Table 4: Historic Places

Historic Place	Historic Place (Other Names)	Location	Historic Significance	Period of Significance
Andrew B. VanHuys Round Barn	Kincaid Barn	Boone County	Architecture/Engineering; Event	1900-1949
Appleyard	Alexander C. Stevenson Farm; Ballard Farm	Putnam County	Person	1825-1899
The Boulders	James Orville Cammack and Adelene Buston House	Putnam County	Architecture/Engineering	1900-1949
Brick Chapel United Methodist Church	Montgomery Chapel	Putnam County	Event	1825-1974
Courthouse Square Historic District	Courthouse Square District	Putnam County	Architecture/Engineering; Event	1800-1949
Delta Kappa Epsilon Fraternity House		Putnam County	Event; Architecture/Engineering	1925-1949
East College of DePauw University	East College of Indiana Asbury University	Putnam County	Event; Architecture/Engineering	1850-1899
Alfred Hirt House		Putnam County	Architecture/Engineering; Person	1875-1949
McKim Observatory, DePauw University		Putnam County	Event; Architecture/Engineering	1875-1899
F.P. Nelson House		Putnam County	Architecture/Engineering	1850-1874
James Edington Montgomery O'Hair House	J.E.M. O'Hair House	Putnam County	Architecture/Engineering	1825-1899
Putnam County Bridge No. 159	Reelsville Bridge	Putnam County	Architecture/Engineering; Event	1925-1949
Putnamville Presbyterian Church	Putnamville Methodist Church; Putnamville United Methodist Church	Putnam County	Architecture/Engineering; Event	1825-1849
Lycurgus Stoner House	Edna Brown House	Putnam County	Architecture/Engineering	1875-1899
William C. VanArsdel House	The Elms	Putnam County	Architecture/Engineering	1900-1924

