Quality Assurance Project Plan
for
Little Cicero Creek Watershed Management Plan
in
Hamilton and Tipton Counties, Indiana

A305-4-140

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Prepared for:

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Section 1: Study Description

Historical Information

The Little Cicero Creek watershed includes all of the land that drains to Little Cicero Creek. The Little Cicero Creek watershed encompasses all of two 14-digit watersheds including the Little Cicero Creek-Bennett Ditch/Taylor Creek (HUC 05120201080080) and Little Cicero Creek-Teter Branch (HUC 05120201080090) watersheds within the larger Upper White River basin (HUC 05120201). The watershed includes nearly 26,775 acres or 41.8 square miles of Hamilton and Tipton Counties (Figure 1). Drainage from the watershed includes the towns of Sheridan, Atlanta, and Arcadia. Water drains from Little Cicero Creek into Morse Reservoir, a major drinking water supply for Hamilton and Marion County residents. Water flows from Morse Reservoir to the West Fork White River, which eventually combines with the Wabash River in southwest Indiana.

State and local agencies have conducted a limited number of water quality assessments that focus on water bodies in the Little Cicero Creek watershed. These studies indicate that water quality is moderately poor throughout the watershed. The Indiana Department of Environmental Management sampled Little Cicero Creek at 266th Street on numerous occasions from 1992 to 2004. In general, nutrient concentrations were typical of levels observed throughout Indiana. However, *E. coli* concentrations exceeded the state standard during the 2004 assessment. Additionally, sampling of the aquatic biota within the watershed indicated that the streams were only partially supporting for their aquatic life use designation (IDEM, 2004). For these reasons, Little Cicero Creek is listed on the 2004 list of impaired waterbodies for *E. coli* and impaired biotic communities.

Additional reasons for completing a watershed management plan for the Little Cicero Creek watershed are that the stream drains one of the remaining rural areas of Hamilton County and because the county's population increased by 58% from 1990 to 1999. Pro-active planning on the part of Hamilton County should help to prevent the decline in water quality typically associated with sharp increases in community growth and development. Furthermore, planned growth will hopefully minimize the impact of development in the Little Cicero Creek watershed to the stream and its water quality. To this end, the Hamilton County Surveyor's office, along with watershed stakeholders, will develop a watershed management plan for Little Cicero Creek and its watershed. Once completed, the plan will help prevent further ecological degradation of the watershed and guide future watershed management efforts to ensure the area's ecological health.

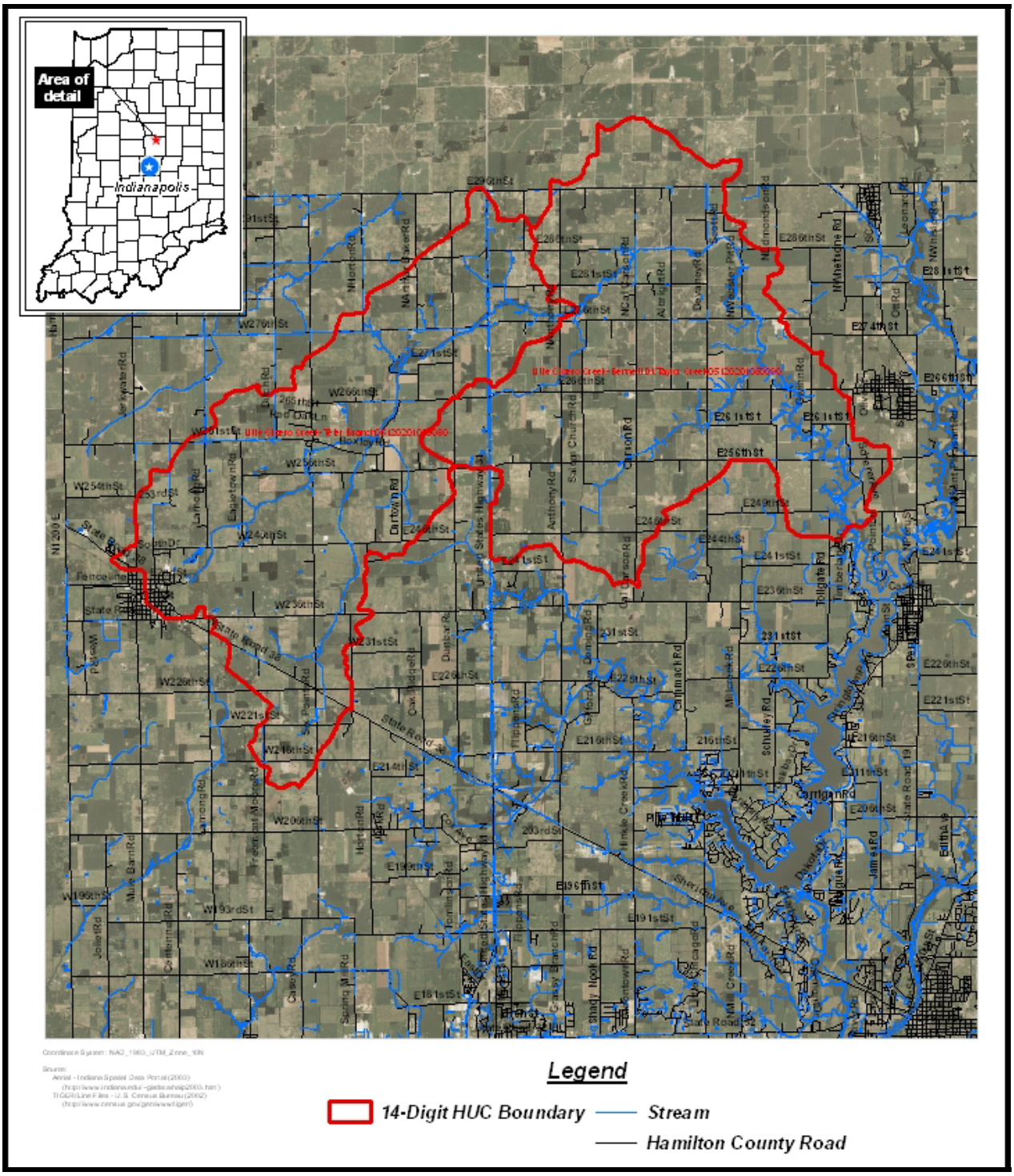


Figure 1. 14-Digit watersheds within the Little Cicero Creek Watershed.

Study Goals

The goal of the sampling/water quality collection portion of this study is to determine the quality of water in the major tributaries to Little Cicero Creek and Little Cicero Creek itself. Chemical and physical conditions of the selected streams will be documented. The collection of this data

will allow for the identification of problem areas, characterization of the watershed, and implementation of broad management decision making for the development of a watershed management plan for the Little Cicero Creek watershed. This information will be supplemented with historical data documenting the conditions of the watershed such as land use, soils, and cultural resources and stakeholder concerns and issues discussed through watershed meetings. Data collected during this sampling will be combined with previously collected data to determine changes in the watershed and will serve as baseline data for the tracking of water quality improvement success.

In summary, the goal of the sampling/water quality collection portion of this study is to determine the quality of water in the major streams in the Little Cicero Creek watershed. This goal will be achieved with the following actions:

Action 1: Field and laboratory water chemistry data collection at each of the eight sites will include dissolved oxygen, temperature, pH, total dissolved solids, nitrate+nitrite, ammonia, total Kjeldahl nitrogen, total organic nitrogen, dissolved phosphorus, total phosphorus, turbidity, total suspended solids, biological oxygen demand (BOD), chemical oxygen demand (COD), fecal coliform, and *E. coli*.

Action 2: Collect discharge measurements at each sampling site for each of the four sampling events to use in the calculation of pollutant loading.

Action 3: Conduct habitat assessment at each of the eight sample sites to assess physical stream conditions.

Action 4: Analyze chemical and physical data to allow for comparison with historical data and to provide baseline water quality information.

