water quality suitable for all uses. The five different aquatic life uses currently defined in the Ohio WQS are described as follows:

1) *Warmwater Habitat (WWH)* - this use designation defines the "typical" warmwater assemblage of aquatic organisms for Ohio rivers and streams; *this use represents the principal restoration target for the majority of water resource management efforts in Ohio.*

2) *Exceptional Warmwater Habitat (EWH)* - this use designation is reserved for waters which support "unusual and exceptional" assemblages of aquatic organisms which are characterized by a high diversity of species, particularly those which are highly intolerant and/or rare, threatened, endangered, or special status (*i.e.,* declining species); *this designation represents a protection goal for water resource management efforts dealing with Ohio's best water resources.*

3) *Cold-water Habitat (CWH)* - this use is intended for waters which support assemblages of cold water organisms and/or those which are stocked with salmonids with the intent of providing a put-and-take fishery on a year round basis which is further sanctioned by the Ohio DNR, Division of Wildlife; this use should not be confused with the Seasonal Salmonid Habitat (SSH) use which applies to the Lake Erie tributaries which support periodic "runs" of salmonids during the spring, summer, and/or fall.

4) *Modified Warmwater Habitat (MWH)* - this use applies to streams and rivers which have been subjected to extensive, maintained, and essentially permanent hydromodifications such that the biocriteria for the WWH use are not attainable *and where the activities have been sanctioned by state or federal law;* the representative aquatic assemblages are generally composed of species which are tolerant to low dissolved oxygen, silt, nutrient enrichment, and poor quality habitat.

5) *Limited Resource Water (LRW)* - this use applies to small streams (usually <3 mi^2 drainage area) and other water courses which have been irretrievably altered to the extent that no appreciable assemblage of aquatic life can be supported; such waterways generally include small streams in extensively urbanized areas, those which lie in watersheds with extensive drainage modifications, those which completely lack water on a recurring annual basis (*i.e.,* true ephemeral streams), or other irretrievably altered waterways.

Chemical, physical, and/or biological criteria are generally assigned to each use designation in accordance with the broad goals defined by each. As such the system of use designations employed in the Ohio WQS constitutes a "tiered" approach in that varying and graduated levels of protection are provided by each. This hierarchy is especially apparent for parameters such as dissolved oxygen, ammonia-nitrogen, temperature, and the biological criteria. For other parameters such as heavy metals, the technology to construct an equally graduated set of criteria has been lacking, thus the same water quality criteria may apply to two or three different use designations.

Ohio Water Quality Standards: Non-Aquatic Life Uses
In addition to assessing the appropriateness and status of aquatic life uses, each biological and water quality survey also addresses non-aquatic life uses such as recreation, water supply, and human health concerns as appropriate. The recreation uses most applicable to rivers and streams are the Primary Contact Recreation (PCR) and Secondary Contact Recreation (SCR) uses. The criterion for designating the PCR use can be having a water depth of at least one meter over an area of at least 100 square feet or, lacking this, where frequent human contact is a reasonable expectation. If a water body does not meet either criterion, the SCR use applies. The attainment status of PCR and SCR is determined using bacterial indicators (*e.g.,* fecal coliform, *E. coli)* and the criteria for each are specified in the Ohio WQS.

Attainment of recreation uses are evaluated based on monitored bacteria levels. The Ohio Water Quality Standards state that all waters should be free from any public health nuisance associated with raw or poorly treated sewage (Administrative Code 3745-1-04, Part F). Additional criteria

(Administrative Code 3745-1-07) apply to waters that are designated as suitable for full body contact such as swimming (PCR- primary contact recreation) or for partial body contact such as wading (SCR- secondary contact recreation). These standards were developed to protect human health, because even though fecal coliform bacteria are relatively harmless in most cases, their presence indicates that the water has been contaminated with fecal matter.

Water supply uses include Public Water Supply (PWS), Agricultural Water Supply (AWS), and Industrial Water Supply (IWS). Public Water Supplies are simply defined as segments within 500 yards of a potable water supply or food processing industry intake. The Agricultural Water Supply (AWS) and Industrial Water Supply (IWS) use designations generally apply to all waters unless it can be clearly shown that they are not applicable. An example of this would be an urban area where livestock watering or pasturing does not take place, thus the AWS use would not apply. Chemical criteria are specified in the Ohio WQS for each use and attainment status is based primarily on chemical-specific indicators. Human health concerns are additionally addressed with fish tissue data, but any consumption advisories are issued by the Ohio Department of Health.

MECHANISMS FOR WATER QUALITY IMPAIRMENT

The following paragraphs are provided to present the varied causes of impairment that were encountered during the Vermilion and Old Woman Creek study. While the various perturbations are presented under separate headings, it is important to remember that they are often interrelated and cumulative in terms of the detrimental impact that can result.

Habitat and Flow Alterations
Habitat alteration, such as channelization, impacts biological communities directly by limiting the complexity of living spaces available to aquatic organisms. Consequently, fish and macroinvertebrate communities are not as diverse. Indirect impacts include the removal of riparian trees and field tiling to facilitate drainage. Following a rain event, most of the water is quickly removed from tiled fields rather than filtering through the soil, recharging groundwater, and reaching the stream at a lower volume and more sustained rate. As a result, small streams more frequently go dry or become intermittent.

Tree shade is important because it limits the energy input from the sun, moderates water temperature, and limits evaporation. Removal of the tree canopy further degrades conditions because it eliminates an important source of coarse organic matter essential for a balanced ecosystem. Erosion impacts channelized streams more severely due to the lack of a riparian buffer zone to slow runoff, trap sediment and stabilize banks. Additionally, deep trapezoidal channels lack a functioning flood plain and therefore cannot expel sediment as would occur during flood events along natural watercourses.

The lack of water movement under low flow conditions can exacerbate impacts from organic loading and nutrient enrichment by limiting reaeration of the stream. The amount of oxygen soluble in water decreases as temperature increases. This is one reason why tree shade is so important. The two main sources of oxygen in water are diffusion from the atmosphere and plant photosynthesis. Turbulence at the water surface is critical because it increases surface area and promotes diffusion, but channelization eliminates turbulence produced by riffles, meanders, and debris snags. Plant photosynthesis produces oxygen, but at night, respiration reverses the process and consumes oxygen. Oxygen is also used by bacteria that decay dead organic matter. Nutrient enrichment can promote the growth of nuisance algae that subsequently dies and serves as food for bacteria. Under these conditions, oxygen can be depleted unless it is replenished from the air.

Siltation and Sedimentation
Whenever the natural flow regime is altered to facilitate drainage, increased amounts of sediment are likely to enter streams either by overland transport or increased bank erosion. The removal of wooded riparian areas furthers the erosional process. Channelization keeps all but the highest flow events confined within the artificially high banks. As a result, areas that were formerly flood plains and allowed for the removal of sediment from the primary stream channel no longer serve this function. As water levels fall following a rain event, interstitial spaces between larger rocks fill with sand and silt and the diversity of available habitat to support fish and macroinvertebrates is reduced. Silt also can clog the gills of both fish and macroinvertebrates, reduce visibility thereby excluding site feeding fish species, and smother the nests of lithophilic fishes. Lithophilic spawning fish require clean substrates with interstitial voids in which to deposit eggs. Conversely, pioneering species benefit. They are generalists and best suited for exploiting disturbed and less heterogeneous habitats. The net result is a lower diversity of aquatic species compared with a typical warmwater stream with natural habitats.

Sediment also impacts water quality, recreation, and drinking water. Nutrients absorbed to soil particles remain trapped in the watercourse. Likewise, bacteria, pathogens, and pesticides which also attach to suspended or bedload sediments become concentrated in waterways where the channel is functionally isolated from the landscape. Community drinking water systems address these issues with more costly advanced treatment technologies.

Nutrient Enrichment
The element of greatest concern is phosphorus because it is critical for plant growth and is often the limiting nutrient. The form that can be readily used by plants and therefore can stimulate nuisance algae blooms is orthophosphate (PO_4^{-3}). The amount of phosphorus tied up in the nucleic acids of food and waste is actually quite low. This organic material is eventually converted to orthophosphate by bacteria. The amount of orthophosphate contained in synthetic detergents is a great concern however. It was for this reason that the General Assembly of the State of Ohio enacted a law in 1990 to limit phosphorus content in household laundry detergents sold in the Lake Erie drainage basin to 0.5 % by weight. Inputs of phosphorus originate from both point and nonpoint sources. Most of the phosphorus discharged by point sources is soluble. Another characteristic of point sources is they have a continuous impact and are human in origin, for instance, effluents from municipal sewage treatment plants. The contribution from failed on-lot septic systems can also be significant, especially if they are concentrated in a small area. The phosphorus concentration in raw

waste water is generally 8-10 mg/l and after secondary treatment is generally 4-6 mg/l. Further removal requires the added cost of chemical addition. The most common methods use the addition of lime or alum to form a precipitate, so most phosphorus (80%) ends up in the sludge.

A characteristic of phosphorus discharged by nonpoint sources is that the impact is intermittent and associated with stormwater runoff. Most of this phosphorus is bound tightly to soil particles and enters streams from erosion, although some comes from tile drainage. Urban stormwater is more of a concern if combined sewer overflows are involved. The impact from rural stormwater varies depending on land use and management practices and includes contributions from livestock feedlots and pastures and row crop agriculture. Crop fertilizer includes granular inorganic types and organic types such as manure or sewage sludge. Pasture land is especially a concern if the livestock have access to the stream. Large feedlots with manure storage lagoons create the potential for overflows and accidental spills. Land management is an issue because erosion is worse on streams without any riparian buffer zone to trap runoff. The impact is worse in streams that are channelized because they no longer have a functioning flood plain and cannot expel sediment during flooding. Oxygen levels must also be considered, because phosphorus is released from sediment at higher rates under anoxic conditions.

There is no numerical phosphorus criterion established in the Ohio Water Quality Standards, but there is a narrative criterion that states phosphorus should be limited to the extent necessary to prevent nuisance growths of algae and weeds (Administrative Code, 3745-1-04, Part E). Phosphorus loadings from large volume point source dischargers in the Lake Erie drainage basin are regulated by the National Pollutant Discharge Elimination System (NPDES). The permit limit is a concentration of 1.0 mg/l in final effluent. Research conducted by the Ohio EPA indicates that a significant correlation exists between phosphorus and the health of aquatic communities (Miltner and Rankin, 1998). It was concluded that biological community performance in headwater and wadeable streams was highest where phosphorus concentrations were lowest. It was also determined that the lowest phosphorus concentrations were associated with the highest quality habitats, supporting the notion that habitat is a critical component of stream function. The report recommends WWH criteria of 0.08 mg/l in headwater streams (<20 mi^2 watershed size), 0.10 mg/l in wadeable streams (>20-200 mi^2) and 0.17 mg/l in small rivers (>200-1000 mi^2).

Organic Enrichment and Low Dissolved Oxygen

The amount of oxygen soluble in water is low and it decreases as temperature increases. This is one reason why tree shade is so important. The two main sources of oxygen in water are diffusion from the atmosphere and plant photosynthesis. Turbulence at the water surface is critical because it increases surface area and promotes diffusion. Drainage practices such as channelization eliminate turbulence produced by riffles, meanders, and debris snags. Although plant photosynthesis produces oxygen by day, it is consumed by the reverse process of respiration at night. Oxygen is also consumed by bacteria that decay organic matter, so it can be easily depleted unless it is replenished from the air. Sources of organic matter include poorly treated waste water, livestock waste, sewage bypasses, and dead plants and algae.

Dissolved oxygen criteria are established in the Ohio Water Quality Standards to protect aquatic life. The minimum and average limits are tiered values and linked to use designations (Administrative Code 3745-1-07, Table 7-1).

Ammonia

Ammonia enters streams as a component of fertilizer and manure run-off and wastewater effluent. Ammonia gas (NH_3) readily dissolves in water to form the compound ammonium hydroxide (NH_4OH). In aquatic ecosystems an equilibrium is established as ammonia shifts from a gas to undissociated ammonium hydroxide to the dissociated ammonium ion (NH_4^{+1}). Under normal conditions (neutral pH 7 and 25°C) almost none of the total ammonia is present as gas, only 0.55% is present as ammonium hydroxide, and the rest is ammonium ion. Alkaline pH shifts the equation toward gaseous ammonia production, so the amount of ammonium hydroxide increases. This is important because while the ammonium ion is almost harmless to aquatic life, ammonium hydroxide is very toxic and can reduce growth and reproduction or cause mortality.

The concentration of ammonia in raw sewage is high, sometimes as much as 20-30 mg/l. Treatment to remove ammonia involves gaseous stripping to the atmosphere, biological nitrification and de-nitrification, and assimilation into plant and animal biomass. The nitrification process requires a long detention time and aerobic conditions like that provided in extended aeration treatment plants. Under these conditions, bacteria first convert ammonia to nitrite and then to nitrate. Nitrate can then be reduced by bacteria through the de-nitrification process and nitrogen gas and carbon dioxide are produced as by-products.

Ammonia criteria are established in the Ohio Water Quality Standards to protect aquatic life. The maximum and average limits are tiered values based on sample pH and temperature and linked to use designations (Administrative Code 3745-1-07, Tables 7-2 through 7-8).

Metals

Metals can be toxic to aquatic life and hazardous to human health. Although they are naturally occurring elements many are extensively used in manufacturing and are by-products of human activity. Certain metals like copper and zinc are essential in the human diet, but excessive levels are usually detrimental. Lead and mercury are of particular concern because they often trigger fish consumption advisories. Mercury is used in the production of chlorine gas and caustic soda and in the manufacture of batteries and fluorescent light bulbs. In the environment it forms inorganic salts, but bacteria convert these to methyl-mercury and this organic form builds up in the tissues of fish. Extended exposure can damage the brain, kidneys, and developing fetus. The Ohio Department of Health (ODH) issued a statewide fish consumption advisory in 1997 advising women of child bearing age and children six and under not to eat more than one meal per week of any species of fish from waters of the state because of mercury. Lead is used in batteries, pipes, and paints and is emitted from burning fossil fuels. It affects the central nervous system and damages the kidneys and reproductive system. Copper is mined extensively and used to manufacture wire, sheet metal, and pipes. Ingesting large amounts can cause liver and kidney damage. Zinc is a by-product of mining, steel production, and coal burning and used in alloys such as brass and bronze. Ingesting large amounts can cause stomach cramps, nausea, and vomiting.

Metals criteria are established in the Ohio Water Quality Standards to protect human health, wildlife, and aquatic life. Three levels of aquatic life standards are established (Administrative Code 3745-1-07, Table 7-1) and limits for some elements are based on water hardness (Administrative Code 3745-1-07, Table 7-9). Human health and wildlife standards are linked to either the Lake Erie (Administrative Code 3745-1-33, Table 33-2) or Ohio River (Administrative Code 3745-1-34, Table 34-1) drainage basins. The drainage basins also have limits for additional elements not established elsewhere that are identified as Tier I and Tier II values.

Bacteria

High concentrations of either fecal coliform bacteria or Escherichia coli (E. coli) in a lake or stream may indicate contamination with human pathogens. People can be exposed to contaminated water while wading, swimming, and fishing. Fecal coliform bacteria are relatively harmless in most cases, but their presence indicates that the water has been contaminated with feces from a warm-blooded animal. Although intestinal organisms eventually die off outside the body, some will remain virulent for a period of time and may be dangerous sources of infection. This is especially a problem if the feces contained pathogens or disease producing bacteria and viruses. Reactions to exposure can range from an isolated illness such as skin rash, sore throat, or ear infection to a more serious wide spread epidemic. Some types of bacteria that are a concern include *Escherichia*, which cause diarrhea and urinary tract infections, *Salmonella*, which cause typhoid fever and gastroenteritis (food poisoning), and *Shigella*, which cause severe gastroenteritis or bacterial dysentery. Some types of viruses that are a concern include polio, hepatitis A, and encephalitis. Disease causing microorganisms such as cryptosporidium and giardia are also a concern.

Since fecal coliform bacteria are associated with warm-blooded animals, there are both human and animal sources. Human sources, including effluent from sewage treatment plants or discharges by on-lot septic systems, are a more continuous problem. Bacterial contamination from combined sewer overflows are associated with wet weather events. Animal sources are usually more intermittent and are also associated with rainfall, except when domestic livestock have access to the water. Large livestock farms store manure in holding lagoons and this creates the potential for an accidental spill. Liquid manure applied as fertilizer is a runoff problem if not managed properly and it sometimes seeps into field tiles.

Bacteria criteria are established in the Ohio Water Quality Standards to protect human health. The maximum and average limits are tiered values and linked to use designation, but only apply during the May 1-October 15 recreation season (Administrative Code 3745-1-07, Table 7-13). The standards also state that streams must be free of any public health nuisance associated with raw or poorly treated sewage during dry weather conditions (Administrative Code 3745-1-04, Part F).

Sediment Contamination

Chemical quality of sediment is a concern because many pollutants bind strongly to soil particles and are persistent in the environment. Some of these compounds accumulate in the aquatic food chain and trigger fish consumption advisories, but others are simply a contact hazard because they cause skin cancer and tumors. The physical and chemical nature of sediment is determined by local geology, land use, and contribution from manmade sources. As some materials enter the water column they are attracted to the surface electrical charges associated with suspended silt and clay particles. Others simply sink to the bottom due to their high specific gravity. Sediment layers form as suspended particles settle, accumulate, and combine with other organic and inorganic materials. Sediment is the most physically, chemically, and biologically reactive at the water interface because this is where it is affected by sunlight, current, wave action, and benthic organisms. Assessment of the chemical nature of this layer can be used to predict ecological impact.

The Ohio EPA evaluation of sediment chemistry results are evaluated using a dual approach, first by ranking relative concentrations based on a system developed by Ohio EPA (1996) and then by determining the potential for toxicity based on guidelines developed by MacDonald et al (2000). The Ohio EPA system was derived from samples collected at ecoregional reference sites. Classes are grouped in ranges that are based on the median analytical value (non-elevated) plus 1 (slightly elevated), 2 (elevated), 4 (highly elevated), and 8 (extremely elevated) inter-quartile values. The MacDonald guidelines are consensus based using previously developed values. The system predicts that sediments below the threshold effect concentration (TEC) are absent of toxicity and those greater than the probable effect concentration (PEC) are toxic.

Sediment samples collected by the Ohio EPA are measured for a number of physical and chemical properties. Physical attributes included % particle size distribution (sand $\geq 60\ \mu$, silt 5-59 μ, clay $\leq 4\ \mu$), % solids, and % organic carbon. Due to the dynamics of flowing water, most streams do not contain a lot of sediment and samples often consist mostly of inert sand. This scenario changes if the stream is impounded by a dam or channelized. Chemical attributes included metals, volatile and semi-volatile organic compounds, pesticides, and poly-chlorinated biphenyls (PCBs).

NONPOINT SOURCE POLLUTION IMPACTS AND REMEDIATION PROJECTS

Nonpoint sources of pollution to a water resource are a direct function of surrounding land use. All land use contributes to nonpoint sources of pollution that impair Ohio watersheds. Land use impacts water resources by affecting stream flow, stream habitat, nutrient enrichment, and siltation. Since agriculture occupies about 71% of the land area in the Vermilion River watershed and over 66% of the land use in the Old Woman Creek basin, agricultural land uses are responsible for much of the nonpoint source pollution in area streams (Huron SWCD, 2004 and Erie SWCD, 2004). Agricultural land use is a source of nonpoint source pollution as it may increase habitat alteration, nutrient enrichment, siltation and flow alteration. Nonpoint source pollution and land use impacts on water resources in the Vermilion River and Old Woman Creek watersheds include the following.

A. Impacts on Drinking Water
- Nitrate concentrations often exceed drinking water standards
- Seasonally elevated herbicide levels
- High concentrations of suspended solids during runoff events

B. Impacts to Aquatic Life
- Failure to attain aquatic life uses set by Ohio Water Quality Standards
- Fish and wildlife kills due to spills
- Sedimentation impairment to in-stream habitat for fish and macroinvertebrates

C. Impacts to Recreational Water Use
- Primary and Secondary Contact Recreation Uses limited by high bacteria events
- Fish consumption advisory for the entire Vermilion River watershed
- Aesthetic impairment from sediment and algal blooms

D. Impacts on Lake Erie through pollutant loading
- Phosphorus loading to Old Woman Creek and Lake Erie
- Suspended sediment degradation to Vermilion River, Old Woman Creek, and Lake Erie habitat
- Pesticides, nitrates, and other organic chemical pollutants transported by sediment

E. Impacts from Urban Land Use
- Impervious surfaces cause accelerated runoff volume to the river
- Failing septic systems
- Contaminated storm runoff

Over the past fifteen years many programs for reducing nonpoint source pollution have been introduced within the Vermilion River watershed, including the Continuous Conservation Reserve Program (CCRP), the Conservation Reserve Enhancement Program (CREP), Upper Vermilion Nutrient Management Program, Vermilion River Water Quality 319 project and the USDA Agricultural Stabilization and Conservation Service Best Management Practices (HWSCD, 2004). The high amount of agricultural practices affecting water quality throughout the study area indicates that increased participation in these and similar programs is needed. Additional educational and outreach activities may help boost involvement in these programs and thereby reduce the impacts of agricultural practices on water quality.

Biological and Water Quality Study of the Vermilion River, Old Woman Creek Chappel Creek, Sugar Creek, and Select Tributaries 2002

Ashland, Huron, Erie, Richland and Lorain Counties

State of Ohio Environmental Protection Agency
Division of Surface Water
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INTRODUCTION

The Vermilion River study area consisted of the Vermilion River mainstem from State Route 60/250 in Ashland County at river mile (RM) 63.8 to Lake Erie in the Village of Vermilion, Erie County at RM 0.1. The study area also included the following tributaries: unnamed tributary to Vermilion River (RM 63.52), Clear Creek, unnamed tributary to Vermilion River (RM 54.62), unnamed tributary to Vermilion River (RM 32.98), unnamed tributary to Vermilion River (RM 8.29), unnamed tributary to Vermilion River (RM 24.35), unnamed tributary to Vermilion River (RM 12.1), East Fork Vermilion River, unnamed tributary to East Fork Vermilion River (RM 8.47), Skellinger Creek, Frankenburg Creek, East Branch Vermilion River, unnamed tributary to East Branch Vermilion River (RM 8.2), Indian Creek, Southwest Branch Vermilion River, unnamed tributary to Southwest Branch Vermilion River (RM 2.3), unnamed tributary to Southwest Branch Vermilion River (RM 5.35), Buck Creek, and an unnamed tributary to Buck Creek (RM 4.92). The Old Woman Creek portion of the study included Old Woman Creek from County Line Road (RM 11.4) to the mouth (RM 0.1), an unnamed tributary to Old Woman Creek (RM 8.82), and an unnamed tributary to Old Woman Creek (RM 3.7). Select Lake Erie tributaries included in the study area were Chappel Creek, Sugar Creek, and Darby Creek (chemical sampling only). See Table 2 and Figure 1 for a complete list of sampling locations.

Specific objectives of this study were to:

1) evaluate all streams in the basin which drain at least 4 mi^2 to determine the status of resident aquatic communities,

2) assess the physical conditions in all basin streams to identify their potential to support aquatic biological communities,

3) evaluate the biological potential to support the WWH use designation in any subsequently

identified candidate WWH stream,

4) characterize the amount of aquatic resource degradation attributable to various land uses including agricultural practices and rural community development, and

5) determine any aquatic impacts from known point sources including the Vermilion, Wakeman, New London and Greenwich WWTPs, and from unsewered communities.

The findings of this evaluation may factor into regulatory actions taken by the Ohio EPA (e.g., NPDES permits, Director's Orders, or the Ohio Water Quality Standards (OAC 3745-1)), and may eventually be incorporated into State Water Quality Management Plans, the Ohio Nonpoint Source Assessment, and the biennial Integrated Water Quality Monitoring and Assessment Report (305[b] and 303[d] report).

SUMMARY

Aquatic Life Use Attainment Status and Trends

During 2000-2002, sampling in the Vermilion River and Old Woman Creek watersheds resulted in assessment of aquatic life uses at 70 sites ranging in drainage area from 1.8 mi^2 to 268 mi^2 (Figure 1). The Aquatic Life Use Attainment table (Table 2) provides biological metric scores along with causes and sources of impairment for each site. Twenty-three (32.86%) of the sites fully met either the currently designated or the recommended use. Ten (14.29%) of the sites partially met and thirty-seven (52.86%) of the sites were not attaining their designated or recommended use. The primary sources leading to impairment were high intensity agricultural land use, failing septic systems and suburban development.

Several data sets were available to assess environmental condition of the Vermilion River over time. These data included fish survey results from 1983, 1987, 1988, 1993, 1997, and 2002 (Figure 2). Historically, sampling was limited to discrete portions of the mainstem and no previous efforts evaluated the entire Vermilion River mainstem. Therefore, the analysis of trends examined several historical segments and stations and compared the results with similar river reaches or stations evaluated in 2002.

Longitudinal plots of biological community index scores versus river miles for all years sampled show a few areas consistently performing below WWH expectations (Figure 2). The biological communities present in the headwaters do not meet WWH criteria due to the historical and current habitat alterations through channelization activities and the nutrient enrichment effects of the Bailey Lakes WWTP. The second area of impairment was noted in the impounded area behind Wakeman Dam. The lacustuary area showed the third area of impairment, which is a result of both agricultural activities and suburban development occurring throughout the watershed.

The stretch of the Vermilion River from State Route 250 (RM 45.7) to Zenobia Road (RM 33.6) performed near EWH standards in 2002, though the performance is inconsistent over time. Sampling from the late 1990s revealed performance meeting WWH criteria, but not as high as the data from 2002. However, scores similar to those recorded in 2002 were found in 1987 for the State Route 250 (RM 45.7) site. Addressing impairments found in the tributaries and headwaters upstream from RM 33.6 will likely enhance the quality of biological communities in the Vermilion River mainstem. However, it is unlikely that the mainstem will perform consistently at EWH levels. Therefore, the WWH designation should be maintained for this stretch of the Vermilion River mainstem.

Ohio EPA first sampled the Old Woman Creek basin in 2000. The Old Woman Creek mainstem from State Route 113 (RM 9.4) to Mason Road (RM 5.4) was sampled both in 2000 and 2002. MIwb scores were not applicable to the size drainage areas encountered, and insufficient quantitative data existed to complete an ICI trend. The two upper sites, State Route 113 (RM 9.4) and Billamy Road (RM 8.4) decreased in biological performance as the IBI scores dropped from 40 and 36 in 2000, to 36 and 32 in 2002, respectively (Figure 3). The extreme drought conditions present in the basin in 2002 may account for the drop in scores in these headwater areas.

An examination of QHEI scores by drainage area of Vermilion River tributaries and streams within the Old Woman Creek basin indicates that the majority of poor habitat areas may be found in streams with $<10mi^2$ drainage area (Figure 4). Agricultural practices including riparian cover removal, channelization, and livestock access to streams have resulted in a degradation of available habitat to instream biological communities.

Recreation Use Attainment Status

The recreation use status throughout the Vermilion River and Old Woman Creek watersheds was assessed by bacterial sampling. The Recreation Use Evaluation table (Table 3) lists exceedances of the recreation use criteria, and not necessarily violations of the Ohio Water Quality Standards criteria. The results from the sampling indicate elevated bacterial levels throughout each watershed, potentially impairing the designated or recommended recreation use.

Since fecal coliform bacteria are associated with warm-blooded animals, there are both human and animal sources. Human sources, including effluent from sewage treatment plants or discharges by on-lot septic systems, are a more continuous problem. Exceedances noted downstream of the Bailey Lakes WWTP and the New London WWTP indicate potential concerns with each system. In addition, failing septic systems near unsewered communities including Fitchville, Clarksfield, West Clarksfield, Kipton, and Greenwich likely influenced the high bacterial counts noted in the Vermilion River basin. Failing septic systems in the Village of Berlinville are a likely source of fecal coliform in the Old Woman Creek basin.

Animal sources are usually more intermittent, as manure enters the stream via runoff associated with rainfall. However, if domestic livestock have direct access to streams, the effects on water quality are much greater. In several areas throughout the Vermilion and Old Woman Creek basins, livestock were noted to have direct access to streams. Large livestock farms store manure in holding lagoons and this creates the potential for an accidental spill. Liquid manure applied as fertilizer is a runoff problem if not managed properly and may seep into field tiles. In particular, application of manure to frozen fields was noted throughout the Old Woman Creek basin during January 2004. As temperatures warm and the ground thaws, the manure will likely directly enter the stream as run-off.

Public Water Supplies

The only public water supply that receives water directly from surface waters within the Vermilion River basin is the Village of New London. According to the Drinking Water Source Assessment for the village of New London (Ohio EPA, 2003) the Village of New London operates a community public water system that serves a population of approximately 3,200 (Plant #1) and 10,100 (Plant #2) people. The source is surface water taken from Buck Creek. The system's treatment capacity is approximately 520,000 gallons per day (Plant #1) and 900,000 gallons per day (Plant #2), but current average production is about 285,000 gallons per day (Plant #1) and 714,000 gallons per day (Plant #2).

Water Quality Standards (WQS) established for the Public Water Supply Use (OAC 3745-1-33) apply within 500 yards of an intake. Though no chemical sampling completed during the 2002 sampling season was this close to an intake, 10 sites within the Corridor Management Zone (CMZ) were sampled. The CMZ is an area along streams and tributaries within the source water assessment area that warrants delineation, inventory and management for drinking water purposes.

Results of sampling within the CMZ showed frequent low levels of dissolved oxygen below the WQS criterion (OAC 3745-1) in an unnamed tributary of the Vermilion River (RM 54.62). Manganese levels in nearly all the samples exceeded the WQS criterion established for the protection of human health in drinking water. In addition, Ohio EPA's Pesticide Special Study (1995-1999) showed that low levels of nitrate and several pesticides (alachlor, atrazine, metolachlor, metribuzin, simazine and cyanazine) have been detected in the finished water, indicating an impact from land use activities within the Village of New London's protection area.

Strategies for protecting Buck Creek should include controlling runoff from agricultural areas, establishment of an early warning and emergency response plan for spills, controlling home and commercial septic system discharges from failing systems, coordination with local emergency response agencies, and evaluation of the potential impacts from wastewater treatment plant sludge application within the protection area. Additional information regarding New London's public water supply can be obtained from the Ohio EPA report "Drinking Water Source Assessment for the Village of New London" November 2003. A copy of the report can be obtained by visiting the Ohio EPA website at **http://www.epa.state.oh.us/ddagw/pdu/swap.html** or by contacting Ohio EPA's North West District Office at 419-352-8461.

Sediment Quality

Sediment data were evaluated using guidelines established in *Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems* (MacDonald *et al*. 2000), and USEPA Region 5, RCRA Appendix IX compounds - Ecological Screening Levels (ESLs) (USEPA 2003). The consensus-based sediment guidelines define two levels of ecotoxic effects. A *Threshold Effect Concentration* (TEC) is a level of sediment chemical quality below which harmful effects are unlikely to be observed. A *Probable Effect Concentration* (PEC) indicates a level above which harmful effects are likely to be observed. Ecological screening levels (ESLs) are initial screening levels used by USEPA to evaluate RCRA site constituents. In addition, the Ohio Sediment Reference Value represent ecoregion background conditions. This tiered approach to evaluating sediment is consistent with OAC 3745-300-09.

The chemical sediment quality was accessed at 18 locations throughout the Vermilion River basin, Old Woman Creek basin and several small Lake Erie tributaries. Sediments selected for sampling consisted mainly of fine silts and clays, which are generally associated with persistent environmental contaminants. Chemical quality of sediment is a concern because many pollutants bind strongly to soil particles, are persistent in the environment, and accumulate in the food chain.

Sediment grab samples were analyzed for inorganic metals, semi-volatile organics, polychlorinated biphenyls (PCBs), and pesticides. Sediments with chemical concentrations reported above the Consensus-Based Probable Effect Concentration (PEC) and/or the Ohio Sediment Reference Value may result in negative environmental impacts and warrant further evaluation. Results of sediment samples are summarized in Table 17, located in the Sediment Chemistry portion of the Results section of this report. Organic parameters were only reported if detected above the analytical method detection limits. No semi-volatile organics were detected.

Throughout the Vermilion River and Old Woman Creek watersheds, sediment chemical contamination was minimal when compared to other Lake Erie tributaries in Ohio. Though exceedances of various metals occurred, no indications of potential significant environmental impairment from metals contained in sediment were noted. However, heptachlor epoxide, a breakdown product of the pesticide heptachlor, was detected at levels indicating a potential for environmental impacts at the following locations: Vermilion River (RM 44.5) at Fayette Road, Old Woman Creek (RM 11.33) at Nash Road, and the unnamed tributary to Old Woman Creek (RM 3.07) at Chapin Road.

Chemical Water Quality

The chemical and physical water quality was assessed at 77 locations throughout the Vermilion River basin, Old Woman Creek basin and several small Lake Erie tributaries. Surface water grab samples were analyzed for organic, inorganic metals and nutrients. Dissolved oxygen levels, pH and temperatures were recorded in the field at each sampling location. At the majority of sites, six sampling runs were conducted on a two-week interval. Organic samples were only collected twice at selected sites. Fecal coliform bacteria samples were collected three times at most sites during the survey. Chemical water quality values which exceeded established criteria but did not necessarily represent violations of the Ohio WQS are presented in Table 16, located in the Chemical Water Quality portion of the Results section of this report. However, exceedances do indicate potential for water quality impairment.

Overall, the free flowing segments of the Vermilion River mainstream exhibited fair chemical water quality, the exception being the headwater segment located in northwest Ashland County and reaches in the vicinity of the villages of Fitchville, West Clarksfield and Clarksfield. In these areas water quality has been adversely influenced by elevated nutrients and fecal coliform bacteria. The East Branch and Southwest Branch of the Vermilion River also reflected conditions associated with nutrient enrichment and elevated fecal coliform bacteria. Similar conditions existed on the East Fork of the Vermilion River with the addition of elevated copper levels associated with discharges from a commercial green house facility.

Old Woman Creek and its tributaries exhibited fair chemical water quality. Low dissolved oxygen levels were recorded on several occasions, most likely the result of low flows due to drought conditions. Aluminum, copper, iron and lead were significantly elevated downstream of Berlin Heights at Mason Road during one sampling event. The elevated metal levels were likely influenced by fill dirt entering the stream from a bank stabilization project just upstream of the sampling location.

Fish Tissue

Throughout the state of Ohio there is a limit of no more than one meal per week of any sport fish due to mercury contamination. For the Vermilion basin, there is an additional advisory of no more than one meal per month of smallmouth bass due to mercury contamination. For additional information related to the Fish Consumption Advisory, see the 2004 Fish Consumption Advisory report available at **http://www.epa.state.oh.us/dsw/fishadvisory/index.html**.

Spills

At least 5 spills were reported between 2000-2003 within the study area (Figure 5). It is likely that other pollutant releases went unreported during this time. The spills primarily involved the loss of petroleum products, greenhouse wastes, or silo liquors. Causes included equipment failures and deliberate dumping. Spill investigations resulting from petroleum products included oil well brine that overflowed from a pit to tile into Chappel Creek (RM 15.9) on June 5, 2001 and oils with gasoline found in a retention pond near an unnamed tributary to Vermilion River (RM 12.0) on February 26, 2000. Agricultural related spills included the drainage of silo liquors into an unnamed tributary to Vermilion River (RM 27.73) on October 28, 2002, and chemicals with fertilizers chronically discharged from a greenhouse facility into the East Fork (RM 8.9) first reported on August 9, 2002. The fifth fish kill was reported on August 10, 2003 in an unnamed tributary to the Vermilion River. No cause or source of the kill was determined and it was concluded that the kill may have been caused by seasonal changes.

RECOMMENDATIONS

Current and recommended aquatic life, water supply and recreation uses are presented in Table 1. A number of the tributary streams evaluated in this study were originally assigned aquatic life use designations in the 1978 and 1985 Ohio WQS based largely on best professional judgement, while others were left undesignated. The current biological assessment methods and numerical criteria did not exist then. This study, as an objective and robust evaluation of beneficial uses, is precedent setting in comparison to the 1978 and 1985 designations. Several sub-basin streams have been evaluated for the first time using a standardized biological approach as part of this study. Ohio EPA is obligated by a 1981 public notice to review and evaluate all aquatic life use designations outside of the WWH use prior to basing any permitting actions on the existing, unverified use designations. Thus, some of the following aquatic life use recommendations constitute a fulfillment of that obligation.

This survey is the first time the Vermilion River mainstem has been thoroughly sampled so that a use attainability analysis may be completed. The existing Exceptional Warmwater Habitat aquatic life use designation for the Vermilion River from the Erie-Huron County Line (RM 19.7) to the mouth (RM 0.1) was based on 1978 and 1985 Ohio WQS. The results of this survey indicate that the entire Vermilion River mainstem should have the Warmwater Habitat aquatic life use. The lacustuary portion of the mainstem, from the mouth (RM 0.1) to river mile 2.8 has exhibited poor biological performance from both fish and macroinvertebrate communities over time (Figure 2). The lacustuary acts as a sink for silt and nutrients generated from upstream agricultural and development activities. In addition, the mouth of the mainstem is maintained for navigational purposes for both commercial and residential use. The modified nature of the mouth and the low flow throughout the lacustuary portion of the mainstem indicates that suitable conditions do not exist to support EWH communities.

The biological communities present from river mile 2.8 to the Erie-Huron county line (RM 19.7) have not consistently performed within EWH expectations over time (Figure 2). The macroinvertebrate community has not performed within EWH expectations throughout this reach in every year that sampling has occurred, while the MIwb for the fish community has performed under EWH expectations at river miles 10.7 and 6.4. The WWH performance of the biological communities in this segment indicate that EWH is not an appropriate designation for the area. The WWH aquatic life use designation should apply to the entire Vermilion mainstem.

Use attainability analyses of Indian Creek (RM 3.5) resulted in the recommended designation of a Modified Warmwater Habitat (MWH) segment where poor habitat quality was unlikely to improve in the foreseeable future. This stream was channelized and maintained to facilitate agricultural activities and offered very limited habitat. It is not realistic to expect typical WWH aquatic communities under these conditions. This survey is the first time Indian Creek has been evaluated using biological and habitat data and does not represent a downgrading of the previous WWH use which was based on unverified designations in the 1978 and 1985 water quality standards. Other small streams were impacted by habitat modification but retained the WWH use where recovery of natural habitat features such as a wooded riparian and multiple cover types was evident. Additional habitat improvement is possible through the application of management practices to limit soil loss and restore wooded riparian areas.

The predominant agricultural land use throughout the study area indicates that the agricultural water supply use is appropriate for most streams. However, within the Old Woman Creek preserve, the agricultural water supply use shall not apply. The Old Woman Creek preserve is protected as a State Nature Preserve and National Estuarine Research Reserve. The focus of the preserve is on long-term protection of the estuary for research, monitoring, and education purposes, and specifically prohibits agricultural activities within the preserve area.

Improvements may be made to water quality throughout the study area by addressing the causes and sources identified within the Aquatic Life Use Attainment table (Table 2). The causes and sources associated with agricultural practices may be addressed by improving riparian buffers, fencing livestock out of streams, proper fertilizer and pesticide application, avoidance of winter land application of manure and ceasing of traditional ‘cleaning’ of streams. Funding opportunities should be sought to improve agricultural practices and could include any of the above listed improvements. Non-agricultural impairments could be addressed through a combination of regulatory, educational and funding actions including improvements at the Bailey Lakes WWTP and New London WWTP, management of failing septic systems, and alternatives to traditional stream channelization and riparian removal.

Table 1. Waterbody use designations for the Vermilion River and Old Woman Creek basins. Designations based on Ohio EPA biological field assessments appear as a plus sign (+). Designated use based on the 1978 water quality standards appear as an asterik (*). Designations based on the 1978 and 1985 standards for which results of a biological field assessment are now available are displayed to the right of existing markers. Designated uses based on results other than Ohio EPA biological data are marked with an circle (o). A delta (Δ) indicates a new recommendation based on the findings of this report.