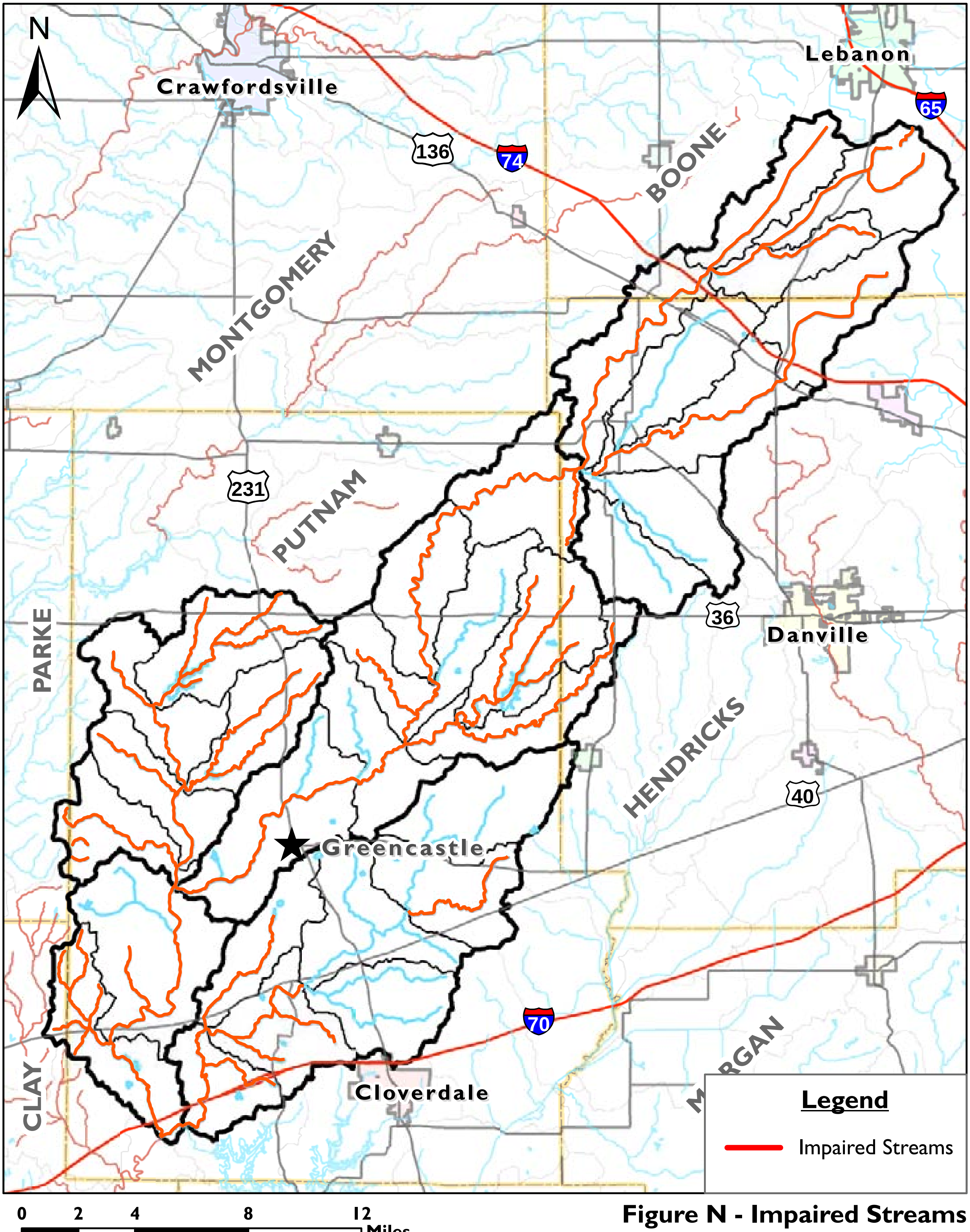

Figure N - Impaired Streams

Big Walnut Creek Watershed

Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

assemblages, but also including macroinvertebrates and aquatic plants, dates back to the late 1960's. He continued assessments and analyses into the late 1990's. His work during the 1990's in the Big Walnut Creek Watershed led to the assessment of critical areas within the watershed (compilation of several references used, see References Section). Dr. Gammon's observations and assessments were summarized and geographically interpreted by authors of this plan. Critical areas identified by summarizing Dr. Gammon's work were based solely on fish IBIs (Index of Biotic Integrity). This analysis was made in order to render subwatershed conclusions for comparative purposes to current subwatershed conditions/critical areas, as well as to aid in restoration prioritization (Figure O). This illustration shows the most critical areas (subwatersheds) in red, moderate areas in yellow, and low priority areas in green.

Two of the three identified critical areas are located in Boone County at the headwaters of Big Walnut Creek. This area is known to be largely agricultural. The third critical area is located in the area of Deer Creek in Putnam County. This area is also largely agricultural and is home to several confined animal feeding operations.

4.3 Regulated Environmental Issues

A search of IDEM's Office of Land Quality records located areas/sites within the Big Walnut Watershed that could pose a threat to the environment and are therefore regulated entities. The search revealed the following regulated environmental issues within the watershed: Permitted Solid Waste – 1, Brownfields – 1, Confined Feeding Operations (CFO) – 27, Open Dumps – 2, National Pollutant Discharge Elimination System (NPDES) Pipes – 17, Waste Septage Sites – 3, Leaking Underground Storage Tanks (LUST) – 32. Figures P1-P5 (Appendix A) present these findings and the locations of the environmental issues.

4.4 Additional Regulated Entity Information

Further research was conducted on NPDES dischargers (noted above). The Environmental Protection Agency's (EPA) Envirofacts Warehouse and Enforcement and Compliance History Online (ECHO) give listings of dischargers by county. There are 21 listed dischargers in the Big Walnut Watershed. Half of these NPDES dischargers are for sewerage systems or water supplies. The remainders of the permits are for industries or schools. These NPDES sites and a summary of their recent compliance records are shown in Figure Q and are listed in Table 5. This analysis provides important perspective when interpreting current water quality data in upcoming sections of this plan. Regular non-compliance of some NPDES dischargers could result in elevated concentrations of pollutants that may otherwise be attributed to non-point sources of pollution, including those being investigated and targeted as part of this plan.

The Indiana Department of Natural Resources (IDNR) Division of Water maintains a database of Significant Water Withdrawal Facilities (SWWF). This database lists all facilities that withdrawal significant amounts of ground and surface water. The database has information from 2004 to 2006. There are 14 facilities with the Big Walnut Creek Watershed that are listed as SWWFs. Of these 14 facilities, four are of notable interest, pumping over 100,000 gallons of water annually. Figure R maps the location of these facilities. Table 6 lists the facilities with corresponding numbers to the map locations, along with water source, well depth, annual pumping, and other additional information. Consideration of these facilities aids in understanding demands and pressures on groundwater supplies and base flows in Big Walnut