Action 5: Use chemical and physical data to evaluate and rank priority areas in the watershed and to develop recommendations for appropriate Best Management Practices to improve watershed water quality.

To achieve the goal of evaluating and ranking priority areas within the watershed, standardized data collection methodology and analysis will be used for each of the sampling stations. Consistencies in methodology will ensure sampling stations can be compared to one another, enabling the Technical Project Manager to determine which sites are most degraded relative to others in the watershed. Methodologies will follow those established and accepted by the scientific community and regulatory agencies (Indiana Department of Environmental Management (IDEM), Ohio Environmental Protection Agency (Ohio EPA), and U.S. Environmental Protection Agency (USEPA)). For example, habitat will be analyzed using a protocol developed by the Ohio EPA. Habitat data will be analyzed using Ohio EPA's Qualitative Habitat Evaluation Index (QHEI). This index is also used by the IDEM throughout the state to assess Indiana's stream habitat. Standardized methodology and analysis will also allow comparisons to be made to past studies within and outside of the Little Cicero Creek watershed that have used these methodologies.

Study Site

The project site is the Little Cicero Creek watershed encompassing approximately 41.8 square miles in northern Hamilton and southern Tipton Counties, Indiana. Because the project's goal is to document the ecological conditions in the Little Cicero Creek watershed, the study will

examine and/or identify the following parameters: 1.Water chemistry (dissolved oxygen, temperature, pH, total dissolved solids, nitrate+nitrite, ammonia, total Kjeldahl nitrogen, total organic nitrogen, dissolved phosphorus, total phosphorus, turbidity, total suspended solids, biological oxygen demand (BOD), chemical oxygen demand (COD), fecal coliform, and *E. coli*) and 2. Riparian/stream habitat quality in the watershed.

Sampling Design

All parameters (water chemistry and habitat) will be collected and analyzed at each of the eight sample sites. Sample sites were selected to achieve an accurate representation of the variety of stream habitat types found within the watershed. Preliminary site selection was based on map analysis. The map analysis consisted of locating tributaries with relatively large watersheds and accessible sampling points (road crossings). This approach was also taken in an attempt to have sampling stations that may be able to indicate which subwatersheds are contributing the most pollutants to the Little Cicero Creek watershed. The sampling stations selected based on this map analysis were then field checked by the Project Manager for confirmation of site accessibility and appropriateness for the physical assessment protocol (QHEI). Following the field inspection, eight sampling stations were selected for water chemistry and habitat assessment. Approximate locations of these sites are shown in Figure 2 and will be georeferenced during the course of the study. Appendix A provides additional details on the site locations. Landowners at these sampling stations will be contacted to obtain permission to conduct sampling in those areas. Should permission be denied, acceptable substitute stations will be selected using the same criteria outlined above. Any changes in sampling locations will be submitted as an addendum to this QAPP.

JFNew will collect baseline stream water chemistry data at eight sites within the Little Cicero Creek watershed (Figure 2). Specifics detailing sample site selection are included in Section 3. Details about each sample site including location and stream name is included in Appendix A. Water chemistry parameters to be sampled include dissolved oxygen, temperature, pH, total dissolved solids, nitrate+nitrite, ammonia, total Kjeldahl nitrogen, total organic nitrogen, dissolved phosphorus, total phosphorus, turbidity, total suspended solids, biological oxygen demand (BOD), chemical oxygen demand (COD), fecal coliform, and *E. coli*. Dissolved oxygen, temperature, pH, and total dissolved solids will be analyzed *in situ* with field equipment. Discharge will be measured at each site to allow loading calculations and comparison of relative contributions of each of the tributaries.

Water chemistry samples will be collected four times during the study period. Samples will be taken two times during base flows and two times during storm (peak) flow events. Water chemistry sampling events will be timed to capture samples from base flow and peak flow (1” or more of rain in a 24-hour period) events. If soils are saturated by previous storm events, a storm event releasing 0.75” of rain may be sufficient to produce runoff and will be used as a storm event sample. JFNew will use best professional judgment to determine if a rain event of less than 1” qualifies as a storm event. This timing allows collection during a wide range of temporal and seasonal factors that may impact water quality. The water chemistry sampling schedule is flexible to prevent sampling during inappropriate weather or when equipment is not working. Following each sampling event, water chemistry samples will be delivered to the appropriate, contracted laboratory. JFNew will deliver nitrate-nitrogen, ammonia-nitrogen, total suspended

solids, fecal coliform, and *E. coli* samples to Veolia Water Indianapolis in Indianapolis, Indiana. The total phosphorus, dissolved phosphorus, total Kjeldahl nitrogen, BOD, and COD samples will be delivered to ESG Laboratories in Indianapolis, Indiana. Water chemistry data gathered during this study will be compared to state and USEPA recommended criteria.

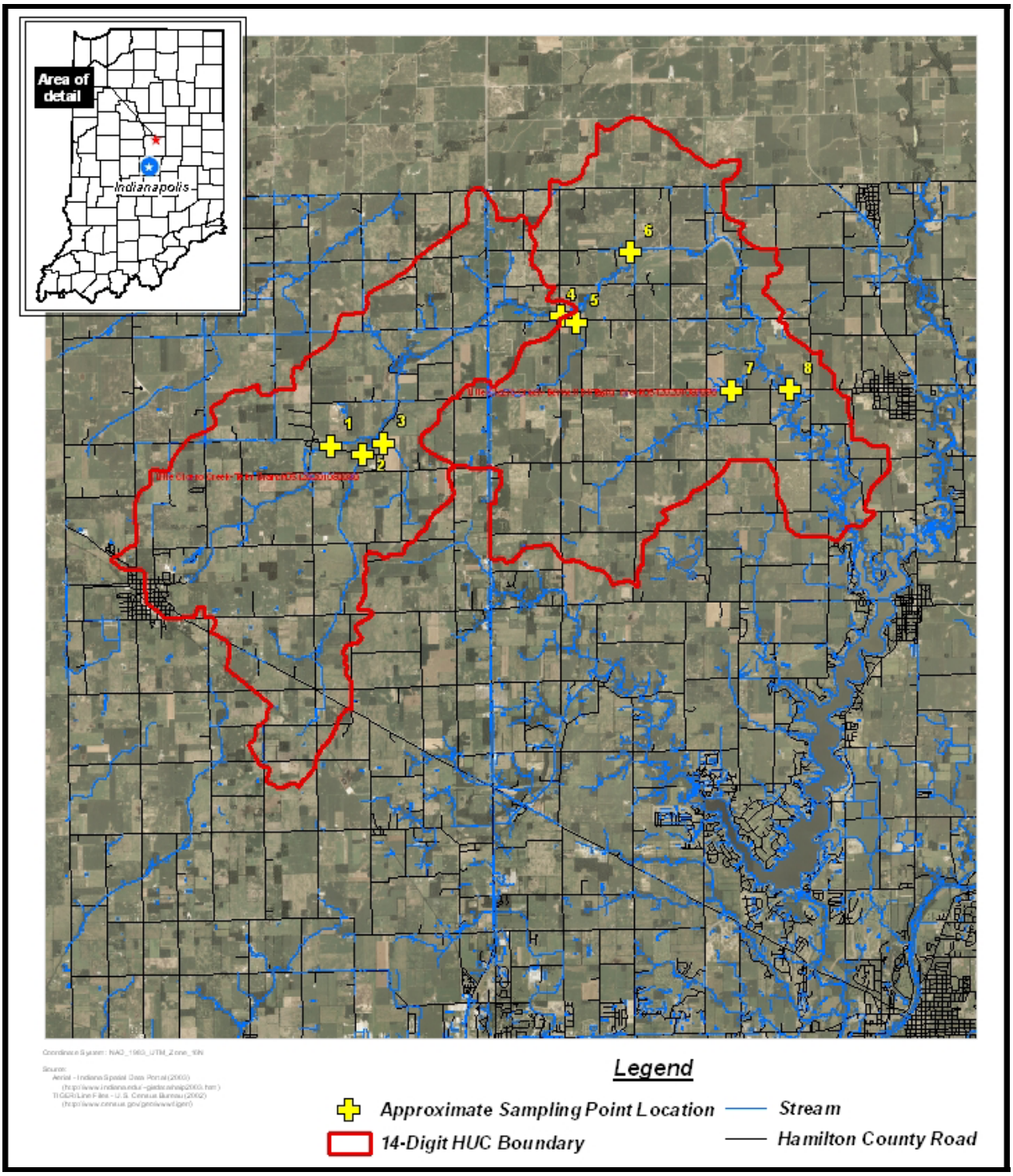


Figure 2. Sampling locations. Appendix A contains detailed sample site information.