Water Body Segment	Use Designations													Comments
		Aquatic Life Habitat						Water Supply			Recreation			
	SRW	WWH	EWH	MWH	SSH	CWH	LRW	PWS	AWS	IWS	BW	PCR	SCR	
Vermilion River - Erie-Huron county line to estuary		Δ	*		o				*+	*+		*+		
- Mill Hollow-Bacon Woods park boundaries	*	Δ	*		o				*+	*+		*+		
- at RM 52.24		*+						o	*+	*+		*+		
- all other segments		*+							*+	*+		*+		
East Fork		*+							*+	*+		*+		
Unnamed tributary to East Fork (RM 8.47)		Δ							Δ	Δ		Δ		
East Branch		*+							*+	*+		*+		
Unnamed tributary to East Branch (RM 8.2)		Δ							Δ	Δ		Δ		
Skellinger Creek		+							+	+			+	
Indian Creek - RM 3.5		*		Δ					*+	*+		*+		

Water Body Segment	Use Designations													Comments
		Aquatic Life Habitat						Water Supply			Recreation			
	SRW	WWH	EWH	MWH	SSH	CWH	LRW	PWS	AWS	IWS	BW	PCR	SCR	
-all other segments		Δ							Δ	Δ		Δ		
Southwest Branch		*+							*+	*+		*+		
Unnamed tributary to Southwest Branch (RM 2.3)		Δ							Δ	Δ		Δ		
Unnamed tributary to Southwest Branch (RM 5.35)		Δ							Δ	Δ		Δ		
Buck Creek		*+							*+	*+		*+		
Unnamed tributary to Buck Creek (RM 4.92)		Δ							Δ	Δ		Δ		
Clear Creek		*+							*+	*+		*+		
Unnamed tributary to Vermilion River (RM 8.29)		Δ							Δ	Δ		Δ		
Unnamed tributary to Vermilion River (RM 12.0)		Δ							Δ	Δ		Δ		
Unnamed tributary to Vermilion River (RM 24.35)		Δ							Δ	Δ		Δ		
Unnamed tributary to Vermilion River (RM 32.98)		Δ							Δ	Δ		Δ		
Unnamed tributary to Vermilion River (RM 54.62)		Δ							Δ	Δ		Δ		
Unnamed tributary to Vermilion River (RM 63.52)		Δ							Δ	Δ		Δ		
Frankenburg Creek		Δ							Δ	Δ		Δ		

Water Body Segment	Use Designations													Comments
		Aquatic Life Habitat						Water Supply			Recreation			
	SRW	WWH	EWH	MWH	SSH	CWH	LRW	PWS	AWS	IWS	BW	PCR	SCR	
Old Woman Creek-estuary	o	*+							Δ	Δ		Δ		
-within boundaries of Old Woman Creek preserve	o	*+										Δ		
-all other segments		*+							Δ	Δ		Δ		
Unnamed tributary to Old Woman Creek (RM 8.82)		Δ							Δ	Δ		Δ		
Unnamed tributary to Old Woman Creek (RM 3.70)		Δ							Δ	Δ		Δ		
Chappel Creek		*+							Δ	Δ		Δ		
Sugar Creek		*+							Δ	Δ		Δ		

SRW = state resource water; WWH = warmwater habitat; EWH = exceptional warmwater habitat; MWH = modified warmwater habitat; SSH = seasonal salmonid habitat;

CWH = coldwater habitat; LRW = limited resource water; PWS = public water supply; AWS = agricultural water supply; IWS = industrial water supply; BW = bathing water;

PCR = primary contact recreation; SCR = secondary contact recreation.

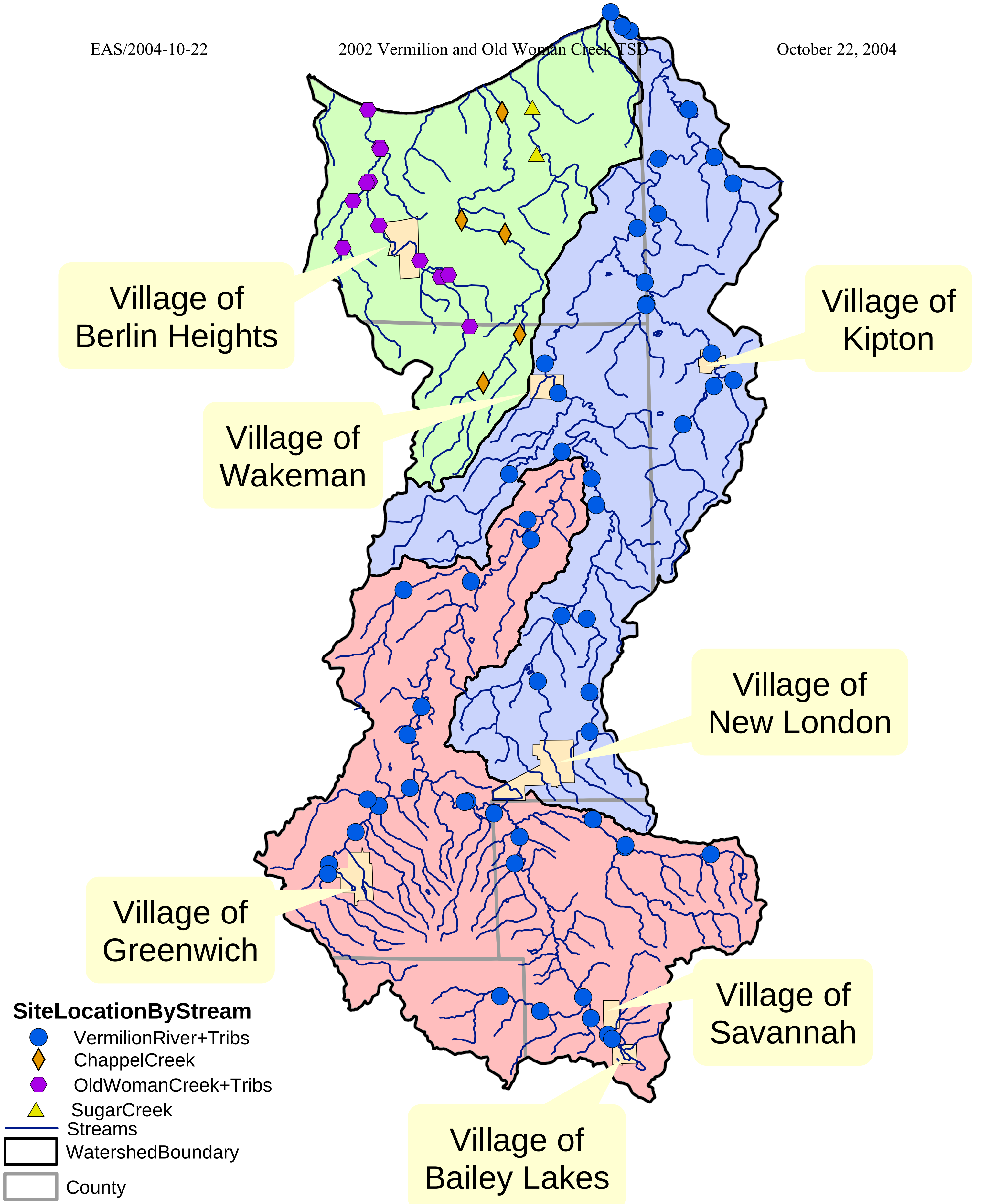

Figure 1. Sampling locations throughout the Vermilion River basin, Old Woman Creek basin and select Lake Erie tributaries, 2000-2002.

Table 2. Aquatic life use attainment status for stations sampled in the Vermilion River basin, Old Woman Creek basin, and select Lake Erie tributaries based on data collected July-September, 2002. Sampling results from 2000 and 2001 (noted in **bold**) were included in the table where sampling could not be completed in 2002. The Index of Biotic Integrity (IBI), Modified Index of well being (MIwb), and Invertebrate Community Index (ICI) are scores based on the performance of the biotic community. The Qualitative Habitat Evaluation Index (QHEI) is a measure of the ability of the physical habitat to support a biotic community.

Stream Name	River Mile	Drainage Area	IBI	MIwb[a]	ICI[b]	QHEI	Attainment Status[c]	Causes[d]	Sources[e]
Vermilion River			*WWH - EOLP Ecoregion*						
	–/63.8	8.3			P*		**(NON)**	Habitat alteration	Channelization - Ag. & Dev.[f]
								Nutrient enrichment	Bailey Lakes WWTP
	63.0[H]/63.0	10.0	30*	NA	F*	45.0	**NON**	Habitat alteration/siltation	Channelization - Ag.
	62.1[W]/62.0	23.0	30*	NA	MG[NS]	62.5	PARTIAL	Organic enrichment/siltation	Onsite waste system Channelization-Ag.
	54.0[W]/56.2	41.0	32*	5.9*	34	59.0	PARTIAL	Organic enrichment/siltation	Septic systems/chan.-Ag.
	50.7[W]/50.6	69.0	38	7.9	MG[NS]	68.0	FULL		
	45.7[W]/45.9	76.0	48	8.8	VG	79.0	FULL		
			WWH - ECBP Ecoregion						
	44.5[W]/44.5	78.0	43	7.8[NS]	44	79.0	FULL		
	33.6[W]/33.6	130.0	53	10.1	50	80.5	FULL		
	29.2[W]/29.2	178.0	41	8.3	E	80.0	FULL		
	23.9[B]/23.9	192.0	34*	7.9*	F*	48.5	**NON**	Flow alteration	Impoundment
	22.5[W]/22.5	193.0	45	9.4	50.0	79.0	FULL		
			EWH existing/WWH recommended - ECBP Ecoregion						
	14.5[W]/14.5	242.0	52	9.2	32[NS]	81.0	PARTIAL/ FULL		
	10.7[W]/10.7	251.0	45	8.7	VG	75.5	PARTIAL/ FULL		

Table 2. (Continued)

Stream Name	River Mile	Drainage Area	IBI	MIwb[a]	ICI[b]	QHEI	Attainment Status[c]	Causes[d]	Sources[e]
Vermilion River			*EWH existing/WWH recommended - EOLP Ecoregion*						
	6.4^{W}/6.4	262.0	51	8.8	VG	71.5	PARTIAL/ FULL		
			EWH existing/WWH recommended - EOLP Ecoregion with Lacustuary Benchmark						
	1.4^{O}/1.1	267.0	32*	8.2*	18*	36.5	**NON**	Siltation/nutrient enrichment	Ag and Development
	--/0.8	267.0			18*		**(NON)**	Siltation/nutrient enrichment	Downstream Vermilion WWTP
	--/0.1	268.0			24*		**(NON)**	Siltation/nutrient enrichment	Ag and Development
Buck Creek			*WWH - EOLP Ecoregion*						
	8.2^{H}/8.1	2.4	32*	NA	F*	44.0	**NON**	Siltation	Pasture
								Nutrient enrichment	Septic Systems
	5.0^{H}/--	16.0	32*	NA		74.0	**(NON)**	Flow alteration	Natural (drought)
	3.2^{H}/3.2	16.8	34*	NA	G	75.0	PARTIAL	Flow alteration	Natural (drought)
	1.1^{H}/1.0	19.7	35*	NA	G	66.0	PARTIAL	Flow alteration	Natural (drought)
Clear Creek			*WWH - EOLP Ecoregion*						
	4.0^{H}/--	5.1	22*	NA		52.0	**(NON)**	Siltation/flow alteration	Natural (drought)
	1.8^{H}/2.1	7.7	46	NA	MG^{NS}	71.0	FULL		
Indian Creek			*WWH existing/MWH recommended - ECBP Ecoregion*						
	3.5^{H}/3.5	5.7	26*	NA	F	36.0	**NON**	Habitat alteration	Channelization - Ag.
			WWH - ECBP Ecoregion						
	0.4^{H}/0.4	8.1	42	NA	F*	71.5	PARTIAL	Siltation/flow alteration	Agriculture
Southwest Branch			*WWH - ECBP Ecoregion*						
	5.6^{H}/5.6	7.3	38^{NS}	NA	F*	62.5	PARTIAL	Siltation	Agriculture
	3.9^{H}/3.9	12.0	26*	NA	F*	65.0	**NON**	Nutrient/organic enrichment	Pasture
	2.5^{H}/2.5	17.4	34*	NA	MG^{NS}	65.5	PARTIAL	Siltation	Non-irrigated crop/pasture

Table 2. (Continued)

Stream Name	River Mile	Drainage Area	IBI	MIwb[a]	ICI[b]	QHEI	Attainment Status[c]	Causes[d]	Sources[e]
Southwest Branch			*WWH - ECBP Ecoregion*						
	1.0^W/1.0	30.0	28*	5.8*	MG^{NS}	47.5	**NON**	Siltation	Non-irrigated crop/pasture
Trib. to Southwest Branch (2.3)			*Undesignated/WWH recommended - ECBP Ecoregion*						
	--/0.7	4.2			F*		**(NON)**	Nutrient/organic enrichment	Non-irrigated crop/pasture
Trib. to Southwest Branch (5.35)			*Undesignated/WWH recommended - ECBP Ecoregion*						
	--/0.6	4.1			F*		**(NON)**	Flow alteration	Natural (drought)
Trib. to Vermilion River (32.98)			*Undesignated/WWH recommended - ECBP Ecoregion*						
	--/1.0	4.2			G		(FULL)		
Trib. to Vermilion River (63.52)			*Undesignated/WWH recommended - EOLP Ecoregion*						
	0.2^H/0.3	4.1	34*	NA	F*	38.0	**NON**	Nutrient enrichment/habitat alteration	Channelization - Dev.
Trib. to Buck Creek (4.92)			*Undesignated/WWH recommended - EOLP Ecoregion*						
	0.1^H/0.1	8.4	40	NA	MG^{NS}	64.0	FULL		
Trib. to Vermilion River (54.62)			*Undesignated/WWH recommended - EOLP Ecoregion*						
	0.5^H/--	5.6	34*	NA		67.0	**(NON)**	Habitat alteration	Natural (drought)
East Branch			*WWH - EOLP Ecoregion*						
	8.6^H/8.3	15.7	34*	NA	F*	62.0	**NON**	Siltation	Channelization - Ag.
			WWH - ECBP Ecoregion						
	2.7^W/3.6	36.0	30*	7.7*	G	66.0	PARTIAL	Nutrient enrichment	Non-irrigated crop production
	1.4^W/1.4	37.0	42	8.2^{NS}	VG	77.0	FULL		
East Fork			*WWH - ECBP Ecoregion*						
	10.9^H/10.9	8.3	34*	NA	MG^{NS}	58.0	PARTIAL	Siltation	Channelization - Ag.
								Nutrient enrichment	Septic systems
	8.9^H/9.1	10.9	24*	NA	VP*	67.0	**NON**	Nutrient/organic enrichment	Industrial point source (Green Circle Growers)

Table 2. (Continued)

Stream Name	River Mile	Drainage Area	IBI	MIwb[a]	ICI[b]	QHEI	Attainment Status[c]	Causes[d]	Sources[e]
East Fork			*WWH - ECBP Ecoregion*						
	7.4[H]/7.4	16.4	36[NS]	NA	VP*	68.0	**NON**	Nutrient/organic enrichment	Industrial point source (Green Circle Growers) Septic Systems
	2.3[W]/2.3	33.0	38[NS]	8.0	MG[NS]	64.0	FULL		
Frankenburg Creek			*Undesignated/WWH recommended - ECBP Ecoregion*						
	0.2[H]/0.2	6.5	46	NA	G	77.0	FULL		
Skellinger Creek			*Undesignated/WWH recommended - EOLP Ecoregion*						
	0.8[H]/1.0	4.0	20*	NA	F*	48.5	**NON**	Nutrient/organic enrichment Siltation	Pasture/non-irrigated crop production New London WWTP
Trib. to East Branch (8.2)			*Undesignated/WWH recommended - EOLP Ecoregion*						
	5.8[H]/--	3.6	20*	NA		43.5	**(NON)**	Nutrient/organic enrichment Habitat alteration	Pasture
	4.0[H]/--	8.7	20*	NA		40.5	**(NON)**	Nutrient/organic enrichment Habitat alteration	Septic systems Pasture
	1.1[H]/1.0	10.7	34*	NA	G	56.0	**NON**	Organic enrichment Habitat alteration	Septic systems Residential
Trib. to East Fork (8.47)			*Undesignated/WWH recommended - ECBP Ecoregion*						
	0.7[H]/0.7	3.5	32*	NA	VP*	53.5	**NON**	Nutrient/organic enrichment	Industrial point source (Green Circle Growers)
Trib. to Vermilion River (12.0)			*Undesignated/WWH recommended - ECBP Ecoregion*						
	--/1.5	3.1			MG[NS]		(FULL)		
Trib. to Vermilion River (24.35)			*Undesignated/WWH recommended - ECBP Ecoregion*						

Table 2. (Continued)

Stream Name	River Mile	Drainage Area	IBI	MIwb[a]	ICI[b]	QHEI	Attainment Status[c]	Causes[d]	Sources[e]
	5.5^{H}/5.5	8.5	24*	NA	F*	55.5	**NON**	Siltation/organic enrichment	Pasture
	0.2^{H}/0.2	13.0	36^{NS}	NA	G	71.0	FULL		
Trib. to Vermilion River (8.29)			*Undesignated/WWH recommended - ECBP Ecoregion*						
	--/2.0	5.0			MG^{NS}		(FULL)		
	1.0^{H}/0.9	5.7	40	NA	G	63.0	FULL		
Chappel Creek			*WWH - ECBP Ecoregion*						
	16.6^{H}/--	5.5	24*	NA		67.5	**(NON)**	Nutrient/organic enrichment	Pasture/non-irrigated crop production
	14.1^{H}/--	9.9	30*	NA		64.0	**(NON)**	Nutrient/organic enrichment	Pasture
	9.1^{H}/--	14.5	18*	NA		64.0	**(NON)**	Nutrient/organic enrichment	Pasture/non-irrigated crop
			WWH - EOLP Ecoregion						
	7.4^{H}/7.4	18.2	34*	NA	F*	64.0	**NON**	Habitat alteration	Non-irrigated crop production
	1.3^{W}/1.1	23.0	49	7.7^{NS}	G	59.0	FULL		
Sugar Creek			*WWH - EOLP Ecoregion*						
	3.5^{H}/--	5.7	32*	NA		69.0	**(NON)**	Flow alteration	Natural (drought)
	1.5^{H}/--	6.4	36^{NS}	NA		61.0	(FULL)		
Old Woman Creek			*WWH - ECBP Ecoregion*						
	11.4^{H}/11.3	2.4	24*	NA	P*		NON	Flow alteration	Natural (drought)
	9.4^{H}/9.4	3.4	36^{NS}	NA	F*	41.0	PARTIAL	Siltation/habitat alteration	Channelization -Ag.
			WWH - EOLP Ecoregion						
	8.4^{H}/8.4	7.8	32*	NA	P*	74.5	NON	Organic/nutrient enrichment	Livestock
	5.4^{H}/5.2	11.8	38^{NS}	NA	G	66.0	FULL		
	3.5^{H}/3.6	21.0	38^{NS}	NA	MG^{NS}	73.5	FULL		
	1.8^{O}/1.9^{L}	29.0	24*	NA	16*		NON	Siltation/nutrient enrichment	Non-irrigated crop production

Table 2. (Continued)

Stream Name	**River Mile**	**Drainage Area**	**IBI**	**MIwb**[a]	**ICI**[b]	**QHEI**	**Attainment Status**[c]	**Causes**[d]	**Sources**[e]
	0.2[O]/0.2[L]	30.0	19*	5.4*	P*	36.5	NON	Siltation/nutrient enrichment	Non-irrigated crop production
Trib. to Old Woman Creek (8.82)			*Undesignated/WWH recommended - ECBP Ecoregion*						
	--/**0.9**	1.8			VP*		NON	Siltation/habitat alteration	Channelization -Ag.
Trib. to Old Woman Creek (3.7)			*Undesignated/WWH recommended - EOLP Ecoregion*						
	3.1[H]/**4.9**	4.5	28*	NA	F*	67.5	NON	Flow alteration	Natural (drought)
	0.7[H]/0.9	7.9	26*	NA	P*		NON	Flow alteration	Natural (drought)

Ecoregion Biocriteria: Eastern Corn Belt Plain

	IBI			MIwb			ICI		
Site Type	WWH	EWH	MWH	WWH	EWH	MWH	WWH	EWH	MWH
Headwaters	40	50	24				36	46	22
Wading	40	50	24	8.3	9.4	4.0	36	46	22
Boat	42	48	24	8.5	9.6	4.0	36	46	22

Lacustuary Scoring Benchmarks

Site Type	IBI	MIwb	ICI
WWH	42	8.6	42

Ecoregion Biocriteria: Eastern-Ontario Lake Plain

	IBI			MIwb			ICI		
Site Type	WWH	EWH	MWH	WWH	EWH	MWH	WWH	EWH	MWH
Headwaters	40	50	24				34	46	22
Wading	38	50	24	7.9	9.4	6.2	34	46	22
Boat	40	48	24	8.7	9.6	5.8	34	46	22

a - MIwb is not applicable to headwater streams with drainage areas $\leq$ 20 mi^2.
b - A qualitative narrative evaluation based on best professional judgement and sampling attributes such as community composition, EPT taxa richness, and QCTV scores was used when quantitative data were not available or considered unreliable due to current velocities less than 0.3 fps flowing over the artificial substrates.
c - Attainment status is given for both existing and recommended use designations.
d - Causes listed are considered to be a primary influence on water quality, but may not be the only issue leading to impairment. See text for discussion of additional causes that cumulatively have led to impairment.
e - Sources listed are considered to be a primary influence on water quality, but may not be the only source leading to impairment. See text for discussion of additional sources that cumulatively have led to impairment.
f - Ag. refers to agricultural impacts while Dev. refers to impacts associated through urbanization and development.
H -Headwater site.
W -Wading site.
B - Boat site.
O - Fish Lacustuary site. Scores have been compared to lacustuary scoring method.
L - Macroinvertebrate Lacustuary site. Scores have been compared to lacustuary scoring method.
NS - Nonsignificant departure from biocriteria ($\leq$4 IBI or ICI units, or $\leq$0.5 MIwb units).
* - Indicates significant departure from applicable biocriteria (>4 IBI or ICI units, or >0.5 MIwb units). Underlined scores are in the Poor or Very Poor range.

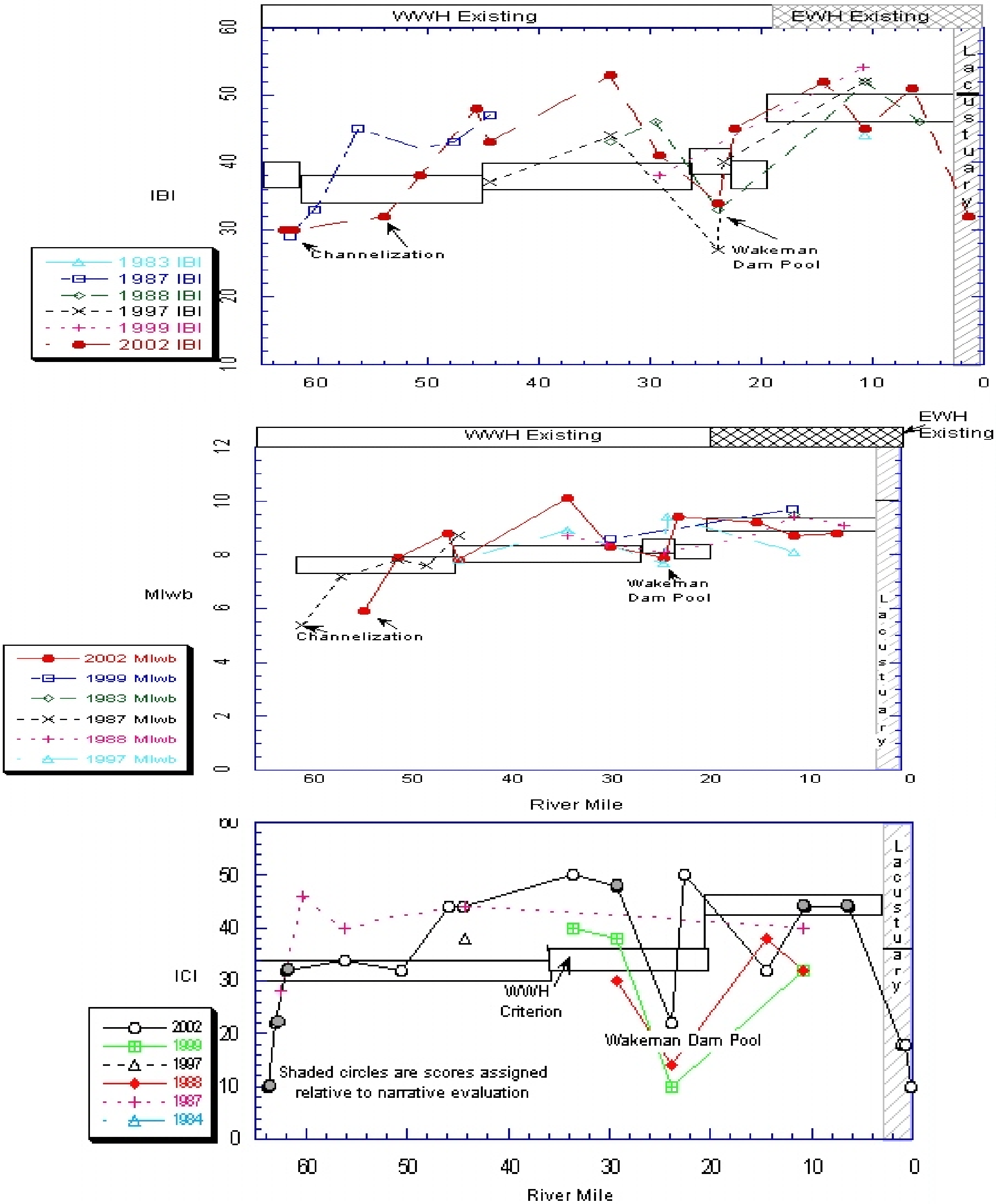

Figure 2. Longitudinal plots of biological community index scores versus river miles of the Vermilion River mainstem for 1983, 1987, 1988, 1993, 1997 and 2002. Sites consistently below WWH criteria indicate long-term impairments.

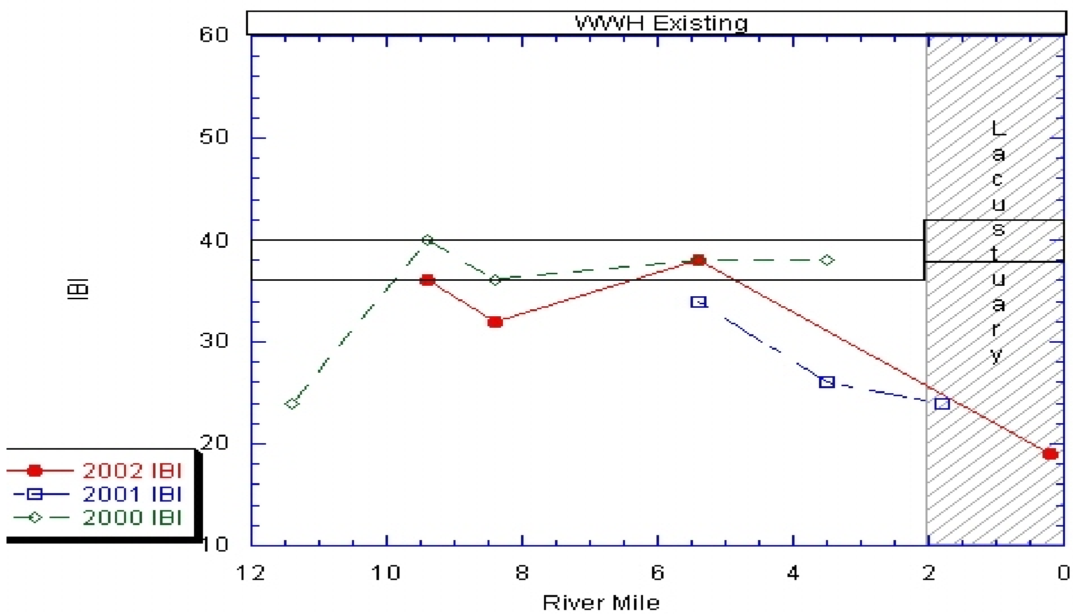

Figure 3. Longitudinal plot of IBI scores for Old Woman Creek mainstem, 2000-2002.

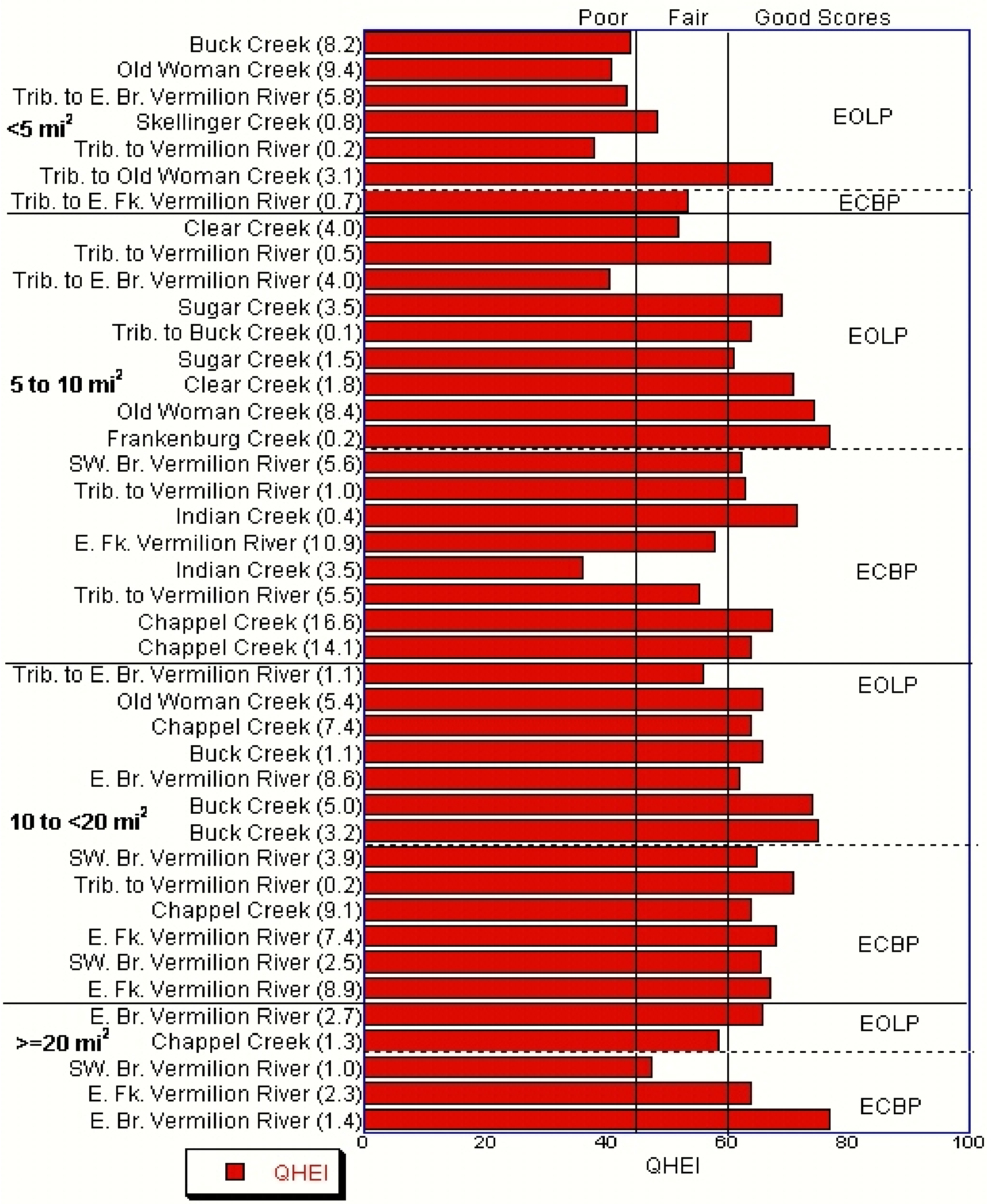

Figure 4. QHEI scores of Vermilion River tributaries, Old Woman Creek and select Lake Erie tributaries arranged by drainage area. Poor habitat conditions occur most often in streams with <10mi^2 drainage areas.

Table 3. Recreation use exceedances of the Ohio Water Quality Standards criteria (Ohio Administrative Code 3745-1-07). Units for fecal coliform bacteria are #/100 ml. Recreation use designations within the study area include: Primary Contact Recreation (PCR) and Secondary Contact Recreation (SCR).

HUC Stream/River Mile	Existing (Recommended) Use Designation	Fecal Coliform Result
04100012 050 (Vermilion River headwaters to above East Branch)		
Vermilion River		
63.85	PCR	2100[b], 6800[ab]
62.88	PCR	4000[b], 1400[c]
33.50	PCR	1800[b]
Southwest Branch		
3.81	PCR	1500[c], 1500[c]
2.53	PCR	1400[c]
0.94	PCR	4400[b], >10,000[ab]
Southwest Branch Tributary (2.30)		
0.57	None (PCR)	1100[c]
Buck Creek		
3.21	PCR	1200[c], 1200[c]
1.06	PCR	1200[c]
Clear Creek		
3.99	PCR	2900[b], 4200[b], 3600[b]
04100012 060 (Vermilion River above East Branch to Lake Erie)		
Vermilion River		
29.22	PCR	2400[b]
23.69	PCR	2200[b]
Vermilion River Tributary (24.35)		
0.20	None (PCR)	>10,000[ab]
Vermilion River Tributary (12.10)		
1.99	None (PCR)	>10,000[ab]
Vermilion River Tributary (8.29)		

Table 3. Recreation use exceedances of the Ohio Water Quality Standards criteria (Ohio Administrative Code 3745-1-07). Units for fecal coliform bacteria are #/100 ml. Recreation use designations within the study area include: Primary Contact Recreation (PCR) and Secondary Contact Recreation (SCR).

1.93	None (PCR)	2200[b]
East Fork		
10.87	PCR	>10,000[ab]
East Fork (continued)		
9.04	PCR	5200[ab]
7.41	PCR	2800[b], 9800[ab]
East Branch Vermilion River		
8.31	PCR	3400[b], 9200[ab], 10,000[b]
3.60	PCR	2000[b], 9400[ab]
1.02	PCR	2200[b]
East Branch Vermilion River Tributary (8.20)		
4.03	None (PCR)	2400[b]
Skellinger Creek		
0.95	SCR	10,000[ab]
04100012 040 (Lake Erie tributaries from below Huron River to above Vermilion River)		
Chappel Creek		
7.33	PCR	1000[c]
1.30	PCR	2000[b]
Old Woman Creek Tributary (3.70)		
5.02	None (PCR)	1800[c]

a - Exceeds maximum criterion for protection of Secondary Contaction Recreation use.

b - Exceeds maximum criterion for protection of Primary Contact Recreation use.

c - Exceeds geometric mean criterion for protection of Primary Contact Recreation use.

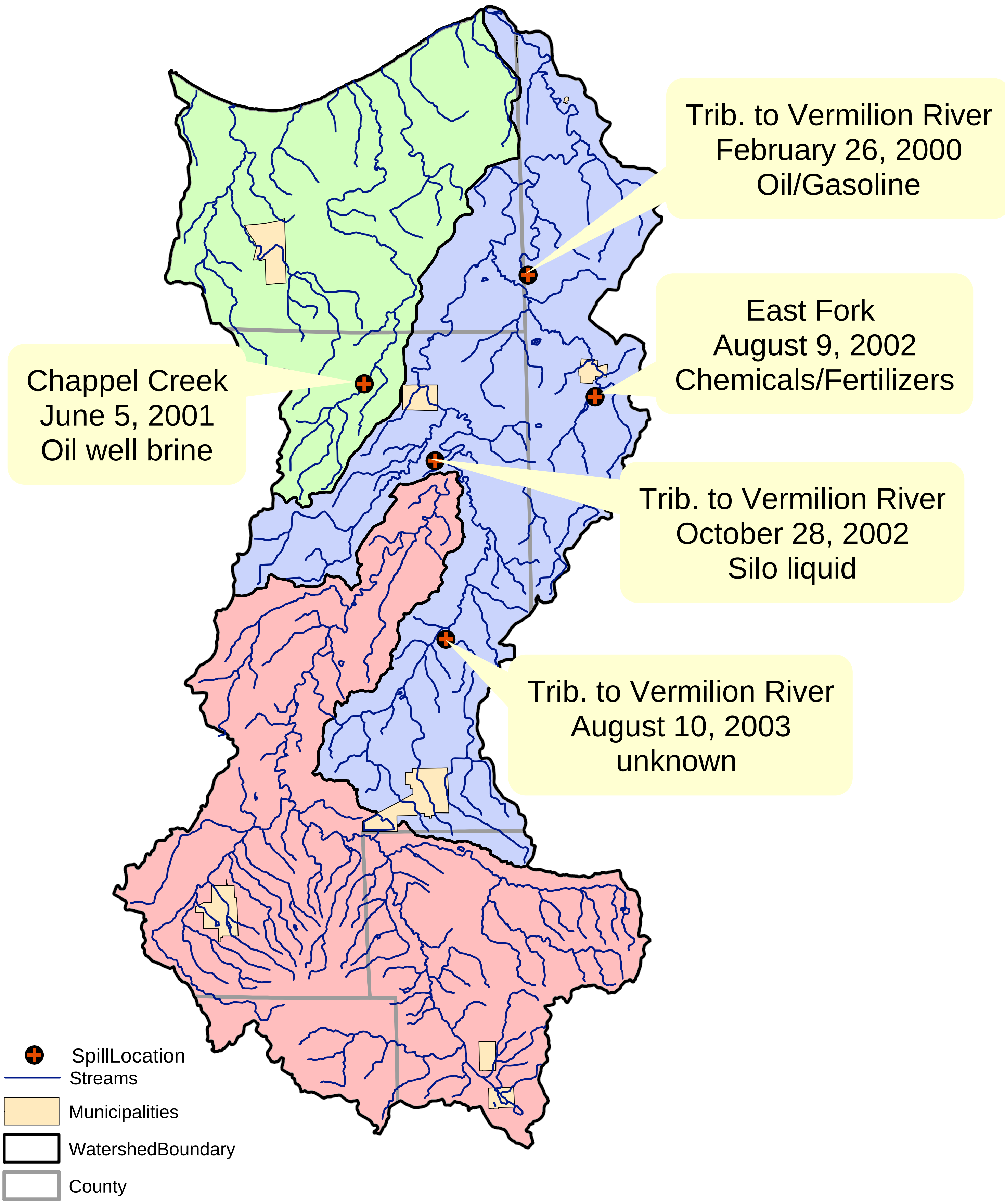

Figure 5. Reported spills related to fish kills within the study area from 2000-2003.

Watershed Assessment Unit Status and Recommendations

The entire study area may be subdivided into three Watershed Assessment Units (WAUs), **04100012 040**, **04100012 050**, and **04100012 060**, that provide a local summary of water quality. Summary statistics related to aquatic life use performance and a synopsis of each WAU are provided in individual tables within each WAU summary. The comments provided for each WAU include principal causes and sources of impact on aquatic life and recreation uses and significant contaminants in sediment and fish tissue.

*WAU - **04100012 040** Lake Erie tributaries (East of Huron River to West of Vermilion River)*

A total of 17 sites in the WAU **04100012 040** Lake Erie tributaries (East of Huron River to West of Vermilion River) ranging in drainage areas between 1.8 mi^2 and 30 mi^2 were sampled between 2000 and 2002 (Table 3 and Figure 6). All the sites within the WAU were designated Warmwater Habitat (WWH), though only 4 sites were in full attainment of the aquatic life use. One site was in partial attainment and the remaining 12 sites were in non-attainment for the aquatic life use. The WAU aquatic life use attainment score based on data collected from 2000 to 2002 was 36.11 (Table 4). The aquatic life use attainment score was calculated according to the method established in the 2004 Integrated Water Quality Monitoring and Assessment Report, which is available at:

http://www.epa.state.oh.us/dsw/tmdl/2004IntReport/2004OhioIntegratedReport.html

The low WAU score reflects the few sites meeting the WWH use designation. Primary causes of impairment with the WAU were nutrient and organic enrichment, habitat alteration, siltation, and flow alteration. The sources for these causes were primarily agricultural practices including non-irrigated crop production, livestock in streams and pastures, and channelization activities (Tables 5 & 6, Figures 7 & 8).

Several sites suffered flow alterations from the drought conditions present during the sampling activities. Several streams were dry or had only occasional pools. The effects of the drought may have been exacerbated by the presence of drain tile within the agricultural fields. Though efforts were made with Huron and Erie SWCDs to obtain information related to the amount of agricultural land containing drain tile within these watersheds, the SWCDs were unable to provide the requested information.

Chappel Creek flows through a heavy agricultural area and was primarily impacted by habitat alterations and nutrient and organic enrichment. Habitat alterations included narrow, poor quality riparian buffers adjacent to non-irrigated crop production and pasture areas. Chemistry sampling noted elevated nutrient levels from Wakeman Townline Road (RM 16.6) to Main Road (RM 9.0). Nutrient and organic enrichment occurred via run-off from the agricultural row cropping and from livestock having direct access to the stream. The persistent organic pesticide a-BHC was detected above the Tier I value for the protection of aquatic life and human health. Though historically a component of the now banned pesticide Lindane, a-BHC is currently used as a seed treatment for grain.