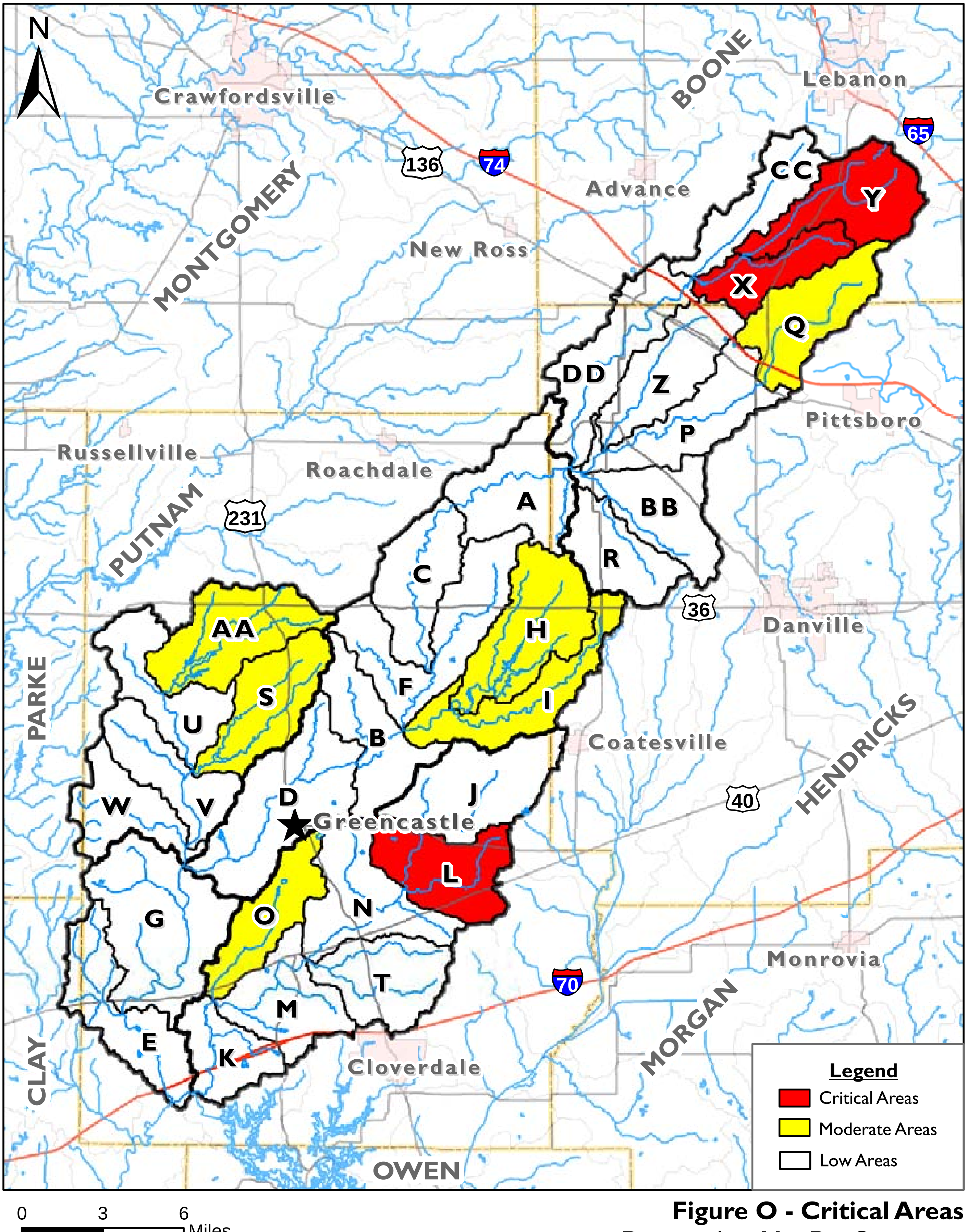

Figure O - Critical Areas Determined by Dr. Gammon

Big Walnut Creek Watershed

Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

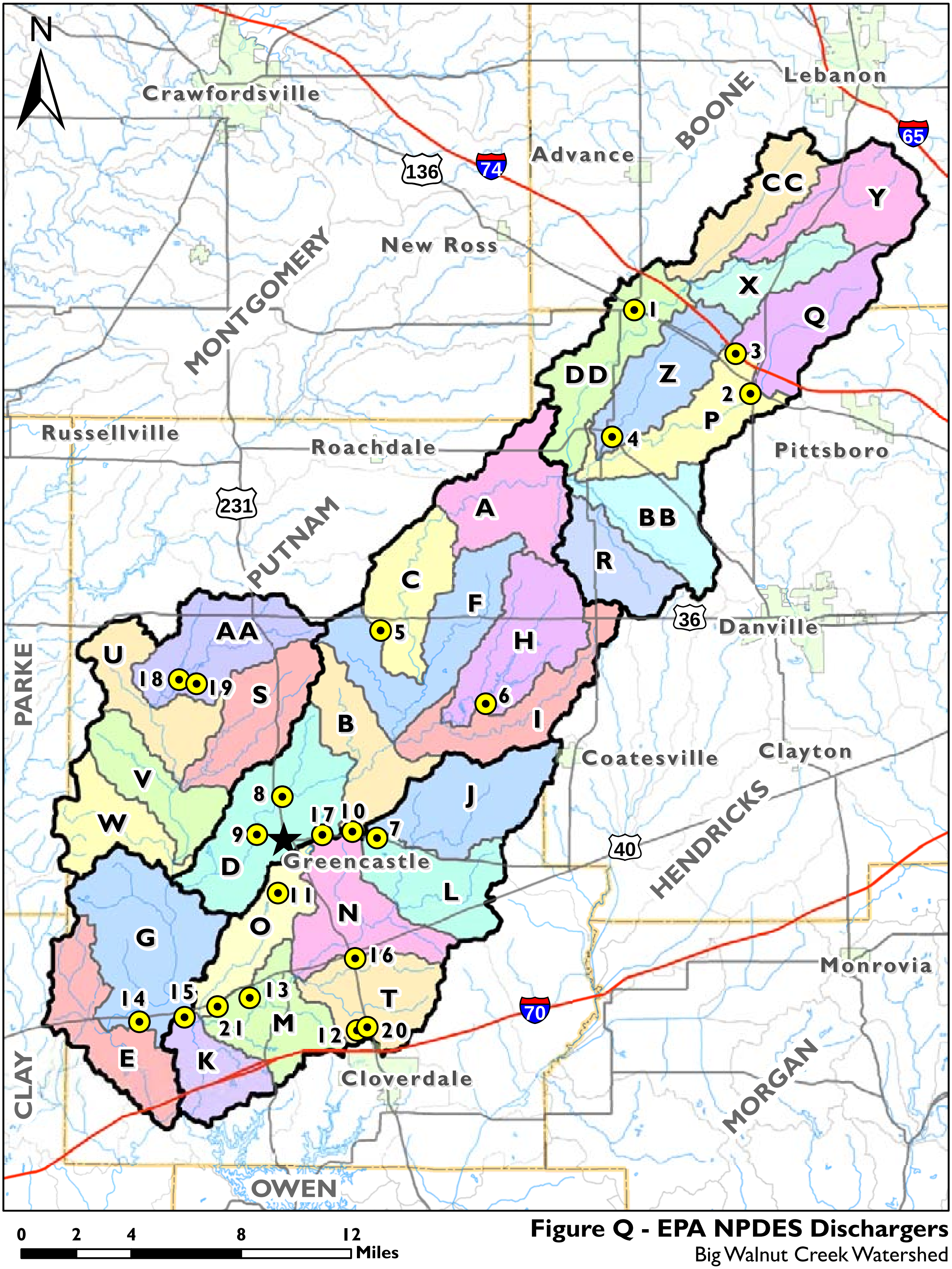

Figure Q - EPA NPDES Dischargers

Big Walnut Creek Watershed

Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

Table 5: NPDES Dischargers

Site	Discharger	NPDES Discharge Category	County	Quarters of Non-Compliance (out of 12 qtrs- current as of Oct-Dec 07)	Violation
1	Jamestown WWTP	Sewerage System	Boone	3	Chlorine, Nitrogen, DO, TSS
2	Lizton Municipal STP	Sewerage System	Hendricks	10	Nitrogen, E. coli, TSS
3	Lizton Rest Areas I-74	Regulation & Administration of Transportation Systems	Hendricks	n/a	n/a
4	North Salem WWTP	Sewerage System	Hendricks	1	TSS
5	Bainbridge Municipal WWTP	Sewerage System	Putnam	8	pH, BOD
6	Clear Creek Conservancy District	Sewerage System	Putnam	3	Nitrogen, E. coli, TSS
7	Crown Point Equipment Corporation	Motor Vehicle Parts and Accessories	Putnam	n/a	n/a
