APPENDIX E

Monitoring Program Methodology

Methods of sampling and analysis conform to the Quality Assurance Project Plan submitted to the IDEM (ARN # A 305-1-00-206) in June of 2002.

Physical Parameter Methods

Precipitation Measurements

Data logging precipitation gauges have been installed in all three subwatersheds to measure the timing and depth of precipitation. The precipitation gauge consists of two major components, a tipping bucket precipitation collector and a HOBO event data logger. The water enters the gauge, is funneled in a downward motion and is deposited onto the tipping bucket. The bucket tips with each 0.01 inch of rain and the water flows out of the bottom of the precipitation gauge. The data logger will record the date and time of each tip. The data loggers information was downloaded and exported using BoxCar 4.0 software.

Water Level Measurements

Two Global Water WL-15 water level loggers were installed in the Killbuck Creek and Buck Creek Subwatersheds. This instrument has a submersible sensor that is connected to a data logger housed in PVC pipe. Slits were made in the vertical portions of the PVC pipe placed in the stream to allow water to enter the pipe. The data was downloaded (using the Global Water software) to a personal computer. The data was extracted into a Microsoft Excel spreadsheet to display the difference in the water levels at a given time and day. The water level loggers are located near the Killbuck Creek subwatershed by CR 650 North and 450 West near the Cardinal Greenway and at Buck Creek subwatershed at sampling site BC-3.

Discharge Measurements

The rate of flow, or discharge, of a stream is the quantity of water flowing past a cross section of the stream in a unit of time. Discharge in the subwatersheds was accomplished by measuring the water depth and stream velocity for several stream subsections. The first step is to measure the width of a cross section in the subwatershed from bank to bank and separate the width into approximately twenty (20) subsections. An ideal cross section has uniform flow, a confined channel, a stable streambed and easy access. Subsections with shallow depths and visibly low velocity will be wider than areas with greater depths and visibly higher velocity. Sampling depth of each subsection is determined by multiplying the measured depth by 0.6. For depths greater than two and a half feet, velocity was obtained at 0.2 and 0.8 depth ratios in each subsection. These depths are used to approximate the average velocity in the stream subsection. The current/velocity meter used by Ball State University (BSU) is a Teledyne Gurley. In order to obtain current velocity, the Teledyne Gurley instrument is positioned in the appropriate level in each subsection and a cone-shaped bucket wheel on the instrument turns as the water flows past. One revolution of the bucket wheel sends an electrical impulse that is translated into an audible click. The numbers of revolutions, or clicks, are counted for sixty (60) seconds. A table is used to determine feet per second based on the rpm on a sixty (60) second time interval.

The following equation was used to calculate discharge.

$$Q = AV$$

Q = discharge (ft^3 per second)

V = velocity (feet per second)

A = area (ft^2)-subsection width times depth of subsection

Finally, the total discharge for the cross section can be calculated by summing discharges in the several subsections. English units of cubic feet per second are then converted to scientific units of cubic meters per second by multiplying by 0.028. Early discharge measurements were made at 0.6 of the depth from the bottom of the streambed. A correction factor was applied by calculating the discharge at KB-1A and BC-3 by measuring the velocity at 0.6 of the depth from the bottom of the streambed and 0.6 of the depth from the water surface. A ratio was calculated (BC = 1.19, KB = 1.22, PC = 1.22) and applied to discharge measurements in July and August of 2003. The Indiana American Water Company had opened the Prairie Creek Reservoir at PC-3 on 8/27/03 at a flow rate of 3 Million Gallons per Day (MGD) and was shut down on 10/09/03.

Chemical and Bacteriological Parameter Methods

Ambient Temperature: The outside air temperature is measured with a standard thermometer and reported in degrees Celsius.

Stream Temperature: The stream temperature is measured at each sampling location using EPA method 170.1 and reported in degrees Celsius.

Stream Temperature

Month	Ohio River Main Stem °F (°C)	Other Indiana Streams °F (°C)
January	50 (10)	50 (10)
February	50 (10)	50 (10)
March	60 (15.6)	60 (15.6)
April	70 (21.1)	70 (21.1)
May	80 (26.7)	80 (26.7)
June	87 (30.6)	90(32.2)
July	89 (31.7)	90(32.2)
August	89 (31.7)	90(32.2)
September	87 (30.7)	90(32.2)
October	78 (25.6)	78 (25.5)
November	70 (21.1)	70 (21.1)
December	57 (14.0)	57 (14.0)

Total Suspended Solids (TSS): The weight of particles that are suspended in water. The Bureau of Water Quality (BWQ) analyzed TSS using EPA method 160.2.

pH: The negative log of the hydrogen ion concentration (-log [H+]) is a measure of the acidity or alkalinity of a solution. Water pH is 7 for neutral solutions, increases with increasing alkalinity and decreases with increasing acidity. The scale range is 0-14. The BWQ analyzed pH using EPA method 150.1.