Habitat sampling will occur once during the study period. The habitat sampling event will take place during low flow conditions in the summer to provide information on habitat availability during the highest period of stress for in-stream biota. Habitat quality will be assessed using Ohio Environmental Protection Agency (OEPA) Qualitative Habitat Evaluation Index (QHEI) protocol (OEPA, 1989).

This sampling design reflects our sampling goals. Furthermore, the design allows JFNew to meet the goals to determine the quality of water in the major streams in the Little Cicero Creek watershed and to evaluate and rank the conditions of the Little Cicero Creek watershed streams for subwatershed prioritization.

Study Schedule

Sampling station specific chemical and physical parameters will be sampled periodically throughout the project (Table 1). Habitat sampling will occur once during the summer, while chemical sampling will occur four times during a variety of conditions (base flow during spring, summer, and fall and storm flow during the growing season). Geolocation of sample sites will occur once during the sampling period.

Table 1. Parameters studied.

	Type of Sample/ Parameter	Number of Sampling Stations	Sampling Event Frequency	Sampling Period
Physical	Habitat	8	1	Summer 2005
Chemical	Water Chemistry*	8	4	Spring-Fall 2005
	Discharge	8	4	Spring-Fall 2005
Geolocation	GPS	8	1	Spring-Fall 2005

*Water chemistry samples will be analyzed for dissolved oxygen, temperature, pH, total dissolved solids, nitrate+nitrite, ammonia, total Kjeldahl nitrogen, total organic nitrogen, dissolved phosphorus, total phosphorus, turbidity, total suspended solids, biological oxygen demand (BOD), chemical oxygen demand (COD), fecal coliform, and *E. coli*.

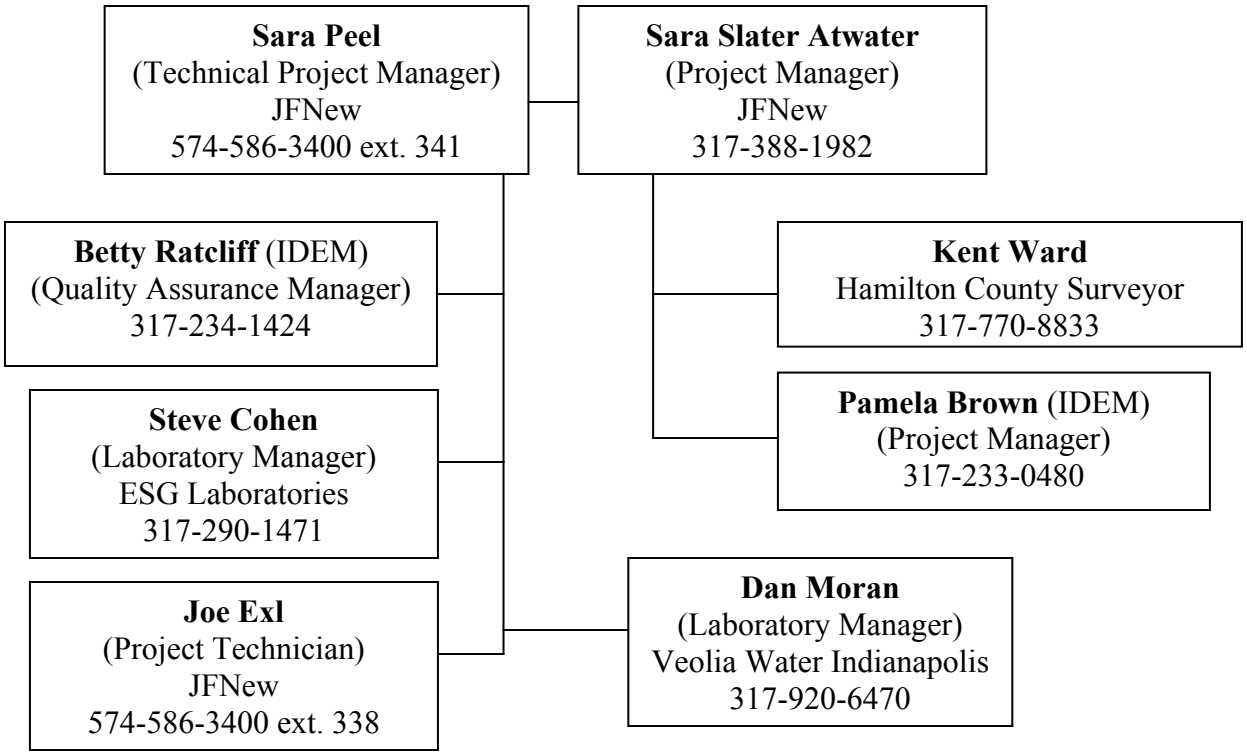
Section 2: Study Organization and Responsibility

Key Personnel

In general, JFNew will be responsible for the design, planning, execution, analysis and documentation of technical aspects of the project. JFNew will also assist with coordination of public input and development of the watershed plan. The water-testing laboratories (Veolia Water Indianapolis and ESG Laboratories) will be responsible for chemical water quality analysis. The Hamilton County Surveyor's office will be responsible for providing forums for public input and documenting the public's concerns and goals. Indiana Department of Environmental Management (IDEM) will provide the overall project guidance and assistance. Specific duties and responsibilities are outlined below.

In general, the Project Technicians report to the Technical Project Manager. The Technical Project Manager coordinates with the laboratories (Veolia Water Indianapolis and ESG Laboratories), the IDEM Quality Assurance Manager, and the JFNew Project Manger. The

JFNew Project Manger coordinates with the IDEM Project Manager and the Hamilton County Surveyor's office.



Project Organization

Project Technician is responsible for:

- Collection of general watershed parameters
- Collection of historical water quality data
- Water chemistry sampling
- Habitat sampling
- Data entry for water chemistry, macroinvertebrate, and habitat samples

Project Manager is responsible for:

- Selection of sampling site locations
- Implementation of QAPP
- Water chemistry sampling
- Coordination with IDEM and the Hamilton County Surveyor's office

Technical Project Manager is responsible for:

- QAPP development
- Review of general watershed parameters
- Review of historical data
- Geolocation of sampling sites
- Water chemistry sampling

Technical Project Manager responsibilities (cont.):

- Habitat sampling
- Oversight of Project Technician's duties listed above
- Review water chemistry and habitat field data sheets prior to leaving sampling site
- Review of water chemistry and habitat data entry for completeness and accuracy
- Implementation of QAPP
- Analysis of collected information

Section 3: Data Quality Objectives for Measurement of Data

The project goal is to obtain an overview of water quality in the Little Cicero Creek watershed from which a watershed management plan can be developed. Like many projects, this project has financial, temporal, and other constraints. For examples, we will collect physical and chemical data from each of the major streams in the Little Cicero Creek watershed. Sites sampled on each of the streams will provide information on the relative pollutant inputs of each subwatershed. This information will prioritize one subwatershed over another subwatershed when evaluating where to spend limited funding. Likewise, samples collected along the mainstem of Little Cicero Creek will allow for the determination of which portion of the watershed (Upper, Middle, or Lower) carries the greatest pollutant load. The sampling design will not; however, provide representative data for the whole watershed. Specificity will be sacrificed in order to obtain a greater quantity of general information on the entire watershed, rather than specific information on a portion of it. Based on this, the general data quality objectives are to gather representative information on the ecosystem's health at a watershed scale, collect broad, watershed scale data to make broad conclusions, and perform collection by accepted protocols to ensure the effort can be repeated in the future.