8	Greencastle Department of Water	Water Supply	Putnam	7	n/a
9	Greencastle Municipal STP	Sewerage System	Putnam	8	Nitrogen
10	IBM (Int'l Business Machines) Corporation	Die Cut Paper - Paperboard and Cardboard	Putnam	0	
11	Lone Star Industries Landfill	Cement, Hydraulic	Putnam	7	TSS
12	Martin Marietta Cloverdale 524	Crushed and Broken Limestone	Putnam	2	TSS
13	Putnamville Correctional Facility	Correctional Institutions	Putnam	5	pH, BOD, E. coli, TSS
14	Reelsville Elementary School	Elementary and Secondary Schools	Putnam	10	missed schedule, BOD
15	Reelsville Water Treatment Plant	Water Supply	Putnam	n/a	n/a
16	South Putnam High School	Elementary and Secondary Schools	Putnam	8	BOD, TSS
17	United (Speedway) 6022	Gasoline Service Station	Putnam	n/a	n/a
18	Van Bibber Lake Conservancy District	Sewerage System	Putnam	4	Missed Schedule
19	Van Bibber Water Treatment Plant	Water Supply	Putnam	4	pH, E. coli
20	Altra Indiana, LLC		Putnam	n/a	n/a
21	Buzzi Unicem - Manhattan Shale Mine		Putnam	n/a	n/a