Dissolved Oxygen (DO): The amount of oxygen present in the water column. Dissolved oxygen refers to the volume of oxygen that is contained in water. Oxygen enters the water by photosynthesis of aquatic biota and by the transfer of oxygen across the air-water interface. The amount of oxygen that can be held by the water depends on the water temperature, salinity, and pressure. Gas solubility increases with decreasing temperature (colder water holds more oxygen). Gas solubility also decreases as atmospheric pressure decreases. Fish need as least 3-5 parts per million (ppm) of DO. The BWQ analyzed DO using method 4500-0 G from Standard Methods 18th Edition.

Biochemical Oxygen Demand (BOD): The quantity of largely organic materials present in a water sample as measured by a specific test. Although BOD is not a specific compound, it is defined as a conventional pollutant under the federal Clean Water Act. The BWQ analyzed BOD using method 5210 B, from Standard Methods 18th Edition.

Ammonia (NH_3): Ammonia (NH_3) is a colorless gas with a pungent odor. It is easily liquefied and solidified and is very soluble in water. According to the IAC, maximum unionized ammonia concentrations within the temperature and pH ranges measured for the study streams should range between approximately 0.015 and 0.21 mg/L (327 IAC 2-1-6). Toxic levels are both pH and temperature dependent. High pH increases the conversion of NH_4 to NH_3. Ammonia was analyzed by the BWQ using EPA method 350.3.

Maximum Ammonia Concentrations (Unionized Ammonia as N mg/l)

	Temperature (°Celsius)						
pH	0	5	10	15	20	25	30
6.5	0.0075	0.0106	0.0150	0.0211	0.0299	0.0299	0.0299
6.6	0.0092	0.0130	0.0183	0.0259	0.0365	0.0365	0.0365
6.7	0.0112	0.0158	0.0223	0.0315	0.0444	0.0444	0.0444
6.8	0.0135	0.0190	0.0269	0.0380	0.0536	0.0536	0.0536
6.9	0.0161	0.0228	0.0322	0.0454	0.0642	0.0642	0.0642
7.0	0.0191	0.0270	0.0381	0.0539	0.0761	0.0761	0.0761
7.1	0.0244	0.0316	0.0447	0.0631	0.0892	0.0892	0.0892
7.2	0.0260	0.0367	0.0518	0.0732	0.1034	0.1034	0.1034
7.3	0.0297	0.0420	0.0593	0.0837	0.1183	0.1183	0.1183
7.4	0.0336	0.0474	0.0669	0.0946	0.1336	0.1336	0.1336
7.5	0.0374	0.0528	0.0746	0.1054	0.1489	0.1489	0.1489
7.6	0.0411	0.0581	0.0821	0.1160	0.1638	0.1638	0.1638
7.7	0.0447	0.0631	0.0892	0.1260	0.1780	0.1780	0.1780
7.8	0.0480	0.0678	0.0958	0.1353	0.1911	0.1911	0.1911
7.9	0.0510	0.0720	0.1017	0.1437	0.2030	0.2030	0.2030
8.0	0.0536	0.0758	0.1070	0.1512	0.2135	0.2135	0.2135
8.1	0.0537	0.0758	0.1071	0.1513	0.2137	0.2137	0.2137
8.2	0.0537	0.0758	0.1071	0.1513	0.2137	0.2137	0.2137
8.3	0.0537	0.0758	0.1071	0.1513	0.2137	0.2137	0.2137
8.4	0.0537	0.0758	0.1071	0.1513	0.2137	0.2137	0.2137
8.5	0.0537	0.0758	0.1071	0.1513	0.2137	0.2137	0.2137

8.6	0.0537	0.0758	0.1071	0.1513	0.2137	0.2137	0.2137
8.7	0.0537	0.0758	0.1071	0.1513	0.2137	0.2137	0.2137
8.8	0.0537	0.0758	0.1071	0.1513	0.2137	0.2137	0.2137
8.9	0.0537	0.0758	0.1071	0.1513	0.2137	0.2137	0.2137
9.0	0.0537	0.0758	0.1071	0.1513	0.2137	0.2137	0.2137

Nitrate + Nitrite as N: Nitrate is a form of nitrogen which is readily available to plants as a nutrient. Generally, nitrate is the primary inorganic form of nitrogen in aquatic systems. Nitrate and nitrite as N was analyzed by the BWQ using EPA method 353.2.