Sugar Creek had less intense land use than Chappel Creek, with moderate buffers adjacent to residential land use. However, the flow of the stream was reduced due to the drought.

Old Woman Creek flows through a primarily agricultural landscape. Low flow and low dissolved oxygen in the headwaters were noted due to drought conditions. The effects of the drought may have been exacerbated by the presence of drain tile in the surrounding agricultural fields and channelization activities. Sources of siltation included recent channelization activities for agricultural purposes, direct stream access for livestock, and poor quality buffers adjacent to agricultural areas. Organic and nutrient enrichment resulted from livestock access to the streams and surface run-off from the surrounding agricultural fields. Elevated inorganic metals were noted in several locations.

Figure 9. Aerial photograph of Old Woman Creek (RM 9.4). Notice the lack of buffers adjacent to the stream.

Support status of the recreation use within the WAU was assessed by bacterial sampling. The results from the sampling indicate a problem with bacterial levels throughout the watershed (Table 6).

Throughout the state of Ohio, there is a limit of no more than one meal per week of any sport fish due to mercury contamination (Table 7). For additional information related to the Fish Consumption Advisory, see the 2004 Fish Consumption Advisory report available at "www.epa.state.oh.us/dsw/fishadvisory/index.html".

The intense agricultural use within the WAU has led to its aquatic life use impairment (Figure 9). While the drought experienced in 2002 is listed as a source of impairment for several streams, the effects of the drought were likely exaceberated by the lack of riparian buffers and presence of drain tile within the watershed. A combination of education and funding for improved land use practices could potentially diminish the negative effects of agricultural practices on water quality.

Agricultural practices addressed through education could include alternatives to winter land application of manure and traditional 'cleaning' of streams, benefits of improved buffers and woody vegetation, proper application of pesticides and fertilizers, and fencing of livestock out of streams.

Funding opportunities should be sought to improve agricultural practices and could include any of the above listed improvements. Improvements to manure management and fencing of livestock out of streams may also address the bacterial issues and their effect on the recreation use.

Table 4. Existing and recommended Aquatic Life Use designations for Lake Erie tributaries (East of Huron River to West of Vermilion River) Watershed Assessment Unit - **04100012 040** by drainage area based on sampling conducted in 2000 - 2002.

04100012 040 Lake Erie tributaries (East of Huron River to West of Vermilion River)							
Site size vs. type	Total	EWH	WWH	MWH	LRW	CWH or SSH	Mix Zone(s) (excluded from assessment)
Number of sites $\leq 50mi^2$	17	0	17	0	0	0	0
Number of sites $\geq 50mi^2$	0	0	0	0	0	0	0
Size of smallest sampled drainage area in HUC: 1.8 mi^2				Size of largest sampled drainage area in HUC: 30 mi^2			

Table 5. Aquatic life use attainment status for Lake Erie tributaries (East of Huron River to West of Vermilion River) Watershed Assessment Unit - **04100012 040** based on sampling conducted in 2000 - 2002. The assessment unit score is an average grade of aquatic life use status. The method of calculation is presented in the 2004 Integrated Water Quality Monitoring and Assessment Report . The attainment status of recommended uses was used in lieu of existing uses when calculating the WAU score, when applicable. A maximum assessment unit score of 100 is possible if all monitored sites meet designated aquatic life uses.

WAU: **04100012 040,** Lake Erie tributaries (East of Huron River to West of Vermilion River)

Stream Names: *Old Woman Creek, Sugar Creek, Chappel Creek, U.T. to Old Woman Creek (RM 8.82), and U.T. to Old Woman Creek (RM 3.70).*

Data Collected: 2000, 2001 and 2002. Integrated Report (IR) Category: **5**

04100012 040 Lake Erie tributaries (East of Huron River to West of Vermilion River)			
Attainment Categories for sites ≤50mi²	Data Group 1 ≤5mi²	Data Group 2 >5mi² to ≤20mi²	Data Group 3 >20mi² to ≤50mi²
Number of sites in FULL attainment	0(a)	2(a)	2(a)
Total Number of sites	4(b)	9(b)	4(b)

WAU Attainment Spatial Score Calculation:

Data Group 1	Data Group 2	Data Group 3	
≤ 5 mi²	> 5 mi² to ≤ 20 mi²	> 20 mi² to ≤ 50 mi²	Spatial Score

$$\frac{\frac{(a/b + a/b)}{2} + (a/b)}{2} * 100 = c$$

where
- a = number of sites in full attainment
- b = number of sites in data group
- c = spatial attainment score for WAU

WAU Attainment Spatial Score = **36.11**

The WAU **04100012 040** does not contain any sites >50mi², therefore, no linear score was calculated for the WAU. The WAU Attainment Final Score is **36.11**.

Table 6. Aquatic life use attainment status for the streams sampled in the Lake Erie tributaries (East of Huron River to West of Vermilion River) Watershed Assessment Unit - **04100012 040** during July to September, 2002. Additional sampling collected in 2000 and 2001 (noted in **bold**) are included where sampling could not be completed in 2002. The Index of Biotic Integrity (IBI), Modified Index of well being (MIwb), and Invertebrate Community Index (ICI) are scores based on the performance of the biotic community. The Qualitative Habitat Evaluation Index (QHEI) is a measure of the ability of the physical habitat to support a biotic community.

Stream Name	River Mile	Drainage Area	IBI	MIwb[a]	ICI[b]	QHEI	Attainment Status[c]	Causes[d]	Sources[e]
Chappel Creek			*WWH - ECBP Ecoregion*						
	16.6^{H}/--	5.5	24*	NA		67.5	**(NON)**	Nutrient/organic enrichment	Pasture/non-irrigated crop production
	14.1^{H}/--	9.9	30*	NA		64.0	**(NON)**	Nutrient/organic enrichment	Pasture
	9.1^{H}/--	14.5	18*	NA		64.0	**(NON)**	Nutrient/organic enrichment	Pasture/non-irrigated crop production
			WWH - EOLP Ecoregion						
	7.4^{H}/7.4	18.2	34*	NA	F*	64.0	**NON**	Habitat alteration	Non-irrigated crop production
	1.3^{W}/1.1	23.0	49	7.7^{NS}	G	59.0	FULL		
Sugar Creek			*WWH - EOLP Ecoregion*						
	3.5^{H}/--	5.7	32*	NA		69.0	**(NON)**	Flow alteration	Natural (drought)
	1.5^{H}/--	6.4	36^{NS}	NA		61.0	(FULL)		
Old Woman Creek			*WWH - ECBP Ecoregion*						
	11.4^{H}/11.3	2.4	24*	NA	P*	0.0	**NON**	Flow alteration	Natural (drought)
	9.4^{H}/9.4	3.4	36^{NS}	NA	F*	41.0	PARTIAL	Siltation/habitat alteration	Channelization -Ag.
			WWH - EOLP Ecoregion						
	8.4^{H}/8.4	7.8	32*	NA	P*	74.5	**NON**	Nutrient/Organic enrichment	Livestock
	5.4^{H}/5.2	11.8	38^{NS}	NA	G	66.0	FULL		
	3.5^{H}/3.6	21.0	38^{NS}	NA	MG^{NS}	0.0	FULL		
	1.8^{O}/1.9^{L}	29.0	24*	NA	16*	0.0	**NON**	Siltation/nutrient enrichment	Non-irrigated crop production
	0.2^{O}/0.2^{L}	30.0	19*	5.4*	P*	0.0	**NON**	Siltation/nutrient enrichment	Non-irrigated crop production
Trib. to Old Woman Creek (RM 8.82)			*Undesignated/Recommended WWH - ECBP Ecoregion*						
	--/**0.9**	1.8			VP*	0.0	**NON**	Siltation/habitat alteration	Channelization -Ag.
Trib. to Old Woman Creek (RM 3.7)			*Undesignated/Recommended WWH - EOLP Ecoregion*						
	3.1^{H}/**4.9**	4.5	28*	NA	F*	67.5	**NON**	Flow alteration	Natural (drought)
	0.7^{H}/0.9	7.9	26*	NA	P*	0.0	**NON**	Flow alteration	Natural (drought)

a -MIwb is not applicable to headwater streams with drainage areas $\leq$ 20 mi^2.

b - A qualitative narrative evaluation based on best professional judgement and sampling attributes such as community composition, EPT taxa richness, and QCTV scores was used when quantitative data were not available or considered unreliable due to current velocities less than 0.3 fps flowing over the artificial substrates.

c - Attainment status is given for both existing and recommended use designations.

d - Causes listed are considered to be a primary influence on water quality, but may not be the only issue leading to impairment. See text for discussion of additional causes that cumulatively have led to impairment.

e - Sources listed are considered to be a primary influence on water quality, but may not be the only source leading to impairment. See text for discussion of additional sources that cumulatively have led to impairment.

H - Headwater site.

W - Wading site.

B - Boat site.

O - Fish Lacustuary site. Scores have been compared to lacustuary scoring method.

L - Macroinvertebrate Lacustuary site. Scores have been compared to lacustuary scoring method.

NS - Nonsignificant departure from biocriteria ($\leq$4 IBI or ICI units, or $\leq$0.5 MIwb units).

* - Indicates significant departure from applicable biocriteria (>4 IBI or ICI units, or >0.5 MIwb units). Underlined scores are in the Poor or Very Poor range.

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Table 7. Causes and sources of impairment of the Aquatic Life Use and status of the Recreation Use and Fish Consumption Advisory for Lake Erie tributaries (East of Huron River to West of Vermilion River) Watershed Assessment Unit - **04100012 040**. The information provided includes principal causes and sources of impairment for aquatic life and recreation uses and significant contaminants in sediment and fish tissue.

04100012 040 Lake Erie tributaries (East of Huron River to West of Vermilion River)		
Aquatic Life Use	**Causes of Impairment**	**Sources of Impairment**
	Nutrient and Organic enrichment	Pasture and non-irrigated crop production
		Livestock
	Habitat alteration	Non-irrigated crop production
	Siltation and Habitat alteration	Channelization from agricultural activities
	Flow alteration	Natural (drought)[1]
	Siltation and Nutrient enrichment	Non-irrigated crop production
Recreation Use[2]	Elevated levels of bacteria indicate a problem with bacteria throughout the watershed.	
Fish Consumption Advisory[3]	**Statewide**: No more than one meal per week of any sport fish due to mercury contamination	

1 - While the drought is considered a natural occurrence, the anthorpogenic manipulations to the stream channels and surrounding land (removal of riparian cover, presence of drain tile, and straightening of the channel) likely exaceberated the drought conditions.

2 - See the 2004 Integrated Water Quality Monitoring and Assessment Report for additional information at "www.epa.state.oh.us/dsw/tmdl/2004IntReport/2004OhioIntegratedReport.html." and also the Chemistry section of this report.

3 - See the 2004 Fish Consumption Advisory report for more detailed information at "www.epa.state.oh.us/dsw/fishadvisory/index.html".

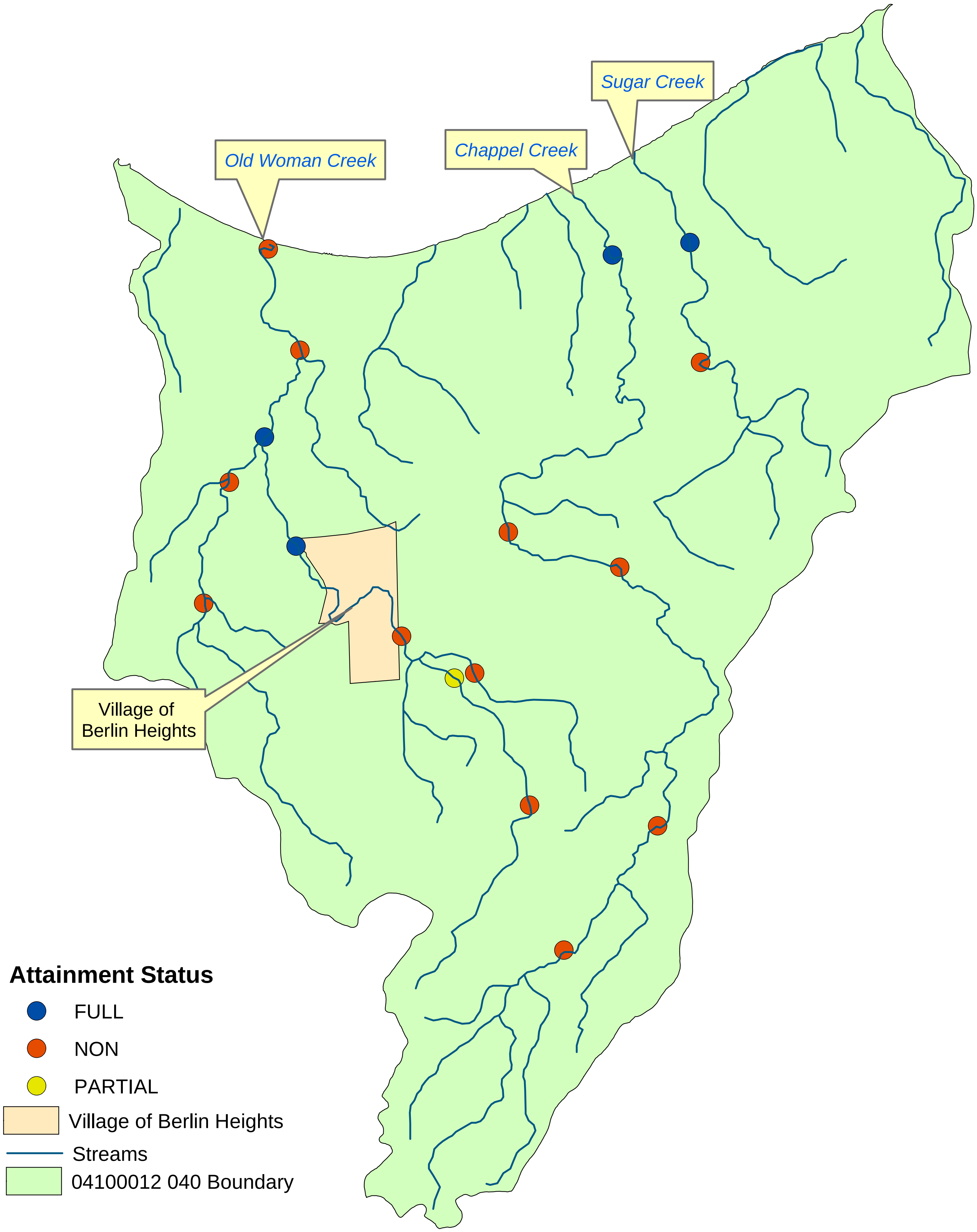

Figure 6. WAU 04100012 040 sampling sites by attainment status.

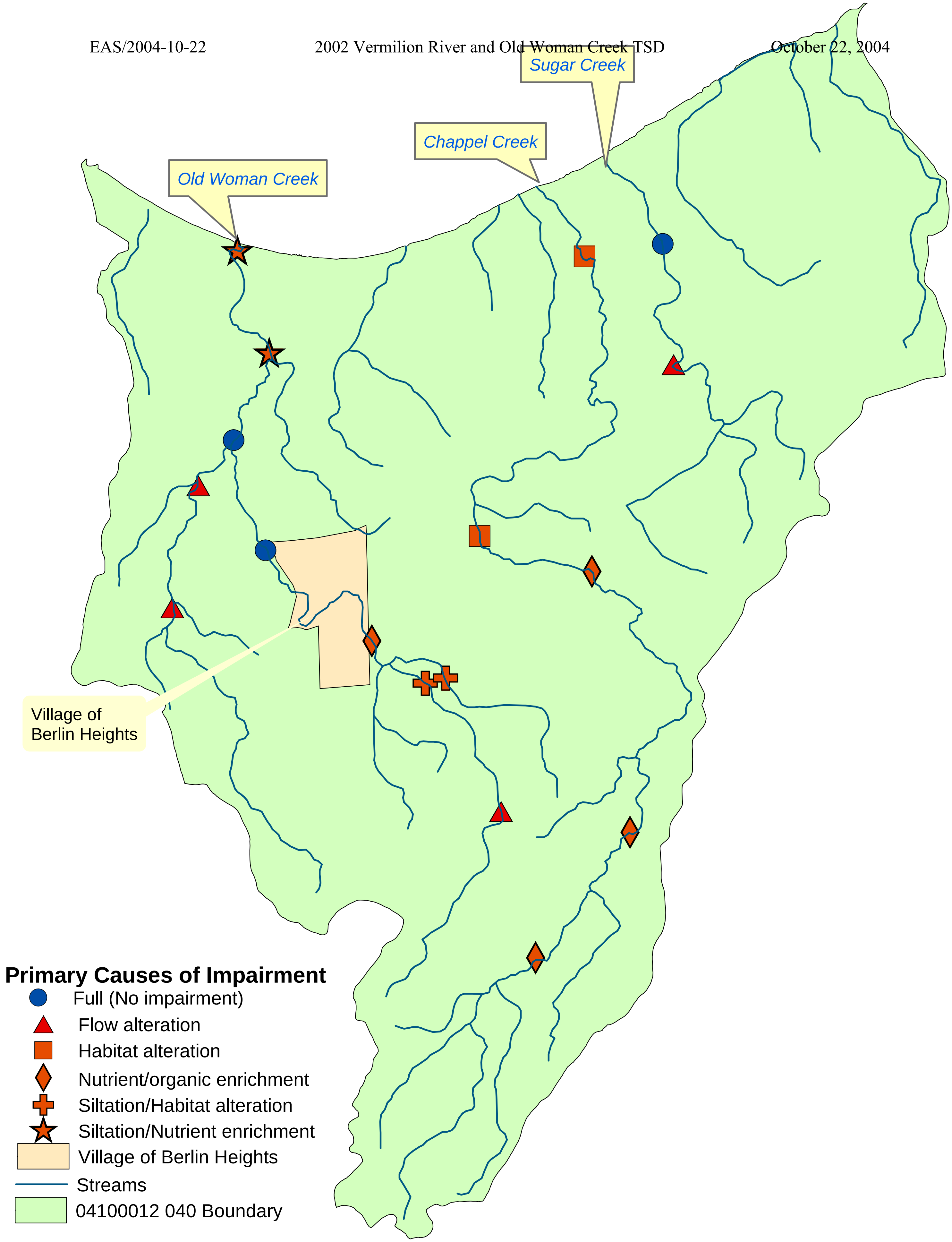

Figure 7. Primary causes of impairment within WAU 04100012 040. Sites in blue are in full attainment and not impaired.

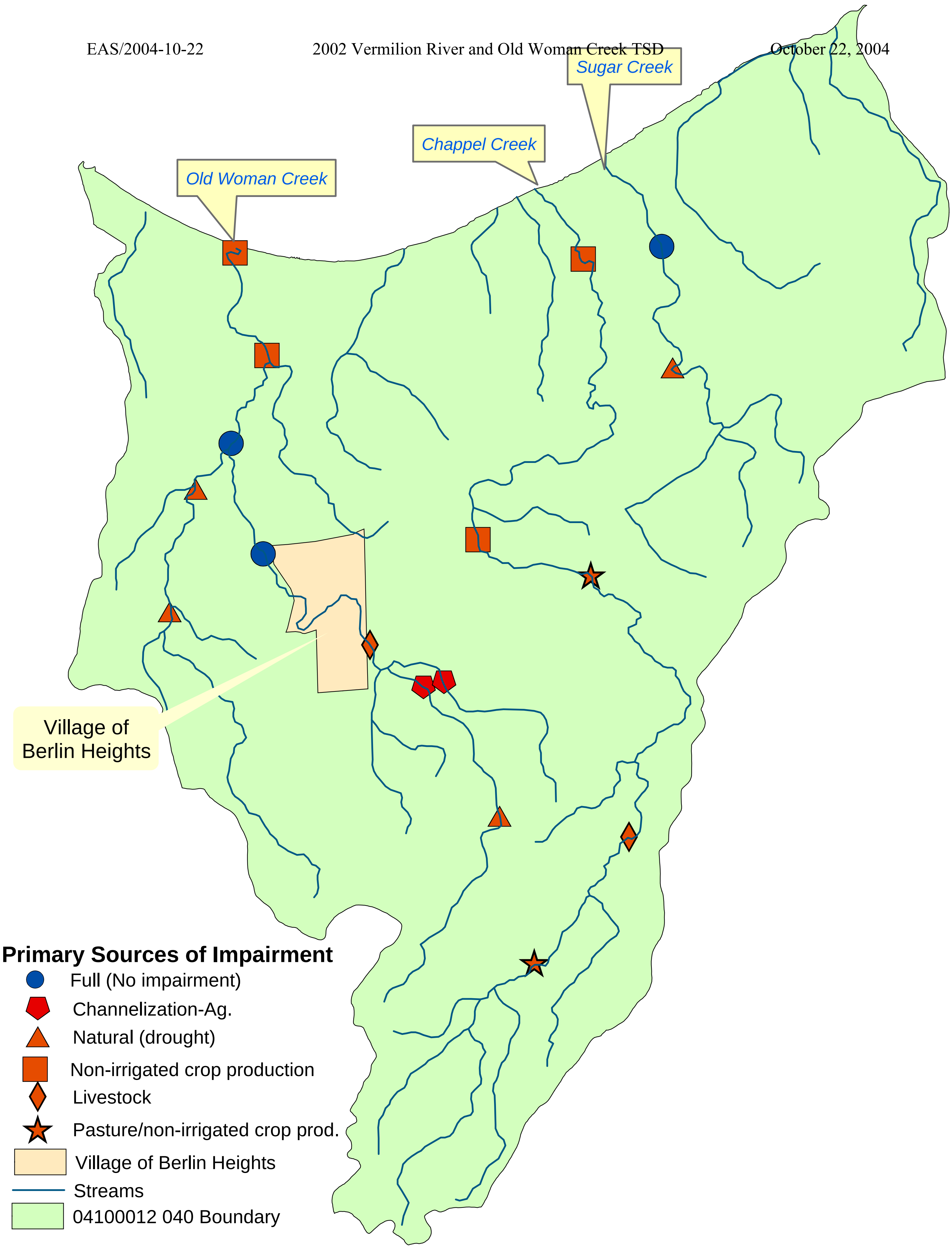

Figure 8. Primary sources of impairment within WAU 04100012 040. Sites in blue are in full attainment and not impaired.

*WAU - **04100012 050** Vermilion River (headwaters to upstream East Branch Vermilion River*

A total of 26 sites in the WAU 04100012 050 Vermilion River (headwaters to upstream East Branch Vermilion River) ranging in drainage areas between 2.4 mi^2 and 130 mi^2 were sampled in 2002 (Table 7 and Figure 10). All the sites within the WAU were designated Warmwater Habitat (WWH), though one site is recommended for MWH. Based on existing and recommended aquatic life uses, only 7 sites were in full attainment. Seven sites were in partial attainment and the remaining 12 sites were in non-attainment of the aquatic life use. The WAU spatial attainment score was 8.75, the WAU linear attainment score was 100 and the overall WAU aquatic life use attainment score based on data collected in 2002 was 54.38 (Table 8). The linear attainment score, spatial attainment score and overall attainment score were calculated according to the protocol established in the 2004 Integrated Water Quality Monitoring and Assessment Report, which is available at:

http://www.epa.state.oh.us/dsw/tmdl/2004IntReport/2004OhioIntegratedReport.html

The low WAU spatial score reflects the few sites meeting the WWH use designation at sampling locations with <50 mi^2 drainage. Primary causes of impairment within the WAU were nutrient and organic enrichment, habitat alteration, siltation, and flow alteration. The sources for these causes included both agricultural and non-agricultural sources. Agricultural sources of impairment included channelization, non-irrigated crop production, and livestock. At several sites, the multiple sources were noted and aggregated under ‘Agriculture’ as a source. Non-agricultural sources of impairment included development, failing septic systems and channelization. The term ‘Development’ as a source refers to the various effects and sources development may have on water quality and include, but are not limited to, removal of riparian buffers, increased stormwater run-off, increased erosion, and increased nutrient loading (Tables 9 & 10, Figures 11-13).

Habitat alterations combined with siltation, and nutrient and organic enrichment were the primary causes of impairment in the headwaters of the Vermilion River (RM 54.0 to RM 63.8). Bailey Lakes WWTP influenced the nutrient enrichment in the very headwaters of the Vermilion River (RM 63.8), while channelization activities there and further downstream (RM 63.0) were the sources of habitat alteration and siltation. A combination of channelization and potentially failing septic systems and onsite waste water systems were the primary sources of organic enrichment and siltation observed from Township Road 126 (RM 54.0) to Township Road 608 (RM 62.1). Several sites suffered flow alterations from the drought conditions present during the sampling activities, though these conditions may have been exacerbated by the presence of drain tile in the surrounding agricultural areas.

Buck Creek flows through a mixture of land uses including residential communities, agricultural fields, pastures, old fields, and forested areas. Elevated levels of total dissolved solids and nutrients were noted at several locations. Siltation and nutrient enrichment were contributed to the headwaters of Buck Creek by run-off from surrounding livestock pastures and failing septic systems.

Clear Creek received sediment loads from surrounding agricultural fields. In addition to run-off from crop fields, livestock access to the stream was noted at each sampling location. Discharge from a failing septic system was noted near Townline Road (RM 4.0).

Figure 14. Southwest Branch RM 4.0. Livestock accessing stream has resulted in trampling of banks and increased erosion of banks, as indicated by arrows.

Indian Creek flowed through a residential community and agricultural area where recent channelization activities had altered the habitat available to biological communities and increased the amount of siltation and embedded substrates present. These habitat alterations also likely contributed to the low dissolved oxygen levels recorded along the stream.

The Southwest Branch was impaired by nutrient enrichment, organic enrichment and siltation from the surrounding high intensity agricultural use. The drought impacted the biological community in the headwaters, though its effects may have been magnified by the presence of drain tile in the surrounding agricultural landscape. The presence of agricultural crops bracketed by poor buffers and livestock freely roaming through the stream contributed to the high siltation and excessive organic and nutrient enrichment observed (Figure 14). Point sources influencing the water quality included the Village of Greenwich and associated failing onsite septic systems.

The support status of the recreation use within the WAU was assessed by bacterial sampling. The results from the sampling indicate a problem with elevated bacterial levels throughout the watershed (Table 11).

Throughout the state of Ohio there is a limit of no more than one meal per week of any sport fish due to mercury contamination (Table 5). For the Vermilion River, there is an additional advisory of no more than one meal per month of smallmouth bass due to mercury contamination (Table 11). For additional information related to the Fish Consumption Advisory, see the 2004 Fish Consumption Advisory report available at “www.epa.state.oh.us/dsw/fishadvisory/index.html”.

Water quality concerns throughout the WAU may be addressed through improvements addressing the causes and sources of impairment. The primary causes and sources of impairment through the WAU may be divided into agricultural and non-agricultural activities. Agricultural activities to be addressed through educational and funding projects could include alternatives to channelization, improvement to riparian corridors, fencing livestock out of streams and waste management. Non-agricultural impairments could be addressed through a combination of regulatory, educational and funding actions including improvements at the Bailey Lakes WWTP, management of failing septic systems, and alternatives to traditional stream channelization and riparian removal.

Table 8. Existing and recommended Aquatic Life Use designations for Vermilion River (headwaters to upstream East Branch Vermilion River) Watershed Assessment Unit - **04100012 050** by drainage area based on sampling conducted in 2000 - 2002.

04100012 050 Vermilion River (headwaters to upstream East Branch Vermilion River)							
Site size vs. type	Total	EWH	WWH	MWH	LRW	CWH or SSH	Mix Zone(s) (excluded from assessment)
Number of sites ≤50mi²	22	0	21	1	0	0	0
Number of sites ≥50mi²	4	0	4	0	0	0	0
Size of smallest sampled drainage area in HUC: 2.4 mi²				Size of largest sampled drainage area in HUC: 130 mi²			

Table 9. Aquatic life use attainment status for Vermilion River (headwaters to upstream East Branch Vermilion River) Watershed Assessment Unit - **04100012 050** based on sampling conducted in 2002. The assessment unit score is an average grade of aquatic life use status. The method of calculation is presented in the 2004 Integrated Water Quality Monitoring and Assessment Report . The attainment status of recommended uses was used in lieu of existing uses when calculating the WAU score, when applicable. A maximum assessment unit score of 100 is possible if all monitored sites meet designated aquatic life uses.

WAU: **04100012 050,** Vermilion River (headwaters to upstream East Branch Vermilion River)

Stream Names: *Vermilion River (headwaters to Zenobia Road, RM 33.6), Indian Creek, Southwest Branch Vermilion River, Buck Creek, Clear Creek, U.T. to Buck Creek (RM 4.92), U.T. to Vermilion River (RM 63.52), U.T. to Vermilion River (RM 54.62), U.T. to Vermilion River (RM 32.98), U.T. to Southwest Branch Vermilion River (RM 2.3), and U.T. to Southwest Branch Vermilion River (RM 5.35).*

Data Collected:2002. Integrated Report (IR) category: **5**

04100012 050 Vermilion River (headwaters to upstream East Branch Vermilion River)			
Attainment Categories for sites $\leq$50mi^2	Data Group 1 $\leq 5mi^2$	Data Group 2 $>5mi^2$ to $\leq 20mi^2$	Data Group 3 $>20mi^2$ to $\leq 50mi^2$
Number of sites in FULL attainment	1(a)	2(a)	0(a)
Total Number of sites	5(b)	14(b)	3(b)

WAU Spatial Attainment Score Calculation:

Data Group 1 ≤ 5 mi^2	Data Group 2 > 5 mi^2 to ≤ 20 mi^2	Data Group 3 > 20 mi^2 to ≤ 50 mi^2	Spatial Score

$$\frac{\dfrac{(a/b + a/b)}{2} + (a/b)}{2} * 100 = c$$

where
- a = number of sites in full attainment
- b = number of sites in data group
- c = spatial attainment score for WAU

WAU Spatial Attainment Score = **8.57**

Table 9. (Continued)

WAU Linear Attainment Score

04100012 050 Vermilion River (headwaters to upstream East Branch Vermilion River)			
Attainment Categories for sites ≥50mi²	Total number of miles >50mi²	Number of miles >50mi² in FULL attainment	Percent of miles >50mi² in FULL attainment
Vermilion River, 29.8 to 50.7	23.7(a)	23.7(b)	**100%**

WAU Linear Attainment Score is calculated by the following expression: (a/b)*100

The Linear Attainment Score for WAU 04100012 050 is **100**.

The WAU Attainment Score is calculated by averaging the WAU Linear Attainment Score with the WAU Spatial Attainment Score. For WAU 04100012 050 , the overall attainment score is **54.38**.

Table 10. Aquatic life use attainment status for the streams sampled in the Vermilion River (headwaters to upstream East Branch Vermilion River) Watershed Assessment Unit - **04100012 050** during July to September, 2002. The Index of Biotic Integrity (IBI), Modified Index of well being (MIwb), and Invertebrate Community Index (ICI) are scores based on the performance of the biotic community. The Qualitative Habitat Evaluation Index (QHEI) is a measure of the ability of the physical habitat to support a biotic community.

Stream Name	River Mile	Drainage Area	IBI	MIwb[a]	ICI[b]	QHEI	Attainment Status[c]	Causes[d]	Sources[e]
Buck Creek			*WWH - EOLP Ecoregion*						
	8.2^{H}/8.1	2.4	32*	NA	F*	44.0	**NON**	Siltation	Pasture
								Nutrient enrichment	Septic Systems
	5.0^{H}/--	16.0	32*	NA		74.0	**(NON)**	Flow alteration	Natural (drought)
	3.2^{H}/3.2	16.8	34*	NA	G	75.0	PARTIAL	Flow alteration	Natural (drought)
	1.1^{H}/1.0	19.7	35*	NA	G	66.0	PARTIAL	Flow alteration	Natural (drought)
Clear Creek			*WWH - EOLP Ecoregion*						
	4.0^{H}/--	5.1	22*	NA		52.0	**(NON)**	Siltation/flow alteration	Livestock
	1.8^{H}/2.1	7.7	46	NA	MG^{NS}	71.0	FULL		
Indian Creek			*WWH existing/MWH recommended - ECBP Ecoregion*						
	3.5^{H}/3.5	5.7	26*	NA	F	36.0	**NON**	Habitat alteration	Channelization - Ag.
			WWH - ECBP Ecoregion						
	0.4^{H}/0.4	8.1	42	NA	F*	71.5	PARTIAL	Siltation/flow alteration	Agriculture
Southwest Branch			*WWH - ECBP Ecoregion*						
	5.6^{H}/5.6	7.3	38^{NS}	NA	F*	62.5	PARTIAL	Siltation	Agriculture
	3.9^{H}/3.9	12.0	26*	NA	F*	65.0	**NON**	Nutrient/organic enrichment	Pasture
	2.5^{H}/2.5	17.4	34*	NA	MG^{NS}	65.5	PARTIAL	Siltation	Non-irrigated crop/pasture
	1.0^{W}/1.0	30.0	28*	5.8*	MG^{NS}	47.5	**NON**	Siltation	Non-irrigated crop/pasture
Trib. to Southwest Branch (2.3)			*Undesignated/WWH recommended - ECBP Ecoregion*						
	--/0.7	4.2			F*		**(NON)**	Nutrient/organic enrichment	Non-irrigated crop/pasture

Table 10. (Continued)

Stream Name	River Mile	Drainage Area	IBI	MIwb[a]	ICI[b]	QHEI	Attainment Status[c]	Causes[d]	Sources[e]
Trib. to Southwest Branch (5.35)			*Undesignated/WWH recommended - ECBP Ecoregion*						
	--/0.6	4.1			F*		**(NON)**	Flow alteration	Natural (drought)
Trib. to Vermilion River (32.98)			*Undesignated/WWH recommended - ECBP Ecoregion*						
	--/1.0	4.2			G		(FULL)		
Trib. to Vermilion River (63.52)			*Undesignated/WWH recommended - EOLP Ecoregion*						
	0.2^{H}/0.3	4.1	34*	NA	F*	38.0	**NON**	Nutrient enrichment Habitat alteration	Channelization - Dev.
Trib. to Buck Creek (4.92)			*Undesignated/WWH recommended - EOLP Ecoregion*						
	0.1^{H}/0.1	8.4	40	NA	MG^{NS}	64.0	FULL		
Trib. to Vermilion River (54.62)			*Undesignated/WWH recommended - EOLP Ecoregion*						
	0.5^{H}/--	5.6	34*	NA		67.0	**(NON)**	Habitat alteration	Natural (drought)
Vermilion River			*WWH - EOLP Ecoregion*						
	--/63.8	8.3			P*		**(NON)**	Habitat alteration Nutrient enrichment	Channelization - Ag. & Dev. Bailey Lakes WWTP
	63.0^{H}/63.0	10.0	30*	NA	F*	45.0	**NON**	Habitat alteration/siltation	Channelization - Ag.
	62.1^{W}/62.0	23.0	30*	NA	MG^{NS}	62.5	PARTIAL	Organic enrichment Siltation	Onsite waste system Channelization-Ag.
	54.0^{W}/56.2	41.0	32*	5.9*	34	59.0	PARTIAL	Organic enrichment Siltation	Septic systems Channelization-Ag.
	50.7^{W}/50.6	69.0	38	7.9	MG^{NS}	68.0	FULL		
	45.7^{W}/45.9	76.0	48	8.8	VG	79.0	FULL		
			WWH - ECBP Ecoregion						
	44.5^{W}/44.5	78.0	43	7.8^{NS}	44	79.0	FULL		
	33.6^{W}/33.6	130.0	53	10.1	50	80.5	FULL		

a - MIwb is not applicable to headwater streams with drainage areas $\leq$ 20 mi^2.

b - A qualitative narrative evaluation based on best professional judgement and sampling attributes such as community composition, EPT taxa richness, and QCTV scores was used when quantitative data were not available or considered unreliable due to current velocities less than 0.3 fps flowing over the artificial substrates.

c - Attainment status is given for both existing and recommended use designations.

d - Causes listed are considered to be a primary influence on water quality, but may not be the only issue leading to impairment. See text for discussion of additional causes that cumulatively have led to impairment.

e - Sources listed are considered to be a primary influence on water quality, but may not be the only source leading to impairment. See text for discussion of additional sources that cumulatively have led to impairment.

H - Headwater site.

W -Wading site.

B - Boat site.

O - Fish Lacustuary site. Scores have been compared to lacustuary scoring method.

L - Macroinvertebrate Lacustuary site. Scores have been compared to lacustuary scoring method.

NS - Nonsignificant departure from biocriteria ($\leq$4 IBI or ICI units, or $\leq$0.5 MIwb units).

* - Indicates significant departure from applicable biocriteria (>4 IBI or ICI units, or >0.5 MIwb uits). Underlined scores are in the Poor or Very Poor range.

Table 11. Causes and sources of impairment of the Aquatic Life Use and status of the Recreation Use and Fish Consumption Advisory for Vermilion River (headwaters to upstream East Branch Vermilion River) Watershed Assessment Unit - **04100012 050**. The information provided includes principal causes and sources of impairment for aquatic life and recreation uses and significant contaminants in sediment and fish tissue.

04100012 050 Vermilion River (headwaters to upstream East Branch Vermilion River)		
Aquatic Life Use	**Causes of Impairment**	**Sources of Impairment**
	Habitat alteration	Channelization - from both agricultural and development activities
	Nutrient enrichment	Bailey Lakes WWTP, septic systems
	Habitat alteration and siltation	Channelization - Agriculture
	Organic enrichment and siltation	Septic systems, onsite waste systems, channelization -Agriculture
	Siltation and Flow alteration	Agriculture activities and Natural (drought)
	Siltation	Agriculture activities including pasture and non-irrigated crop production
	Nutrient enrichment and Habitat alteration	Channelization from development activities
	Organic and Nutrient enrichment	Agriculture activities including pasture and non-irrigated crop production
	Flow alteration and Habitat alteration	Natural (drought)[1]
Recreation Use[2]	Elevated levels of bacteria indicate a problem with bacteria throughout the watershed.	
Fish Consumption Advisory[3]	**Statewide**: No more than one meal per week of any sport fish due to mercury contamination	**Vermilion River**: No more than one meal per month of Smallmouth Bass due to mercury contamination

1 - While the drought is considered a natural occurrence, the anthorpogenic manipulations to the stream channels and surrounding land (removal of riparian cover, presence of drain tile, and straightening of the channel) likely exaceberated the drought conditions.

2 - See the 2004 Integrated Water Quality Monitoring and Assessment Report for additional information at "www.epa.state.oh.us/dsw/tmdl/2004IntReport/2004OhioIntegratedReport.html." and also the Chemistry section of this report.

3 - See the 2004 Fish Consumption Advisory report for more detailed information at "www.epa.state.oh.us/dsw/fishadvisory/index.html".