Like any project, this project has financial and temporal constraints. The project goal is to document the ecological conditions of the watershed with special emphasis on water quality from which a watershed management plan can be developed. The project's data quality goals are based on this overall project goal. Based on this, the general data quality objectives for measurement of data are to gather representative information on the ecosystem to make broad conclusions, and perform collection by accepted protocols to ensure the effort can be repeated in the future. The data quality objectives for measurement of data are precision, accuracy, representativeness, comparability, and completeness.

DQO: Precision and Accuracy

Field Water Chemistry Parameters

Field equipment will be calibrated in accordance with manufacturer's specifications as detailed in Section 6. Replicate field measurements will be taken with the following field equipment: the Hanna Instruments HI 98129 pH, EC/TDS and temperature meter; the YSI Model 55 temperature and dissolved oxygen meter; and Marsh McBirney model 2000 portable flow meter. One replicate will be taken in every eight measurements or once per sampling event. Precision will be calculated using the Relative Percent Difference equation:

$$RPD = \frac{(C - C') \times 100\%}{(C + C')/2}$$

Where:
C = the larger of the two values
C' = the smaller of the two values

The acceptable relative percent difference for field water chemistry parameters is detailed in Table 2. Regular, scheduled maintenance will occur in accordance with manufacturer's instructions and will be used to insure equipment precision and accuracy.

Field equipment will be calibrated following manufacturers specifications on the day of sample collection. Field equipment use will follow recommended usage by the equipment manufacturer. Expected accuracy measurements for field equipment measurements are those listed by the equipment manufacturers and are displayed in Table 2.

Laboratory Water Chemistry Parameters
The Technical Project Manager and Project Manager (or Technical Project Manager and Project Technician if the Project Manager is not available) will collect samples in accordance with the contracted laboratories' Quality Assurance/Quality Control (QA/QC) requirements. For all parameters analyzed by ESG Laboratories and Veolia Water Indianapolis this will include the collection of one duplicate sample in every eight samples collected, or one duplicate sample per sampling event. One set of field blank samples (one sample per parameter) will be collected during each sampling trip. Duplicate and field blank sample analysis will occur following the laboratory procedure detailed in the laboratory QA/QC plans (Appendices B and C). The contracted laboratories will implement QA/QC measures to ensure data quality as detailed in the laboratories' QA/QC documents (Appendices B and C). Section 7 of ESG Laboratories Quality Management Plan provides information on the procedures followed for these DQO's. Likewise, Section 7 of Veolia Water Indianapolis Quality Management Plan provides information on the procedures followed for these DQO's. The laboratory standards are sufficient to meet the stated goals of this project. Table 2 summarizes the data quality objectives for measurement of data for the water chemistry parameters. Data not meeting laboratory standards for duplicates or field blanks will be removed from the sample set and will not be used for watershed prioritization.

Habitat Parameters
To ensure precision, all sampling protocols will be carried out as required in the procedural documentation by qualified individuals. The same field crew, consisting of the Technical Project Manager and Project Manager (or Project Technician and Technical Project Manager if the Project Manager is not present) will sample each site using the same procedure to maintain consistency among sites. The consistency of field personnel and procedural organization will enhance precision by minimizing sampling variability.

Habitat evaluation will be conducted by an experienced/trained Technical Project Manager and Project Manager. Habitat will be evaluated on an individual basis then compared. Any discrepancies in habitat scoring will be noted and discussed in order to obtain an accurate and precise habitat score through collaboration. If a score can not be determined through

collaboration, then the Technical Project Manager's will be used for scoring purposes. Table 2 outlines the parameters, measurement range, accuracy, and precision of habitat evaluation.

Global Positioning System Parameters
Location coordinate data precision is expected to be high, while accuracy is submeter. Table 2 lists detailed precision and accuracy information for the Trimble Pro XRS GPS.

Table 2. Data quality objectives for measurement of data for field and laboratory methods.

Parameter	Precision	Accuracy	Completeness
pH	RPD<5%	± 0.01	75%
Temperature	RPD<5%	± 2%	75%
Dissolved Oxygen	RPD<5%	± 0.3 mg/l	75%
Total Dissolved Solids	RPD<5%	± 2% f.s.	75%
Flow	RPD <5%	±2% + zero stability zs=±0.03 ft/sec	75%
Ammonia	See Appendix C.	See Appendix C.	75%
Biological Oxygen Demand	See Appendix B.	See Appendix B.	75%
Chemical Oxygen Demand	See Appendix B.	See Appendix B.	75%
E. coli	See Appendix C.	See Appendix C.	75%
Fecal Coliform	See Appendix B.	See Appendix B.	75%
Nitrate+nitrite	See Appendix C.	See Appendix C.	75%
Dissolved phosphorus	See Appendix B.	See Appendix B.	75%
Total Kjeldahl Nitrogen	See Appendix B.	See Appendix B.	75%
Total Organic Nitrogen	See Appendix B.	See Appendix B.	75%
Total Phosphorus	See Appendix B.	See Appendix B.	75%
Total Suspended Solids	See Appendix C.	See Appendix C.	75%
GPS	High	50 cm ± 1 ppm	100%
Habitat Analysis	High	High	100%

DQO: Completeness
In the event that some catastrophic event (i.e. weather anomaly, chemical spill, or other event that would prohibit access to sampling sites) were to take place, the first action taken would be to delay the sampling to a later time that year, in hopes that sampling would occur under more representative conditions. There is flexibility built into the project schedule to allow sampling to occur during favorable conditions, preserving data quality.

Field and Laboratory Water Chemistry Parameters
One hundred percent (100%) collection of field and laboratory water chemistry samples is expected. Sampling locations have been field checked to ensure sampling access and proper sampling hydrology is present at each site. However, climatic or other changes beyond the project's control may alter conditions in the watershed. Refusal of landowners to grant access to the property may also limit the sample collection. Equipment malfunction or problems during sample collection and analysis could also limit the amount of water chemistry data over the term of the project. Sites 4, 6, and 8 are all located along Little Cicero Creek's mainstem. Samples

collected at Site 8 would provide information on the pollutant concentration and loads carried by Little Cicero Creek. The loss of Sites 4 and 6 would still enable watershed stakeholders to prioritize subwatersheds. Therefore, loss of two sample sites would not prevent the project from attaining its goal of developing a watershed management plan. Based on this 75% completeness (see equation below) for water chemistry samples will be acceptable for completion of the project.

$$\% \text{ completeness} = \frac{(\text{number of valid measurements}) \times 100\%}{(\text{number of valid measurements expected})} = \frac{24 \times 100\%}{32} = 75\ \%$$

Habitat Parameters
Again, one hundred percent (100%) collection of habitat samples is expected. Sampling will occur at the same sites as those utilized for water chemistry sample collected. Sample locations have been field checked to ensure sampling access and proper sampling hydrology is present at each site. Climatic or other changes beyond the project's control may alter the condition of the watershed; however, since habitat data is being collected once over the lifetime of the project sample collection could be rescheduled to allow for data collection. Still, the refusal of landowners to grant access to the property may limit the sample collection at the selected sites. Again, the loss of the first two sample sites along Little Cicero Creek's mainstem would not prevent the project from attaining its goal of developing a watershed management plan. Based on this 75% completeness (see equation below) will be acceptable for completion of the project.

$$\% \text{ completeness} = \frac{(\text{number of valid measurements}) \times 100\%}{(\text{number of valid measurements expected})} = \frac{6 \times 100\%}{8} = 75\ \%$$

Global Positioning System Parameters
The geolocation of the sample sites is not dependent upon the weather or other climatic situations (barring the loss of satellites). Since GPS data can be collected over the length of the project, 100% completeness should be achieved.