Orthophosphate as P: Orthophosphate as P is an inorganic form of phosphorus found in natural waters and readily available to plants. This is the tested form of phosphate because it is the form of phosphate used in fertilizer and applied to agricultural fields and residential lawns. Orthophosphate as P was analyzed by the BWQ using the American Society for Testing and Materials (ASTM) method D515-88(A).

***Escherichia coli* (*E. coli*)**: This is a type of bacteria normally found in the intestines of people and animals. Although most strains of *E. coli* are harmless, some can cause illness or even death. Testing for *E. coli* is a simple, inexpensive process that provides valuable information regarding water quality, as *E. coli* often indicates the presence of other pathogenic organisms. *E. coli* levels were analyzed by the BWQ using the Coliscan Method by membrane filtration.

Biological and Stream Habitat Parameter Methodology

Biological communities reflect an ecosystem's overall chemical, physical and biological integrity because they are sensitive to changes in a wide array of environmental factors (EPA, 1989; Karr, 1981). The Qualitative Habitat Evaluation Index (QHEI) is composed of several metrics that describe the physical attributes of the habitat that may be important in explaining species presence or absence and composition of fish communities in a stream (Rankin, 1989). A fish community is a group of fishes belonging to a number of different species that live in the same area and interact with each other (Baker & Frey, 1997). The QHEI represents a measure of stream geography. The interrelated metrics include stream cover, channel morphology, riparian and bank condition, substrate, pool and riffle quality, and gradient. The QHEI is a score of the combination of these metrics, in which 100 is the best possible score. These attributes have shown to be correlated with stream fish communities (Rankin, 1989). Physical habitat in streams strongly influences fish community composition (Richards *et al.*, 1996). Generally, the preferred fish sampling season is middle to late summer, when stream and river flows are moderate to low and less variable than during other seasons (EPA, 1989). The Index of Biological Integrity (IBI) is composed of several metrics that are combined to produce a total score. The scores range from 12 (worst) to 60 (best). The metrics include total number of fish, community function or feeding types, tolerant species, intolerant species, presence of hybrids, reproductive function, and abnormalities. The IBI is positively correlated with habitat quality as measured by the QHEI (Smith, 1999).

Aquatic macroinvertebrates are important indicators of environmental change in streams and rivers. The insect community composition reflects water quality and research demonstrates that different macroinvertebrate orders and families react differently to pollution sources. Indices of biotic integrity are valuable because aquatic biota integrate cumulative effects of sediment and nutrient pollution (Ohio EPA, 1995). The Invertebrate Community Index (ICI) is very similar to the Index of Biological Integrity (IBI) except it measures the health of the macroinvertebrate community. The ICI is comprised of ten metrics based on community structure that are scored 0, 2, 4, or 6 depending on how closely the results approximate least disturbed reference conditions. A score of 6 approaches the highest quality community conditions. Summation of the individual metric scores yields an ICI value between 0 and 60.

Fish sampling methods are based on the electrofishing guidelines provided by the U.S. Environmental Protection Agency and Ohio Environmental Protection Agency (OEPA). These methods were used for the determination of the Index of Biological Integrity (IBI) within the Eastern Corn Belt Plains ecoregion (OEPA, 1989; Simon & Dufour, 1997). The sampling sites indicated (QAPP, 2002) were sampled twice between June and September of 2002 and 2003. Whenever possible, the sampling sites were sampled with a tote-barge electrofishing sampler (TBS). In extremely small tributaries where a TBS is inoperable a lightweight, battery-powered backpack electrofishing (BPS) was used (QAPP, 2002). The TBS has an output of 4 to 6 amperes and the BPS unit has 0.5 to 1.5 amperes of output. Sample sites were classified as headwater (<20 square miles), wading (>20 square miles and shallow enough to wade) and boat sites (too deep to wade) (QAPP, 2002). Headwater and wading sites sampling lengths were at least 150 meters or 15 times the average width of the stream (QAPP, 2002). In the field, all fish were sorted by species and measured in one of two ways. Game fish, such as bass, bluegill, and catfish were individually measured for length and weight. Non-game species, such as minnow, suckers, and darters were mass weighed and measured for a single minimum and maximum length. Since the MIwb is not valid in headwater streams, weight measurements will not be taken at these sites to reduce unnecessary stress on the fish (QAPP, 2002). Fish under 20 mm were not included due to difficulties in reliable identification. If the identification of any fish was in question, it was preserved in 10% formalin and taken to the lab for identification (QAPP, 2002). Any endangered, threatened, or rare species were photographed and released. According to Scientific Collector's Permit regulations, the collection of any endangered or threatened species were reported to the State Endangered Species Coordinator within five business days (QAPP, 2002).