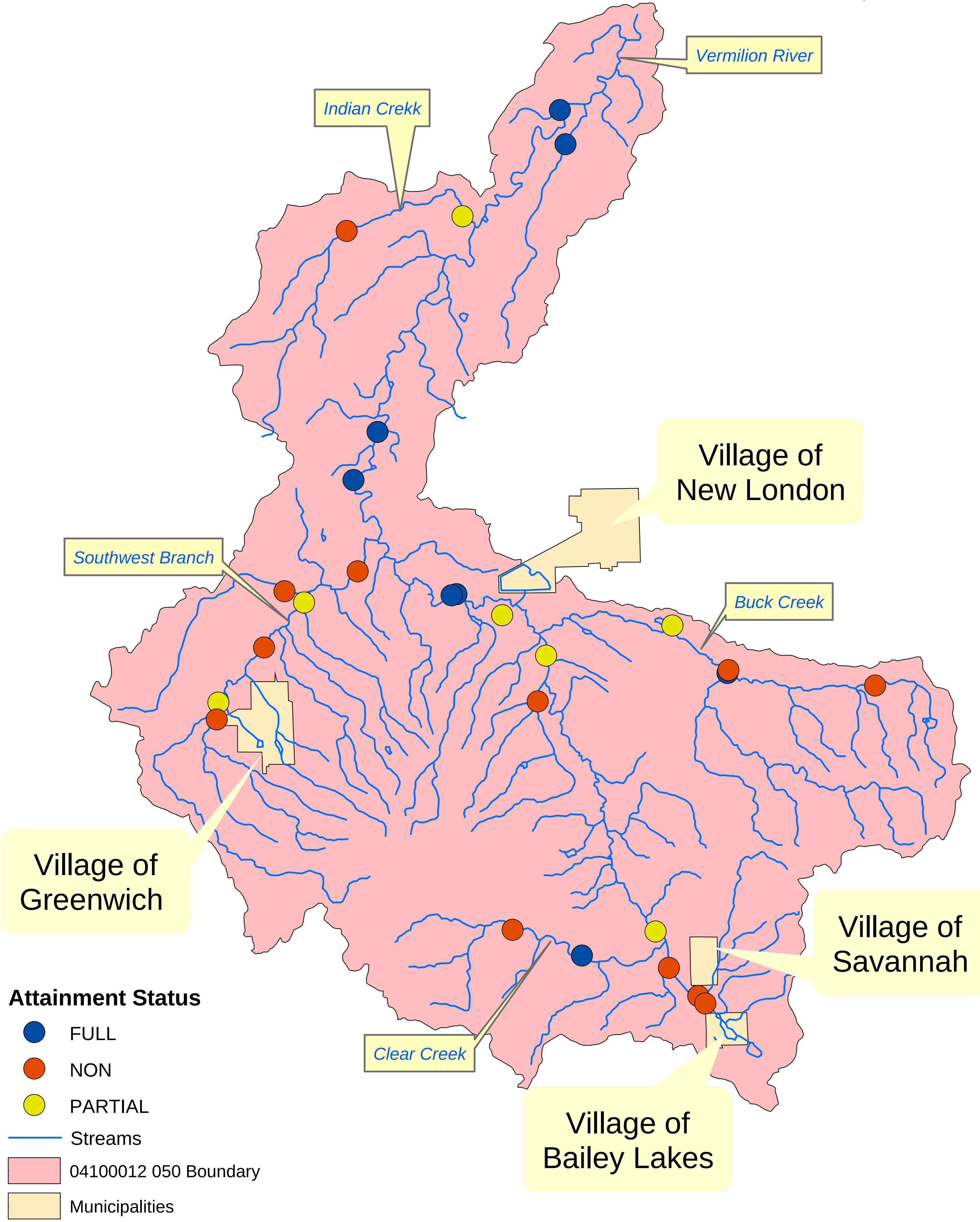

Figure 10. WAU 04100012 050 sampling sites by attainment status.

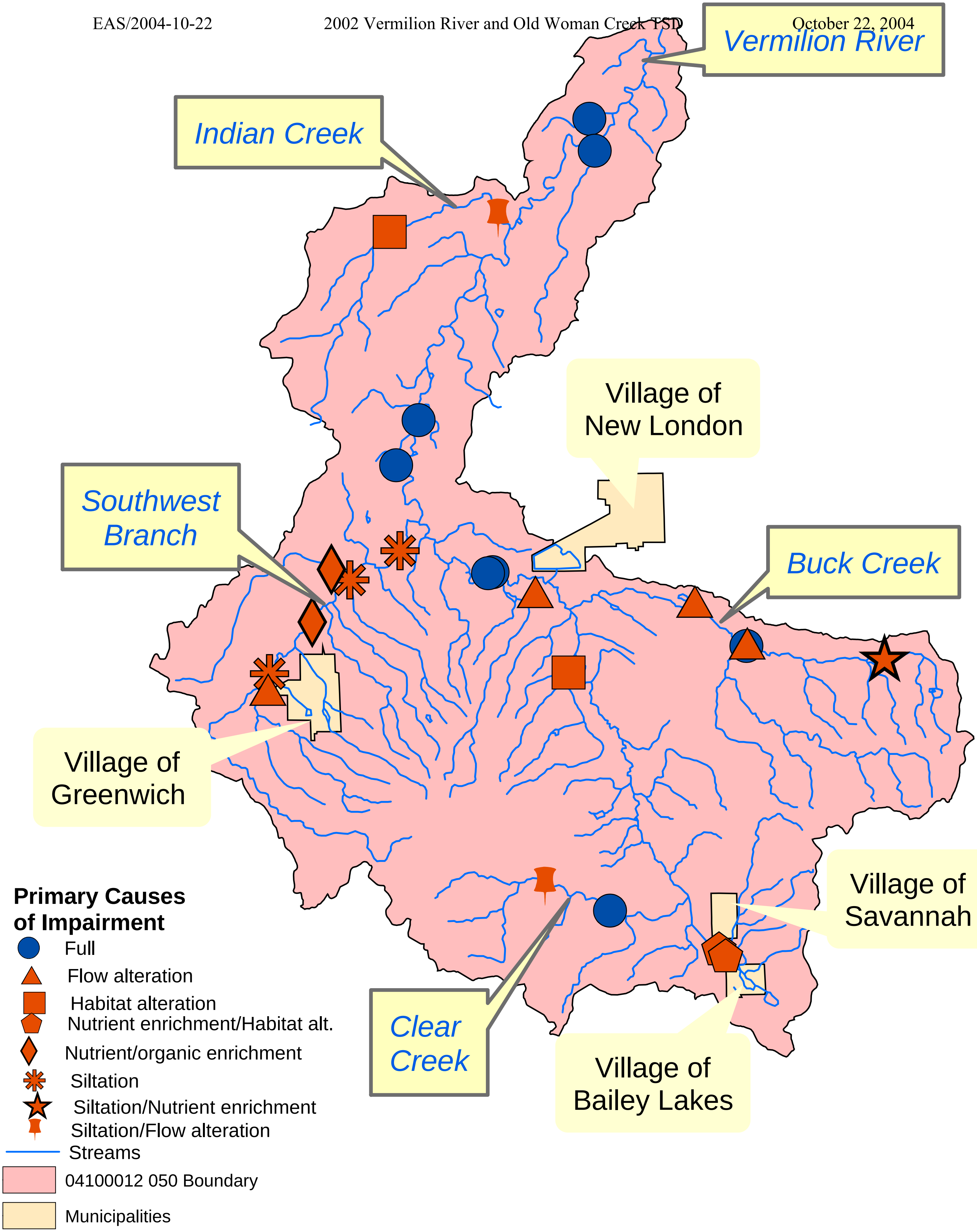

Figure 11. Primary causes of impairment within WAU 04100012 050. Sites in blue are in full attainment and not impaired.

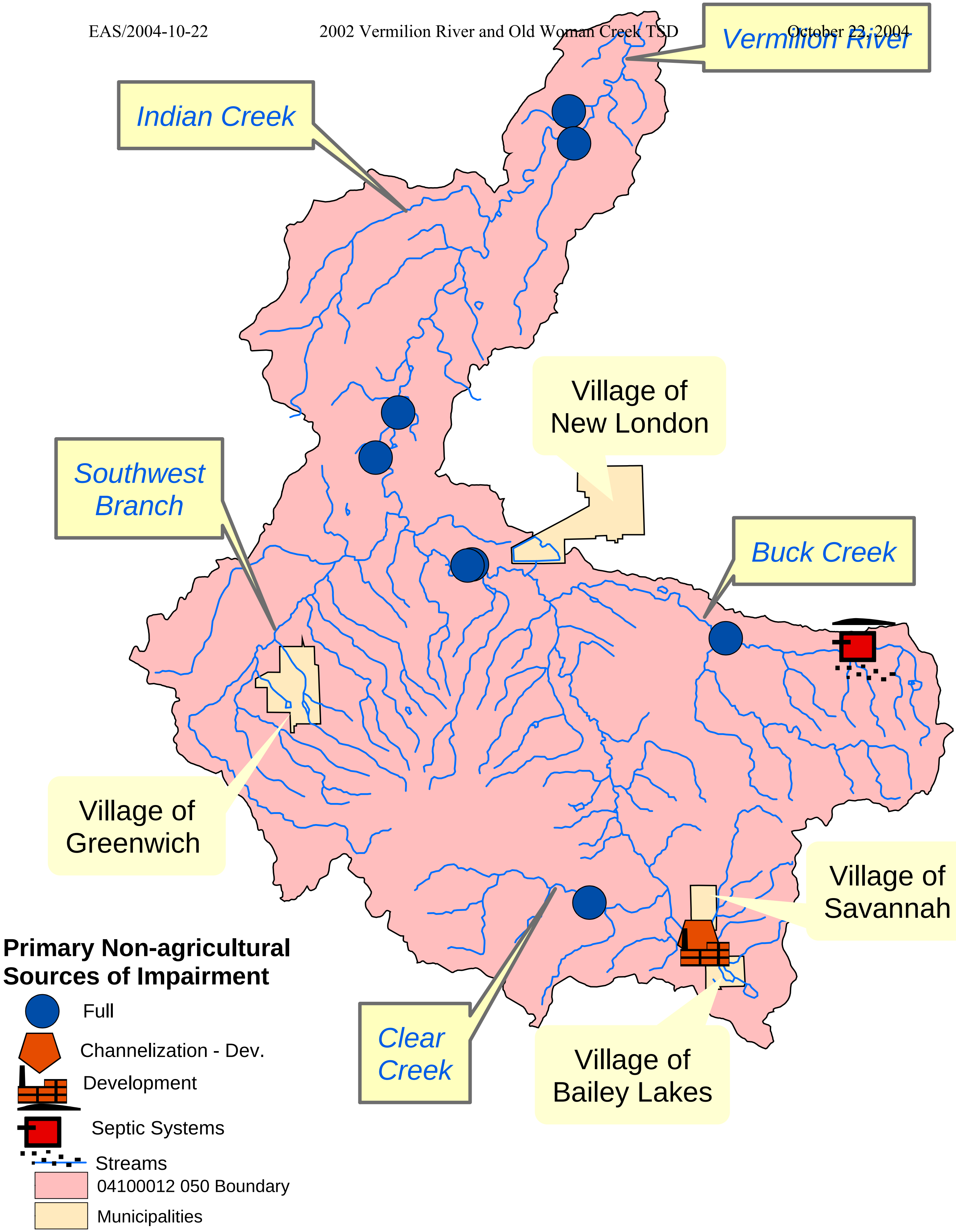

Figure 12. Primary non-agricultural sources of impairment within WAU 04100012 050. Sites in blue are in full attainment and not impaired.

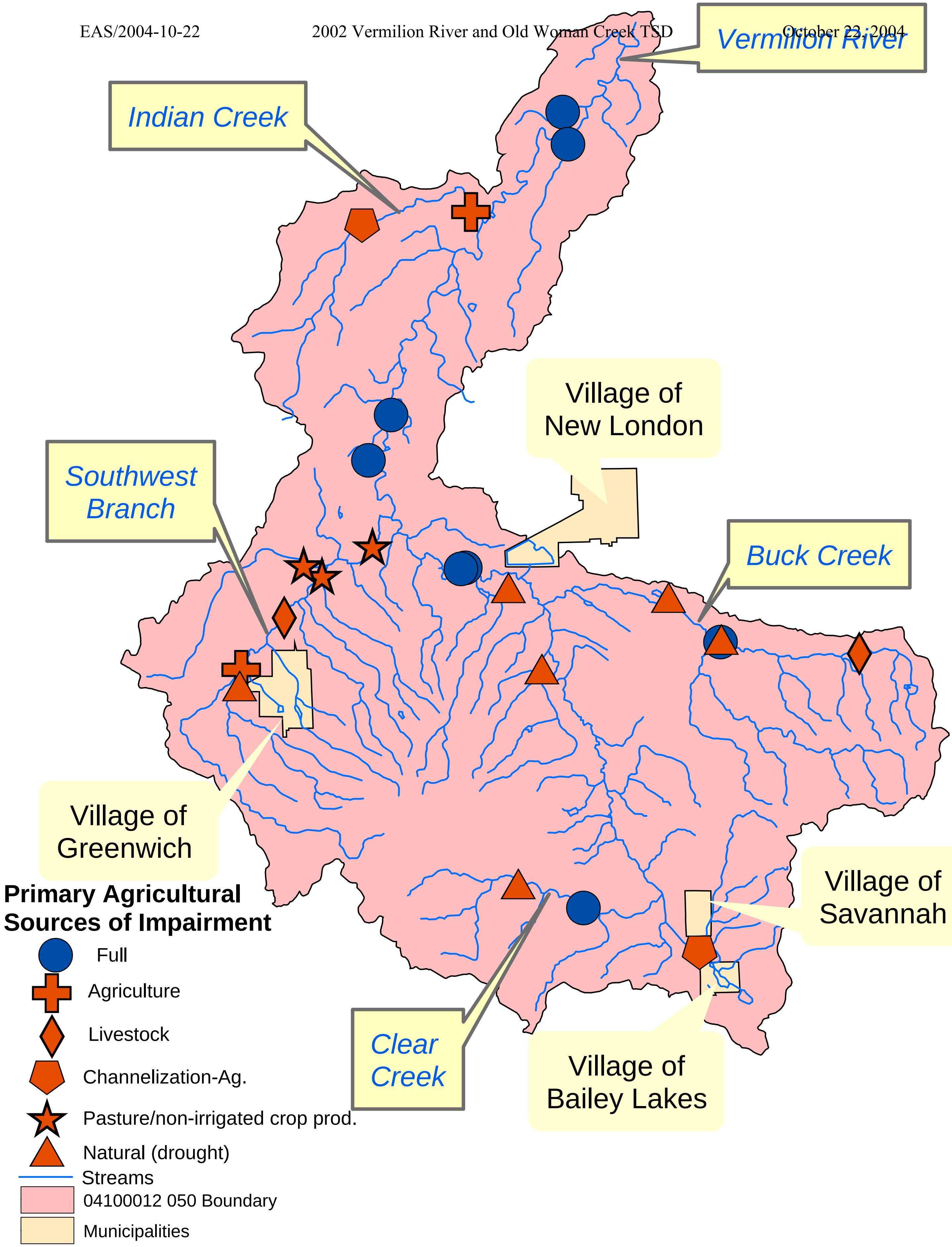

Figure 13. Primary agricultural sources of impairment within WAU 04100012 050. Sites in blue are in full attainment and not impaired.

*WAU - **04100012 060** Vermilion River (upstream East Branch to mouth)*

A total of 27 sites in the WAU 04100012 060 Vermilion River (upstream East Branch to mouth) ranging in drainage areas between 3.1 mi^2 and 268 mi^2 were sampled in 2002 (Table 11 and Figure 15). All the sites within the WAU were designated or are recommended Warmwater Habitat (WWH). Based on existing and recommended aquatic life uses, 12 sites were in full attainment. Two sites were in partial attainment and the remaining 13 sites were in non-attainment of the aquatic life use. The WAU spatial attainment score was 50.83, the WAU linear attainment score was 78.79 and the overall WAU attainment score based on data collected in 2002 was 64.81 (Table 12).

The low WAU spatial score reflects the few sites meeting the WWH use designation at sampling locations with <50 mi^2 drainage area. Primary causes of impairment within the WAU were nutrient and organic enrichment, habitat alteration, siltation, and flow alteration. The sources for these causes varied, and were dependent upon site location and surrounding land use (Tables 13 & 14, Figures 16-18).

Figure 19. Wakeman Dam impounds approximately 2.5 miles of the Vermilion River and is a source of aquatic life impairment.

The Vermilion River from Auster Road (RM 29.2) to the mouth (RM 0.1) flowed through both agricultural lands and developed communities. Full attainment of the WWH designation was maintained from Auster Road (RM 29.2) to north of West Ridge Road (RM 6.4) except for the approximately 2.5 miles impounded by Wakeman Dam (Figure 19). The lacustuary (flooded river mouth) portion of the Vermilion extended from the mouth (RM 0.1) to east of Valley View School (RM 1.5). Siltation and nutrient enrichment were excessive. This area acts as a sink for pollutants emanating from the upper reaches of the watershed. Agricultural run-off, stormwater run-off and the Vermilion WWTP all contributed to the high nutrient enrichment and siltation noted in the lacustuary portion of the Vermilion River.

The unnamed tributaries to the Vermilion River within this WAU were predominantly in good condition, except for the headwaters of the unnamed tributary to the Vermilion River (RM 24.35). Unrestricted livestock access to the stream resulted in organic enrichment and excessive siltation.

Agricultural practices increased the levels of siltation and nutrient enrichment present in the East Branch, resulting in fair scores for the biological communities present. Nutrient enrichment from the New London WWTP via Skellinger Creek (RM 12.67) increased eutrophication in the East

Branch. The tributary to the East Branch (RM 8.2) was influenced by both agricultural and point sources of pollution. Habitat alterations, and nutrient and organic enrichment were attributed to livestock noted near Chenango and Fayette Road (RM 4.0) and Chenango Road (RM 5.8), though heavy sewage odors in the area also indicate the potential presence of failing septic systems. The failing septic systems of the residential area near Chenango Road (RM 1.1) and the habitat alterations consisting of very narrow buffers and few habitat types contributed to the poor biological community performance in this section of the East Branch.

While agricultural activities and failing septic systems contributed to the poor biological community performance of the East Fork near Baird Road (RM 10.9), significant drops in performance were noted downstream of an unpermitted nursery facility, Green Circle Growers (RM 9.1). Exceedances of the WQS criteria for copper, phosphorus, fecal coliform and ammonia were noted downstream of Green Circle Growers, as were elevated levels of nitrate+nitrite. The unnamed tributary to East Fork (RM 8.47) also received organic and nutrient enrichment from Green Circle Growers. Organic and nutrient enrichment from Green Circle Growers and the unsewered Village of Kipton extended downstream of Vermilion Road (RM 7.4).

Frankenburg Creek, a small tributary to the East Fork at RM 3.24, in part exhibited good water quality, though fecal coliform bacteria and nitrate+nitrite were slightly elevated. Moderate amounts of diverse instream cover, moderate to wide buffers and diverse currents with normal amounts of silt and embedded substrates provided substantial habitat quality for biological communities.

Skellinger Creek received organic and nutrient enrichment from livestock and from the New London WWTP. Severely elevated levels of total phosphorus, nitrate+nitrite and fecal coliform were noted downstream of the New London WWTP. Agricultural activities, including livestock access to the stream and row cropping without buffers, contributed to poor habitat quality and intensified the effects of the organic and nutrient enrichment and siltation.

Impairment to the recreation use within the WAU was assessed by bacterial sampling. The results from sampling indicate a problem with elevated bacterial levels throughout the watershed (Table 15).

Throughout the state of Ohio there is a limit of no more than <u>one meal per week</u> of any sport fish due to mercury contamination (Table 5). For the Vermilion River, there is an additional advisory of no more than <u>one meal per month</u> of smallmouth bass due to mercury contamination (Table 15). For additional information related to the Fish Consumption Advisory, see the 2004 Fish Consumption Advisory report available at "www.epa.state.oh.us/dsw/fishadvisory/index.html".

The section of the Vermilion River mainstem within the WAU was mostly in full attainment, except for the section impounded by Wakeman Dam and the lacustuary area to the mouth.

Removal of the Wakeman Dam would likely eliminate the impairment noted in this section. Addressing the water quality concerns in the lacustuary area to the mouth of the Vermilion River would require an assortment of improvements throughout the watershed. The impairment in the lacustuary area may be attributable to both the agricultural and development activities occurring throughout the watershed. The lacustuary area acts as a sink for silt, organic matter and nutrients produced from upstream agricultural and non-agricultural activities. Addressing the causes and sources in the upstream WAU #04100012 050 in conjunction with improvements within this WAU, should improve conditions within the lacustuary area.

The tributaries within this WAU are impaired due to a combination of point and non-point sources. Green Circle Growers, an unpermitted nursery facility, was investigated in August 2002. Green Circle Growers is a primary cause of impairment in the East Fork and one of its tributaries. An enforcement case is currently underway to address this facility as a source of impairment to water quality.

Additional sources of non-agricultural excessive nutrient and organic enrichment is caused by the New London WWTP, the unsewered community of the Village of Kipton, and many potentially failing septic systems noted throughout the study area. Habitat alterations for residential development and residential yards affected the quality of habitat available for aquatic organisms. Regulatory actions and education activities could be used to address these sources of impairment and improve water quality.

Tributaries throughout the WAU were also affected by non-point agricultural sources including livestock access to streams and poor buffers adjacent to non-irrigated crop fields. Educational outreach combined with promotion of funding sources (319 program) to address these concerns could improve water quality throughout the WAU.

Table 12. Existing and recommended aquatic life use designations for Vermilion River (upstream East Branch to mouth) Watershed Assessment Unit - **04100012 060** by drainage area based on sampling conducted in 2000 - 2002. Recommended aquatic life use designations are provided where sampling indicates the existing use should be changed.

04100012 060 Vermilion River (upstream East Branch to mouth)							
Site size vs. type	Total	EWH	WWH	MWH	LRW	CWH or SSH	Mix Zone(s) (excluded from assessment)
Number of sites ≤50mi^2	18	0	18	1	0	0	0
Number of sites ≥50mi^2	9	0	9	0	0	0	0
Size of smallest sampled drainage area in HUC: 3.1 mi^2				Size of largest sampled drainage area in HUC: 268 mi^2			

Table 13. Aquatic life use attainment status for Vermilion River (upstream East Branch to mouth) Watershed Assessment Unit - **04100012 060** based on sampling conducted in 2002. The assessment unit score is an average grade of aquatic life use status. The method of calculation is presented in the 2004 Integrated Water Quality Monitoring and Assessment Report . The attainment status of recommended uses was used in lieu of existing uses when calculating the WAU score, when applicable. A maximum assessment unit score of 100 is possible if all monitored sites meet designated aquatic life uses.

WAU: **04100012 060,** Vermilion River (upstream East Branch to mouth)

Stream Names: *Vermilion River (upstream East Branch(RM 29.2) to mouth), East Fork Vermilion River, East Branch Vermilion River, U.T. to East Branch Vermilion River (RM 8.2), U.T. to Vermilion River (RM 8.29), U.T. to Vermilion River (RM 12.0), U.T. to Vermilion River (RM 24.35), Frankenburg Creek, U.T. to East Fork Vermilion River (RM 8.47), and Skellinger Creek..*

Data Collected:2002. Integrated Report (IR) category: **5**

04100012 060 Vermilion River (upstream East Branch to mouth)			
Attainment Categories for sites ≤ 50mi²	Data Group 1 ≤ 5mi²	Data Group 2 >5mi² to ≤ 20mi²	Data Group 3 >20mi² to ≤ 50mi²
Number of sites in FULL attainment	2(a)	3(a)	2(a)
Total Number of sites	5(b)	10(b)	3(b)

WAU Spatial Attainment Score Calculation:

Data Group 1	Data Group 2	Data Group 3	
< 5 mi²	> 5 mi² to < 20 mi²	> 20 mi² to < 50 mi²	Spatial Score

$$\frac{\frac{(a/b + a/b)}{2} + (a/b)}{2} * 100 = c$$

where
- a = number of sites in full attainment
- b = number of sites in data group
- c = spatial attainment score for WAU

WAU Spatial Attainment Score = **50.83**

WAU Linear Attainment Score

04100012 060 Vermilion River (upstream East Branch to mouth)			
Attainment Categories for sites ≥50mi²	Total number of miles >50mi² in FULL attainment	Number of miles >50mi²	Percent of miles>50mi² in FULL attainment
Vermilion River, 29.8 to mouth	23.48(a)	29.8(b)	**78.79**

WAU Linear Attainment Score is calculated by the following expression: (a/b)*100

The Linear Attainment Score for WAU 04100012 060 is **78.79**.

The WAU Overall Attainment Score is calculated by averaging the WAU Linear Attainment Score with the WAU Spatial Attainment Score. For WAU 04100012 060 , the overall attainment score is **64.81**.

Table 14. Aquatic life use attainment status for the streams sampled in the Vermilion River (upstream East Branch to mouth) Watershed Assessment Unit - **04100012 060** during July to September, 2002. The Index of Biotic Integrity (IBI), Modified Index of well being (MIwb), and Invertebrate Community Index (ICI) are scores based on the performance of the biotic community. The Qualitative Habitat Evaluation Index (QHEI) is a measure of the ability of the physical habitat to support a biotic community.

Stream Name	River Mile	Drainage Area	IBI	MIwb[a]	ICI[b]	QHEI	Attainment Status[c]	Causes[d]	Sources[e]
East Branch			*WWH - EOLP Ecoregion*						
	$8.6^{H}/8.3$	15.7	34*	NA	F*	62.0	**NON**	Siltation	Channelization - Ag.
			WWH - ECBP Ecoregion						
	$2.7^{W}/3.6$	36.0	30*	7.7*	G	66.0	PARTIAL	Nutrient enrichment	Non-irrigated crop production
	$1.4^{W}/1.4$	37.0	42	8.2^{NS}	VG	77.0	FULL		
East Fork			*WWH - ECBP Ecoregion*						
	$10.9^{H}/10.9$	8.3	34*	NA	MG^{NS}	58.0	PARTIAL	Siltation	Channelization - Ag.
								Nutrient enrichment	Septic systems
	$8.9^{H}/9.1$	10.9	<u>24*</u>	NA	<u>VP*</u>	67.0	**NON**	Organic/nutrient enrichment	Industrial point source (Green Circle Growers)
	$7.4^{H}/7.4$	16.4	36^{NS}	NA	<u>VP*</u>	68.0	**NON**	Organic/nutrient enrichment	Industrial point source (Green Circle Growers) Septic Systems
	$2.3^{W}/2.3$	33.0	38^{NS}	8.0	MG^{NS}	64.0	FULL		
Frankenburg Creek			*Undesignated/WWH recommended - ECBP Ecoregion*						
	$0.2^{H}/0.2$	6.5	46	NA	G	77.0	FULL		
Skellinger Creek			*Undesignated/WWH recommended - EOLP Ecoregion*						
	$0.8^{H}/1.0$	4.0	<u>20*</u>	NA	F*	48.5	**NON**	Organic/nutrient enrichment	Pasture/non-irrigated crop production
								Siltation	New London WWTP

Table 14. (Continued)

Stream Name	River Mile	Drainage Area	IBI	MIwb[a]	ICI[b]	QHEI	Attainment Status[c]	Causes[d]	Sources[e]
Trib. to East Branch (8.2)			*Undesignated/WWH recommended - EOLP Ecoregion*						
	5.8[H]/--	3.6	20*	NA		43.5	**(NON)**	Organic/nutrient enrichment Habitat alteration	Pasture
	4.0[H]/--	8.7	20*	NA		40.5	**(NON)**	Organic/nutrient enrichment Habitat alteration	Septic systems Pasture
	1.1[H]/1.0	10.7	34*	NA	G	56.0	**NON**	Organic enrichment Habitat alteration	Septic systems Residential
Trib. to East Fork (8.47)			*Undesignated/WWH recommended - ECBP Ecoregion*						
	0.7[H]/0.7	3.5	32*	NA	VP*	53.5	**NON**	Organic/nutrient enrichment	Industrial point source (Green Circle Growers)
Trib. to Vermilion River (12.0)			*Undesignated/WWH recommended - ECBP Ecoregion*						
	--/1.5	3.1			MG[NS]	0.0	(FULL)		
Trib. to Vermilion River (24.35)			*Undesignated/WWH recommended - ECBP Ecoregion*						
	5.5[H]/5.5	8.5	24*	NA	F*	55.5	**NON**	Siltation/organic enrichment	Pasture
	0.2[H]/0.2	13.0	36[NS]	NA	G	71.0	FULL		
Trib. to Vermilion River (8.29)			*Undesignated/WWH recommended - ECBP Ecoregion*						
	--/2.0	5.0			MG[NS]		(FULL)		
	1.0[H]/0.9	5.7	40	NA	G	63.0	FULL		
Vermilion River			*WWH - ECBP Ecoregion*						
	29.2[W]/29.2	178.0	41	8.3	E	80.0	FULL		
	23.9[B]/23.9	192.0	34*	7.9*	F*	48.5	**NON**	Flow alteration	Impoundment
	22.5[W]/22.5	193.0	45	9.4	50.0	79.0	FULL		
Vermilion River			*EWH existing/WWH recommended - ECBP Ecoregion*						
	14.5[W]/14.5	242.0	52	9.2	32[NS]	81.0	PARTIAL/FULL		

Table 14. (Continued)

Stream Name	River Mile	Drainage Area	IBI	MIwb[a]	ICI[b]	QHEI	Attainment Status[c]	Causes[d]	Sources[e]
Vermilion River			*EWH existing/WWH recommended - ECBP Ecoregion*						
	10.7[W]/10.7	251.0	45	8.7	VG	75.5	PARTIAL /FULL		
			EWH existing/WWH recommended - EOLP Ecoregion						
	6.4[W]/6.4	262.0	51	8.8*	VG	71.5	FULL		
			EWH existing/WWH recommended - EOLP Ecoregion with Lacustuary Benchmark						
	1.4[O]/1.1	267.0	32*	8.2*	18*	0.0	**NON**	Siltation/nutrient enrichment	Ag and Development
	--/0.8	267.0			18*	0.0	(NON)	Siltation/nutrient enrichment	Downstream Vermilion WWTP
	--/0.1	268.0			24*	0.0	(NON)	Siltation/nutrient enrichment	Ag and Development

a - MIwb is not applicable to headwater streams with drainage areas ≤ 20 mi^2.

b - A qualitative narrative evaluation based on best professional judgement and sampling attributes such as community composition, EPT taxa richness, and QCTV scores was used when quantitative data were not available or considered unreliable due to current velocities less than 0.3 fps flowing over the artificial substrates.

c - Attainment status is given for both existing and recommended use designations.

d - Causes listed are considered to be a primary influence on water quality, but may not be the only issue leading to impairment. See text for discussion of additional causes that cumulatively have led to impairment.

e - Sources listed are considered to be a primary influence on water quality, but may not be the only source leading to impairment. See text for discussion of additional sources that cumulatively have led to impairment.

H - Headwater site.

W - Wading site.

B - Boat site.

O - Fish Lacustuary site. Scores have been compared to lacustuary scoring method.

L - Macroinvertebrate Lacustuary site. Scores have been compared to lacustuary scoring method.

NS - Nonsignificant departure from biocriteria (≤4 IBI or ICI units, or ≤0.5 MIwb units).

* - Indicates significant departure from applicable biocriteria (>4 IBI or ICI units, or >0.5 MIwb uits). Underlined scores are in the Poor or Very Poor range.

Table 15. Causes and sources of impairment of the Aquatic Life Use and status of the Recreation Use and Fish Consumption Advisory for Vermilion River (upstream East Branch to mouth) Watershed Assessment Unit - **04100012 060**. The information provided includes principal causes and sources of impairment for aquatic life and recreation uses and significant contaminants in sediment and fish tissue.

04100012 060 Vermilion River (upstream East Branch to mouth)		
Aquatic Life Use	**Causes of Impairment**	**Sources of Impairment**
	Habitat alteration	Agricultural activities including channelization and pastures Development activities including channelization and residential developments
	Siltation and organic enrichment	Pastures
	Organic enrichment	Septic systems
	Nutrient enrichment	Non-irrigated crop production
	Siltation	Channelization from agricultural activities
	Siltation and nutrient enrichment	Agriculture activities including pasture, channelization and non-irrigated crop production Development activities including riparian removal, channelization, septic systems and the Vermilion WWTP
	Organic and Nutrient enrichment	Industrial point sources including Green Circle Growers and Village of Kipton and New London WWTP Agricultural activities including pastures and non-irrigated crop production Septic systems
	Flow alteration	Impoundment
Recreation Use[1]	Elevated levels of bacteria indicate a problem with bacteria throughout the watershed.	
Fish Consumption Advisory[2]	**Statewide**: No more than <u>one meal per week</u> of any sport fish due to mercury contamination	**Vermilion River**: No more than <u>one meal per month</u> of Smallmouth Bass due to mercury contamination

1 - See the 2004 Integrated Water Quality Monitoring and Assessment Report for additional information at "www.epa.state.oh.us/dsw/tmdl/2004IntReport/2004OhioIntegratedReport.html." and also the Chemistry section of this report.

2 - See the 2004 Fish Consumption Advisory report for more detailed information at "www.epa.state.oh.us/dsw/fishadvisory/index.html".

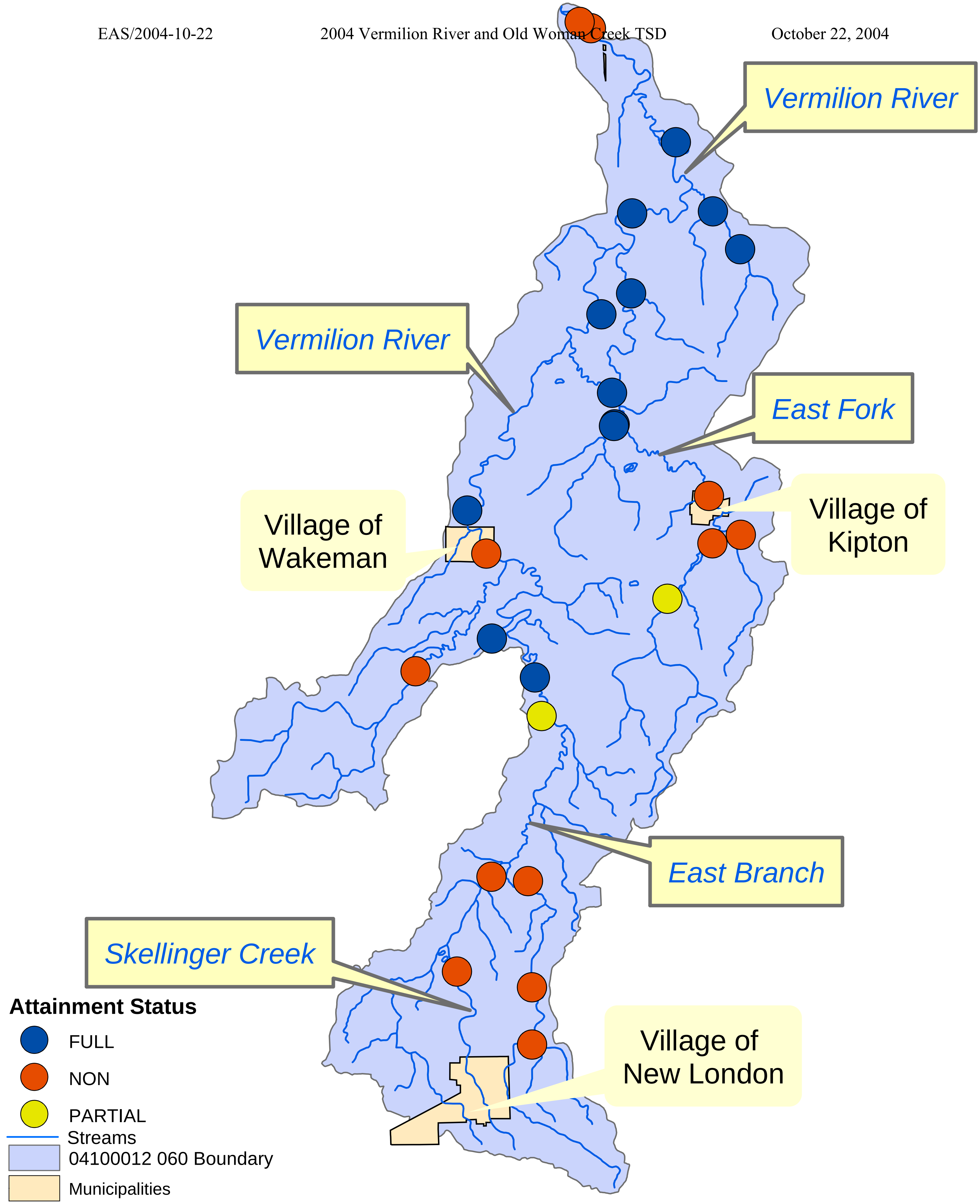

Figure 15. Sampling locations by attainment status within WAU 04100012 060.