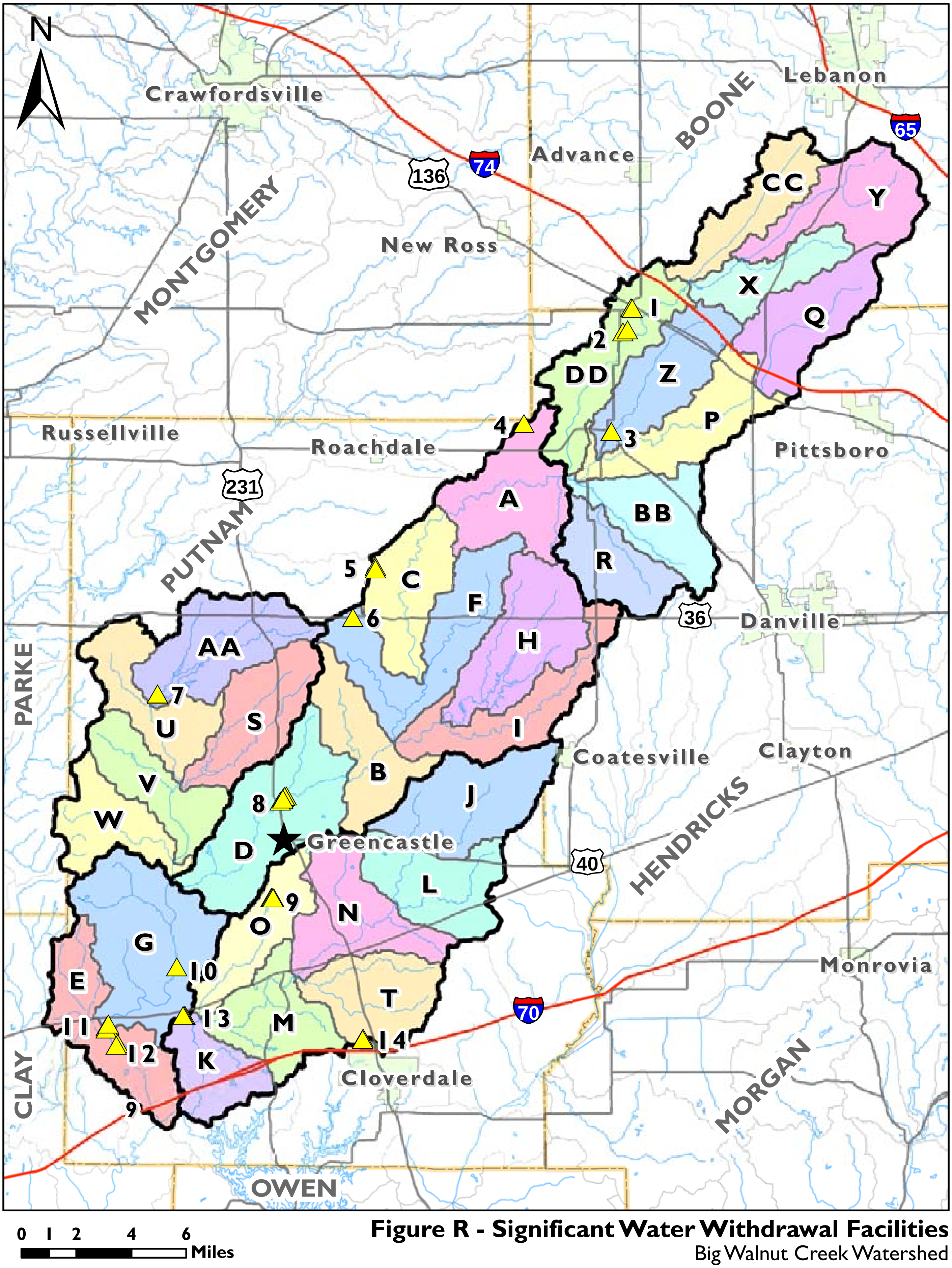

Figure R - Significant Water Withdrawal Facilities
Big Walnut Creek Watershed
Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

Table 6: Significant Water Withdrawal Facilities

SITE	USER	CATEGORY	SOURCE	DEPTH (FEET)	AQUIFER/WATER SOURCE	PUMPING CAPACITY (GPM)	YEAR	PUMPED ANNUALLY
1	Jamestown Mun Water Works	Public Supply	WELL	31	Sand and Gravel	40	2004	0
1	Jamestown Mun Water Works	Public Supply	WELL	31	Sand and Gravel	40	2005	0
1	Jamestown Mun Water Works	Public Supply	WELL	31	Sand and Gravel	40	2006	0
1	Jamestown Mun Water Works	Public Supply	WELL	63	Sand and Gravel	30	2004	0
1	Jamestown Mun Water Works	Public Supply	WELL	64	Sand and Gravel	30	2005	0
1	Jamestown Mun Water Works	Public Supply	WELL	65	Sand and Gravel	30	2006	0
2	Tomahawk Hills GC	Irrigation	INTAKE		Unknown Lake	300	2004	3957
2	Tomahawk Hills GC	Irrigation	WELL	160	Sand and Gravel	10	2004	0
2	Tomahawk Hills GC	Irrigation	INTAKE		Unknown Lake	300	2004	3957
2	Tomahawk Hills GC	Irrigation	WELL	160	Sand and Gravel	10	2004	0
2	Tomahawk Hills GC	Irrigation	INTAKE		Unknown Lake	300	2004	3957
2	Tomahawk Hills GC	Irrigation	WELL	160	Sand and Gravel	10	2004	0
3	North Salem Water Corp	Public Supply	WELL	100	Sand and Gravel	100	2004	8345