DQO: Representativeness
Representativeness is the most important data quality metric in the project since the project objective is to provide watershed scale data. Representativeness of sampling sites was achieved by performing a desktop review of potential sampling sites. Because the number of watershed streams draining to Little Cicero Creek exceeds the number of sites that can be sampled by this project given the limited resources, not all streams could be sampled. The following criteria were used to narrow the set of potential sites. Potential sites were selected based on accessibility (proximity to a road) and location in the watershed (ensuring that all major streams draining Little Cicero Creek are sampled). Potential sites were then field checked by the Project Manager to ensure accessibility to sampling stations and that the variety of physical, riparian, and in-stream habitats in the watershed were all represented in the sampling stations. Landowner permission will confirm potential sampling locations usability as sampling sites. An additional criterion for choosing sites is whether it has been used in historical studies to which this project's data may be compared. IDEM sampled macroinvertebrates and water chemistry at two of the selected sample sites.

DQO: Comparability

Water chemistry parameters are expected to be comparable to other studies if sampling and laboratory protocols and data quality objectives for measurement of data are similar. Results of this study can be compared to other studies that use this protocol and similar data quality objectives. All laboratory water chemistry analysis will be conducted using common, EPA-approved methods. All chemical data to be used for direct comparison with the data collected during the present study will be reviewed prior to its use to ensure comparability. As noted in the Sampling Design section, any non-analogous historical data (data collected under a different protocol with different data quality objectives) used in the study will be cited as such in the final product.

The habitat samples are expected to be comparable because the project will follow habitat assessment procedures set forth by Ohio EPA's Quality Habitat Evaluation Index (QHEI). Results of this study can be compared to other studies using these protocols. All habitat data to be used for direct comparison with the data collected during the present study will be reviewed prior to its use to ensure comparability.

Section 4: Sampling Procedures

The sampling methods and equipment are summarized in Table 2.

Water Chemistry Sampling

Water chemistry samples will be taken at each station to test the parameters listed in Table 2. Temperature, dissolved oxygen, pH, total dissolved solids, and flow measurements will be made in the field using the following instruments: YSI Model 55 dissolved oxygen/temperature meter; Hanna Instruments HI 98129 pH, EC/TDS, and temperature meter; and the Marsh McBirney Model 2000 portable flow meter. All measurements will be taken according to the standard operating procedures provided by the manufacturer of the equipment. Project biologists will record water chemistry field measurements on standardized field log data sheets (Appendix D). Sampling location, sample number/field ID, date, time, weather, Universal Transverse Mercantor (UTM) coordinates (North American Descent 1983, Zone 16), and any additional field notes will also be recorded on the field sheet.

Flow measurements will be taken utilizing protocols outlined in Marsh-McBirney (1990). A tape measure will be staked across the width of the channel prior to any measurements being taken. If the stream is less than two inches (2") deep, then multiple point velocity measurements will be taken throughout the width of the channel. Channel depths will be measured at a minimum of five points across the channel. Discharge will be calculated using the following formula:

$$\text{Discharge} = \frac{\left(\sum d_i\right)}{(n+1)} \; w*v$$

where d equals stream depth, n equals the number of streams depths measured, w equals the width of the stream, and v equals the velocity of the stream (0.9 times the fastest velocity recorded). This equation has been modified from EPA (1997).

If the stream is greater than two inches in depth, then the trapezoid channel method will be utilized to calculate stream discharge. The interval width, thus the number of flow measurements recorded across the channel, is determined by the channel width. If the channel width is less than fifteen feet, then the interval width will be equal to the stream width divided by five. If the channel is greater than fifteen feet wide, then the interval width will be equal to the channel width multiplied by 0.1. Stream depths will be recorded at the right and left edges of the predetermined trapezoid (SI_o and SI_1). Flow measurements will be recorded at the midpoint of each trapezoid ($SI_{1/2}$). All data will be recorded on the data sheet included in Appendix D. Discharge will be calculated using a calibrated Excel spreadsheet to minimize data errors involved in performing hand calculations.

Grab samples will be collected for the remaining water chemistry parameters (nitrate+nitrite, ammonia, total Kjeldahl nitrogen, total organic nitrogen, total phosphorus, dissolved phosphorus, total suspended solids, BOD, COD, fecal coliform, and *E. coli)*. Samples will be placed in prepared containers supplied by ESG Laboratories, Indianapolis, Indiana and Veolia Water Indianapolis, LLC in Indianapolis, Indiana (Table 3). The laboratories will provide the appropriate preservative in the pre-packaged containers as necessary. Sample collection will proceed in a manner similar to that outlined in *EPA Volunteer Stream Monitoring: A Methods Manual* (1997). One member of the field crew will wade to the center of the stream's thalweg to collect the water sample. The crewmember will invert a clean sample bottle (an extra one, not one used for sample storage) from the laboratory into the stream's thalweg. At a depth of approximately 8 to 12 inches below the water surface, the crewmember will turn the bottle into the current to allow for collection of water. (If the stream at the sampling station is shallower than 16 inches, water collection will occur mid-way between the water's surface and the stream bottom.) Once the bottle is full, the crewmember will scoop the bottle up toward the surface. Water in this bottle will be poured into the sample containers provided by the analytical laboratories.

The sample containers will be labeled as outlined in the proceeding section, stored on ice and transported to the appropriate laboratory for analysis. Nitrate-nitrogen, ammonia-nitrogen, total suspended solids, and *E. coli* samples will be stored on ice and transported to Veolia Water Indianapolis in Indianapolis. Required chain of custody procedures as outlined in Veolia's Laboratory Quality Assurance Plan (Appendix C) will be followed. All other samples including total phosphorus, dissolved phosphorus, total Kjeldahl nitrogen, total organic nitrogen, BOD, COD, and fecal coliform will be stored on ice and transported to ESG Laboratories in Indianapolis, Indiana. Required chain of custody procedures as outlined in the laboratory's QA/QC plan (Appendix B) will be followed. Water chemistry samples will be processed at both labs using the laboratory's standard operating protocol (see Table 3). All four water chemistry samples collection events will follow this protocol for each of the eight sample sites, duplicates, and field blanks. Analytical results from the water quality labs will be based on their schedule, but are anticipated within 2-3 weeks of sample collection.

Table 3. Sampling procedures.

Parameter	Sample Frequency	Sample Container*	Sample Volume	Holding Time
pH	4	N/A	N/A	N/A
Temperature	4	N/A	N/A	N/A
Dissolved Oxygen	4	N/A	N/A	N/A
Total Dissolved Solids	4	N/A	N/A	N/A
Flow	4	N/A	N/A	N/A
Ammonia	4	HDPE Nalgene	See Appendix C.	28 days
BOD	4	HDPE Nalgene	See Appendix B.	24 hours
COD	4	HDPE Nalgene	See Appendix B.	24 hours
E. coli	4	HDPE Nalgene	See Appendix C.	6 hours†
Fecal Coliform	4	HDPE Nalgene	See Appendix B.	6 hours†
Nitrate+nitrite	4	HDPE Nalgene	See Appendix C.	28 days
Dissolved phosphorus	4	HDPE Nalgene	See Appendix B.	48 hours
Total Kjeldahl Nitrogen	4	HDPE Nalgene	See Appendix B.	28 days
Total Organic Nitrogen	4	HDPE Nalgene	See Appendix B.	28 days
Total Phosphorus	4	HDPE Nalgene	See Appendix B.	28 days
Total Suspended Solids	4	HDPE Nalgene	See Appendix C.	7 days
GPS	1	N/A	N/A	N/A
Habitat Analysis	1	N/A	N/A	N/A

*Sample containers will be provided and preserved by the contracted laboratory. ESG Laboratories will provide and preserve containers for BOD, COD, dissolved phosphorus, total phosphorus, total Kjeldahl nitrogen, total organic nitrogen, and fecal coliform sampling. Veolia Water Indianapolis will provide and preserve sample bottles for all remaining laboratory parameters.