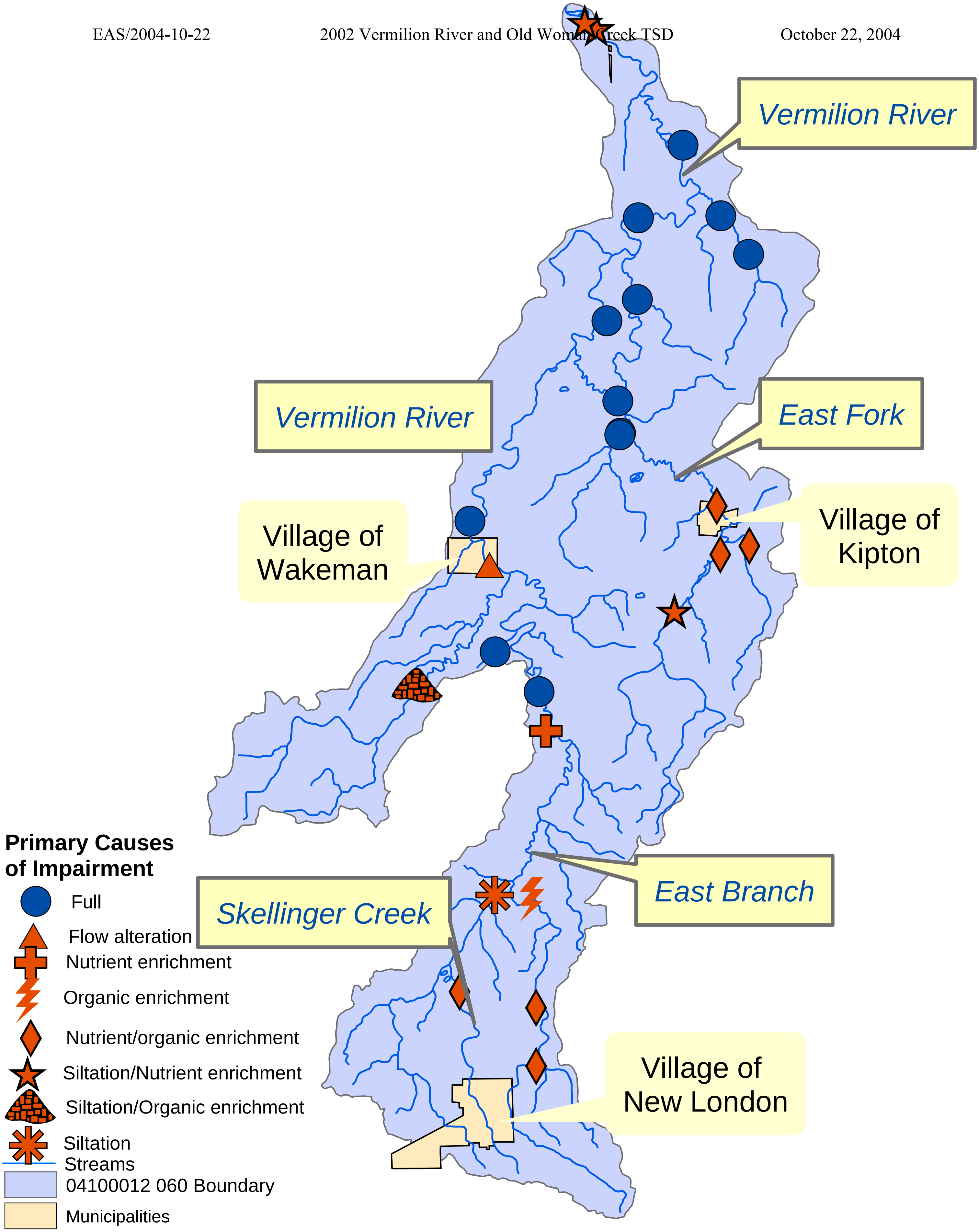

Figure 16. Primary causes of impairment within WAU 04100012 060. Sites in blue are in full attainment and not impaired

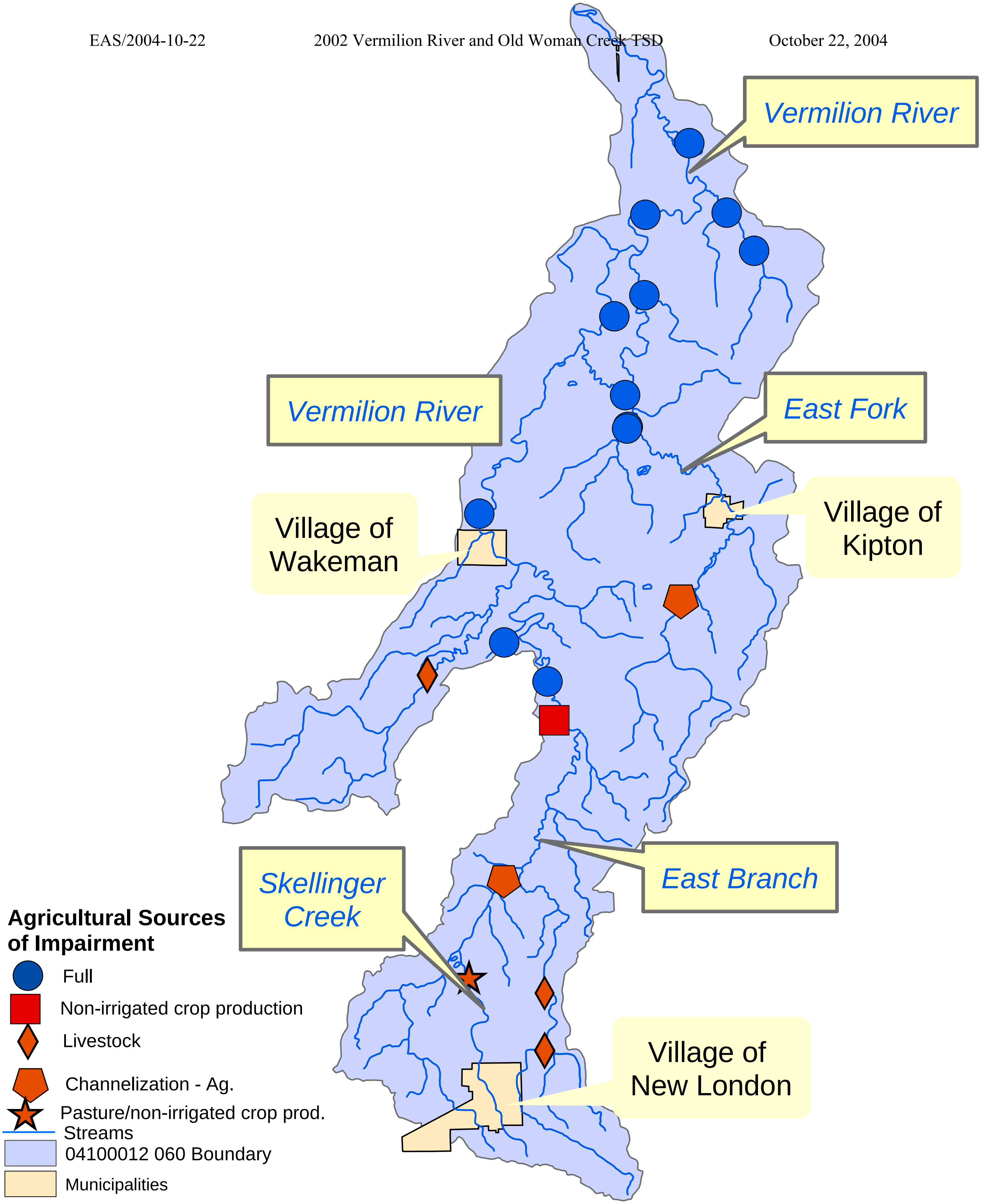

Figure 17. Primary agricultural sources of impairment within WAU 04100012 060. Sites in blue are in full attainment and not impaired

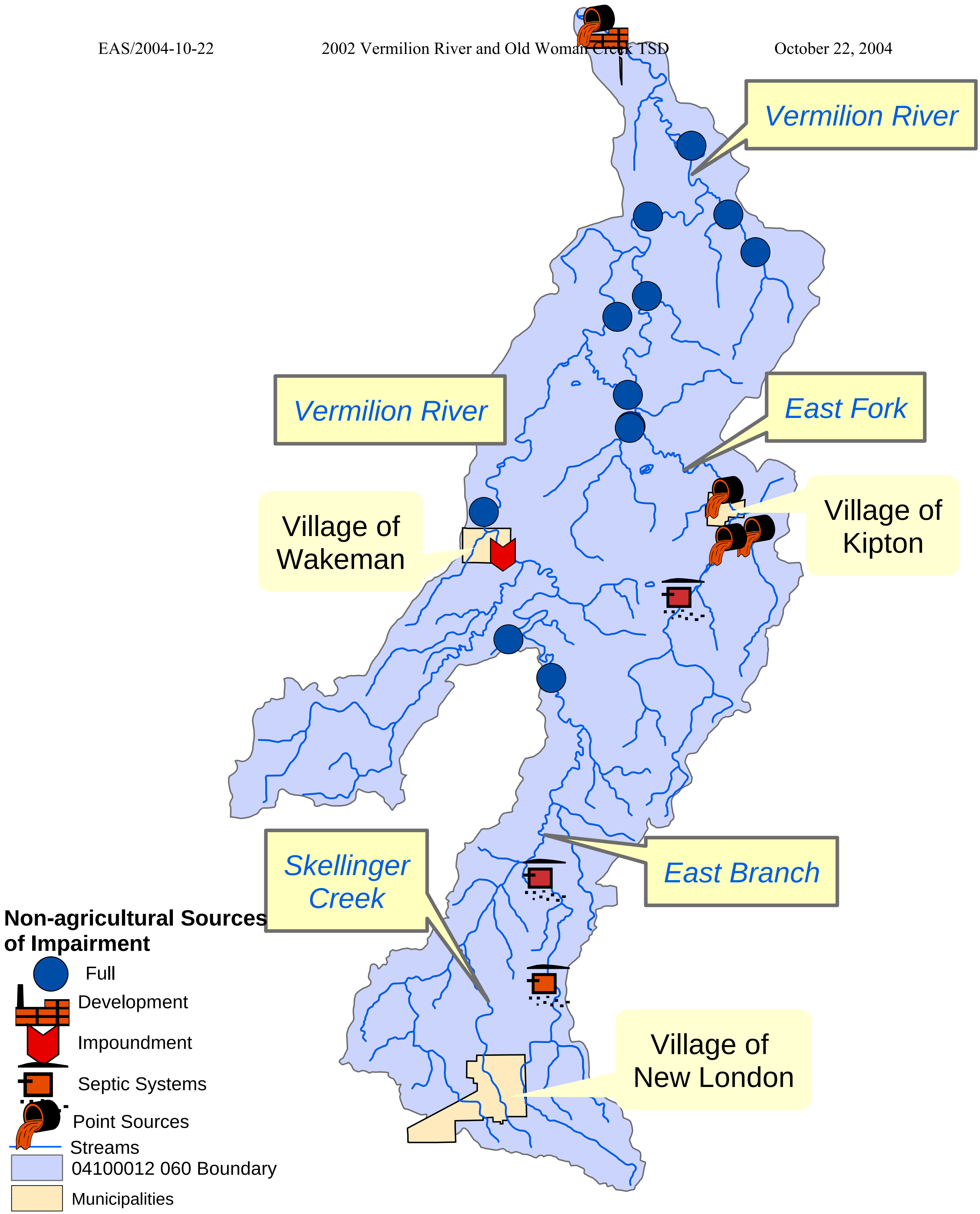

Figure 18. Primary nonagricultural sources of impairment within WAU 04100012 060. Sites in blue are in full attainment and not impaired.

METHODS

All physical, chemical, and biological field, laboratory, data processing, and data analysis methodologies and procedures adhere to those specified in the Manual of Ohio EPA Surveillance Methods and Quality Assurance Practices (Ohio Environmental Protection Agency 1989a) and Biological Criteria for the Protection of Aquatic Life, Volumes I-III (Ohio Environmental Protection Agency 1987a, 1987b, 1989b, 1989c), The Qualitative Habitat Evaluation Index (QHEI): Rationale, Methods, and Application (Rankin 1989, 1995) for aquatic habitat assessment, and the Ohio EPA Sediment Sampling Guide and Methodologies (Ohio EPA 2001). Sampling locations are listed in Table 2.

Determining Use Attainment Status

Use attainment status is a term describing the degree to which environmental indicators are either above or below criteria specified by the Ohio Water Quality Standards (WQS; Ohio Administrative Code 3745-1). Assessing aquatic use attainment status involves a primary reliance on the Ohio EPA biological criteria (OAC 3745-1-07; Table 7-15). These are confined to ambient assessments and apply to rivers and streams outside of mixing zones. Numerical biological criteria are based on multimetric biological indices including the Index of Biotic Integrity (IBI) and modified Index of Well-Being (MIwb), indices measuring the response of the fish community, and the Invertebrate Community Index (ICI), which indicates the response of the macroinvertebrate community. Three attainment status results are possible at each sampling location - Full, partial, or non-attainment. Full attainment means that all of the applicable indices meet the biocriteria. Partial attainment means that one or more of the applicable indices fails to meet the biocriteria. Non-attainment means that none of the applicable indices meet the biocriteria or one of the organism groups reflects poor or very poor performance. An aquatic life use attainment table (Table 1) is constructed based on the sampling results and is arranged from upstream to downstream and includes the sampling locations indicated by river mile, the applicable biological indices, the use attainment status (*i.e.,* full, partial, or non), the Qualitative Habitat Evaluation Index (QHEI), and a sampling location description.

Habitat Assessment

Physical habitat was evaluated using the Qualitative Habitat Evaluation Index (QHEI) developed by the Ohio EPA for streams and rivers in Ohio (Rankin 1989, 1995). Various attributes of the habitat are scored based on the overall importance of each to the maintenance of viable, diverse, and functional aquatic faunas. The type(s) and quality of substrates, amount and quality of instream cover, channel morphology, extent and quality of riparian vegetation, pool, run, and riffle development and quality, and gradient are some of the habitat characteristics used to determine the QHEI score which generally ranges from 20 to less than 100. The QHEI is used to evaluate the characteristics of a stream segment, as opposed to the characteristics of a single sampling site. As such, individual sites may have poorer physical habitat due to a localized disturbance yet still support aquatic communities closely resembling those sampled at adjacent sites with better habitat, provided water quality conditions are similar. QHEI scores from hundreds of segments around the state have indicated that values greater than 60 are *generally* conducive to the existence of warmwater faunas whereas scores less than 45 generally cannot support a warmwater assemblage consistent with the WWH biological criteria. Scores greater than 75 frequently typify habitat conditions which have the ability to support exceptional warmwater faunas.

Sediment and Surface Water Assessment

Fine grain sediment samples were collected in the upper 4 inches of bottom material at each location using decontaminated stainless steel scoops. Decontamination of sediment sampling equipment followed the procedures outlined in the Ohio EPA sediment sampling guidance manual (Ohio EPA 2001). Sediment grab samples were homogenized in stainless steel pans (material for VOC analysis was not homogenized), transferred into glass jars with teflon lined lids, placed on ice (to maintain 4°C) in a cooler, and shipped to an Ohio EPA contract lab. Sediment data is reported on a dry weight basis. Surface water samples were collected, preserved and delivered in appropriate containers to either an Ohio EPA contract lab or the Ohio EPA Division of Environmental Services. Surface water samples were evaluated using comparisons to Ohio Water Quality Standards criteria, reference conditions, or published literature. Sediment evaluations were conducted using guidelines established in MacDonald *et al.* (2000) and Ohio Specific Reference Values (2003).

Macroinvertebrate Community Assessment

Macroinvertebrates were collected from artificial substrates and from the natural habitats. The artificial substrate collection provided quantitative data and consisted of a composite sample of five modified Hester-Dendy multiple-plate samplers colonized for six weeks. At the time of the artificial substrate collection, a qualitative multihabitat composite sample was also collected. This sampling effort consisted of an inventory of all observed macroinvertebrate taxa from the natural habitats at each site with no attempt to quantify populations other than notations on the predominance of specific taxa or taxa groups within major macrohabitat types (e.g., riffle, run, pool, margin). Detailed discussion of macroinvertebrate field and laboratory procedures is contained in Biological Criteria for the Protection of Aquatic Life: Volume III, Standardized Biological Field Sampling and Laboratory Methods for Assessing Fish and Macroinvertebrate Communities (Ohio EPA 1989b).

Fish Community Assessment

Fish were sampled using pulsed DC electrofishing methods. Fish were processed in the field, and included identifying each individual to species, counting, weighing, and recording any external abnormalities. Discussion of the fish community assessment methodology used in this report is contained in Biological Criteria for the Protection of Aquatic Life: Volume III, Standardized Biological Field Sampling and Laboratory Methods for Assessing Fish and Macroinvertebrate Communities (Ohio EPA 1989b).

Causal Associations

Using the results, conclusions, and recommendations of this report requires an understanding of the methodology used to determine the use attainment status and assigning probable causes and sources of impairment. The identification of impairment in rivers and streams is straightforward - the numerical biological criteria are used to judge aquatic life use attainment and impairment (partial and non-attainment). The rationale for using the biological criteria, within a weight of evidence framework, has been extensively discussed elsewhere (Karr *et al.* 1986; Karr 1991; Ohio EPA 1987a,b; Yoder 1989; Miner and Borton 1991; Yoder 1991; Yoder 1995). Describing the causes and sources associated with observed impairments relies on an interpretation of multiple lines of evidence including water chemistry data, sediment data, habitat data, effluent data, land use data, and biological results (Yoder and Rankin 1995). Thus the assignment of principal causes and sources of impairment in this report represent the association of impairments (based on response indicators) with stressor and exposure indicators. The reliability of the identification of probable causes and sources is increased where many such prior associations have been identified, or have been experimentally or statistically linked together. The ultimate measure of success in water resource management is the restoration of lost or damaged ecosystem attributes including aquatic community structure and function. While there have been criticisms of misapplying the metaphor of ecosystem "health" compared to human patient "health" (Suter 1993), in this document we are referring to the process for evaluating biological integrity and causes or sources associated with observed impairments, not whether human health and ecosystem health are analogous concepts.

RESULTS

Chemical Water Quality

Chemical and physical water quality was assessed at 77 locations throughout the Vermilion River basin, Old Woman Creek basin and several small Lake Erie tributaries. Surface water grab samples were analyzed for organic, inorganic metals and nutrients. Dissolved oxygen levels, pH and temperatures were recorded in the field at each sampling location. At the majority of sites, six sampling runs were conducted on a two-week interval. Organic samples were only collected twice at selected sites. Fecal coliform bacterial samples were collected three times at most sites during the survey. Sample results are presented in Appendix A.

Vermilion River

Water quality samples were collected at 17 locations from the Vermilion River mainstem. Three of the sites were located within the lacustuary (flooded Lake Erie river mouth) zone. The remaining sites were located in free flowing segments. Sample results that exceeded the Ohio Water Quality Standards (WQS) numerical criteria are tabulated in Table 16. Strontium levels exceeded the Tier II, OMZA criteria at numerous sampling sites. The source of strontium was likely a result of natural background conditions.

Results of samples collected downstream of Bailey Lake at RMs 63.85 and 62.88, revealed numerous exceedances of the WQS criteria. Water quality in this stream segment appears to be impaired by nutrient enrichment and elevated bacteria levels. Results for phosphorus and fecal coliform bacteria are presented in Figures 20 & 21. Bailey Lake WWTP discharges to this segment of the Vermilion

River and may be contributing to the impairment along with nutrient inputs from agricultural practices. At State Route 60/US250 (RM 63.85) iron exceeded the state wide criteron for the protection of agricultural uses on three occasions while aluminum exceeded the Tier II nondrinking value for protection of human health on one occasion. The source of elevated metal concentrations may be associated with the Bailey Lake WWTP. However, both metals naturally occur in the earth crust and are routinely present in stream samples.

The recreation use criterion for fecal coliform bacteria was exceeded on two occasions. Dissolved oxygen levels were below the WWH criterion for protection of aquatic life and may have been influenced by drought conditions. Results from samples collected further downstream at Clear Creek Road (RM 62.88), revealed exceedances of the fecal coliform recreation use criterion in two samples and elevated levels of phosphorus in one sample.

Water quality significantly improved from Noble Road (RM 62.10) downstream to US Route 250 (RM 45.77) . At Noble Road the only documented WQS criteria exceedance was low dissolved oxygen during one sampling event, which was likely a natural occurrence caused by drought conditions. Approximately five miles downstream, at US Route 250 (RM 50.63), no WQS criteria exceedances were documented. However, further downstream at Fayette Road (RM 44.19), phosphorus was elevated above one mg/l and fecal coliform bacteria were elevated as can be seen in Figures 19 & 20. Failed septic systems in the unsewered community of Fitchville and agricultural practices in the area are likely having a negative water quality impact.

From RM 33.50 at Zenobia Road to the Wakeman Dam at RM 23.69, the only water quality issue was elevated fecal coliform bacteria levels. Samples collected on July 23, 2002 exceeded the recreation use criterion at three locations. The most probable source of bacteria in this stream segment was discharges from failed septic systems in the Villages of Clarkfield and West Clarksfield. No significant water quality concerns were documented from downstream of the Wakeman Dam (RM 23.69) to Mill Hollow at North Ridge Road (RM 6.32). The only exception, alpha-BHC, was detected slightly above the Tier I criterion for the protection of human health at Gore-Orphanage Road (RM 10.70). This persistent compound is an isomer of lindane, which was widely used as an insecticide and is no longer manufactured in the United States. However, lindane is still imported into this country for use as an ingredient in shampoo for lice treatment and as seed treatment for grain crops.

Results from samples collected from the lacustuary zone of the Vermilion River indicated several exceedances of the WQS criteria. At RM 1.81, located upstream of the Vermilion WWTP outfall, dissolved oxygen levels were below the minimum average on one occasion, copper exceeded the OMZA criterion for protection of aquatic life in one sample and dieldrin was detected above the Tier I value for the protection of human health. Samples collected downstream of the Vermilion WWTP indicated extremely elevated nitrite+nitrate levels, well above the recommended target value for WWH streams as shown in Figure 22 . In addition, hexachlorobenzene exceeded its Tier I human health criterion. Hexachlorobenzene was used as a fungicide on grain crops until it was discontinued in 1965. It can be formed as a by-product of burning municipal waste and in the wood preservation process. At RM 0.1, just upstream of the confluence with Lake Erie, zinc exceeded the maximum criterion for the protection of aquatic life during one sampling event.

Vermilion River Tributaries

Six small, unnamed tributaries to the Vermilion River mainstem were sampled during 2002. Most locations on these tributaries were only sampled twice during the survey due to low flows caused by drought conditions. Sample results that exceeded the WQS numerical criteria are listed in Table 16.

East Fork Vermilion River

Surface water grab samples were collected at four sites to evaluate water quality condition of the East Fork Vermilion River. Two small tributaries to the East Fork were also sampled. Sample results that exceeded the WQS numerical criteria are listed in Table 16. East Fork sample results indicated that water quality was degraded, as nutrient enrichment, elevated fecal coliform bacteria and high copper levels were documented. A combination of agricultural and non-agricultural sources were identified and are discussed below. Strontium levels exceeded the Tier II, OMZA criterion at numerous sampling sites. The source of strontium was likely a result of natural background conditions.

At State Route 303 (RM 10.87), a dissolved oxygen measurement was below the WWH minimum criterion during a single event, which may have been influenced by drought conditions. Fecal coliform bacteria levels exceeded the PCR use criterion (10,000 #/100 ml) and was likely caused by failed septic systems and possibly animal waste from livestock. Downstream at State Route 511 (RM 9.04) water quality was severely degraded. Sample results for fecal coliform bacteria, ammonia, and copper exceeded WQS criteria, phosphorus exceeded the benchmark value, and nitrate+nitrite levels were elevated well above the target value. Unpermitted discharges from Green Circle Growers, a large scale green house facility, was most likely the cause of impairment. As can be seen in Figure 24, copper levels peaked at RM 9.04 and improved downstream at RM 7.41. Nutrient and fecal coliform bacteria levels continued to increase, likely influenced by failed onsite septic systems in the Village of Kipton (Figure 25).

Green Road (RM 2.3) was the only location on the East Fork where organic samples were collected. Dieldrin and alpha-BHC results exceeded Tier I criteria for the protection of aquatic life and human health. Dieldrin is a break down product of the pesticide aldrin. Manufacturing of aldrin was halted in 1974. Alpha-BHC is a persistent isomer once used in insecticides and no longer manufactured in the United States. The remainder of sample results indicated significant water quality recovery as presented in Figures 23-25.

Results of samples collected at Baird Road (RM 0.48), from a small headwater stream to the East Fork, indicated a violation of the minimum dissolved oxygen criterion for protection of the WWH aquatic life use. This was most likely caused by low flow due to drought conditions. Results of samples collected from another headwater stream at U.S. Route 20 (RM 0.70), indicated elevated phosphorus levels and during one sampling event exceeding the benchmark for protection of aesthetic conditions of one milligram per liter. Dissolved oxygen levels were consistently low. This tributary may be experiencing an impact from the Green Circle Growers facility.

Frankenburg Creek, a small tributary to the East Fork at RM 3.24, exhibited good water quality, though fecal coliform bacteria and nitrate+nitrite were slightly elevated in several samples.

East Branch Vermilion River

Four locations were sampled on the East Branch Vermilion River mainstem, three sites were sampled on the tributary to the East Branch at RM 8.20 and one site was sampled on Skellinger Creek. Townline Road (RM 1.05) and Zenobia Road (RM 3.60) were the only sites selected for analysis of organic parameters. Sample results that exceeded the WQS numerical criteria are listed in Table 16. Strontium exceeded the Tier II, OMZA criterion at numerous sampling sites. The source of strontium is likely a result of natural background conditions.

The main cause of water quality impairment appeared to be nutrient enrichment and elevated fecal coliform bacteria levels. As presented in Figures 26 - 28, nutrient and bacteria levels peaked downstream of Skellinger Creek at Vesta Road (RM 8.31). Upstream of the confluence of Skellinger Creek at Fayette Road (RM 12.67), no WQS criteria were exceeded. The most probable source of the elevated nutrient and bacteria levels was the New London WWTP, which discharges to Skellinger Creek at RM 3.2. Results of samples collected from Skellinger Creek, downstream of the New London WWTP outfall at Fayette Road (RM 0.95), revealed severely elevated nitrate+nitrite, total phosphorus and fecal coliform bacteria levels. Downstream of the confluence of Skellinger Creek and the East Branch at Vesta Road (RM 8.30), bacteria results exceeded the PCR maximum criterion. This condition persisted at Zenobia Road (RM 3.60). Further downstream at Townline Road (RM 1.02), fecal coliform bacteria levels were slightly above the PCR maximum criterion; however, water quality was greatly improved compared to the upstream sites. The pesticide isomer, a-BHC, exceeded its Tier I criterion for the protection of aquatic life and human health at RM 3.60. Pesticide compounds dieldrin, a-BHC, and y-BHC exceeded Tier I criteria for the protection of aquatic life and human health at RM 1.02.

The East Branch tributary at RM 8.20 consistently maintained a low dissolved oxygen level, in part, due to low flow caused by drought conditions. At Fayette Road (RM 4.03), ammonia-N levels were elevated and exceeded the maximum criterion for the protection of WWH aquatic life during one sampling event. On another occasion, fecal coliform bacteria levels exceeded the maximum PCR criterion, indicating impacts caused by failed septic systems and/or livestock animal waste.

Indian Creek

Two locations were sampled on Indian Creek, near the confluence with the Vermilion River at Fitchville River Road (RM 0.36) and upstream at Hartland Center Road (RM 3.45). Strontium levels exceeded the Tier II, OMZA criterion in numerous samples collected at RM 3.45. The source of strontium is likely a result of natural background conditions. Low dissolved oxygen levels were recorded on several occasions at RM 0.36, most likely caused by low flow due to drought conditions. Sample results that exceeded the WQS numerical criteria are listed in Table 16.

Southwest Branch Vermilion River

Five locations were sampled on the Southwest Branch of the Vermilion River and one location on each of two unnamed tributaries. The upper most headwater site on the Southwest Branch at Baseline Road (RM 10.89), was only sampled on two occasions and the next site downstream at RM 5.60 was only sampled on three occasions, due to drought conditions. Fecal coliform bacteria samples were not collected at these sites. Sample results that exceeded the WQS numerical criteria are listed in Table 16. Strontium levels exceeded the Tier II, OMZA criterion at numerous sampling sites. The source of strontium is likely a result of natural background conditions.

Primary causes of water quality impairment appeared to be nutrient enrichment and elevated fecal coliform bacteria levels. Sources of impairments were a combination of agricultural practices, a municipal point source from the Village of Greenwich and failed onsite septic systems.

Samples at Base Line Road (RM 10.89) reflected good water quality. Further downstream at Greenwich-Milan Road (RM 5.60), dissolved oxygen levels were low due to low flow caused by drought conditions. Directly upstream of Greenwich-Angling Road was pasture land, where livestock had access to the stream and stream banks showed signs of erosion. At this sampling station, fecal coliform bacteria and nutrient levels were elevated as depicted in Figures 29 and 30. Dissolved oxygen levels were below the minimum WWH criterion for the protection of WWH aquatic life on two occasions, partially caused by low flow. At Omega Road (RM 2.53) water quality began to improve; however, fecal coliform bacteria levels were still evaluated. At State Route 13 (RM 0.94), cows were observed in the stream on several occasions and bacteria levels were severely elevated and total phosphorus levels were high.

Results of samples collected from the tributary to Southwest Branch (RM 5.35) at Greenwich-Milan Road (RM 0.60) revealed no WQS criteria exceedances. However, nitrate+nitrite levels were significantly elevated above the ecoregional target value. This site was only sampled on two occasions because of drought conditions. The Southwest Branch tributary (RM 2.30) was sampled at Rome Greenwich Road (RM 0.57). Sample results revealed elevated nitrate+nitrite and fecal coliform bacteria levels.

Buck Creek

Four locations were sampled on Buck Creek and one site on a tributary of Buck Creek at RM 4.92. Three upper headwater sites on Buck Creek were only sampled on two occasions due to drought conditions. Bacteria samples were not collected at these three sites. Sample results that exceeded the WQS numerical criteria are listed in Table 16. Strontium levels exceeded the Tier II, OMZA criterion at numerous sampling sites. The source of strontium was likely a result of natural background conditions.

The main water quality concern within the Buck Creek watershed appeared to be nutrient enrichment and elevated fecal coliform bacteria levels. At State Route 511 (RM 8.23) livestock had direct access to the stream. Sample results for total dissolved solids and conductivity exceeded the criteria for the protection of WWH aquatic life and nutrient levels were elevated (see Figures 31 and 32).

At Township Road 1181 (RM 7.05) dissolved oxygen levels were low during one sampling event, probably due to drought conditions. At County Road 1181 water quality conditions improved as no WQS exceedances were documented, though nitrate+nitrite levels were slightly elevated. Further downstream at Township Road 1281 (RM 3.21) and Township Road 1461 (RM 1.06) fecal coliform bacteria levels were elevated. The pesticide compound dieldrin exceeded the Tier I value for protection of aquatic life and human health at RM 1.06. The Buck Creek tributary at RM 4.92 was sampled just upstream of the confluence and exhibited good water quality.

Clear Creek

Two locations were sampled on Clear Creek. Sample results that exceeded the WQS numerical criteria are listed in Table 16. Livestock had access to the stream at both sampling locations. At Townline Road (RM 3.99) water quality was severely degraded and a septic discharge was noted from a failed system. Fecal coliform bacteria concentrations exceeded the maximum PCR criterion on three occasions. Ammonia levels were extremely elevated exceeding the maximum WQS criterion for protection of WWH aquatic life during two events with an exceedance of the average criterion on another. Result of samples collected at Clear Creek Road (RM 1.83), indicated slight improvement; however, dissolved oxygen levels were low and ammonia levels exceeded the average criterion in one sample. Nuisance algae mats were observed indicating nutrient enrichment.

Chappel Creek

Five sites were sampled on Chappel Creek. Sample results that exceeded the WQS numerical criteria are listed in Table 16. Livestock had access to the stream at three sampling stations. The stream was intermittent and dissolved oxygen levels were low at times during the survey period, due to drought conditions. Nutrient levels were slightly elevated from Wakeman Townline Road (RM 17.0) downstream to Main Road at RM 9.02 (see Figure 33). Fecal coliform bacteria levels were elevated at Thorpe Road (RM 7.33) and Poorman Road (RM 1.30), most likely the result of discharges from failed septic systems (Figure 34). The persistent organic pesticide a-BHC was detected above the Tier

I value for the protection of aquatic life and human health.

Cranberry Creek

Cranberry Creek was sampled in the lacustuary zone at U.S. Route 6. During the six sampling events, stream flow was lakeward and not impacted by seiche effect. Sample results indicated good water quality. Dissolved oxygen levels were low during several events, mostly likely caused by low flow due to drought conditions.

Sugar Creek

Water quality samples were collected at Darrow Road (RM 3.54) and downstream at Barnes Road (RM 0.57). Only four sampling events were conducted at RM 3.54 and three at RM 0.57, because of low flow due to drought conditions. No water quality issues were documented.

Darby Creek

Water quality samples were collected at Risden Road (RM 0.9). Due to drought conditions, only two sampling events were conducted. No water quality issues were documented.

Old Woman Creek

Water quality samples were collected at eight sites on Old Woman Creek, at two sites on the unnamed tributary at RM 3.70 and one site on the unnamed tributary at RM 8.78. Sample collection was spread over a two-year period (2001-2002) due to drought conditions. Sample results indicated fair water quality. The main concern regarding water quality was nutrient enrichment (Figure 35) and elevated inorganic metals. Sample results that exceeded the WQS numerical criteria are listed in Table 16.

During the survey, low dissolved oxygen levels were documented on several occasions at various sites, which was most likely due to low flow caused by drought conditions. At Nash Road (RM 11.33), aluminum exceeded the Tier II criterion and iron exceeded the criterion for the protection of the Agricultural Water Supply use. The source of the elevated aluminum levels is unknown. No other water quality exceedances were documented downstream of Nash Road; however, at Mason Road (RM 5.22), aluminum, iron, copper, and lead all exceeded the WQS criteria. These exceedances all occurred on May 6, 2002, when at that time it was noted that the stream was extremely turbid due to soil loading. Upon investigation, it was determined that road bank stabilization was being conducted just upstream, adjacent to Berlin Road. A large track hoe was stationed on the stream bank and dump truck loads of fill dirt were being dumped down the ravine to the creek bank. A large amount of soil was entering the stream, which was the most likely source of the elevated metals in the samples collected downstream. Downstream at Darrow Road (RM 1.84), copper exceeded the criterion for the protection of WWH aquatic life in a single sample collected on October 16, 2001, which indicates there may be a persistent source of copper, possibly from the use of contaminated fill dirt for stream bank stabilization projects. Samples collected in the lacustuary zone at U.S. Route 6 (RM 0.14) documented low dissolved oxygen levels and elevated iron concentrations.

Old Woman Creek Tributary (RM 8.78)

Samples were collected at State Route 113 (RM 1.04). No WQS criteria exceedances were documented.

Old Woman Creek Tributary (RM 3.70)

Samples were collected at State Route 113 (RM 3.70) and Chapin Road (RM 0.69). Low dissolved oxygen levels were documented at both locations, mostly likely caused by low flow due to drought conditions. Sample results indicated that fecal coliform bacteria levels were elevated at State Route 113 (RM 3.70), which likely was caused by failed septic systems in the Village of Berlinville.

Table 16. Exceedances of Ohio Water Quality Standards (Ohio Administrative Code 3745-1) documented within the Vermilion River Basin study area during 2002. Units for metals are presented in μg/l, fecal coliform bacteria are #/100 ml and all other parameters are in mg/l. Use designations within the Vermilion River Basin include: Aquatic life - Warmwater Habitat (WWH); Exceptional Warmwater Habitat (EWH), Seasonal Salmonid Habitat (SSH), State Resource Water (SRW) Water Supply - Public Water Supply (PWS); Agricultural Water Supply (AWS); Industrial Water Supply (IWS), Recreation - Primary Contact (PCR); Secondary Contact (SCR).

Stream (use designation)	
RM	**Parameter (value)**
Vermilion River (WWH, AWS, IWS, PCR)	
63.85	D.O. (3.9[a]); Fecal Coliform (2100[b], 6800[b]); Aluminum (4560[c]); Iron (5500[g], 7720[g], 7780[g])
62.88	Fecal Coliform (4000[b], 1400[bb]); Phosphorus (2.85[d])
62.10	D.O. (3.9[a])
56.20	Strontium (1500[e], 2850[e], 1900[e], 3710[e], 1210[e])
50.63	None
45.77	Strontium (816[e],908[e])
44.19	Strontium (1020[e],1090[e]), Phosphorus (1.13[d])
33.50	Fecal Coliform (1800[bb])
29.22	Fecal Coliform (2400[b])
23.69	Fecal Coliform (2200[b])
22.62	None
	(EWH, SSH, AWS, IWS, PCR)
14.25	None
10.70	a-BHC (0.0056[h])
	(SRW, EWH, SSH, AWS, IWS, PCR)
6.32	None
	(WWH, AWS, IWS, PCR)
1.81	D.O. (4.1[aa]);Copper (44[f]); Dieldrin (0.0029[h])
0.85	Hexachlorobenzene (0.0035[h])
0.01	Zinc (289[f])
Vermilion River Tributary (63.52) (WWH)	
0.30	None
Vermilion River Tributary (54.62) (WWH)	
0.48	None

Table 16 (continued)

RM	Parameter (value)
Stream (use designation)	
Vermilion River Tributary (32.98) (WWH)	
0.92	None
Vermilion River Tributary (24.35) (WWH)	
4.01	Copper (62[f])
0.20	Fecal Coliform (>10000[b])
Vermilion River Tributary (12.10) (WWH)	
1.99	Fecal Coliform (>10000[b])
Vermilion River Tributary (8.29) (WWH)	
3.10	D.O. (4.4[aa], 3.9[aa], 3.6[a], 3.3[a]); Fecal Coliform (2400[b])
1.93	Fecal Coliform (2200[b])
East Fork Vermilion River (WWH, AWS, IWS, PCR)	
10.87	D.O. (3.1[a]); Fecal Coliform (>10000[b]); Strontium (1160[e], 1260[e], 1220[e], 1410[e], 1430[e], 819[e])
9.04	Fecal Coliform (5200[b]); Ammonia (2.20[aa]); Phosphorus (1.12[d], 4.21J[d]), Copper (49[aa], 53[aa],51[aa], 91[f]); Strontium (954[e], 1430[e], 1360[e])
7.41	D.O. (2.9[a]); Fecal Coliform (2800[b], 9800[b]); Phosphorus (3.80[d], 1.88J[d], 2.15[d]); Copper (38[aa], 37[aa], 52[f])
2.23	a-BHC (0.0067[h]); Dieldrin (0.0027[h]);
East Fork Vermilion River Tributary (12.64)	
0.48	D.O. (3.9[a], 0.5[a], 2.6[a])
East Fork Vermilion River Tributary (8.47)	
0.70	D.O. (2.3[a], 2.3[a], 3.2[a]), Phosphorus (1.48J[d]); Strontium (963[e], 1080[e], 814[e], 1240[e])
East Branch Vermilion River (WWH, AWS, IWS, PCR)	
12.67	None
8.31	Fecal Coliform (9200[b], 3400[b], 10000[b])**,** Strontium (1180[e], 1310[e], 1090[e], 989[e])
3.60	Fecal Coliform (9400[b], 2000[b]), Strontium (812[e], 930[e], 1040[e], 865[e]); a-BHC (0.0061[h])
1.02	Fecal Coliform (2200[b]), Strontium (886[e], 950[e], 1070[e], 943[e])a-BHC (0.0060[h]); y-BHC (0.0061[h]); Dieldrin (0.0026[h])
Skellinger Creek (WWH, AWS, IWS, SCR)	
0.95	Fecal Coliform (10000[b]), Phosphorous (1.34[d], 1.82[d], 1.72[d], 2.33[d], 2.93[d], 1.44[d])
East Branch Vermilion River Tributary (8.20)	
5.80	D.O. (2.3[a,] 3.7[aa]),
4.03	D.O. (3.4[a],2.4[a],2.9[a],3.4[a]), Fecal Coliform (2400[b]), Ammonia (2.38[f])

Table 16 (continued)

RM	Parameter (value)
Stream (use designation)	
East Branch Vermilion River Tributary (8.20) (continued)	
1.05	D.O. (2.0[a], 1.9[a], 2.3[a])
Indian Creek	
3.45	Strontium (913[e], 928[e], 3440[e], 3540[e])
0.36	D.O. (3.6[a], 3.1[a])
Southwest Branch Vermilion River (WWH, AWS, IWS, PCR)	
10.89	Strontium (1690[e])
5.60	D.O. (3.9[a], 3.8[a])
3.81	Fecal Coliform (1500[bb],1500[bb]) D.O. (3.8[a], 3.7[a])
2.53	Fecal Coliform(1400[bb])
0.94	Fecal Coliform (4400[b], >10000[b]); Strontium (972[e],1030[e], 997[e],918[e]); a-BHC (0.0067[h]); Dieldrin (0.0028[h])
Southwest Branch Vermilion River Tributary (5.35)	
0.60	None
Southwest Branch Vermilion River Tributary (2.30)	
0.57	Fecal Coliform (1100[aa]); Strontium (2140[e], 3480[e], 3620[e], 3280[e], 914[e])
Buck Creek (WWH, AWS, IWS, PCR)	
8.23	D.O. (4.8[aa]); Strontium (3290[e]); Total Dissolved Solid (2300[f]); Conductivity (2880[f])
7.05	D.O. (3.4[a])
4.93	None
3.21	Fecal Coliform (1200[bb],1200[bb])
1.06	Fecal Coliform (1200[bb]); Strontium (1070[e]); Dieldrin (0.0018[h])
Buck Creek Tributary (4.92)	
0.09	Strontium (995[e])
Clear Creek (WWH, AWS, IWS, PCR)	
3.99	D.O. (4.6[aa]); Fecal Coliform (2900[b],4200[b],3600[b]); Ammonia (4.56[f],14.8[f], 0.899[aa])
1.83	D.O. (3.4[a], 4.6[aa], 4.2[aa]); Ammonia (5.41[aa])
Chappel Creek (WWH, AWS, IWS, PCR)	
16.20	D.O. (4.2[aa])
14.07	D.O. (3.4[a], 3.7[a])
9.02	D.O. (4.0[aa],4.1[aa,] 4.5[aa])

Table 16 (continued)

Stream (use designation) RM	Parameter (value)
Chappel Creek (WWH, AWS, IWS, PCR)	
7.33	D.O. (4.7[aa],4.9[aa]); Fecal Coliform (1000[bb])
1.30	Fecal Coliform (2000[b]); a-BHC (0.0055[h])
Cranberry Creek (WWH, AWS, IWS, PCR)	
0.10	D.O. (4.2[aa], 4.7[aa])
Sugar Creek (WWH, AWS, IWS, PCR)	
3.54	None
0.57	None
Darby Creek (WWH, AWS, IWS, PCR)	
1.99	None
Old Woman Creek (WWH, AWS, IWS, PCR)	
11.33	D.O. (4.6[aa]), Aluminum (5770[c]), Iron (6410[g])
9.37	None
8.33	D.O. (4.0[aa], 3.9[a])
6.10	None
6.07	None
5.22	Aluminum (24800[c]), Iron (44600[g]), Copper (47[f]), Lead (36.8[f])
1.84	Copper (58[f])
0.14	D.O. (3.3[a],3.9[a]), Iron (6350[g], 5860[g])
Old Woman Creek Tributary (8.78)	
1.04	None
0.01	None
Old Woman Creek Tributary (3.70)	
5.02	D.O. (2.9[a]); Fecal Coliform (1800[bb])
0.69	D.O. (3.9[a])

a - Exceeds criteria for protection of aquatic life, outside mixing zone minimum.
aa - Exceeds criteria for protection of aquatic life, outside mixing zone average.
b - Exceeds maximum criteria for protection of recreation use.
bb - Exceeds geometric mean criteria for protection of recreation use.
c - Exceeds Tier II value for protection of human health/nondrink.
d - Exceeds criteria for the protection against adverse aesthetic conditions.
e - Exceeds Tier II value for protection of aquatic life, outside mixing zone average.
f - Exceeds criteria for protection of aquatic life, outside mixing zone maximum.
g - Exceeds criteria for protection of agricultural uses
h - Exceeds Tier I values for protection of aquatic life and human health.