Macroinvertebrate sampling procedures are based on the guidelines provided by the OEPA for determination of the Invertebrate Community Index (ICI) scores (OEPA, 1989; EPA 1990). At each designated sampling site, 3 multi-plate samplers were placed in areas of similar flow velocity (above the 0.3 ft/sec required for ICI calculations) according to the methods of Hester and Dendy (1962) and serve as quantitative samples. The samplers were suspended and secured at similar depths and left in the stream for a period of six weeks between June and September of 2002 (QAPP, 2002). The samplers were removed and placed in bags of 100% isopropyl alcohol in the field. At the time of retrieval, a representative qualitative sample was taken using D-frame kicknets from all major habitat types present. In the lab, all organisms collected from the artificial substrates were washed through a standard #30 sieve (QAPP, 2002). The organisms were placed on a gridded pan and a random numbers table was used to select an associated grid on the pan from which to begin sorting the organisms.

The grids were sorted until at least 100 organisms were sorted. The organisms collected from the quantitative 3 multi-plate samplers were used to calculate the ICI scores and the qualitative kicknet samples were used only to provide an accurate account of the species present (QAPP, 2002).

Buck Creek Temperature Analysis

Temperature affects both biotic and abiotic variables of streams (Myrick and Cech 1998). In addition to decreasing dissolved oxygen levels, higher summer stream temperatures may affect aquatic organisms by disrupting metabolism, increasing susceptibility to toxins, increasing vulnerability to disease, and reducing food supplies. Streams may be classified in terms of their maximum average daily temperature as one of three types; coldwater (< 22 ^{o}C), coolwater (22 to 24 ^{o}C), and warmwater (> 24 ^{o}C) (Simon and Lyons 1995). Coldwater streams are typically dominated by salmonids (trout) or cottids (sculpins), coolwater streams are typically too warm to support either salmonids or cottids, and warmwater streams are most likely to support centrarchids such as, bass and bluegill (Simon and Lyons 1995).

Increased summer stream temperatures may occur as a result of many of the same human activities that are already known to negatively influence other parameters of water quality (Bartholow 2000). The absence of canopy cover reduces shading. The loss of riparian vegetation or the presence of impervious ground cover can inhibit infiltration of rainwater and increase runoff. Reduced infiltration decreases the recharge of ground water subsequently reducing the discharge of springs responsible for supplying cold water to streams during the summer. Many other microclimate characteristics that influence stream temperature may also be negatively affected as a result of riparian loss such as air temperature, humidity, wind speed, ground temperature, ground reflectivity, stream width, and stream roughness.

In 2002 and 2003, the Bureau of Water Quality collected stream temperature data from Buck Creek to examine the potential influence of ground water (springs) on the stream's fish communities. StowAway TidbiT ® data loggers recorded the water temperature every 10 minutes during the summer months to determine the maximum average daily temperature from sites along Buck Creek. In 2002, stream temperatures near the mouth of Buck Creek (Morrow's Meadow) and near Tillotson Avenue had maximum average daily temperatures of ~23 ^{o}C, while sites near the headwaters had temperatures of < 22 ^{o}C. In 2003, all sites along Buck Creek from the mouth to the headwaters had maximum average daily temperatures < 22 ^{o}C. These results suggest either a marginal coldwater or a coolwater thermal regime. The large populations of mottled sculpin collected throughout the Buck Creek further support the possibility of a coldwater stream classification. Since the Index of Biotic Integrity is calibrated for use in warmwater streams, special considerations have been made concerning the interpretation of the results of the fish community samples from Buck Creek. Further collection of temperature data from Buck Creek is planned for 2004.

The potential coldwater status of Buck Creek opens the possibility of introducing trout species. A sustainable trout population would not only provide a fishery resource that is otherwise unavailable in Delaware County, but most importantly, it would create an opportunity to provide greater protection for Buck Creek under the Indiana Administrative Code which requires streams capable of supporting the natural reproduction of trout to be maintained as such. There are no salmonid species native to the White River Watershed, therefore, and the possibility of Buck Creek successfully supporting introduced trout species would require further research.

Current data suggests that the dissolved oxygen and temperature requirements of rainbow trout and brown trout would be marginally consistent with the conditions found within Buck Creek (Wehrly et al. 1999). However, given the historical difficulties with establishing persistent salmonid populations, a thorough investigation would need to be conducted by a fisheries biologist with experience specifically related to the physical habitat requirements of salmonids before stocking could be recommended.

Regardless of whether or not trout are eventually stocked, an effort should be made to maintain or decrease stream temperatures in Buck Creek. The natural structure and function of the fish communities within this cold/coolwater stream are unique within Delaware County, and they are likely dependent on protection of the narrow riparian corridor that remains throughout most of the length of the stream. Additional protection could be provided by increasing the width of the riparian corridor along Buck Creek and its tributaries, and by limiting construction of additional impervious ground cover.