†This value refers to the maximum time between sample collection and analysis, not the holding time from the time the sample arrives at the lab. That holding time is 2 hours.

Habitat Evaluation

Habitat evaluation will be conducted at each station using Ohio EPA's Quality Habitat Evaluation Index (QHEI). The field crew will adhere to OEPA QHEI standard procedures. Assessments will be made by the field crew and noted on QHEI data sheets (Appendix E).

Section 5: Custody Procedures

Field sampling data and data sheets used for water chemistry field sampling will remain in JFNew's custody; therefore, chain of custody does not apply to these measurements.

The field crew consisting of the Technical Project Manager and Project Manager (or Project Technician and Technical Project Manager if the Project Manager is not present) will collect the water chemistry samples using the procedure outlined in Section 4. Samples will be labeled with the sampling location, sample number (same as "Field ID" on the laboratory Chain of Custody Record), date and time of collection, sample parameters, and sampler name(s). This information along with the project name and project number will be recorded on the laboratories' Chain of Custody Records (Appendices B and C). Appendices B and C contain blank Chain of Custody Records for ESG Laboratories and Veolia Water Indianapolis, respectively.

E. coli samples will be stored on ice and transported within 6 hours to Veolia Water Indianapolis laboratory. Nitrate-nitrogen, ammona-nitrogen, and total suspended solids samples will be stored on ice and transported to the Veolia Water Indianapolis laboratory within 24 hours of sample collection. The Technical Project Manager will sign the Chain of Custody Record in the presence of the laboratory technician when samples are released to the laboratory. Veolia Water Indianapolis personnel will review sample labels and remove any samples from the dataset that cannot be attributed to specific samplers, have not been properly preserved, or that exceed the maximum holding time. The laboratory manager will also sign-off on laboratory bench sheets after all checks have been completed. A copy of the chain of custody form will accompany sample result documents from Veolia Water Indianapolis. The report from Veolia Water Indianapolis is expected within 2-3 weeks of sampling.

Fecal coliform samples will be stored on ice and transported to ESG Laboratories within 6 hours of collection. All other water chemistry samples (BOD, COD, total Kjeldahl nitrogen, organic nitrogen, total phosphorus, and dissolved phosphorus) will be analyzed by ESG Laboratories. These samples will be stored on ice and transported to the laboratory within 24 hours of sample collection. The Technical Project Manager will sign the Chain of Custody form in the presence of the laboratory technician when samples are released to the laboratory. ESG Laboratories personnel will review sample labels and remove any samples from the dataset that cannot be attributed to specific samplers, have not been properly preserved, or that exceed the maximum holding time. The laboratory manager will also sign-off on laboratory bench sheets after all checks have been completed. A copy of the chain of custody form will accompany sample result documents from ESG Laboratories. The report from ESG Laboratories is expected within 2-3 weeks of sampling.

Habitat measurements will be noted on the QHEI data sheet located in Appendix E. Samples are not collected as part of this procedure. Habitat assessment data sheets will remain in JFNew's custody; therefore, chain of custody does not apply to these measurements.

Section 6: Calibration Procedures and Frequency

Calibration measures will be performed on all field equipment to be used (where appropriate) based upon the manufacturers recommendations as outlined in the users manual for each individual piece of equipment. Field equipment that cannot be calibrated, such as a tape measure, will not be calibrated. Field equipment calibration will be performed the day of sampling prior to its use in the field. The YSI Model 55 oxygen and temperature probe is auto-calibrated based on the altitude and salinity of the sample prior to time of use. The Hanna Instruments HI 98129 pH, EC/TDS, and temperature meter is calibrated using Fisher pH calibration buffer (pH 4.0 and 7.0) and Oakton calibration solution (1413 μS). The Marsh McBirney Model 2000 flow meter is calibrated by the manufacturer prior to shipping. If equipment cannot be properly calibrated, then sampling will be rescheduled. If the GPS can not be properly calibrated, then GPS measurements will be recorded at a later date following proper calibration and all other sampling will proceed as scheduled. See Appendix B for ESB Laboratories and Appendix C for Veolia Water Indianapolis calibration procedures and frequency.

Section 7: Sample Analysis Procedures

Table 4 summarizes the analytical procedures for each water chemistry parameter. Each laboratory has the capability, as shown in their respective Quality Assurance documents (Appendices B and C), to analyze the water samples according to the procedures listed in Table 4.

All procedures that will be used to analyze the macroinvertebrate samples and QHEI assessments will strictly adhere to the OEPA QHEI protocol, respectively. Because this tool was designed to make rapid assessments at large scales, the use of this tool will enable the achievement of project goals. In general, detection limits are not applicable to the physical habitat assessment used in this project.

Table 4. Analytical procedures.

Matrix	Parameter	Method	Detection Limits
Water	pH	Hanna Instruments HI 98129	0.1
Water	Temperature	YSI Model 55	1°C
Water	Dissolved Oxygen	YSI Model 55	0.1 mg/l
Water	Total Dissolved Solids	Hanna Instruments HI 98129	
Water	Flow	Marsh McBirney Model 2000 portable flow meter	0.1 ft/s
Water	Ammonia	EPA 350.2 or 350.3	0.1 mg/l
Water	Biological Oxygen Demand	EPA 405.1	1.0 mg/l
Water	Chemical Oxygen Demand	EPA 410.4	10 mg/l
Water	*E. coli*	SM 9223	N/A
Water	Fecal Coliform	SM 9224 D	N/A
Water	Nitrate+nitrite	EPA 353.3	0.1 mg/l
Water	Dissolved phosphorus	EPA 365.2	0.25 mg/l as PO_4*
Water	Total Kjeldahl Nitrogen	EPA 351.3 or 350.3	0.10 mg/l
Water	Total Organic Nitrogen	EPA 351.3 or 350.3	0.10 mg/l
Water	Total Phosphorus	EPA 365.2	0.10 mg/l*
Water	Total Suspended Solids	EPA 160.2	1.0 mg/l
Geolocation	GPS	Trimble Pathfinder Pro XRS	submeter
Habitat	Habitat Analysis	Ohio EPA QHEI	N/A

*ESG Laboratories will provide phosphorus reporting levels at 0.01 mg/l for total phosphorus and 0.03 mg/l for dissolved phosphorus and PO_4.

Section 8: Quality Control Procedures

Quality control will be achieved by strict adherence to written protocol. To achieve precision in field measurements, replicate measurements will be taken. Replicate measurements for each field parameter will be taken at one of the eight sampling sites for each sampling event. To achieve accuracy in field measurements, equipment will be properly maintained and equipment calibration will occur as detailed in Section 6. To achieve precision in laboratory measurements, duplicate samples will be collected one time in eight samples or once per sampling trip. The

contracted laboratories have established control limits for all quality control checks established by their protocols (Appendices B and C). To achieve accuracy in laboratory measurements, field blanks collected concurrently with sample collection will be analyzed. Field blank collection will ensure that no outside contamination occurs during the process of sample bottle preparation or sample collection. Additional laboratory QA/QC checks for accuracy and precision will be implemented by ESG Laboratories and Veolia Water Indianapolis (Appendices B and C). Field work will be performed by the same crew at each site. The Technical Project Manger will ensure consistency in sample collection and field work. This quality control procedure will allow for comparison to be made among sampling sites, and thus, achieve the project's goals of identifying hot spots within the watershed for more targeted intensive management.

Quality control in the field will be obtained by adherence to procedures detailed in Sections 3 and 4. This quality control includes replicate samples, equipment calibration, and adherence to procedures as detailed in Section 3. Quality control of laboratory water chemistry analysis will be performed as outlined in the respective laboratories' QA/QC plans (Appendices B and C). This quality control includes use of field replicates, lab duplicates, split samples, field blanks, reference standards, and method blanks where appropriate. This level of quality control is sufficient to achieve project goals.