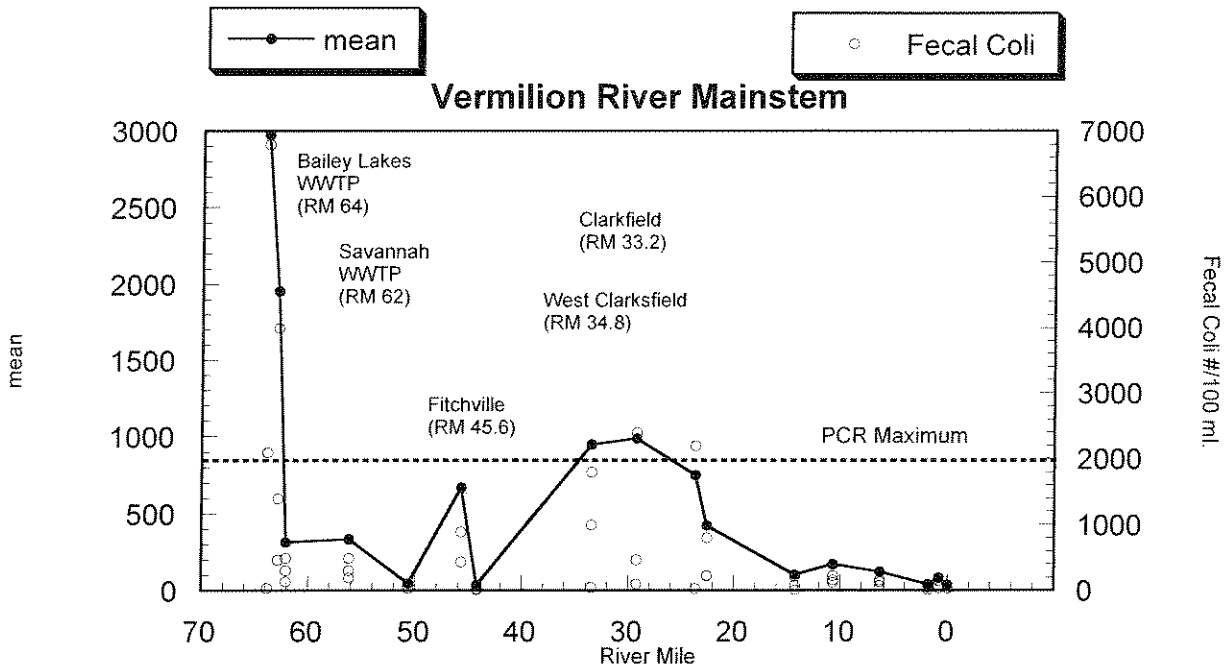

Figure 20. Fecal coliform bacteria values from the Vermilion River mainstem. June - October, 2002.

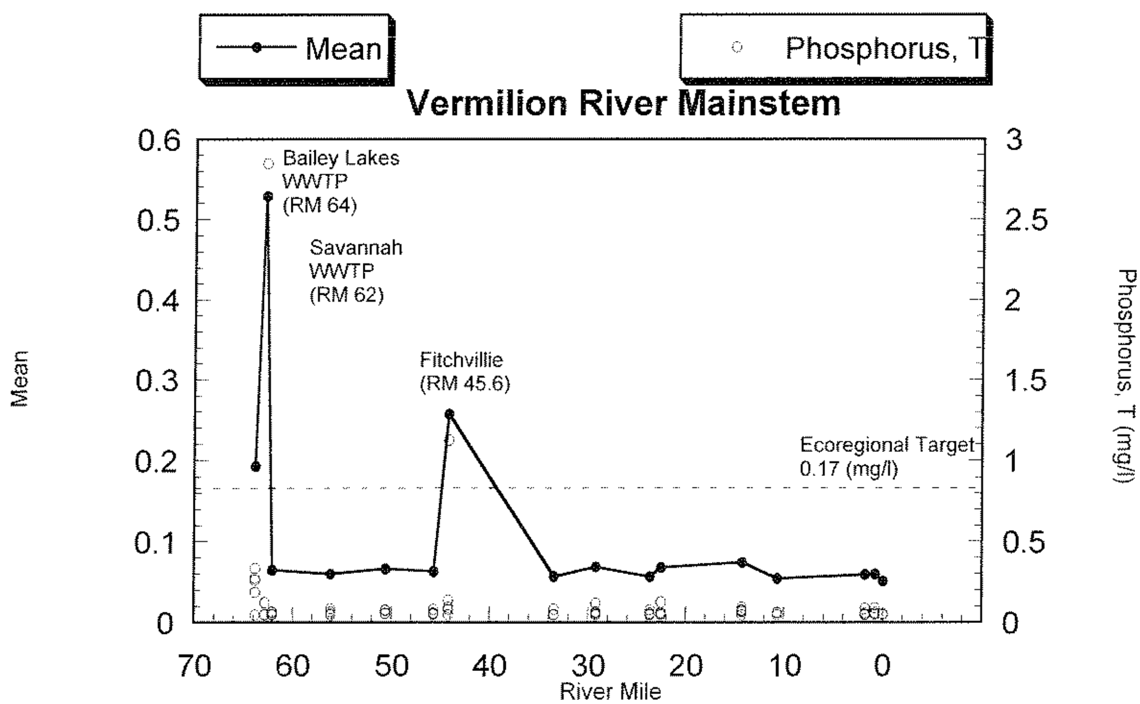

Figure 21. Total Phosphorus values from the Vermilion River mainstem. June - October, 2002.

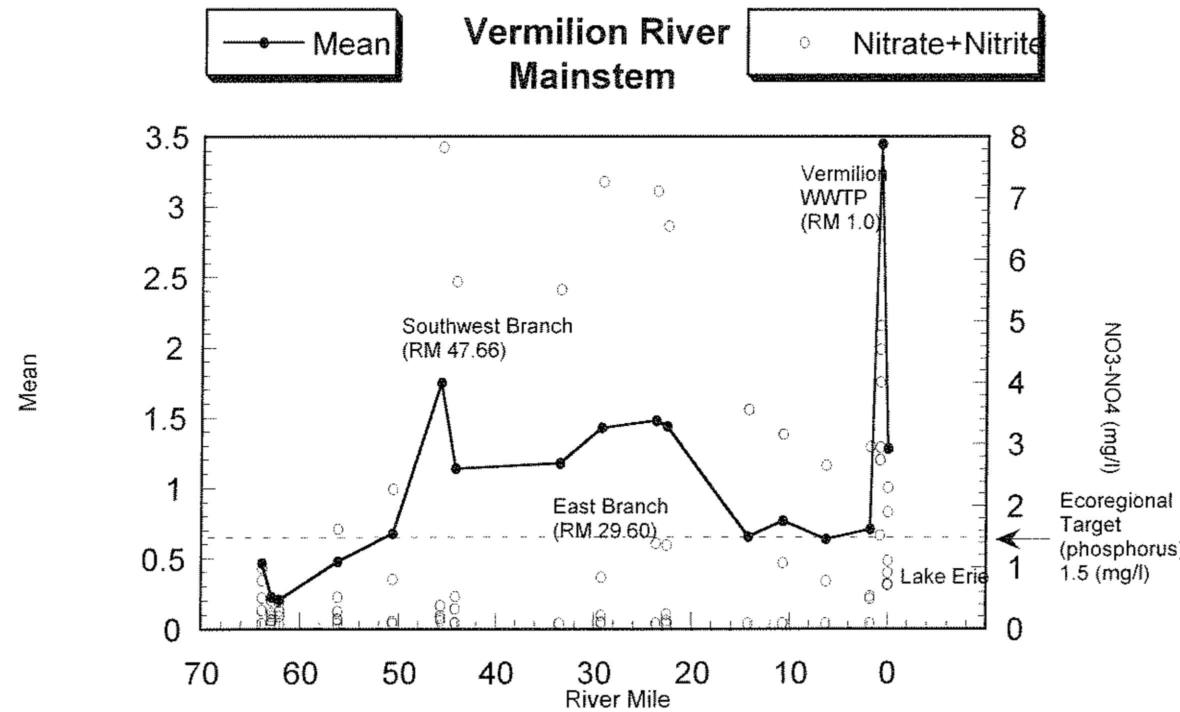

Figure 22. Nitrate+Nitrite values from the Vermilion River mainstem. June - October, 2002.

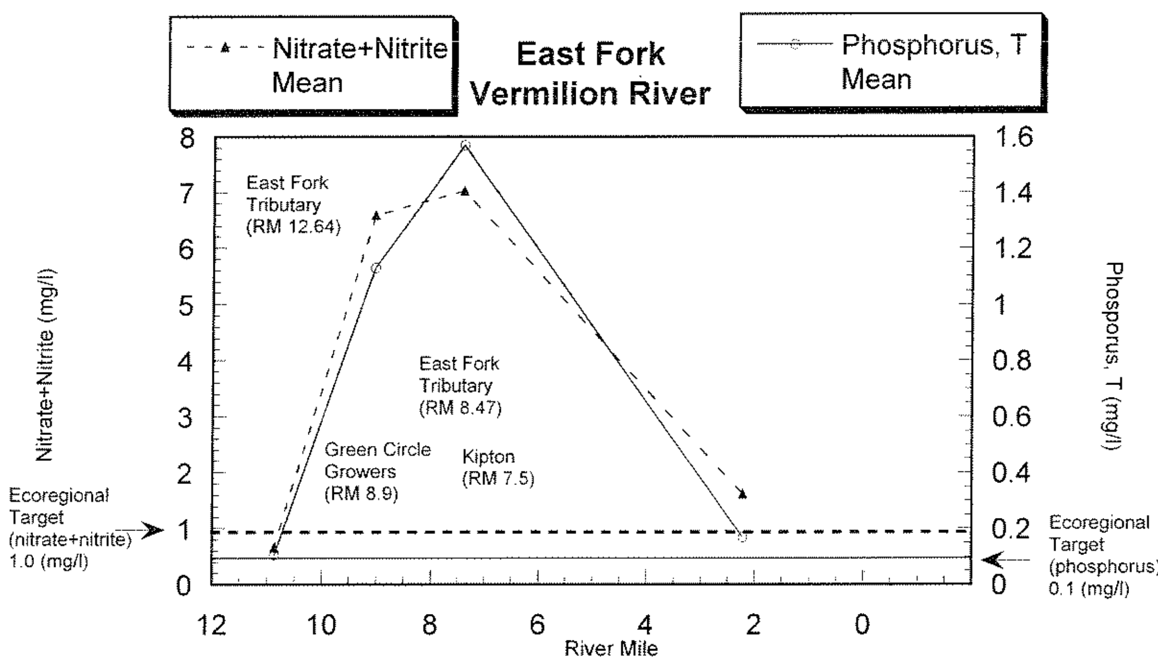

Figure 23. Nitrate+Nitrite & Total Phosphorus values from East Fork Vermilion River. June - October, 2002.

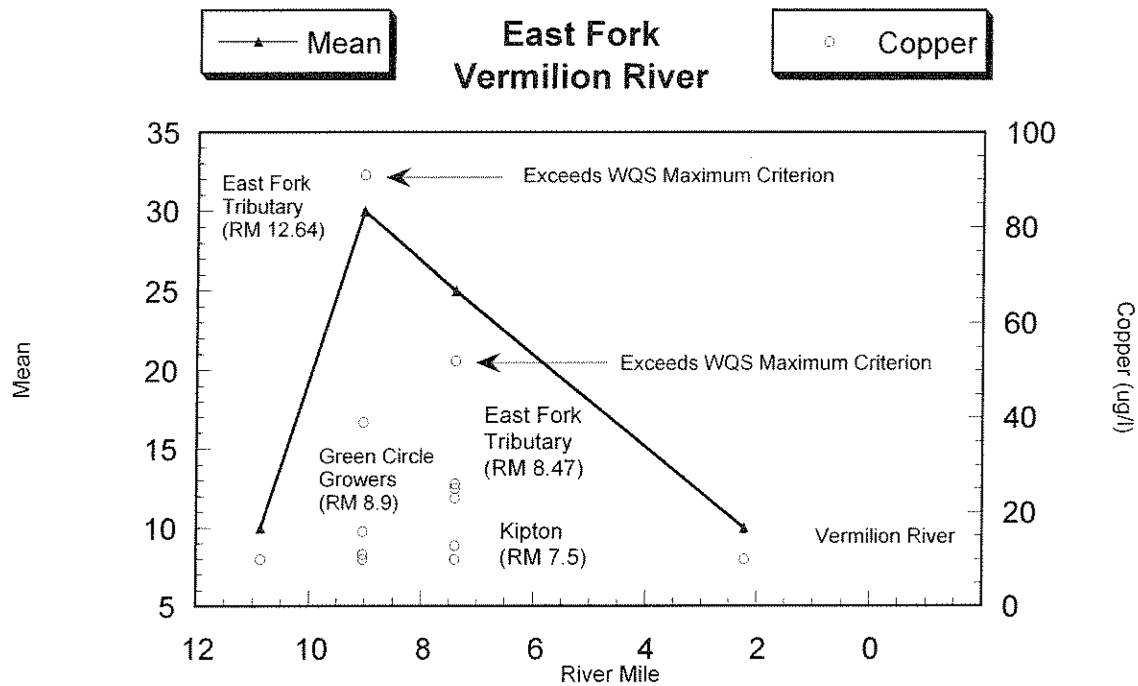

Figure 24. Copper values from East Fork Vermilion River. June - October, 2002.

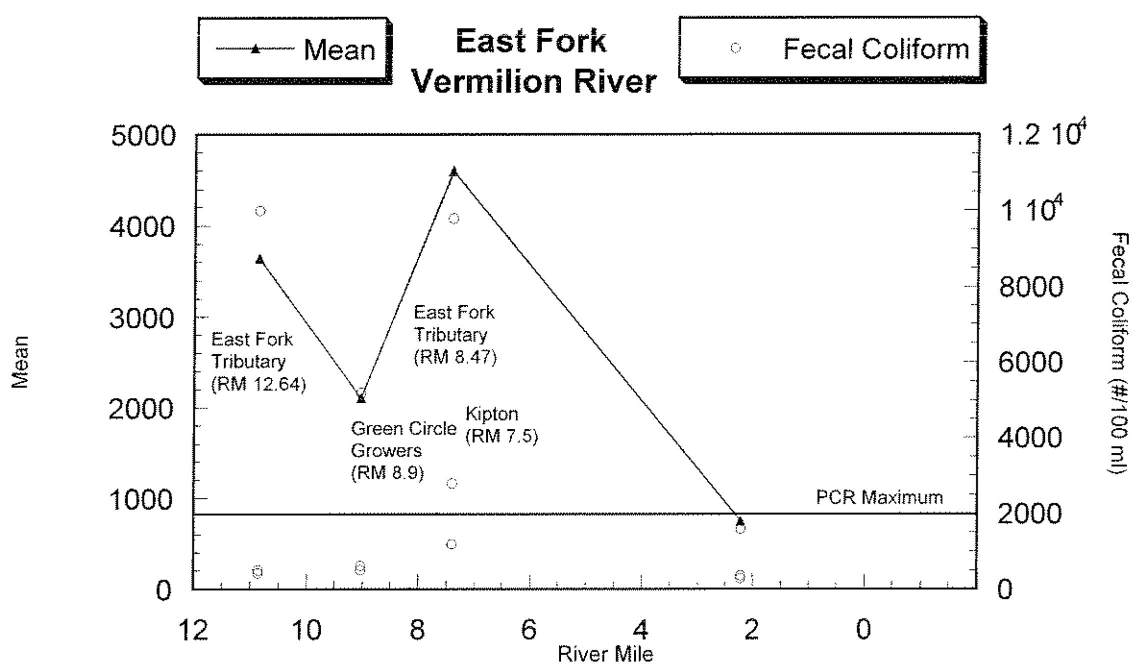

Figure 25. Fecal coliform bacteria values from East Fork Vermilion River. June - October, 2002.

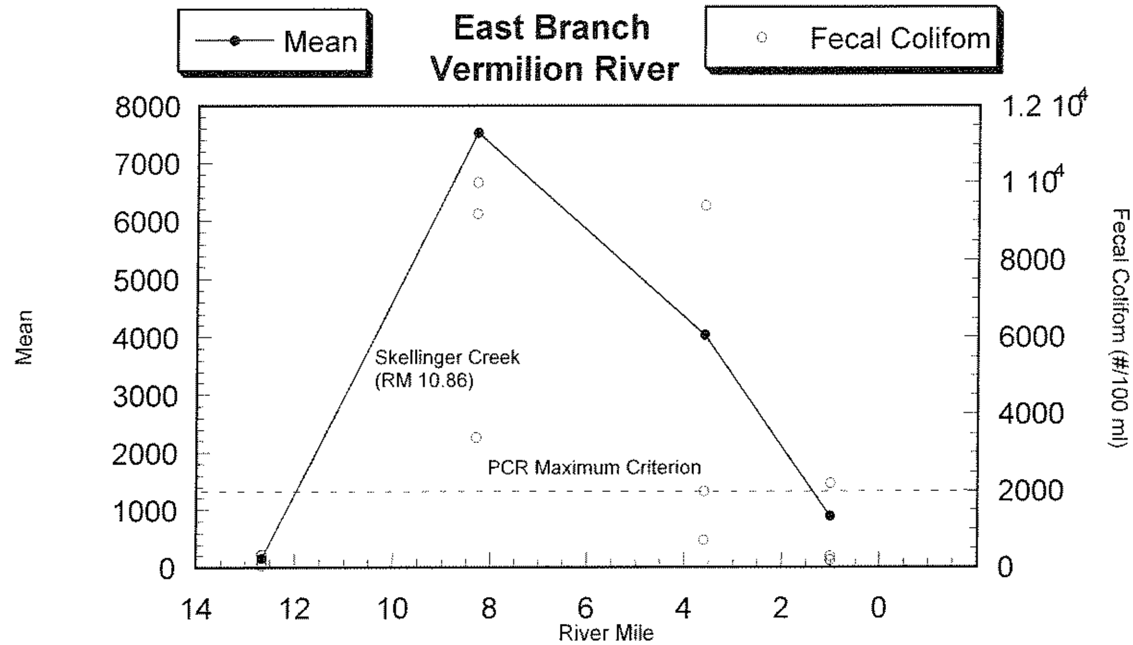

Figure 26. Fecal coliform bacteria values from the East Branch Vermilion River. June - October, 2002.

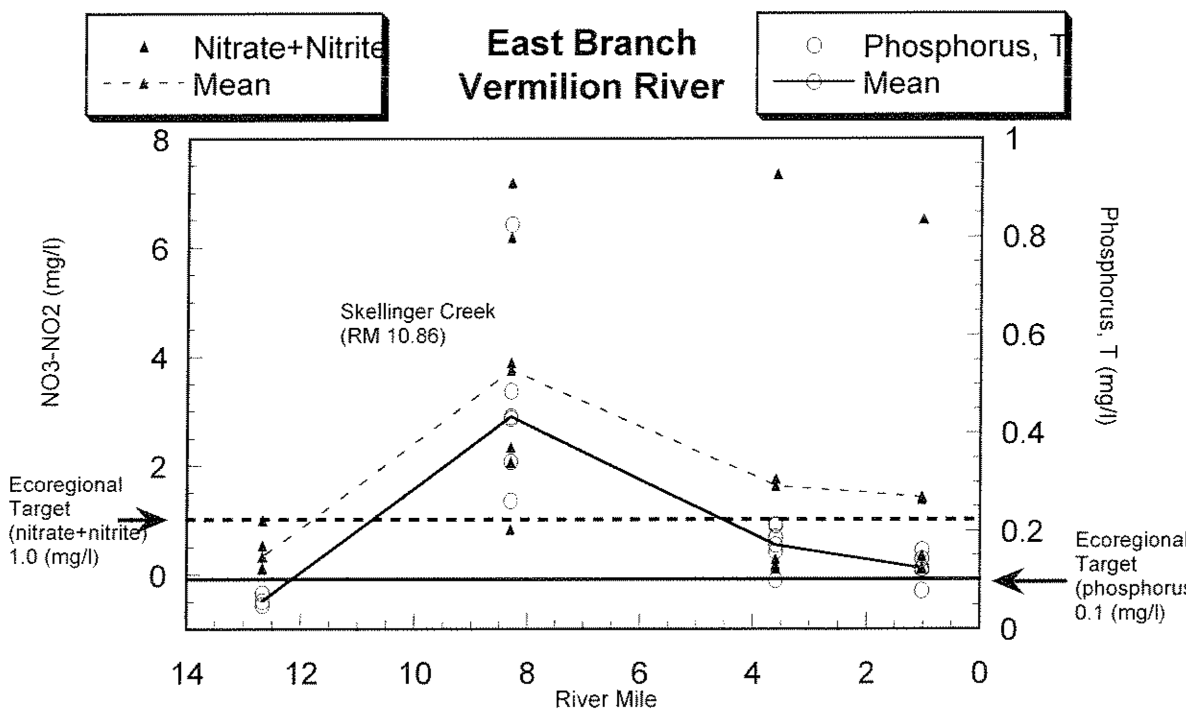

Figure 27. Nitrate+Nitrite & phosphorus mean values from the East Branch Vermilion River. June - October, 2002.

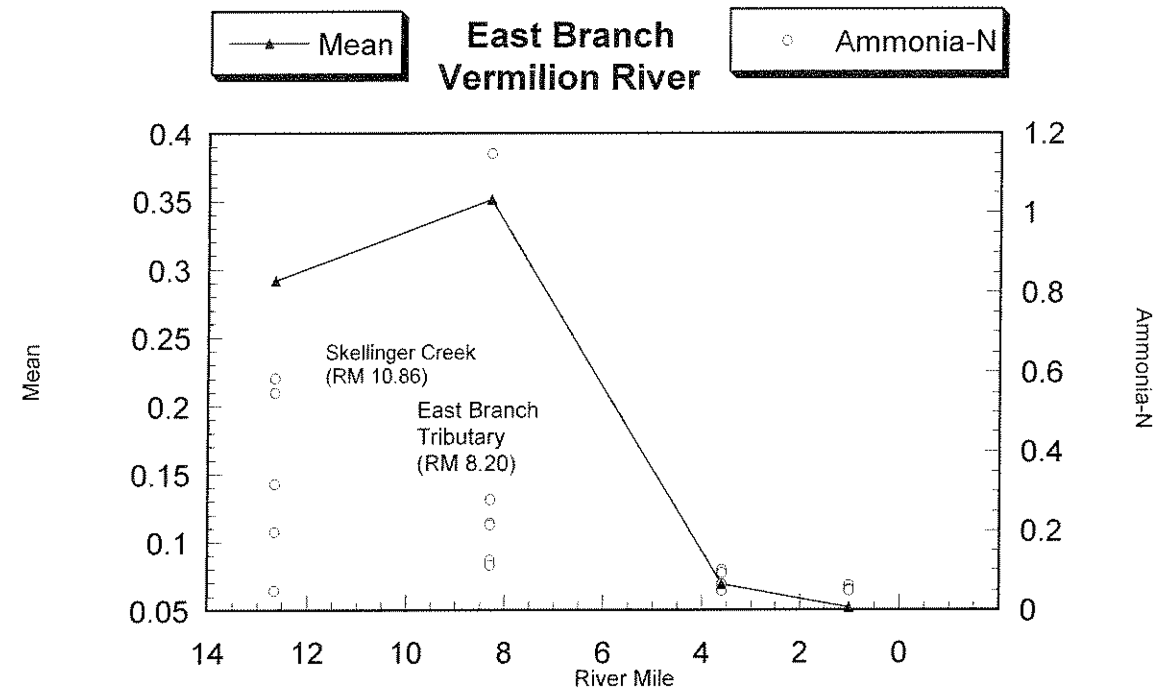

Figure 28. Ammonia-N values from the East Branch Vermilion River. June - October, 2002.

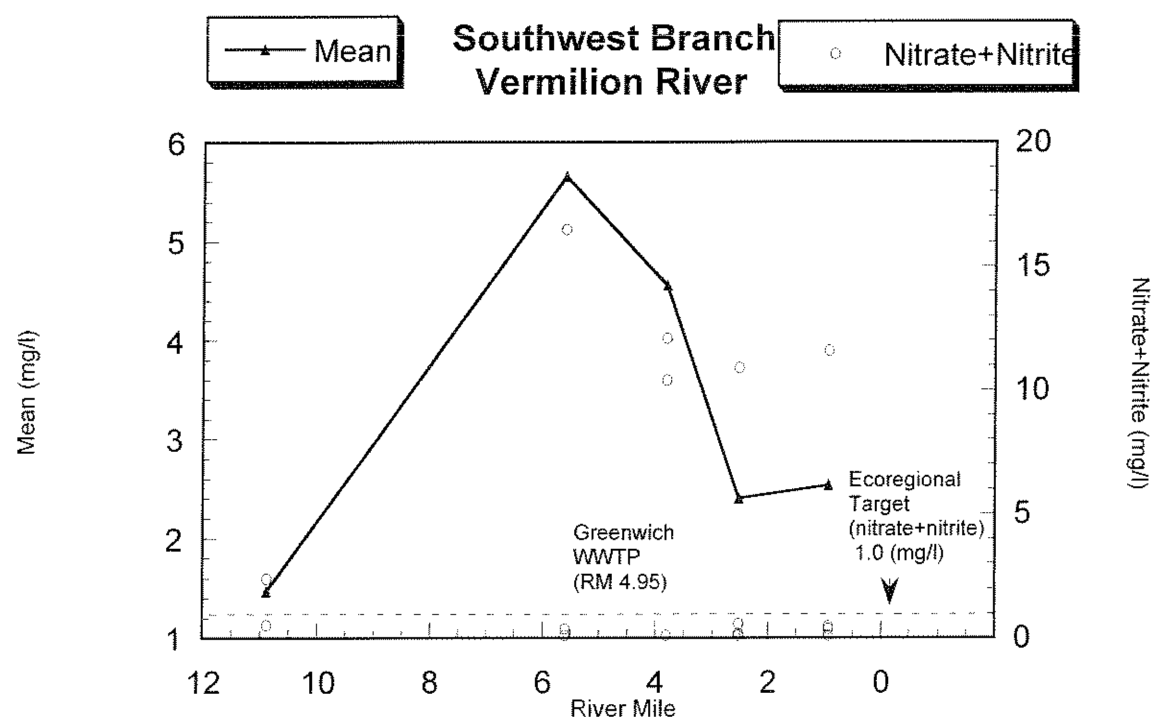

Figure 29. Nitrate+Nitrite values from the Southwest Branch Vermilion River. June - October, 2002.

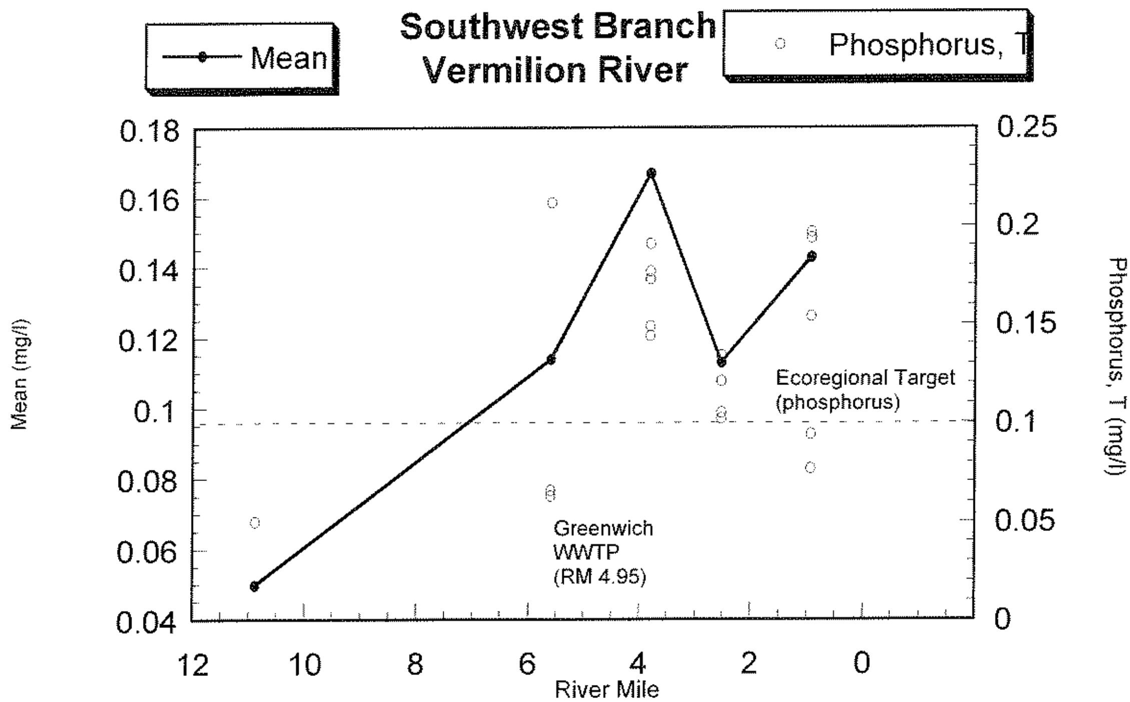

Figure 30. Total Phosphorus values from the Southwest Branch Vermilion River. June - October, 2002.

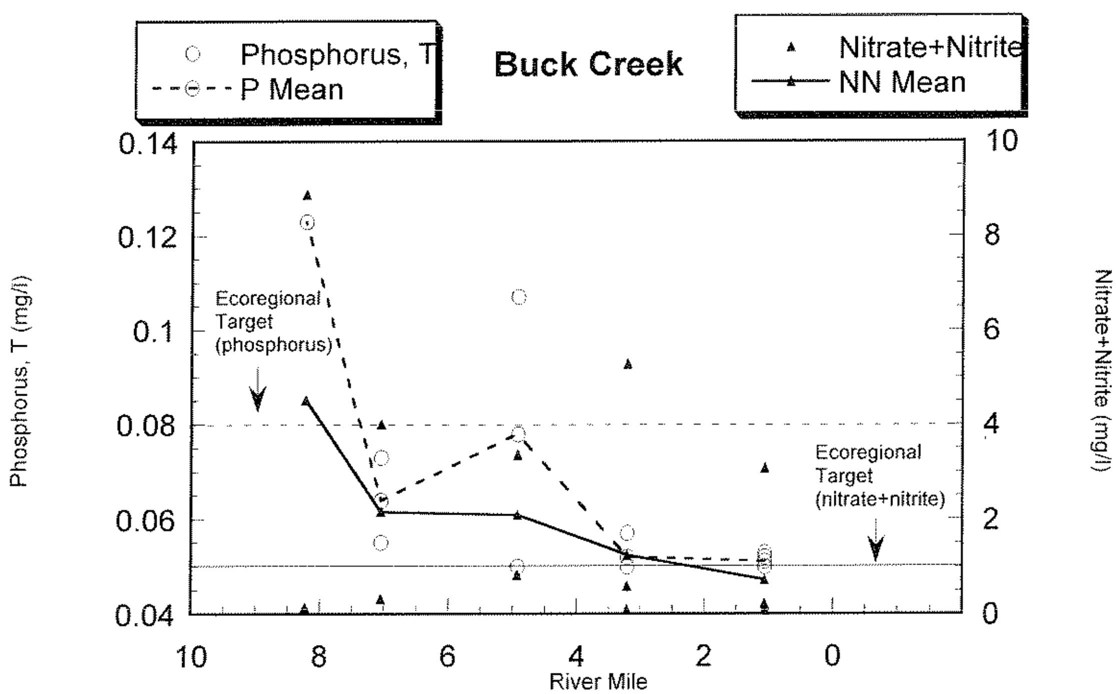

Figure 31. Total phosphorus & nitrate+nitrite values from Buck Creek. June - October, 2002.

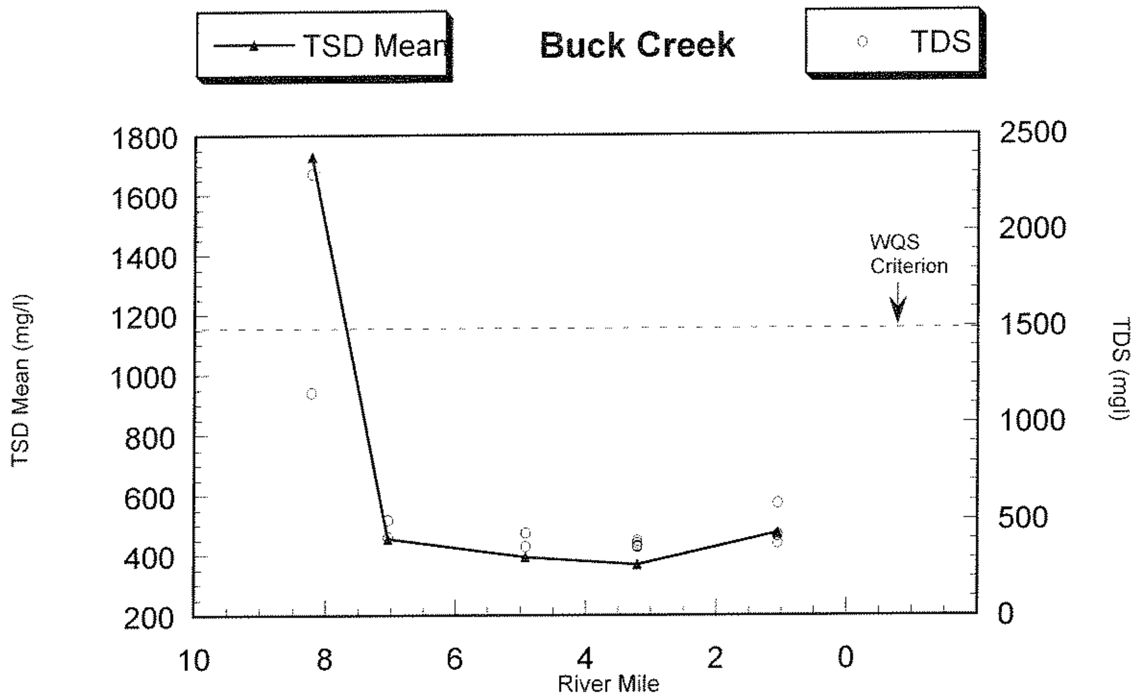

Figure 32. Total dissolved solids value from Buck Creek. June - October, 2002.

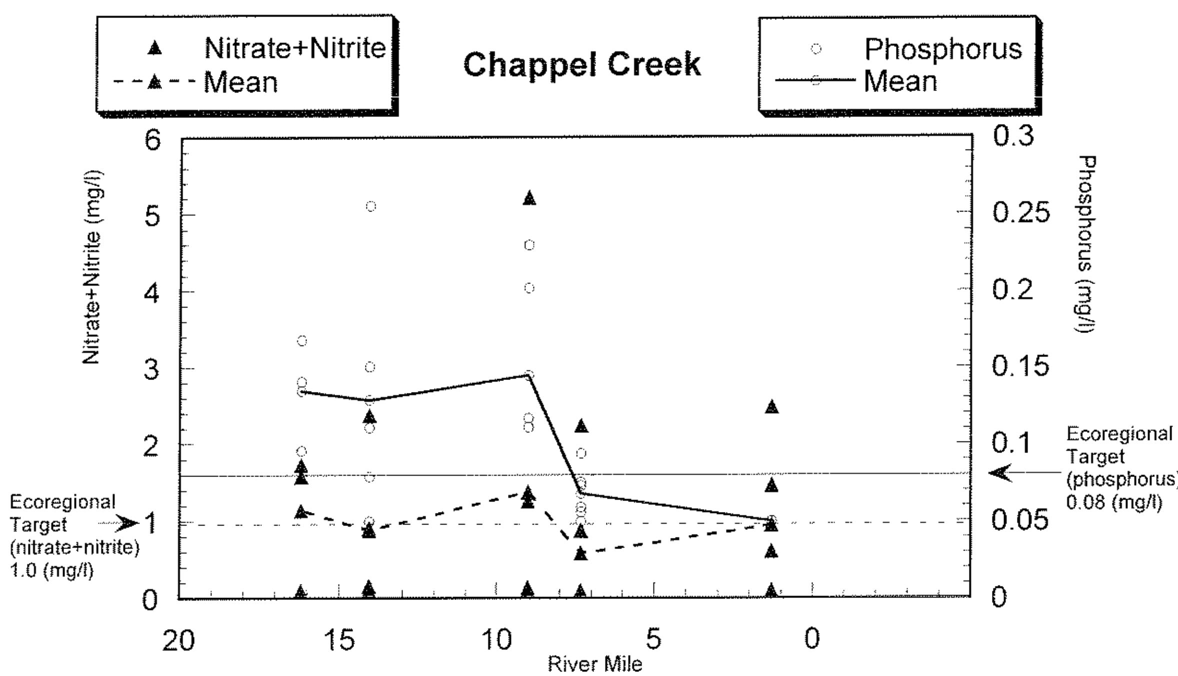

Figure 33. Nitrate+Nitrite & total phosphorus values from Chappel Creek. June - October, 2002.

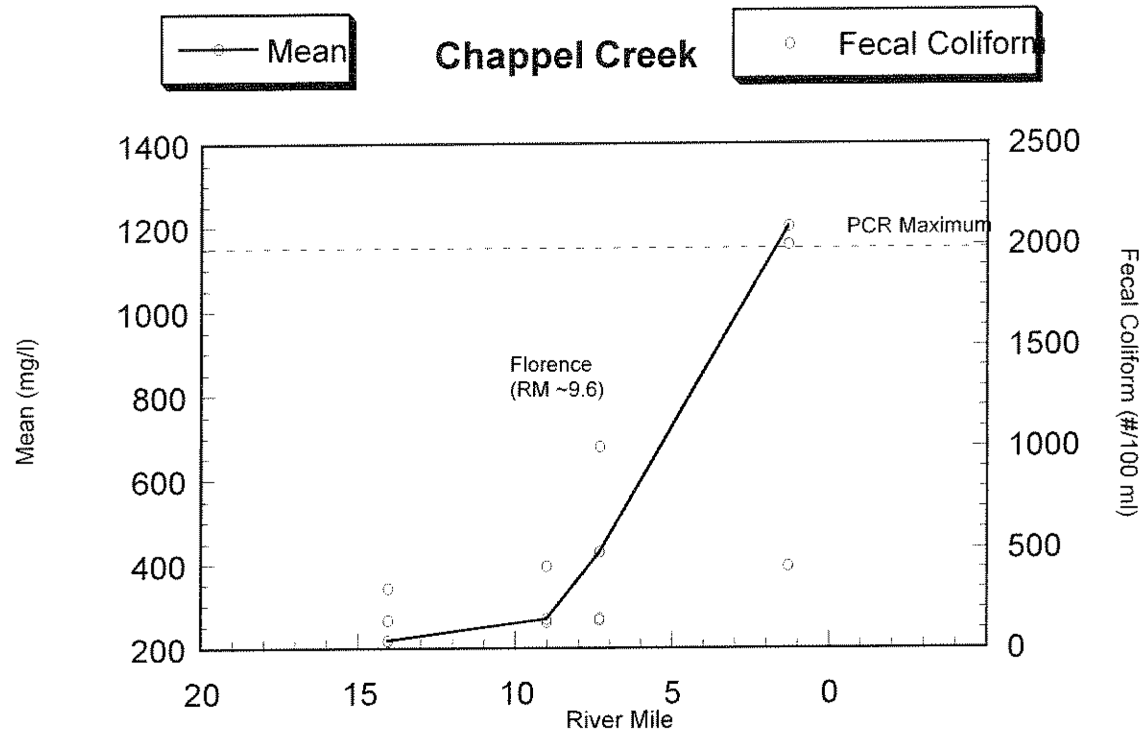

Figure 34. Fecal coliform bacteria values from Chappel Creek. June - October, 2002.

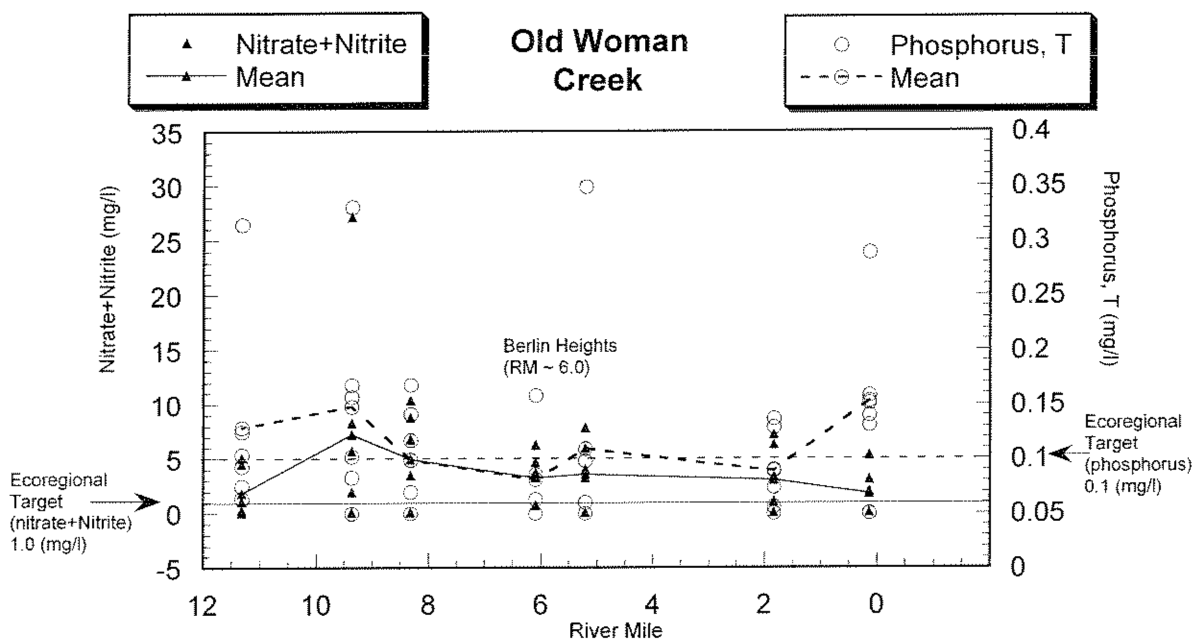

Figure 35. Nitrate+nitrite & total phosphorus values from Old Woman Creek. May - October, 2001 & 2002.

SEDIMENT QUALITY

The chemical sediment quality was assessed at 18 locations throughout the Vermilion River basin, Old Woman Creek basin and several small Lake Erie tributaries. Sediments selected for sampling consisted mainly of fine silts and clays, which are generally associated with persistent environmental contaminants. Sediment grab samples were analyzed for inorganic metals, semi-volatile organics, polychlorinated biphenyls (PCBs), and pesticides. To evaluate analytical results, concentrations were compared to Consensus- Based Sediment Quality Guidelines as described by MacDonald et al. (2000). Inorganic metal results were also compared to Ohio Specific Sediment Reference Values (SRV) (Ohio EPA 2003) which represent ecoregion background conditions. Sample results reported below the Consensus-Based Threshold Effect Concentration (TEC) and/or below the Ohio SRV value are likely not an environmental concern. Sediments with chemical concentrations reported above the Consensus-Based Probable Effect Concentration (PEC) and/or the Ohio SRV value may result in negative environmental impacts and warrant further evaluation. Results of sediment samples are summarized in Tables 17 and 18. Organic parameters were only reported if detected above the analytical method detection limits. No semi-volatile organics were detected.

Vermilion River

Nine sediment sites were sampled on the Vermilion River mainstem. With the exception of lacustarine sites, at most locations very little suitable (i.e., fine silts and clay) sediment existed. Arsenic was detected above the TEC at 78% of the sites. However, arsenic concentrations were below the SRV at all sampling locations, indicating that levels are representative of background conditions. Overall, sediment chemical contamination was minimal in samples collected from the mainstem of the Vermilion River when compared to other Lake Erie tributaries in Ohio.

At Noble Road (RM 62.10) arsenic was detected above the TEC while all other parameters were below the sediment quality guidelines. Downstream of Fitchville at Fayette Road (RM 44.5), barium, chromium, potassium, and strontium were detected slightly above the SRV values. Arsenic and nickel exceeded the TEC value but were below the PEC and the SRV guidelines. Heptachlor epoxide, the breakdown product of the pesticide heptachlor, was detected above the PEC. At Zenobia Road (RM 33.6) arsenic concentrations were slightly above the TEC. Sample results from Auster Road (RM 29.2) and upstream of the Wakeman Dam (RM 23.9) were below sediment quality guidelines. Samples collected at Gore Orphanage Road indicated slightly impacted sediment quality. Cadmium concentrations were elevated above TEC and SRV guidelines. Aluminum, nickel and potassium levels were slightly above the SRV values. Arsenic and zinc concentration were above the TEC value, but below the SRV. Results of a sample collected upstream of the Vermilion WWTP (RM 1.81), indicated that arsenic, copper, nickel and zinc levels were slightly above TEC values, but below SRV guideline. Cadmium concentrations were elevated above the TEC and SRV guidelines. Downstream of the Vermilion WWTP (RM 0.85) and at the Vermilion River mouth (RM 0.1) arsenic and nickel concentrations were slightly above TEC values, but were below SRV guidelines. Barium levels were slightly elevated above the SRV guideline. Cadmium, copper and zinc concentrations were above the TEC and SRV guidelines, but well below PEC values.

East Fork Vermilion

Sediment samples were collected upstream and downstream of the Green Circle Growers facility in order to assess impacts to sediment quality from several unpermitted discharges. Result of samples collected upstream and downstream of the facility at U.S. Route 20 and at State Route 303 respectively, indicated good sediment quality. Organic compounds were below detection limits and all inorganic metal concentrations were below the sediment quality guidelines.

Buck Creek

A sediment sample was collected from Buck Creek at Township Road 1461 (RM 1.06). No organic compounds were detected and all inorganic metal concentrations were below the sediment quality guidelines.

Sugar Creek

A sediment sample was collected from Sugar Creek at Barns Road (RM 3.5). Aluminum, barium, iron, potassium and selenium were detected above SRV guidelines. Arsenic, cadmium, chromium, nickel, selenium and zinc concentrations were above TEC values and SRV guidelines. No organic compounds were detected.

Cranberry Creek

A sediment sample was collected from Cranberry Creek at U.S. Route 6 (RM 0.1). Cadmium was detected above the SRV guideline, but concentrations were below the TEC value. Endosulfan sulfate, a precursor to the insecticide endosulfan, was detected at 15.3 *u*g/kg. No other organic compounds were detected.

Old Woman Creek

Sediment samples were collected at four sites within the Old Woman Creek basin. Arsenic concentrations were above the SRV guideline at Nash Road (RM 11.33) and at U.S. Route 6 (RM 0.14). No other inorganic metals were detected above the guidelines in samples collected from the watershed. Heptachlor epoxide, a break-down product of the pesticide heptachlor, was detected above the TEC in samples collected at Nash Road (RM 11.33) and in a sample collected from a tributary at Chapin Road (RM 0.69). DDE, a break-down product of the insecticide DDT, was detected in samples collected from a tributary at Chain Road (RM 0.69) and at U.S. Route 6.

Table17. Metal concentrations (mg/kg) in sediments collected from the Vermilion River in 2002. Values preceded by a < were below the reporting limit. Those preceded by an (*) exceeded the threshold effect concentration (TEC) described by MacDonald et al. (2000). Values preceded by (#) exceeded Ohio-specific Sediment Reference Values (SRVs).

Vermilion River at RM 62.10 - Noble Rd.

Al	Ba	Ca	Cr	Cu	Fe	Pb	Mg	Mn
19800	110	10400	22	11.1	21100	32	4900	345
Ni	**K**	**Na**	**Sr**	**Zn**	**Hg**	**As**	**Cd**	**Se**
<23	5540	<2920	36	59.4	<0.031	* 14	0.240	<1.17

Vermilion River at RM 44.5 - Fayette Rd.

Al	Ba	Ca	Cr	Cu	Fe	Pb	Mg	Mn
37200	# 199	8370	# 36	18.8	32400	34	5580	868
Ni	**K**	**Na**	**Sr**	**Zn**	**Hg**	**As**	**Cd**	**Se**
* 29	# 9070	<3490	# 70	97.0	<0.037	* 23.7_{J}	0.357	$<1.39_{UJ}$

Vermilion River at RM 33.6 - Zenobia Rd.

Al	Ba	Ca	Cr	Cu	Fe	Pb	Mg	Mn
20600	116	27300	22	21.5	22900	<23	8130	452
Ni	**K**	**Na**	**Sr**	**Zn**	**Hg**	**As**	**Cd**	**Se**
<23	6390	<2900	74	73.2	<0.038	* 13.2	0.437	$<1.16_{UJ}$

Vermilion River at RM 29.2 - Auster Rd.

Al	Ba	Ca	Cr	Cu	Fe	Pb	Mg	Mn
14900	60.1	4260	<16	7.5	11600	<21	3190	130
Ni	**K**	**Na**	**Sr**	**Zn**	**Hg**	**As**	**Cd**	**Se**
<21	3190	<2660	26	45.2	<0.022	5.10	0.229	<1.06

Vermilion River at RM 23.9 - Up Stream Wakeman Dam

Al	Ba	Ca	Cr	Cu	Fe	Pb	Mg	Mn
20200	99.6	7700	17	11.4	17400	<23	4140	262
Ni	**K**	**Na**	**Sr**	**Zn**	**Hg**	**As**	**Cd**	**Se**
<23	4670	<2910	33	72.0	<0.036	7.34	0.373	<1.16

Vermilion River at RM 10.7 - Gore Orphanage Rd.

Al	Ba	Ca	Cr	Cu	Fe	Pb	Mg	Mn
# 31200	# 233	19400	28	20.0	24300	<31	5410	375
Ni	**K**	**Na**	**Sr**	**Zn**	**Hg**	**As**	**Cd**	**Se**
*# 35	# 7740	<3890	55	* 140	<0.049	* 15.0	* # 1.40	<1.56

Table 17. (Continued)

Vermilion River at RM 1.81 - Up Stream Vermilion WWTP

Al	Ba	Ca	Cr	Cu	Fe	Pb	Mg	Mn
27800	301	6500	32	* 32.8	27400	<27	4730	332
Ni	**K**	**Na**	**Sr**	**Zn**	**Hg**	**As**	**Cd**	**Se**
* 36	7770	<3390	40	* 160	<0.042	* 15.2	* # 1.58	1.81

Vermilion River at RM 0.85 - Down Stream Vermilion WWTP

Al	Ba	Ca	Cr	Cu	Fe	Pb	Mg	Mn
30000	# 293	8420	34	* # 47.9	27000	<26	4840	323
Ni	**K**	**Na**	**Sr**	**Zn**	**Hg**	**As**	**Cd**	**Se**
* 34	8330	<3190	42	* # 174	0.046	* 13.5	* # 1.57	1.43

Vermilion River at RM 0.1 Mouth

Al	Ba	Ca	Cr	Cu	Fe	Pb	Mg	Mn
36500	# 278	31800	38	* # 37.7	29200	<29	# 7620	407
Ni	**K**	**Na**	**Sr**	**Zn**	**Hg**	**As**	**Cd**	**Se**
* 32	9540	<3580	62	* #168	0.046	* 15.3	* # 1.47	1.60

East Fork Vermilion River at RM 10.9 - State Route 303

Al	Ba	Ca	Cr	Cu	Fe	Pb	Mg	Mn
9790	59.0	12600	<15	6.8	11900	<20	3890	178
Ni	**K**	**Na**	**Sr**	**Zn**	**Hg**	**As**	**Cd**	**Se**
<20	2830	<2440	40	53.5	<0.210	5.82	0.210	<0.98

East Fork Vermilion River at RM 8.63 - US 20

Al	Ba	Ca	Cr	Cu	Fe	Pb	Mg	Mn
11300	68.5	16900	<17	21.4	13700	<22	4940	296
Ni	**K**	**Na**	**Sr**	**Zn**	**Hg**	**As**	**Cd**	**Se**
<22	3170	<2750	37	116	<0.036	6.13	0.315	<1.10

Buck Creek at RM 1.06 - Twp. Rd. 1461

Al	Ba	Ca	Cr	Cu	Fe	Pb	Mg	Mn
16500	94.3	6780	18	11.7	16000	<23	3650	252
Ni	**K**	**Na**	**Sr**	**Zn**	**Hg**	**As**	**Cd**	**Se**
<23	4510	<2820	45	64.8	<0.026	8.77	0.333	<1.13

Table 17. Continued

Sugar Creek at RM 3.5 - Barnes Rd.

Al	Ba	Ca	Cr	Cu	Fe	Pb	Mg	Mn
# 46900	# 445	3820	*# 51	21.7	# 40700	<21	5400	409
Ni	**K**	**Na**	**Sr**	**Zn**	**Hg**	**As**	**Cd**	**Se**
*# 54	#17000	<2620	47	* #174	0.034	*# 31.0	* # 1.24	# 1.83

Cranberry Creek at RM 0.1 - US 6

Al	Ba	Ca	Cr	Cu	Fe	Pb	Mg	Mn
16800	92.7	5690	19	17.8	14700	<25	3610	236
Ni	**K**	**Na**	**Sr**	**Zn**	**Hg**	**As**	**Cd**	**Se**
<25	4500	<3150	29	79.1	0.043	4.98	# 0.946	<1.26

Old Woman Creek at RM 11.33 - Nash Rd.

Al	Ba	Ca	Cr	Cu	Fe	Pb	Mg	Mn
26500	121	6920	28	15.9	24400	<25	4920	328
Ni	**K**	**Na**	**Sr**	**Zn**	**Hg**	**As**	**Cd**	**Se**
<25	7340	<3110	35	79.8	<0.043	# 13.5	0.402	<1.24

Old Woman Creek at RM 1.84 - Darrow Rd.

Al	Ba	Ca	Cr	Cu	Fe	Pb	Mg	Mn
16000	66.3	5120	16	10.0	13300	<19	3000	184
Ni	**K**	**Na**	**Sr**	**Zn**	**Hg**	**As**	**Cd**	**Se**
<19	4070	<2340	21	51.8	<0.023	5.60	0.290	<0.94

Old Woman Creek at RM 0.14 - US Rt. 6

Al	Ba	Ca	Cr	Cu	Fe	Pb	Mg	Mn
14600	76.1	11100	<22	17.0	19000	<30	5150	317
Ni	**K**	**Na**	**Sr**	**Zn**	**Hg**	**As**	**Cd**	**Se**
<30	3620	<3710	30	94.0	<0.047	# 11.2	0.461	<1.48

Trib to Old Woman Creek at RM 0.69 - Chapin Rd.

Al	Ba	Ca	Cr	Cu	Fe	Pb	Mg	Mn
17400	75.3	3180	17	10.2	16800	<21	2650	250
Ni	**K**	**Na**	**Sr**	**Zn**	**Hg**	**As**	**Cd**	**Se**
<21	4210	<2580	20	54.4	<0.034	10.7	0.284	<1.03

TEC Concentration below which harmful effects are not likely to be seen.
SRV Concentration representative of background conditions for the ecoregion.
J The analyte was positively identified, the associated numerical value is estimated.
UJ The analyte was not detected above the sample quantitation limit (QL). However, the reported QL is estimated.

Table 18._ Organochlorine pesticides concentrations (ug/kg) in sediments collected from the Vermilion River, Old Woman Creek and Lake Erie Tributaries in 2002. Those preceded by an (*) exceeded the threshold effect concentration (TEC) and those proceeded by an (**) exceeded the probable effect concentration (PEC) described by MacDonald et al. (2000). All other tested organochlorine pesticides were reported at concentrations less than analytical detection limits.

Parameter	Result
Vermilion River at Fayette Road (RM 44.5)	
Heptachlor epoxide	** 21.4[P]
East Fork Vermilion River at US 20 (RM 8.63)	
Endosulfan II	8.4
Cranberry Creek at US 6 (RM 0.1)	
Endosulfan sulfate	15.3
Old Woman Creek at US 6 (RM 0.14)	
4,4'-DDE	10.0
Old Woman Creek at Nash Road (RM 11.33)	
Heptachlor epoxide	* 14.5
Old Woman Creek Tributary (RM 3.07) at Chapin Rd. (RM 0.69)	
4,4'-DDE	13.7
Heptachlor epoxide	* 7.6

TEC Concentration below which harmful effects are not likely to be seen.

PEC Concentration above which harmful effects are likely to be seen.

P Analyte is quantitated for pesticides and PCB analysis and there is greater than 40 % difference for the detected concentrations from the two GC columns used for analysis.

Physical Habitat for Aquatic Life

The physical habitat quality of 65 locations within the study area was evaluated using the Qualitative Habitat Evaluation Index (QHEI). The QHEI was developed by Ohio EPA for streams and rivers in Ohio (Rankin 1989, 1995). The QHEI involves scoring various attributes of the habitat based on the overall importance of each to the maintenance of viable, diverse, and functional aquatic faunas. Average QHEI scores greater than 60 are generally conducive to the existence of warmwater fauna whereas scores less than 45 generally can not support a warmwater assemblage consistent with the WWH biological criteria. Average QHEI scores greater than 75 in a stream segment frequently typify habitat conditions which have the ability to support exceptional warmwater faunas.

Vermilion River

The upper reach of the Vermilion River, from Clear Creek Road (RM 63.0) to State Route 250 (RM 50.7), developed primarily from hardpan and tills substrates, though some lacustrine areas were also noted. The dominant sand and gravel substrates were intermixed with boulders, cobble, hardpan, silt, muck and detritus. The most upstream site, Clear Creek Road (RM 63.0), showed signs of recent channelization and was characterized by poor to fair development, low sinuosity and moderate stability. Sparse to moderate amounts of instream cover available to aquatic organisms included overhanging vegetation, woody debris and aquatic macrophytes. Downstream of Township Road 608 (RM 62.1), sinuosity and channel development increased as the stream appeared to have recovered from past channelization and dipping activities. The availability of instream cover also increased downstream and included undercut banks, rootmats, rootwads, pools (>70 cm), boulders, woody debris and logs.

Outside of the river channel, buffers widths varied greatly throughout the upper reach. In several areas, row cropping extended nearly to the stream banks, while few wooded buffers extended greater than 50 meters. The combination of narrow riparian corridors adjacent to agricultural and residential land use activities may have contributed to the siltation present throughout the upper reach of the Vermilion River. The moderate to heavy siltation resulted in moderately embedded substrates, decreasing the amount of interstitial spaces available for aquatic organisms.

QHEI scores reflect the suitability of the stream to support aquatic communities. For the upper reach of the Vermilion River, the lowest QHEI score (QHEI=45) was recorded from Clear Creek Road (RM 63.0), indicating that the recent channelization activities and inadequate buffers reduce the ability of the river to support WWH communities in this location. However, the sites between Township Road 608 (RM 62.1) and State Route 250 (RM 50.7) received QHEI scores between 59 and 68. The scores increased as the amount of instream cover and sinuosity increased, indicating the river should support WWH communities throughout these areas.

While the upper reach developed from hardpan and tills, the lower reach of the Vermilion River, from State Route 250 (RM 45.7) to North Ridge Road (RM 6.4), developed primarily from tills, hardpan and shales, though a few substrate origins included sandstone and lacustrine areas. The streambed of the lower reach of the Vermilion River was predominantly bedrock, sand, gravel, cobble, boulders and slabs. Most sites throughout the lower reach contained greater than five substrate types. Minimal amounts of silt and normal amounts of embedded substrates provided a greater amount of interstitial spaces available for aquatic organisms than in the upper reach. The combination of numerous substrate types and varying currents, from fast riffles to slow eddies, created diverse microcosms of habitat suitable for a variety of aquatic life.

Beyond the banks of the lower reach, a predominance of buffers greater than 10 meters were noted adjacent to a mixture of agricultural and residential land use. In several areas, buffers greater than 50 meters and less intense land uses, such as old fields, a campground and woods were observed. The mix of less intense land use, wide buffers, diverse substrates, well developed sinuosity and high quality stream cover provided excellent habitat for aquatic life. QHEI scores within the lower reach ranged primarily from 71.5 to 81.0, representing more natural stream conditions than the upper reach. The only area providing less than general warmwater habitat conditions was the Wakeman dam pool site (RM 23.9). The presence of the dam has increased the amount of siltation and embedded substrates, decreased the velocity of flow and eliminated sinuosity of the channel. The habitat modifications present as a result of the dam decreased the quality of habitat available for aquatic life, resulting in a QHEI score of 48.5. Based on the QHEI scores, the majority of the lower reach could support EWH or WWH communities, except for the Wakeman dam pool site, which may not be able to support even WWH communities.

East Fork Vermilion River

The East Fork of the Vermilion River, from Baird Road (RM 10.9) to Green Road (RM 2.3) developed primarily from tills, shale and hardpan. Gravel, sand and hardpan dominated the streambed in the upper 3 sites, while the site at Green Road (RM 2.3) was dominated by bedrock. Additional substrate types found throughout the stream included boulders, cobble, gravel, sand, bedrock and anthropogenic deposition of artificial substrates and silt. The amount of silt and embedded substrates exceeded normal amounts in the upper reaches, diminishing the amount of interstitial spaces available for aquatic life.

The majority of buffers along the stream were narrow (5-10 m), while the predominant land uses were residential, old fields and one greenhouse company. Moderate buffers (10-50 m) were noted adjacent to residential areas near Green Road (RM 2.3) and across the stream from the greenhouse company (RM 9.1). QHEI scores within the East Fork of the Vermilion River ranged from 58.0 to 68.0, which represent habitat conditions able to support WWH populations.

East Branch Vermilion River

The physical habitat of the East Branch of the Vermilion River was evaluated from Eaton Road (RM 8.6) to Townline Road (RM 1.4). The substrates were derived primarily from tills and sandstone, though some areas of hardpan were observed. The streambed was dominated by sand, gravel and bedrock, though additional substrates, including boulders, cobble, hardpan, sand, and gravel were present, providing diverse habitat features for aquatic communities. The amount of silt and embedded substrates ranged from normal to moderate amounts, limiting the amount of interstitial spaces available for aquatic macroinvertebrates. Historically, the upper reach may have been channelized, but moderate sinuosity with good channel development was present throughout the majority of the river.

In addition to the likelihood of previous channelization, the upper reach exhibited more narrow buffers and higher intensity land use than the lower reach. Land use activity in the upper reach included residential and agriculture activities, while forests and shrubbery were mixed within the residential and agricultural uses present in the lower reach. QHEI scores for the East Branch of the Vermilion River increased in a downstream direction, from 62.0 to 77.0, as land use intensity decreased and buffers increased. Based on the QHEI scores, the lower site indicates more natural conditions that provide better habitat for aquatic assemblages and may be a historical representation of the pre-anthropogenic conditions of the East Branch of the Vermilion River. The incorporation of better land use practices in the upper section may improve habitat conditions in years to come.

Skellinger Creek

Skellinger Creek was evaluated near Fayette Road (RM 0.8). The substrates appeared to be derived from tills, with gravel as the most dominant substrate present. Areas of cobble, sand and silt were intermixed with the gravel. Silt and embedded substrates were present in normal amounts, though instream cover was sparse. The stream appeared to have recovered from past channelization, though sinuosity was low and stream morphology only fair.

The low stream development was accentuated by the lack of buffers outside the stream channel. Though no bank erosion was observed, old fields/pastures were maintained adjacent to the stream banks. The QHEI score for Skellinger Creek was 48.5.

Indian Creek

Indian Creek was evaluated between Hartland Center (RM 3.5) and Fitchville River Road (RM 0.4). The stream bed materials were derived from tills and hardpan, though beyond the originating substrates, the condition of the stream was significantly different between the upper and lower reaches.

Gravel and sand dominated the streambed in the upper reach, though areas of silt were also present. Normal to moderate amounts of silt and embedded substrates were observed, limiting the availability of interstitial spaces for aquatic organisms. Instream cover was sparse and limited to overhanging vegetation, shallows, and aquatic macrophytes. Evidence of recent channelization including little sinuosity, poor to fair stream development and moderate bank erosion was apparent. Residential and agricultural land uses were maintained up to the stream banks, providing no buffers to filter potential pollutants. The combination of high intensity land use, nonexistent buffers and poor instream cover degraded the quality of the stream. The QHEI score for the upper reach of Indian Creek was 36.0.

In contrast to the upper reach, the lower reach of Indian Creek, while dominated by gravel, contained a variety of substrates including boulders, cobble, hardpan, silt, sand and artificial cover. No evidence of channelization was apparent, as the stream exhibited moderate sinuosity with good stream development and moderate to high stability. Vacant fields extended beyond the narrow (5 - 10 m) buffer along the left descending bank, while a mixture of residential and agricultural use extended beyond the narrow (5-10 m) buffer along the right descending bank. The diversity of available substrates with higher quality stream development and a mixture of land uses provided suitable habitat for a variety of aquatic communities. The QHEI score for the lower reach of Indian Creek was 71.5, which is more than adequate to support WWH communities.

Southwest Branch Vermilion River

The Southwest Branch of the Vermilion River was evaluated from Greenwich Milan Townline Road (RM 5.6) to State Route 13 (RM 1.0). The stream originated from hardpan and tills. Gravel, sand and hardpan were the most dominant substrate types, though occasional areas of boulder, cobble and silt were noted. Silt and embedded substrates were present in normal to moderate amounts throughout the stream.

No evidence of channelization was observed from Greenwich Angling Road (RM 3.9) to Greenwich Milan Townline Road (RM 5.6). Throughout this area, the stream was characterized by moderate to high sinuosity with good channel morphology and moderate to high stability even though the stream flowed through a cow pasture upstream of Greenwich Angling Road (RM 3.9). From Omega Road (RM 2.5) to State Route 15 (RM 1.0), the stream appeared to have recovered from past channelization or dipping, though sinuosity ranged from low to moderate with fair to good channel morphology development.

Outside the stream channel, non-existent or narrow (5 - 10 m) buffers were present adjacent to agricultural activities, while most buffers adjacent to residential areas extended from narrow (5 - 10 m) to moderate (5 - 50 m) widths. The majority of QHEI scores ranged between 62.5 and 65.5, which indicate the stream is capable of supporting a WWH community. However, the QHEI score obtained near State Route 13 (RM 1.0) was 47.5, which indicates a slower recovery in this area from anthropogenic impacts.

Buck Creek

The physical habitat of Buck Creek was evaluated from State Route 511 (RM 8.2) to Township Road 1461 (RM 1.1). The stream substrates originated primarily from tills, though areas of shale and hardpan were observed. The dominant substrate present was gravel, which was intermixed with areas containing bedrock and hardpan. Additional habitat providing substrates noted were boulders, cobble, silt and sand. The substrates showed normal amounts of silt and embedded conditions, illustrating adequate amounts of interstitial spaces were available for aquatic organisms. The majority of the stream appeared unmodified by channelization and exhibited well developed channel morphology with moderate amounts of sinuosity. However, the portion of the stream near State Route 511 (RM 8.2) appeared to have recovered from past channelization and exhibited moderate sinuosity with fair development and moderate to high stability.

Outside of the stream channel, the upstream site near State Route 511 (RM 8.2) was bordered by narrow (5 - 10 m) to moderate (10 - 50 m) buffers beyond which fenced pastures were apparent. The QHEI score for this section was 44.0, which reflects the limited ability of this site to support WWH fauna. For the remaining sites, moderate (10 - 50 m) to wide (>50 m) buffers were observed adjacent to residential, old field and wooded areas, though occasional very narrow (<5 m) to narrow (5 - 10 m) buffers were present adjacent to housing construction sites and residential areas. The QHEI scores from Township Road 1181 (RM 4.9) to Township Road 1461 (RM 1.1) ranged between 66.0 to 75.0, suggesting the stream should support WWH communities and could possibly support EWH communities.

Clear Creek

The physical habitat of Clear Creek was assessed from Townline Road (RM 4.0) to Township Road 1451 (RM 1.8). The stream substrates originated from tills and hardpan. Gravel and cobble were the two most dominant substrate types present, though a variety of substrates including boulders, hardpan, sand, artificial substrates and silt were also noted. Silt and embedded substrates were observed in normal to moderate amounts in the upper reach, while there were fewer embedded substrates in the lower reach. The upper reach appeared to have recovered from past channelization and was characterized by low to moderate sinuosity with fair channel morphology development and high stability. In contrast, the lower reach had likely developed free of channelization, as it exhibited moderate sinuosity with well developed channel morphology and high stability.

Outside of the stream channel, the upper reach had very narrow (<5 m) buffers adjacent to active row cropping and pastured areas. The lower reach had extensive buffers (>50 m) bordering forest areas, though along some residential areas narrow (5 - 10 m) buffers were observed. The combination of lower sinuosity, fair channel development, very narrow buffers and high intensity land use resulted in a QHEI score for the upper reach of 52.0. Therefore, the upper reach provides a lower quality habitat less capable of supporting a WWH community. The combination of moderate sinuosity and well developed channel morphology with extensive buffers adjacent to predominantly low intensity land use resulted in a QHEI score of 71.0 for the lower reach. Based upon the QHEI score, the lower reach would provide very good habitat to WWH communities and could possibly support EWH communities.

Tributary to East Branch of the Vermilion River (RM 8.2)

The physical habitat of the tributary to the East Branch of the Vermilion River (RM 8.2) was evaluated from where Chenango Road (RM 1.1) first crossed the stream to where Chenango Road

(RM 5.8) crossed the stream a second time, south of New London Section Line Road. The upstream site near Chenango Road (RM 5.8) originated from tills. Gravel and sand substrates dominated the streambed and were interspersed with cobble and silt. Normal amounts of silt and embedded substrates were present, allowing aquatic organisms access to interstitial spaces. The upper stream segment appeared to be recovering from past channelization, as low sinuosity with fair channel morphology development and moderate stability were observed. The sparse to moderate instream habitat provided little relief for aquatic organisms, just as the nonexistent to very narrow (<5m) buffers did little to lessen the impacts of the surrounding high intensity agricultural and residential uses.

The middle section of the stream, near Fayette Road (RM 4.0), differed from the upper section as the primary substrate origin appeared to be hardpan. Hardpan was the predominant substrate in the streambed, though areas of silt, gravel and sand were noted. Silt was present in moderate to heavy amounts resulting in moderately embedded substrates. A heavy sewage odor permeated the air throughout this stretch, indicating the presence of failing septic systems. Though the stream appeared to have recovered from past channelization as an increase in sinuosity was observed. However, instream habitat was sparse to moderate, providing little shelter to aquatic organisms. Outside the stream channel, very narrow (<5 m) buffers were observed adjacent to high intensity residential and agricultural land uses.

Similar to the middle section of the stream, the lower section of the stream near Chenango Road (RM 1.1) originated primarily from hardpan substrates. Gravel and hardpan were the dominant substrates in the streambed and were intermixed with cobble, silt and sand. Silt was present in normal to moderate amounts, while embedded substrates were apparent in normal amounts. The morphology of the stream appeared to be natural, exhibiting moderate sinuosity, fair development and moderate stability. Moderate amounts of instream habitat were present for aquatic communities and included rootmats, shallows and woody debris. Though the buffers were predominantly very narrow (<5 m), some wide (>50 m) buffers were noted adjacent to a forested area. The land use in this section was primarily residential, though several areas of forests and old fields were observed.

The mixture of impacts present in each stream segment varied, but similarities in overall quality were apparent. The combination of very narrow buffers, high intensity land use, and channelization resulted in a QHEI score of 43.5 for the upper section, which decreases the likelihood that this area can support a WWH community. In addition to the impacts described for the upper section, the middle segment was impacted by failed septic systems. A QHEI score of 40.5, reflected the poor quality habitat available to aquatic assemblages and the likely inability of this area to support WWH communities. The absence of agricultural activities and related impacts (channelization) in the lower reach resulted in a QHEI score of 56.0. With this score being the highest of the three areas, the lower section could likely is most capable of supporting WWH communities.

Tributary to Buck Creek (RM 4.92)

The tributary to Buck Creek (RM 4.92) was evaluated near Township Road 1181 (RM 0.1). The stream substrates originated from tills and hardpan. Gravel was the primary substrate present, though stretches containing cobble, hardpan, silt, and sand were also noted. Silt and embedded substrates were present in normal amounts and a moderate amount of instream cover including rootmats, overhanging vegetation, logs, and rootwads were available for aquatic organisms. The stream appeared free from channelization, as moderate sinuosity with fair development and moderate to high stability were observed.

Outside the stream channel, buffers were narrow (5-10 m) adjacent to fenced pastures and old fields, though buffers expanded in width (>50 m) adjacent to residential and forested areas. The mixture of buffer sizes, various land uses, and channel development resulted in a QHEI score of 64.0, which indicates the stream should support WWH communities.

Tributary to Vermilion River (RM 63.52)

The physical habitat of the tributary to the Vermilion River (RM 63.52) was evaluated near US 250/State Route 60 (RM 0.2). Tills composed the substrate origin, with gravel the predominant substrate type intermixed with deposits of sand and silt. Silt and embedded substrates were present in normal amounts, though instream cover was sparse and completely absent in several areas. The stream showed evidence of either recent channelization or historical channelization so severe that the stream had not recovered. No sinuosity was apparent and the channel morphological development was poor with low to moderate stability.

The poor quality apparent within the stream channel was reflective of the land use outside of the channel as no buffers were present to lessen the impacts of the surrounding high intensity agricultural and residential use. The QHEI score was 38.0, reflecting the poor habitat conditions available to aquatic life.

Tributary to Vermilion River (RM 8.29)

Located upstream of Vermilion Road (RM 0.9), the primary substrate origins of the stream were shale and tills. Gravel and bedrock were the dominant substrates present, though areas of boulder, cobble, silt and sand were also observed. Silt and embedded substrates were present in normal amounts and moderate instream cover was provided by boulders, woody debris, deep pools and shallows. No evidence of channelization was noted as moderate sinuosity and fair to good channel development with high stability were observed.

The stream channel was flanked by moderate (10-50 m) to wide (>50 m) buffers adjacent to a mixture of residential and forested areas. The QHEI for this stream segment was 63.0, indicating its ability to support a WWH community.

Tributary to Vermilion River (RM 24.35)

The physical habitat of the tributary to the Vermilion River (RM 24.35) was evaluated as it flowed under SR 303 (RM 0.2) and at Fitchville River Road (RM 5.5). The primary substrate origins for the upper reach were hardpan and sandstone. Gravel and sand were the primary substrates present in the streambed, though areas containing cobble, hardpan and silt were also noted. Silt and embedded substrates were present in moderate amounts in the upper reach, limiting the amount of interstitial spaces available for aquatic communities. Moderate amounts of instream cover present included undercut banks, overhanging vegetation, logs, and rootmats. No evidence of channelization was observed, as the channel exhibited moderate sinuosity, fair to good development and moderate to high stability. Outside the upper reach, very narrow (<5 m) to narrow (5-10 m) buffers were observed adjacent to agricultural land uses, while moderate (10-50 m) buffers were identified adjacent to residential areas.

In contrast to the upper reach, the substrate origin for the lower reach was tills. Cobble and gravel were the primary substrates present in the streambed, though sand, boulders and silt were also present. Silt and embedded substrates were recorded in normal amounts, and moderate amounts of instream cover consisted of logs, rootwads, boulders, pools, shallows and overhanging vegetation. No evidence of channelization was observed, as the channel exhibited high stability with moderate sinuosity and fair to good channel development. Outside the lower reach, the right descending bank contained wide (>50 m) buffers adjacent to forested areas and the left descending bank was flanked by narrow (5-10 m) buffers adjacent to residential homes.

For the upper reach, the combination of fair to good channel development, minimal buffers and the surrounding high intensity land use contributed to a QHEI score of 55.5, limiting its potential to support WWH communities. The lower intensity land use and higher quality buffers of the lower reach contributed to a QHEI score of 71.0, indicating that the lower reach could support high quality WWH communities, and possibly EWH communities.

Tributary to Vermilion River (RM 54.62)

The tributary to the Vermilion River (RM 54.62) was evaluated downstream of State Route 250 (RM 0.5). The primary substrate origin of the stream was tills and hardpan. Hardpan and gravel were the predominant substrate, though boulders, cobble, silt and sand were also noted. Silt and embedded substrates were present in normal amounts, while moderate amounts of instream cover consisted of woody debris, boulders, rootwads, pools, undercut banks, shallows, rootmats and overhanging vegetation. No evidence of channelization was apparent, as the stream showed high stability with moderate to high sinuosity and fair to good channel development.

Outside the stream channel, very narrow (<5 m) buffers were observed along the left descending bank adjacent to old fields, while moderate (10-50 m) buffers were observed adjacent to pastures and forest along the right descending bank. The combination of above factors resulted in a QHEI score of 67, indicating that the stream should support WWH communities.

Frankenburg Creek

The physical habitat of Frankenburg Creek was evaluated near County Line Road (RM 0.2). Tills and shale were the primary substrate origins of the stream. The predominant substrates present were cobble and gravel, though boulders, silt, and bedrock were also noted. Silt and embedded substrates were observed in normal amounts. Moderate amounts of instream cover included undercut banks, overhanging vegetation, shallows, rootmats, pools, rootwads, boulders and woody debris. No evidence of channelization was apparent, as the channel exhibited moderate to high stability, moderate sinuosity and good channel development.

Outside the stream channel, wide (>50 m) buffers extended through a forested area along the left descending bank. Moderate (10-50 m) buffers adjacent to a mixture of forested and residential areas were noted along the right descending bank. Frankenburg Creek received a QHEI score of 77.0, indicating that the stream could possibly support EWH communities.

Tributary to East Fork Vermilion River (RM 8.47)

The tributary to the East Fork of the Vermilion River (RM 8.47) was evaluated upstream of US 20 (RM 0.7). The primary substrate origins were tills and hardpan. The predominant substrates present in the streambed included gravel and hardpan, though areas of sand, cobble and silt were also noted. Silt and embedded substrates were present in normal amounts, and instream cover was provided by woody debris, rootwads, rootmats, overhanging vegetation, undercut banks and shallows. The channel appeared to have recovered from past channelization, as moderate to high stability with low to moderate sinuosity and fair channel development were observed.

Surrounding the stream channel, moderate (10-50 m) buffers flanked the stream on either side. Land use beyond the buffer on the left descending bank was a mix of conservation tillage and residential land use, while land use beyond the buffer of the right descending bank was conservation tillage. The stream received a QHEI score of 53.5, indicating that the stream may be able to support WWH communities.

Chappel Creek

The physical habitat of Chappel Creek was assessed from Wakeman Town Line Road (RM 16.6) to Mason Road (RM 1.3). Substrate origins of Chappel Creek varied and included limestone, tills, hardpan, lacustrine, shale, and sandstone. Gravel was the predominant substrate type present, though bedrock, sand, cobble, and hardpan were also noted in large amounts. All sites evaluated along Chappel Creek included 5 or more substrate types. Silt and embedded substrates were present in normal to moderate amounts throughout the stream, while instream cover was present in moderate amounts and included boulders, overhanging vegetation, aquatic macrophytes, shallows, rootwads, woody debris and rootmats. The majority of the stream showed no signs of past channelization, though the stream appeared to have recovered from past channelization between Main Road (RM 9.1) and Tharpe Road (RM 7.4). Moderate sinuosity with fair to good channel development and moderate to high stability was noted throughout Chappel Creek.

Outside the stream channel, buffer widths varied from nonexistent adjacent to agricultural areas near Wakeman (RM 16.6) and Main Road (RM 9.1) to moderate (10-50 m) adjacent to forested and residential areas near Fitchville River Road (RM 14.1) and Wakeman Road (RM 16.6), respectively. Though variability in habitat quality existed along the stream, the QHEI scores were between 58.5 and 67.5. These scores indicate that Chappel Creek is capable of supporting WWH communities.

Sugar Creek

Sugar Creek was evaluated near Darrow and Ernest Roads (RM 3.5) and Stanley Road (RM 1.5). The upper reach, near Darrow and Ernest Roads, exhibited limestone and tills as the primary substrate origin. The dominant substrate type in the upper reach was gravel, which was intermixed with sand, bedrock, silt, boulders and cobble. Silt was present in normal amounts, and embedded substrates were observed in normal to moderate amounts. Instream habitat was provided by moderate amounts of overhanging vegetation, shallows, boulders, and woody debris. No evidence of channelization was apparent, as the channel exhibited moderate sinuosity, fair to good development and high stability. The stream buffers extended in moderate amounts (10-50 m) outside the stream banks to residential areas.

The lower reach, near Stanley Road (RM 1.5), had shale as the primary substrate origin. Gravel and bedrock were the predominant substrate types, though sand, cobble and silt were also noted throughout the streambed. Silt and embedded substrates were present in normal amounts. Instream cover was provided in moderate amounts by undercut banks, shallows, rootmats, rootwads and woody debris. No evidence of channelization was apparent, as the stream showed moderate sinuosity, fair development and moderate to high stability. Outside the stream channel, narrow (5-10 m) to moderate (10-50 m) buffers extended to residential areas.

While the upper and lower reach exhibited different substrates and instream cover, the QHEI scores, 69.0 for the upper reach and 61.0 for the lower reach, indicate the ability of the stream to support WWH communities.

Old Woman Creek

Old Woman Creek was evaluated between State Route 113 (RM 9.4) and Mason Road (RM 5.4). The upper reach, near State Route 113, had substrate origins of tills and lacustrine. The predominant substrate types present were gravel and sand, though some areas of artificial substrates and silt were also observed. Silt was present in moderate amounts and the streambed exhibited moderate embeddedness, suggesting that low amounts of interstitial spaces were available for aquatic organisms. Sparse amounts of instream habitat were provided by overhanging vegetation, shallows and aquatic macrophytes. The stream appeared to be slowly recovering from recent channelization, as low sinuosity with poor to fair channel development and moderate stability were noted. Water flow through the stream was slow to moderate with no riffles. Row cropping extended to the stream banks without providing any buffers.

The lower reach, between Billamy Road (RM 8.4) and Mason Road (RM 5.4), had tills, shale, lacustrine and limestone substrate origins. The predominant substrate types included gravel, cobble and boulder, though areas of slabs, silt, sand and bedrock were also noted. Silt was present in normal amounts, though embeddedness varied from normal to moderate. Instream cover was abundant in moderate amounts and included undercut banks, overhanging vegetation, shallows, rootmats, deep pools (>70 cm), rootwads, boulders, aquatic macrophytes and woody debris. No evidence of channelization was apparent, as the stream exhibited moderate sinuosity with good development and moderate to high stability. Fast, moderate and slow currents were noted throughout the stream, as riffles of 5-10 cm depth and pools between 0.7 - 1.0 m depth provided habitat for aquatic organisms. Land use surrounding the stream included residential and agricultural row cropping, and buffers varied between very narrow (<5 m) to narrow (5-10 m).