Independent QHEI assessments will be made by each member of the field crew to ensure precision and accuracy of habitat assessment. Any differences in assessments will be averaged, if possible, based on the metric. Where averaging of a metric is not possible, the value given by the Technical Project Manager will be accepted. Fieldwork will be performed by the same crew at each site. The Technical Project Manager will ensure consistency in sample collection and fieldwork.

Section 9: Data Reduction, Analysis, Review, and Reporting

Data Reduction

Field data sheets will be inspected for completeness and signed by the Technical Project Manager before leaving the site. The Technical Project Manager will calculate the RPD before leaving the site to ensure the precision data quality objectives for measurement of data for the field measurements are met. It will be assumed that accuracy data quality objective of field measurements are met if there is no problem with equipment calibration. The field data sheet contains fields showing whether the RPD met the data quality objective, if calibration was completed, if the measurement was taken (completeness), and if protocol was followed (comparability). Data from the field data sheets will be used to calculate a QHEI score to indicate the habitat quality of the aquatic system at the specific sites studied. Field measurements using electronic instrumentation need no further reduction. Data reduction in the laboratory will be done in accordance with ESG Laboratories and Veolia Water Indianapolis QA/QC protocol (Appendices B and C).

Data Analysis

Discharge and loadings will be calculated using an electronic spreadsheet/database program designed for this project and compatible with software used by JFNew, IDEM, and the Hamilton County Surveyor's office to minimize errors involved with performing hand calculations. Once

the raw data has been reviewed by the Technical Project Manger, discharge will be calculated using methodology detailed in Section 4 (Marsh McBirney, 1990). Once discharge has been calculated, the pollutant load will be calculated by multiplying the specific site discharge by the concentration of a pollutant found at that site. Pollutant loads among sites will be compared to identify which sites provide the greatest load of pollutant to the Little Cicero Creek watershed.

Data Review

The Project Technician will enter all data into a computerized spreadsheet/database program designed for this project and compatible with software used by JFNew, IDEM, and the Hamilton County Surveyor's office. The Technical Project Manager will review data entry for completeness and errors.

Data Reporting

ESG Laboratories and Veolia Water Indianapolis will provide sample results with qualifying information for any results which fall outside of the control limits. A copy of the chain of custody form will accompany laboratory results.

The Technical Project Manager will be responsible for report production and distribution. The Project Technician will provide assistance in these tasks. The report will contain the data results, interpretation of the data, Best Management Practice proposals for existing watershed conditions, a compilation of watershed stakeholders' concerns and goals, and proposals for future development in the watershed.

Section 10: Performance and System Audits

Specific audits such as those conducted on the contracting laboratories by outside auditors are not applicable to this type of project. Such audits are not necessary to achieve the project goals given the scope of this study and the intended use of the data. However, the following checks and oversight will be utilized to ensure data quality:

- The Technical Project Manager will provide oversight to all technical staff ensuring strict adherence to all protocols.
- Field data sheets will be reviewed for completeness prior to leaving the field.
- Two individuals will make QHEI assessments at each site.

Both ESG Laboratories and Veolia Water Indianapolis have built in audits (Appendices B and C). The Project staff is open to IDEM's audits upon IDEM's request. The Technical Project Manager will conduct a system audit following the first sampling event and at the end of the project to ensure data quality objectives for measurement of data are met.

Section 11: Preventative Maintenance

JFNew will utilize a dissolved oxygen meter/thermometer (YSI Model 55), pH/total dissolved solids meter (Hanna Instruments HI 98129), flow meter (Marsh McBirney Model 2000 portable flow meter), global positioning system (Trimble Pathfinder Pro XRS), and tape measure for water quality sampling. To keep these instruments and equipment in proper working order, all maintenance will be performed as outlined in the users manuals provided with the equipment

where appropriate. Additional batteries for the dissolved oxygen meter and GPS, a separate thermometer, and replacement dissolved oxygen membranes will be present in the field for any necessary field repairs. An additional set of collection bottles and nets will be taken along on each sampling trip (where applicable). Preventative maintenance in each respective laboratory is covered in Appendices B and C.

Section 12: Data Quality Assessment

DQO: Precision and Accuracy

As stated in the Study Goals in Section 1, the goal of the project is to document the physical and chemical condition of the Little Cicero Creek watershed. Collected data will be utilized to identify priority areas in the watershed that may be contributing more non-point source pollutants to the Little Cicero Creek watershed. Data quality controls outlined in the sections above will be sufficient to meet the objectives of the study. Data quality assessments conducted by the contracting laboratories will be sufficient to meet the objectives of the project (Appendices B and C). Laboratory analysis of precision and accuracy checks, including control levels for duplicate and replicate samples and field and laboratory blanks, will be kept on file in the contract laboratories. All laboratory data will be assessed by ESG Laboratories and Veolia Water Indianapolis to determine if data quality falls within the required precision and accuracy levels specified by each laboratory (Appendices B and C). The laboratories will follow established protocols to determine if data is valid. Any data that is determined to not meet laboratory quality control guidelines will not be reported or used for subwatershed prioritization. All QA/QC measures for each run of the samples will be included with the lab's final data analysis and will be included as an appendix in the final report.

Field measurements and habitat data will be accepted as valid provided no significant problems occur during calibration and sampling. Field water chemistry measurements will be repeated if precision failures are observed (RPD>5%). Data that does not meet precision goals will not be included in sample analysis and subwatershed prioritization. The accuracy of field measurements and habitat data will not be quantified. However, the data will be acceptable provided that no significant problems occurred during equipment calibration or sampling. Sampling will be rescheduled if problems occur during equipment calibration. Field measurements will be repeated if difficulties occur during sampling.

DQO: Completeness

All data determined to be accurate and precise will be considered valid and will be reported even if completeness objectives are not met. Due to flexibility in scheduling of sampling events, 75-100% completeness is anticipated. If for some reason (such as ones outlined in previous sections) 100% collection of samples is not possible, the data will be evaluated to determine whether the watershed has been sufficiently represented in the data collection to date.

DQO: Representativeness

Meeting the goal of representation is of primary importance since it is one of the study's goals. Data will be evaluated for representativeness based primarily on the following criteria: all sampling stations have been sampled at least once and water chemistry samples have been collected during storm and base flow events. Those criteria are listed in order of importance.

The first one listed will have more importance in deciding whether the project is complete despite not having collected 100% of the samples. Any decisions to deem the project complete without 100% collection of data will be made by the Technical Project Manager. The IDEM Project Manager will be included in all such decisions.

DQO: Comparability
Data collected during this study will meet comparability requirements if standard operating procedures as outlined in Section 4 are followed. Water chemistry data will be comparable with other data collected using the same protocol. Likewise, macroinvertebrate and habitat data will be comparable to IDEM data only if the standard operating procedures are followed. If problems occur during sample collection that requires the use of non-standardized operating procedures, then that data will be evaluated for comparability. This will likely result in the removal of this data from the data set.

Section 13: Corrective Action

Should extraordinary events occur that could adversely affect the collection of accurate, representative data (extreme climatic conditions, chemical spill, etc.) testing shall be rescheduled during the same year when conditions are more favorable. The data can then be analyzed so that reports can be written. Since water chemistry sampling is to be done four times and macroinvertebrate and habitat one time during the study period, it is feasible to schedule sampling at a time when conditions permit within the project's timeframe. If, for reasons beyond the project's control, samples cannot be collected during the project's timeframe, the prohibitive conditions will be noted and discussed with the IDEM Project Manager.

ESG Laboratories and Veolia Water Indianapolis corrective actions that will be taken for the chemical water quality analysis are noted in Appendices B and C. Although it is not anticipated, should data received from the ESG Laboratories and Veolia Water Indianapolis be unusable given the project's data goals, another sampling event will occur to replace effected data. Assurance from the ESG Laboratories and/or Veolia Water Indianapolis that similar problems in data quality will not be repeated will be obtained prior to submission of any samplings.

Less than 75% accuracy of the checked portion (10%) of the macroinvertebrate sample will trigger corrective actions for the macroinvertebrate identification. Such corrective actions could include discussion with sampler and identifier to determine the source of error, re-identification of part of or the entire sample, and/or discarding an unusable sample where appropriate. Any habitat data collected according to standard operating protocols will meet the data collection objectives. Corrective actions are not applicable to this form of assessment.

Section 14: Quality Assurance Reports

Quality Assurance reports will be submitted to IDEM's Watershed Management Section every three months as part of the Quarterly Progress Report and/or Final Report. Any problems that are found with the data will be documented in the quarterly reports. Quality assurance issues that may be addressed in the quarterly report include, but are not limited to the following:

- Assessment of such items as data accuracy and completeness
- Results of performance and/or systems audit
- Significant QA/QC problems and recommended solutions
- Discussion of whether the QA objectives were met and the resulting impact on decision making
- Limitations on use of the measurement data

If no QA/QC problems arise, this will be noted in the report.

References

APHA et al. 1995. Standard Methods for the Examination of Water and Wastewater, 19th edition. American Public Health Association, Washington, D.C.

ESG Laboratories. 2005. Quality Management Plan. Loose-leaf publication. Indianapolis, Indiana.

Indiana Department of Environmental Management. 2004. Indiana 303(d) List of Impaired Waterbodies. Indianapolis, Indiana.

Marsh-McBirney. 1990. Model 2000 Installation and Operations Manual.

Ohio Environmental Protection Agency. 1989. Biological criteria for the protection of aquatic life: Volume III. Standardized biological field sampling and laboratory methods for assessing fish and macroinvertebrate communities. Division of Water Quality Monitoring and Assessment, Columbus, Ohio.

U.S. Environmental Protection Agency. 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79/020.

U.S. Environmental Protection Agency. 1997. Volunteer Stream Monitoring: A Methods Manual. EPA-841-B-97-003.

Veolia Water Indianapolis, LLC. 2004. Laboratory Quality Assurance Plan. Loose-leaf publication. Indianapolis, Indiana.

APPENDIX A

Sampling Station Locations

	Location	Width	Substrate	Comments
1	Symons Ditch/Little Cicero Creek at Boxley	~25-30’	Silt/Mud	Upstream mowed to edge, tree lined downstream, est. 2’ deep.
2	Jay Ditch/Teeter Branch at Boxley	~15-20’	Sand/Silt	Fence surrounding stream, cattle, may be homeowner issues, est. 1-3’ deep.
3	Ross Ditch at Meridian	~10’	Silt/Mud	Culverted. Fences in and around stream, may be homeowner issues.
4	Little Cicero Creek at Anthony Rd.	~30-35’	Sandy with few large rocks or rip-rap	Rocky under bridge, est. 2’ deep, but deeper downstream.
5	Bennet Ditch at 276th	~5-6’	Sand/Silt	Est. 4” deep.
6	Little Cicero Creek at Cal Carson	~30’	Sandy with few large rocks or rip-rap	
7	Taylor Creek at 266th	~20’	Silt mud with rip-rap	
8	Little Cicero at 266th	~40’	Silt and large rocks	Difficult to see substrate due to water depth and cloudiness

APPENDIX B

ESG Laboratories
Laboratory QA/QC Plan and Chain of Custody Form

APPENDIX C

Veolia Water Indianapolis
Laboratory QA/QC Plan and Chain of Custody Form

APPENDIX D

Water Quality Sampling Data Sheets

WATER QUALITY SAMPLING FIELD LOG SHEET

SITE NUMBER AND LOCATION: _____

DATE: _____ PROJECT NAME: _____

TIME: _____

FIELD CREW: _____

WEATHER CONDITIONS: _____

OTHER OBSERVATIONS: _____

EQUIPMENT CALIBRATION (Date): _____

FIELD PARAMETERS	REPLICATE (if taken)	
pH: _____	pH: _____	RPD = _____
Temperature: _____	Temperature: _____	RPD = _____
Dissolved Oxygen: _____	Dissolved Oxygen: _____	RPD = _____
DO % Saturation: _____	DO % Saturation: _____	RPD = _____
Total Dissolved Solids: _____	TDS: _____	RPD= _____
Calculated Flow: _____		

Relative Percent Difference (RPD)= $\frac{(\text{sample}_1\text{-sample}_2)}{((\text{sample}_1+\text{sample}_2)/2)}$

LAB PARAMETERS

E. Coli: ____
Ammonia: ____
Nitrate: ____
Total Suspended Solids: ____
Total Kjeldahl Nitrogen: ____
Orthophosphorus Phosphorus: ____
Total Phosphorus: ____
Total Organic Nitrogen: ____
BOD: ____
COD: ____
Fecal Coliform:____

Field Crew Leader Signature: _____

Discharge Measurement

Site:_____ Date:_____ Time:_____
Project #:_____ Project Name:_____
Crew Members:_____ Equipment:_____
Physical Site Description:_____
GPS Coordinates:_____

If the stream is <2" deep:
Stream Width:_____feet
Stream Depths: _____, _____, _____, _____, _____, _____, _____, _____, _____, _____feet
U: _____, _____, _____, _____, _____, _____, _____, _____, _____, _____ft/s
U_{max}:_____ft/s

If the stream is >2" deep:
Stream Width (W):_____feet
Interval Width (IW) (If W<15', then IW=W/5. If W>15, then IW=W*0.1):_____feet

Segment	SI_0		SI_1		½ IW		$U_{0.4}$	
	Location	Depth (ft)	Location	Depth (ft)	Location	Depth (ft)	Set Depth	Rate (ft/s)
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								

Field Crew Leader Signature: _____

APPENDIX E

Qualitative Habitat Evaluation Index (QHEI) Data Sheets

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

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

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

SUBSTRATE ORIGIN (all)

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

SILT COVER (one)

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

Extent of Embeddedness (check one)

☐ EXTENSIVE(-2) ☐ MODERATE(-1)
☐ LOW(0) ☐ NONE(1)

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

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

COMMENTS: _____

2) INSTREAM COVER: **COVER SCORE** ☐

TYPE (Check all that apply)

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

AMOUNT (Check only one or Check 2 and AVERAGE)

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

COMMENTS: _____

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

SINUOSITY

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

DEVELOPMENT

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

CHANNELIZATION

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

STABILITY

☐ HIGH(3)
☐ MODERATE(2)
☐ LOW(1)

MODIFICATION/OTHER

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

COMMENTS: _____

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

River Right Looking Downstream

RIPARIAN WIDTH (per bank)

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

EROSION/RUNOFF-FLOODPLAIN QUALITY

L	R	(most predominant per bank)	L	R	(per bank)
☐	☐	FOREST, SWAMP(3)	☐	☐	URBAN OR INDUSTRIAL(0)
☐	☐	OPEN PASTURE/ROW CROP(0)	☐	☐	SHRUB OR OLD FIELD(2)
☐	☐	RESID.,PARK,NEW FIELD(1)	☐	☐	CONSERV. TILLAGE(1)
☐	☐	FENCED PASTURE(1)	☐	☐	MINING/CONSTRUCTION(0)

BANK EROSION

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

COMMENTS: _____

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

MAX.DEPTH (Check 1)

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

MORPHOLOGY (Check 1)

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

POOL/RUN/RIFFLE CURRENT VELOCITY (Check all that Apply)

☐ TORRENTIAL(-1) ☐ EDDIES(1)
☐ FAST(1) ☐ INTERSTITIAL(-1)
☐ MODERATE(1) ☐ INTERMITTENT(-2)
☐ SLOW(1)

COMMENTS: _____

RIFFLE SCORE ☐

RIFFLE/RUN DEPTH

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

RIFFLE/RUN SUBSTRATE

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

RIFFLE/RUN EMBEDDEDNESS

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

COMMENTS: _____

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