The lack of recovery from recent channelization and high intensity land use resulted in a QHEI score of 41.0 for the upper reach. The diversity of habitat and instream cover present in the lower reach resulted in QHEI scores of 66.0 and 74.5.

Tributary to Old Woman Creek (RM 3.7)

An unnamed tributary to Old Woman Creek was evaluated near Huff Road (RM 3.1). The stream primarily originated from limestone, tills and shale. The predominant substrate types present included gravel and cobble, though areas of boulders, sand and bedrock were also observed. Silt and embedded substrates were present in normal amounts. Moderate amounts of instream cover was provided by undercut banks, overhanging vegetation, shallow, rootmats, boulders, and woody debris. No evidence of channelization was apparent as moderate sinuosity with fair to good stream development and high stability were noted.

Outside the stream channel, moderate (10 - 50 m) buffers extended to a mixture of forest and residential use on the left descending bank while row cropping and residential use extended along the right descending bank. The moderate buffers, diversified instream cover, and good stream development resulted in a QHEI score of 67.5.

Biological Assessment of the Fish Community

Vermilion River Basin

Fish sampling throughout the Vermilion basin was conducted using pulsed DC electrofishing methods as described in Biological Criteria for the Protection of Aquatic Life: Volume III, Standardized Biological Field Sampling and Laboratory Methods for Assessing Fish and Macroinvertebrate

Communities (Ohio EPA 1989c). The MIwb and IBI were used to evaluate the condition of the fish assemblage throughout the Vermilion basin.

A total of 26,103 fish, comprising 57 species and 4 hybrids, were collected throughout the Vermilion basin between July 17 and August 30, 2002. No endangered or threatened species were collected during the sampling effort, though seven intolerant species, including black redhorse, river chub, bigeye chub, silver shiner, rosyface shiner, mimic shiner, and stonecat madtom were collected. Numerically predominant fish species included bluntnose minnows (18.2%), creek chub (15.0%), and stoneroller minnow (10.9%). Species that dominated in biomass included common carp (32.5%), rock bass (10.9%), golden redhorse (8.7%) and white sucker (8.5%).

Vermilion River

The fish community of the upper Vermilion River mainstem was evaluated at 6 sites between Clear Creek Road (RM 63.0) and Fayette Road (RM 44.5). Community index and narrative evaluations ranged between very good (IBI=48) and fair (IBI=30). The fish communities sampled in the upstream sites, from Clear Creek Road (RM 63.0) to State Route 250 (RM 54.0), may be classified as fair as a result of agriculture practices and residential encroachment. Only three darter species, blackside darter, johnny darter and fantail darter, were collected in the upstream areas, whereas up to 5 species of darters, specifically blackside darter, greenside darter, rainbow darter, johnny darter and fantail darter, were collected at the downstream sites. The downstream sites had between 3-4 sunfish species collected with each pass, while the upstream sites had between 1-3 sunfish species collected per pass. The fish assemblage of the downstream section, from State Route 250 (RM 50.7) to Fayette Road (RM 44.5), may be classified as good to very good as channel sinuosity and instream cover improved.

The fish assemblage of the middle Vermilion River mainstem, between Zenobia Road (RM 33.6) and State Route 113 (RM 14.5), was sampled at 5 locations. Community indices and narrative evaluations at free-flowing sites ranged between good (IBI=41 and MIwb=8.3) and excellent (IBI=53 and MIwb=10.1). Fish populations sampled typically included 6%-19% top carnivores, including rock bass, largemouth bass, and smallmouth bass. The percentage of simple lithophils ranged between 37%-46% and included black redhorse, golden redhorse, northern hog sucker, rosyface shiner, rainbow darter, greenside darter, silver shiner, bigeye chub and blackside darter. On average, the insectivore category of the feeding guild for any middle Vermilion River mainstem site ranged between 52%-61%. The higher quality fish assemblage maintained itself here due to the more natural stream conditions present which offered diverse substrates, increased sinuosity and high quality stream cover. However, the site located upstream of Wakeman Dam (RM 23.9) scored in the fair (IBI=34) to marginally good (MIwb=7.9) range as a result of impoundment by the dam.

The fish community of the lower Vermilion River mainstem, from Dore-Orphanage Road (RM 10.7) to Vermilion Road (RM 1.4), was sampled in 3 locations. The two upstream sites received community indices and narrative evaluations between good (IBI=45 and MIwb=8.7) and excellent (IBI=51). The populations present succeeded due to the well developed stream channel and diverse instream cover. The lower site was within the lacustuary portion of the Vermilion River. Community indices and narrative evaluations developed for lacustuary sites were utilized to evaluate the lower site. The results describe the lower site at Vermilion Road (RM 1.4) as fair (IBI=32) to poor (MIwb=8.2). High percentages of exotic species (25%) and tolerant species (37%) were present in the community, so only low percentages of top carnivores (9%) and cyprinid species (2%) were present.

East Fork Vermilion River

The East Fork of the Vermilion River was sampled in 4 locations from State Route 303 (RM 10.9) to Green Road (RM 2.3). Community indices and narrative evaluations at 3 of 4 sites ranged between fair (IBI=34) and marginally good (IBI=38 and MIwb=8.0), with nutrient enrichment and siltation noted as potential causes of the lower scoring areas. Tolerant fish species comprised between 58% - 88% of the populations present between State Route 303 (RM 10.9) and Kipton Vermilion Road (RM 7.4). The fish community present near Green Circle Growers (RM 8.9) was described as poor (IBI=24) due to organic enrichment. Johnny darter was the only darter species present, and only two species of lithophils, blacknose dace and striped shiner, were collected. The presence of increased buffers likely reduced the amount of nutrients available at the Green Road (RM 2.3) site, providing a better environment for the aquatic organisms as noted in the highest IBI score (IBI=38) on the East Fork of the Vermilion River.

East Branch Vermilion River

The East Branch of the Vermilion River was sampled at three locations between Eaton Road (RM 8.6) and Townline Road (RM 1.4). Community indices and narrative evaluations of the fish communities ranged from fair (IBI=30 and MIwb=7.7) to good (IBI=42 and MIwb=8.2). The lower scores were obtained between Eaton Road (RM 8.6) and Zenobia Road (RM 2.7). Over 50% of the fish collected at these sites were tolerant (79% and 55%, respectively), and percentage of insectivores were 38% and 35%, respectively. In contrast, 63% of the fish species collected at Townline Road (RM 1.4) were insectivores. Lower scores were associated with the upper reaches where agricultural land use dominated, while the higher score was associated with lower intensity land use in the lower reach.

Indian Creek

Two sites were sampled along Indian Creek between Hartland Center (RM 3.5) and Fitchville River Road (RM 0.4). The upper reach scored within the poor range (IBI=26) while the lower reach scored within the good range (IBI=42). The low score associated with the upper reach was attributed to habitat alterations including evidence of channelization and removal of riparian buffers for residential and agricultural usage. The presence of only three species of lithophils, striped shiner, blacknose dace and white sucker at the upstream site, along with only one species of darter, the johnny darter, exemplifies the limited diversity of habitat and interstitial spaces for aquatic organisms. In contrast, six species of lithophils and three additional species of darter: rainbow darter, greenside darter and blackside darter, were collected at the downstream site. These species of darter require habitats which include relatively silt-free interstitial spaces. The habitat in the lower section could potentially support EWH communities, though drought conditions may have influenced the existing presence of a WWH fish community.

Southwest Branch Vermilion River

The Southwest Branch of the Vermilion River fish assemblage was sampled at 4 locations from Greenwich Milan Townline Road (RM 5.6) to State Route 13 (RM 1.0). Community index and narrative evaluations ranged between poor (IBI=26) and marginally good (IBI=38). Fish communities were dominated by tolerant species, which ranged in percentage from 74% to 91% of the species sampled. Siltation and organic enrichment exacerbated by narrow to non-existent buffers adjacent to agricultural land impaired the stream and its ability to support more diverse fish communities.

Buck Creek

The fish assemblage present in Buck Creek was sampled at 4 locations from State Route 511 (RM 8.2) to Township Road 1461 (RM 1.1). Community index and narrative evaluations ranged between fair (IBI=32) and marginally good (IBI=35). Species richness increased in a downstream direction, increasing from 8 species at State Route 51 (RM 8.2) to 21 species at Township Road 1461 (RM 1.1). Drought conditions present in 2002 may have influenced the fish assemblage throughout Buck Creek.

Clear Creek

The fish assemblage of Clear Creek was sampled at 2 locations between Townline Road (RM 4.0) and Township Road 1451 (RM 1.8). The community index and narrative evaluations for the two sites were poor (IBI=22) at the upstream location and very good (IBI=46) at the lower location. Drought conditions present during the summer of 2002 likely exacerbated the effects of the lower quality habitat in the upper reach, reducing the number of species able to exist in the area. Only two species, creek chub and johnny darter, were found in the upper reach. In contrast, 19 species were collected in the lower reach.

Tributary to East Branch Vermilion River (RM 8.2)

The Tributary to East Branch Vermilion River (RM 8.2) was sampled in 3 locations between where it was first crossed by Chenango Road (RM 1.1) to where Chenango Road (RM 5.8) crossed the stream a second time, south of New London Section Line Road. These sites scored from poor (IBI=20) to fair (IBI=34) on the community index and narrative evaluations. Organic enrichment from failing septic systems likely affected the number of species able to survive at the upper two sites, as strong sewage odors were noted during the sampling. The five species collected between the two sites, green sunfish, bluegill, creek chub, bluntnose minnow, and blacknose dace, are all tolerant except the bluegill, which is moderately tolerant. In contrast, eleven species were collected at the downstream site, with only 69% of the species classified as tolerant.

Tributary to Buck Creek (RM 4.92)

The Tributary to Buck Creek (RM 4.92) was sampled near Township Road 1181 (RM 0.1). The IBI score was 40, which reflected a good community. While the total number of fish for this site was low (n=26), 15 species were collected. Two of the species, greenside darter and rainbow darter, are moderately intolerant.

Tributary to Vermilion River (RM 63.52)

The fish assemblage of the Tributary to Vermilion River (RM 63.52) was sampled near US250/State Route 60 (RM 0.2). The community index and narrative evaluation depicted a marginally good (IBI=34) assemblage. The IBI score reflects the poor habitat present, which was caused by channelization. Pioneering species comprised 85% of the population and overlap occurred with the tolerant species, which comprised 58% of the population.

Tributary to Vermilion River (RM 8.29)

The fish assemblage of the Tributary to Vermilion River (RM 8.29) was sampled near Vermilion Road (RM 0.9). The community index and narrative evaluation depicted a good (IBI=40) assemblage. The diversity of substrates and natural stream conditions provided a suitable habitat for a WWH community. Twelve species were collected at the site, including the rainbow darter, which is a moderately intolerant species.

Tributary to Vermilion River (RM 24.35)

Two sampling locations were chosen along the Tributary to the Vermilion River (RM 24.35) between State Route 303 (RM 0.2) and Fitchville River Road (RM 5.5). The fish community sampled at the upstream location was described as poor (IBI=24), while the downstream site was described as marginally good (IBI=36). Ten species were collected at the upstream site, of which 34% were omnivores. However, only 12% of the 16 species collected at the downstream site were omnivores. The high intensity agricultural use adjacent to the upstream site likely contributed to the poor diversity present.

Tributary to Vermilion River (RM 54.62)

The fish assemblage of the Tributary to the Vermilion River (RM 54.62) was sampled downstream of State Route 250 (RM 0.5). The community index and narrative evaluation for the fish community indicated a fair (IBI=34) assemblage. Though only one sensitive species, the rainbow darter, was collected, five species of simple lithophils were also collected. The drought conditions in 2002 likely affected the streams ability to sustain a larger, more diverse fish community.

Frankenburg Creek

The fish assemblage of Frankenburg Creek was sampled near County Line Road (RM 0.2). The community index and narrative evaluation for the fish community was very good (IBI=46). A total of 14 species were collected, depicting a well-balanced and diverse community.

Tributary to East Fork Vermilion River (RM 8.47)

The fish assemblage of the Tributary to the East Fork of the Vermilion River (RM 8.47) was evaluated upstream of US 20 (RM 0.7). The community index and narrative evaluation for the fish community was determined to be fair (IBI=32). Potential nutrient enrichment from Green Circle Growers likely contributed to the borderline WWH community observed in the stream.

Skellinger Creek

Fish sampling in Skellinger Creek occurred near Fayette Road (RM 0.8). The community index and narrative evaluation for the fish community indicated a poor (IBI=20) fish assemblage. Organic enrichment from a municipal point source combined with the lack of a riparian buffer likely contributed to the poor fish assemblage present.

Chappel Creek

The fish communities of Chappel Creek were sampled in 5 locations from Mason Road (RM 1.3) to Wakeman Town Line Road (RM 16.6). The cumulative index and narrative evaluations ranged between poor (IBI=18) and very good (IBI=49). The quality of habitat available throughout Chappel Creek would seem to indicate that higher quality, more diverse fish assemblages should be possible similar to the on collected at Wakeman Town Line Road (RM 16.6). It is likely that the drought conditions affected the ability of the stream to support higher quality fish assemblages.

Sugar Creek

The fish assemblage of Sugar Creek was sampled near Stanley Road (RM 1.5) and near Darrow and Ernest Roads (RM 3.5). The cumulative index and narrative evaluations were fair (IBI=32) at the upstream site and marginally good (IBI=36) at the downstream location. The quality of habitat available throughout Sugar Creek would indicate that higher quality, more diverse fish assemblages should be possible. It is likely that the drought conditions affected the ability of the stream to support higher quality fish assemblages.

Old Woman Creek

The fish assemblage of Old Woman Creek was sampled at three locations between State Route 113 (RM 9.4) and Mason Road (RM 5.4). The community index and narrative evaluations indicated fish assemblages in the fair (IBI=32) to good (IBI=38) range. A total of nine species were collected at each site. Only one species of darter, the rainbow darter, was collected at each site. However, the percent of tolerant fish species ranged from 14% - 48%, and pioneering fish species made up between

9% - 29% of the total population at each site. It is likely that drought conditions may have affected the ability of the stream to support higher quality fish assemblages.

Tributary to Old Woman Creek (RM 3.7)

An unnamed tributary to Old Woman Creek was evaluated near Huff Road (RM 3.1). Seven species including white sucker, fathead minnow, creek chub, stone roller minnow, bluegill, green sunfish, blackside dace, and rainbow trout were collected. The individual rainbow trout that was collected indicated a natural reproducing population in the area, as it was in a younger life stage known as a Parr. Tolerant species comprised 53% of the population, though only 4% of the species were omnivores.

Biological Assessment of the Macroinvertebrate Community

Vermilion River Mainstem

The principal method used to sample macroinvertebrates at Vermilion River mainstem sites was a set of five artificial substrates. A qualitative sampling of the available habitats at each site was also conducted. The resultant collection of taxa in the qualitative sample was used in conjunction with the artificial substrate results to generate the Invertebrate Community Index (ICI) score. The qualitative sampling technique was used alone at sites where a lack of requisite flow and depth precluded a valid artificial substrate sample or where the artificial substrates had been moved or lost due to high water or vandalism. Sampling results are summarized in Table 19.

Macroinvertebrate sampling was conducted at 14 free-flowing sites on the Vermilion River mainstem. An additional three sites were located in the lacustuary (flooded Lake Erie river mouth) portion of the river.

The three uppermost sites on the Vermilion River, RMs 63.8, 63.0 and 62.0, reflected an improving trend in the condition of the macroinvertebrate community with increasing drainage area (Figure 36). The total taxa diversity and number of relatively sensitive Ephemeroptera, Plecoptera and Trichoptera (EPT) taxa increased, from 27 total taxa and one EPT at RM 63.8 to 48 total taxa and 8 EPT at RM 62.0. The macroinvertebrate community was in poor condition at RM 63.8, fair condition at RM 63.0 and was considered marginally good at RM 62.0. The upper two sites were apparently impacted by high nutrients and low diel D.O. levels in combination with limited flow and habitat modification. The site at RM 62.0 was also subject to low flow conditions and had significant bank erosion. Nevertheless, significantly less enrichment and a moderation of D.O levels was evidenced by the improved macroinvertebrate community compared with results from the upstream sites.

Macroinvertebrates were sampled at an additional eleven sites in the lotic portion of the mainstem between U.S. Rt. 224 (RM 56.2) and downstream from North Ridge Rd. (RM 6.4). Only three of the sites did not fully meet WWH expectations. These included RM 50.6 (SR 250), in the Wakeman Dam pool (RM 23.9) and RM 14.5 (adjacent Schoepfle Garden). The macroinvertebrate community at RM 50.6 was limited by low stream gradient and the subsequent lack of habitats with at least moderate current velocity. Qualitative sampling produced 40 taxa including eight EPT taxa and was considered of sufficient quality to rate the community as marginally meeting the WWH aquatic life use.

Sampling at RM 23.9 produced a low diversity macroinvertebrate fauna that was reflective of the impounded stream habitat. The macroinvertebrate community was in fair condition and was primarily affected by limited habitat. Run of river dams function as sinks for sediment, nutrients and contaminants and the lentic environment fosters algal production. Consequently, attainment of the designated WWH use is often severely hampered. If the societal justification for continuing to maintain the Wakeman Dam is adequate, a Modified Warmwater Habitat (MWH) aquatic life use may be warranted for the affected reach of the Vermilion River.

The site at RM 14.5 was in a stream reach that should have supported a similar high diversity of taxa as was found at sites upstream and downstream. However, the ICI declined from 50 (exceptional) at RM 22.5 to 32 (marginally good) at RM 14.5 and the EPT diversity decreased from 20 to seven, respectively. Significantly more silt and a flocculent brown material was noted in pooled areas and the community reflected a somewhat more enriched condition. The reason for such an abrupt change in the community was not readily apparent. This is a site where additional monitoring would be useful to identify causes for the shift toward a more pollution tolerant community.

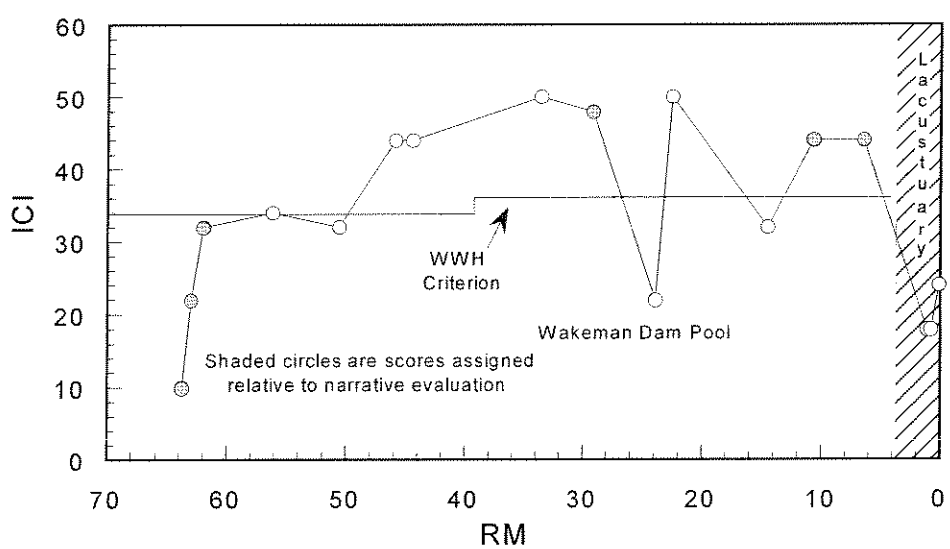

Figure 36. Longitudinal trend of the Invertebrate Community Index (ICI) in the Vermilion River, 2002. Reported scores in the lacustuary are calculated using the Lacustuary Invertebrate Community Index methodology.

With exception of the sites discussed above that were in fair to marginally good condition, the remaining lotic sites supported good to exceptional macroinvertebrate communities. A diversity of habitats, a largely wooded corridor and absence of significant point sources were significant positive attributes in the occurrence of a healthy benthic fauna. The results also demonstrated that nutrients entering from the surrounding watershed were being assimilated. The three lacustarine Vermilion River sites supported a limited macroinvertebrate fauna. The sites at RMs 1.1 and 0.8 were upstream and downstream from the Vermilion WWTP, respectively. Heavy siltation was noted at both sites and similar silt tolerant communities, predominated by midges and aquatic worms, were present. No impact was apparent associated with the Vermilion WWTP. The site nearest the mouth (RM 0.1) was sampled along a break wall constructed of large stone blocks. Qualitative sampling was difficult and yielded only 12 taxa. Quantitative sampling produced similar low diversity and community structure at all three sites. One exception was the increased number of zebra mussel present at RM 0.1 owing to the hard substrate at the site. The Lacustuary ICI (LICI) score was generated to aid in evaluating these sites and the scores are noted in Table 19. All three scores were in the poor range but this result is not unexpected given the altered habitat and siltation common to most lake affected river mouths in Ohio. Sampling conducted at RM 0.8 in 1993 produced an LICI score similar to the 2002 result. The LICI result from RM 0.1 was in the good range in 1993. The differing results probably do not reflect a large decline in community health related to pollution. Due to close proximity to the open lake, temporal variability in the macroinvertebrate community is likely a reflection of the dynamic environment involving the mixing of river and lake waters and periodic scouring.

Vermilion River Tributaries: Headwaters to upstream East Branch

Qualitative macroinvertebrate sampling was conducted at fifteen locations on the network of streams that flow into the Vermilion River upstream from the confluence of the East Branch Vermilion River. Seven of the fifteen sites supported marginally good to good macroinvertebrate communities. Eight sites produced assemblages reflective of a fair resource condition. Impacts were related to the agricultural activities within the drainage areas of the sampled streams. Sedimentation was a widespread impact and nutrients appeared to be excessive at several sites.

The unnamed tributary confluent with the Vermilion River at RM 63.52 was a small grass-lined ditch. The macroinvertebrate community was in fair condition. Masses of filamentous algae were present, the growth of which is promoted by elevated nutrients and abundant sunlight. A predominance of facultative to tolerant organisms also suggested high nutrients.

The macroinvertebrate community in Clear Creek at RM 2.1 was in marginally good condition. Flow in the stream was intermittent or interstitial between occasional deep pools. Only twenty taxa were collected. Low flow and habitat impacts associated with cattle access likely restricted the development of a more diverse community.

The unnamed tributary confluent with Buck Creek at RM 4.92 supported a low density community of macroinvertebrates that marginally met WWH expectations. Some siltation was noted. The stream morphology and habitat were relatively intact but drainage to facilitate agriculture may have contributed to the nearly interstitial conditions that were encountered.

Buck Creek was sampled at three locations. The stream bottom at the upstream site (RM 8.1) was coated with a layer of black organic muck and silt. Algae proliferated in areas with an open canopy and the stream was nearly intermittent. The macroinvertebrates collected were indicative of degraded water quality but the occurrence of burrowing mayflies indicated that overnight dissolved oxygen levels were maintained above an acute level. The results of the sampling were reflective of a fair macroinvertebrate condition. Both of the sites at RMs 3.2 and 1.0 supported good macroinvertebrate assemblages including 9 and 8 EPT taxa, respectively. Attainment of WWH expectations was aided by a relatively undisturbed habitat condition even though surface flow was limited.

Both of the unnamed tributaries to the Southwest Branch of the Vermilion River (confluent at RM 5.35 and RM 2.3) were small streams with less than five miles of drainage area. The first tributary was intermittent with low taxa diversity and a predominance of facultative taxa. It appeared that tile drainage may have contributed to the lack of flow at the site and the subsequent fair macroinvertebrate condition that resulted. The second unnamed tributary had a series of pool, riffles and runs. A relatively diverse macroinvertebrate assemblage was collected, however, facultative taxa predominated. The results were indicative of significant enrichment resulting from agricultural activity in the watershed, and, overall, a fair community condition.

The Southwest Branch of the Vermilion River was sampled at four locations. The two upper sites (RMs 5.6 and 3.9) supported fair macroinvertebrate communities. The upstream site consisted of a series of pools with minimal interstitial flow. Sedimentation and the lack of surface flow limited the diversity of macroinvertebrates (26 taxa collected). The RM 3.9 site was in an open pasture with direct access by livestock. As a result, the stream was organically enriched and had eroded banks. The diversity of taxa collected was significantly higher than the upstream site but facultative and tolerant taxa predominated and only three EPT taxa were collected. It appeared likely that a wide fluctuation in dissolved oxygen was occurring as evidenced by the absence of sensitive taxa from pooled habitats. Condition of the macroinvertebrate communities at the lower two sites (RMs 2.5 and 1.0) was improved compared to upstream. Seven EPT taxa were collected at RM 2.5 and six EPT taxa were collected at RM 1.0; qualitative sampling results marginally met WWH expectations. Both sites had been historically channelized, had little surface flow and had significant sediment and silt deposits all of which can negatively impact benthic communities.

Both sampling locations on Indian Creek produced benthic assemblages reflective of a fair quality community condition. The upstream site (RM 3.5) was channelized and appeared moderately enriched. The habitat at the RM 0.4 site was improved compared to RM 3.5 but the site lacked significant surface flow. A slumped stream bank suggested the watercourse was subject to high stream flows and fine substrates predominated. Theses are all indications that the natural hydrology of the stream had been altered as a result of agricultural activities in the watershed.

The unnamed tributary to the Vermilion River confluent at RM 32.98 was nearly intermittent but had relatively good riparian and substrate characteristics. Thirty-five taxa were collected including 8 EPT taxa. The macroinvertebrate community was in good condition, however, an elevated density of tolerant species suggested nutrient enrichment was having an effect on the stream.

Vermilion River Tributaries: East Branch Vermilion River to mouth

Qualitative macroinvertebrate sampling was conducted at fifteen locations in the East Branch Vermilion River watershed and tributaries to the Vermilion River downstream from the confluence of the East Branch. Six of the fifteen sites supported good to very good macroinvertebrate communities; four sites marginally met WWH expectations; three sites produced assemblages reflective of fair resource condition; and three sites , two on the East Fork Vermilion River and one site on an unnamed tributary to the East Fork, had very poor macroinvertebrate assemblages.

Skellinger Creek was historically channelized but had relatively good pool/riffle/run development and coarse substrates. One factor that restricted development of a typical WWH macroinvertebrate fauna was heavy siltation in areas that did not have strong current. As a result, overall diversity and density were low in pool and run habitats. Sampling yielded 21 taxa including four EPT taxa and reflected fair community conditions.

The upper site on the East Branch Vermilion River (RM 8.3) was impacted by sedimentation. Open pastures upstream and downstream from the sampled location had eroded banks and heavy sedimentation in the stream limited the macroinvertebrate diversity. Twenty-five taxa were collected and the community was considered in fair condition. Both habitat and community condition were improved at the two lower sites on the East Branch. Forty-seven and 54 taxa were collected from RM 3.6 and 1.4, respectively, and diverse EPT assemblages were present.

The unnamed tributary confluent with the Vermilion River at RM 24.35 was a small intermittent stream. Habitat impacts and enrichment related to agriculture in the watershed limited the macroinvertebrate community at RM 5.5. A low diversity of taxa were collected including two EPT taxa. This site reflected a fair community condition that was typical of several other small streams in the study area. The macroinvertebrate community, while not reflective of severely polluted conditions, was impacted by limited flow, habitat alteration and moderate to high enrichment. An improved macroinvertebrate sampling result at RM 0.2 reflected better habitat, flow and riparian conditions at the site. Relatively pollution sensitive taxa were well represented among the taxa collected and the community was in good condition.

The unnamed tributary to the East Fork Vermilion River at RM 8.47 was severely polluted. Sampling at RM 0.7 yielded seventeen taxa. It appeared that the stream was overwhelmed with organic material and a high oxygen demand. Livestock appeared to be one source of the degradation, though wastewater from Green Circle Growers may also have contributed to the degradation. No discharge was observed but, given its close proximity to the stream and based on the number of unpermitted discharges associated with the greenhouses into the East Fork, Green Circle Growers is a likely additional source of impairment.

The East Fork Vermilion River was sampled at four locations. The uppermost site (RM 10.9) was channelized and had slow current; as a result, sedimentation and siltation affected the macroinvertebrate community. Nevertheless, fifty taxa were collected including 8 EPT taxa. The community was considered to be in marginally good condition. Green Circle Growers operates a large greenhouse facility adjacent to the East Fork. Water was pumped from the stream and used in greenhouses. Wastewater was then released back into the stream. The macroinvertebrate sampling site at RM 9.1 (at St. Rt. 511) was in the immediate vicinity of two of these discharges. A severe impact apparently due to both high nutrients and toxicity was evident in the assemblage of macroinvertebrates collected at RM 9.1 and RM 7.4, downstream from the village of Kipton. Twelve pollution tolerant taxa were collected at RM 9.1 and the community was predominated by lunged snails (*Physella* sp.). Fourteen taxa were collected at RM 7.4. No EPT taxa were recorded at either site. The macroinvertebrate community demonstrated significant recovery at RM 2.3 but the high relative number of blackflies (*Simulium* sp.) was evidence of a lingering impact. In addition, the site had excellent in-stream habitat and riparian features and should have yielded more than the 7 EPT taxa collected. The macroinvertebrate community at RM 2.3 was considered marginally good and consistent with WWH expectations.

Sampling of the unnamed tributary confluent with the Vermilion River at RM 12.0 produced 36 macroinvertebrate taxa in low density at RM 1.5. The stream did not appear to be enriched and the community appeared to be in marginally good condition.

The unnamed tributary confluent with the Vermilion River at RM 8.29 produced 28 macroinvertebrate taxa in low density at both RMs 2.0 and 0.9. Neither site appeared to be enriched, rather, low stream flow and a predominance of bedrock restricted the number of organisms collected. The macroinvertebrate assemblage reflected a marginally good resource condition at RM 2.0 and was in good condition at RM 0.9.

Lake Erie Tributaries: East of Huron River to West of Vermilion River

Chappel Creek was sampled at RMs 7.4 and 1.1. The upstream site appeared to be historically channelized and the macroinvertebrate community was in fair condition . Drought conditions exacerbated the effects of silt and sand deposition which limited the macroinvertebrate community and allowed facultative taxa to predominate. Attention to habitatimprovements would likely benefit biological communities in this reach of Chappel Creek. The site at RM 1.1 had much improved habitat features compared with the upstream site. Elevated numbers of blackflies suggested that the site was affected by nutrient enrichment. The collection of 13 EPT taxa indicated that, while enriched, the stream biota was not subjected to low dissolved oxygen levels and that nutrients were being assimilated. The macroinvertebrate community was rated in good condition.

Old Woman Creek

Macroinvertebrate communities were evaluated at 10 stations in the Old Woman Creek basin during 2001 (Table 20). The stations located in the headwaters (< 10 sq mi drainage area) were limited by interstitial to intermittent stream flows. Macroinvertebrate communities sampled at these stations were not meeting aquatic life use expectations. Low EPT diversity (0-5), low number of sensitive taxa (0-5) and predominance of pollution facultative and tolerant taxa were indications of impaired communities. In addition to lack of flow, channelization, siltation, and black sediments observed at Old Woman Creek RMs 11.3, 9.4 and an unnamed tributary to Old Woman Creek (RM 8.82) RM 0.9 were apparent contributing causes to the impairment. Agricultural activities and possibly failing septic systems were the likely sources of impairment at these stations.

Two stations on the free-flowing portion of Old Woman Creek had adequate flow to support macroinvertebrate communities meeting or marginally meeting aquatic life use expectations (RMs 5.2 and 3.6). Improved diversity of EPT (11, 9) and sensitive taxa (12, 16) along with increased predominance of sensitive organisms were indications of improved resource quality at these stations. However, siltation and low flow continued to negatively affect the community performance at these stations.

Two stations were located within the Lake Erie backwaters, otherwise referred to as the lacustuary. The macroinvertebrate communities continued to perform at a level below lacustuary expectations. The communities were predominated by oligochaete worms and the tolerant midges taxa *Glyptotendipes* and *Dicrotendipes simpsoni*. EPT diversity was relatively low with 4 and 1 taxa collected from RMs 1.9 and 0.2, respectively. Siltation and possible nutrient enrichment were considered the primary causes of impairment. Sampling conducted in 1993 at RMs 0.7 and 0.2 provided similar results with low EPT diversity (1 and 0, respectively) and LICI scores of 8 (very poor) at each station.

Table 19. Summary of macroinvertebrate data collected from artificial substrates (quantitative sampling) and natural substrates (qualitative sampling) in the Vermilion River basin, July - August, 2002.

Stream River Mile	Orgs /ft^2	Qual Taxa	Quant Taxa	Qual. EPT [a]	Predominant Organisms	ICI	Narrative Evaluation [b]
Vermilion River							
63.8	-	27	-	1	Water boatmen, midges	-	Poor
63.0	-	36	-	4	Hydropsychid caddis, corixids, snails	-	Fair
62.0	-	48	-	8	Hydropsychid caddis, caenid mayflies, midges	-	Mar. Good
56.2	220	49	44	10	fingernail clams, river snails, mayflies	34	Good
50.6	141	47	40	8	River snails, midges fingernail clams	28 [c]	Mar. Good
45.9	1006	43	49	13	Midges, river snails, fingernail clams	36 [c]	Very Good
44.5	473	58	57	17	Midges, fingernail clams, river snails	44	Very Good
33.6	1974	54	48	19	Mayflies, midges	50	Exceptional
29.2	-	72	-	18	Midges, river snails, riffle beetles	-	Exceptional
23.9	384	30	40	4	Midges	22	Fair
22.5	761	55	49	20	Mayflies, midges	50	Exceptional
14.5	1024	35	40	7	Caddisflies, midges, fingernail clams, flatworms	32 [ns]	Mar. Good
10.7	-	49	-	15	Caddisflies, flatworms, riffle beetles	-	Very good
6.4	-	46	-	14	Caddisflies, flatworms, riffle beetles	-	Very Good
1.1	1754	33	26	3	Midges, aquatic worms	18	Poor
0.8	1700	24	26	1	Midges, aquatic worms	18	Poor
0.1	3019	12	29	1	Zebra mussels, midges, aquatic worms	24	Poor
Trib. to Vermilion River at RM 63.52							
0.3	-	42	-	7	Lunged snails, mayflies, midges	-	Fair
Clear Creek							
2.1	-	20	-	6	Midges	-	Mar. Good
Trib. to Buck Creek at RM 4.92							
0.1	-	34	-	6	Riffle beetles, Hydropsychid caddis, midges	-	Mar. Good

Stream River Mile	Orgs /ft^2	Qual Taxa	Quant Taxa	Qual. EPT [a]	Predominant Organisms	ICI	Narrative Evaluation [b]
Buck Creek							
8.1	-	22	-	3	Fingernail clams	-	Fair
3.2	-	43	-	9	Hydropsychid caddis, riffle beetles, midges	-	Good
1.0	-	27	-	8	Midges, water pennies, mayflies	-	Good
Trib. to Southwest Branch Vermilion River at RM 5.35							
0.6	-	20	-	2	Midges	-	Fair
Trib. to Southwest Branch Vermilion River at RM 2.30							
0.7	-	37	-	4	Midges, fingernail clams	-	Fair
Southwest Branch Vermilion River							
5.6	-	26	-	4	Midges	-	Fair
3.9	-	43	-	3	Midges	-	Fair
2.5	-	27	-	7	Midges	-	Mar. Good
1.0		44		6	Midges, scuds		Mar. good
Indian Creek							
3.5	-	25	-	5	Midges	-	Fair
0.4	-	32	-	4	Midges	-	Fair
Trib. to Vermilion River at RM 32.98							
1.0	-	35	-	8	Fingernail clams	-	Good
Skellinger Creek							
1.0	-	21	-	4	Midges, riffle beetles	-	Fair
East Branch Vermilion River							
8.3	-	25	-	4	Midges, hydropsychid caddis	-	Fair
3.6	409	47	36	12	Midges	34	Good
1.4	-	54	-	16	Midges, mayflies, caddisflies	-	Very Good
Trib. to Vermilion River at RM 24.35							
5.5	-	16	-	2	Midges	-	Fair
0.2	-	26	-	9	Water pennies, midges	-	Good

Stream River Mile	Orgs /ft^2	Qual Taxa	Quant Taxa	Qual. EPT [a]	Predominant Organisms	ICI	Narrative Evaluation [b]
Trib. to East Fork. Vermilion River at RM 8.47							
0.7	-	17	-	0	Midges	-	Very poor
Frankenburg Creek							
0.2	-	38	-	7	Hydropsychid caddis, midges	-	Good
East Fork Vermilion River							
10.9	-	50	-	8	Midges, hydropsychid caddis,	-	Mar. good
9.1	-	12	-	0	Lunged snails	-	Very Poor
7.4	-	14	-	0	Midges, freshwater sponge, flatworms	-	Very Poor
2.3	-	39	-	7	Midges, blackflies	-	Mar. Good
Trib. to Vermilion River at RM 12.10							
1.5	-	36	-	4	Riffle beetles	-	Mar. Good
Trib. to Vermilion River at RM 8.29							
2.0	-	28	-	6	Riffle beetles, flatworms	-	Mar. Good
0.9	-	28	-	9	Caddisflies, beetles	-	Good
Chappel Creek							
7.4	-	45	-	5	Fingernail clams	-	Fair
1.1	-	46	-	13	Midges	-	Good

a - EPT=total Ephemeroptera (mayflies), Plecoptera (stoneflies), & Trichoptera (caddisflies) taxa richness.

b - Qualitative narrative evaluation is based on best professional judgment utilizing sample attributes such as taxa richness, EPT richness, and QCTV score and is used when quantitative data are not available to calculate an Invertebrate Community Index (ICI) score.

c - Qualitative assessment used in lieu of quantitative score due to lack of flow and/or vandalism of artificial substrates.

* - Significant departure from ecoregion biocriterion (>4 ICI units); poor and very poor results are underlined.

ns - Nonsignificant departure from ecoregion biocriterion ($\leq$4 ICI units).

Table 20. Summary of macroinvertebrate data collected from artificial substrates (quantitative sampling) and natural substrates (qualitative sampling) in the Old Woman Creek study area, July to August, 2001.

Stream RM	Dr. Area sq. mi.	Data Codes	Qual. Taxa	Qual. EPT	Sensitive Taxa	Relative Density	Predominant Organisms With Tolerance Category(ies) in Parentheses	ICI/ LICI	Narrative Evaluation
Old Woman Creek (12-005)									
11.3	~2.4	8,9	29	2	1	Low	Snails (F,T), midges (T, F), fingernail clams (F)	-	Poor
9.4	3.4	8,9	39	4	5	Mod.	Red midges (T), snails (T,F), water penny beetles (MI)	-	Low Fair
8.4	7.8	8,9	22	2	3	Low	Other beetles (F), snails (T), crayfish (F)	-	Poor
5.2	~12	-	39	11	12	Mod.	Beetles (MI,F), Caddisflies (F,MI), midges (MI)	-	Good
3.6	~21.1	-	47	9	16	L-M	Midges (MI), water penny beetles (MI), mayflies (F,I)	-	Marg. Good
1.9[L]	29.9	8,11	40	2	3	L-M	Water boatmen (F), red midges (F,MT), sow bugs (MT)	16*	
0.2[L]	30.3	8,11	29	1	0	L-M	Midges (MT,T), water boatmen (F)	-	Poor
Tributary to Old Woman Creek (RM 8.82) (12-016)									
0.9	1.8	8,9	20	0	0	-	Snails (T,F), water boatmen (F), beetles (F)	-	Very Poor
Tributary to Old Woman Creek (RM 3.70) (12-015)									
4.9	3.0	8,9	24	5	5	L-M	Mosquitos (VT,F), beetles (F), water boatmen (F)	-	Low Fair
0.9	6.3	8,9	20	2	4	L-M	Water boatmen (F), snails (T)	-	Poor

Data Codes: 8=Non-Detectable Current, 9=Intermittent or Near-Intermittent Conditions, 11=Lake Erie Influence (Lacustuaries)

Sensitive Taxa: Total taxa listed on the Ohio EPA Macroinvertebrate Taxa List as Tolerance Categories MI or I.

Tolerance Categories: VT=Very Tolerant, T=Tolerant, MT=Moderately Tolerant, F=Facultative, MI=Moderately Intolerant, I=Intolerant

[L]: This station is located in the lacustuary. Lacustuary ICI (LICI): Intermediate LICI goal=34, Final LICI goal=42

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