3	North Salem Water Corp	Public Supply	WELL	96	Sand and Gravel	150	2004	8338
3	North Salem Water Corp	Public Supply	WELL	100	Sand and Gravel	100	2004	8345
3	North Salem Water Corp	Public Supply	WELL	96	Sand and Gravel	150	2004	8338
3	North Salem Water Corp	Public Supply	WELL	100	Sand and Gravel	100	2004	8345
3	North Salem Water Corp	Public Supply	WELL	96	Sand and Gravel	150	2004	8338
4	Britton Farms	Irrigation	WELL	240	Sand and Gravel	1100	2004	0
4	Britton Farms	Irrigation	WELL	240	Sand and Gravel	1100	2005	0
4	Britton Farms	Irrigation	WELL	240	Sand and Gravel	1100	2006	0
5	North Putnam School Corp	Public Supply	WELL	298	Sand and Gravel	110	2004	4176
5	North Putnam School Corp	Public Supply	WELL	298	Sand and Gravel	110	2005	4110

Table 6: Significant Water Withdrawal Facilities (cont)								
SITE	USER	CATEGORY	SOURCE	DEPTH (FEET)	AQUIFER/WATER SOURCE	PUMPING CAPACITY (GPM)	YEAR	PUMPED ANNUALLY
5	North Putnam School Corp	Public Supply	WELL	298	Sand and Gravel	110	2006	3619
5	North Putnam School Corp	Public Supply	WELL	290	Unknown	110	2004	0
5	North Putnam School Corp	Public Supply	WELL	290	Unknown	110	2005	0
5	North Putnam School Corp	Public Supply	WELL	290	Unknown	110	2006	0
6	Town of Bainbridge	Public Supply	WELL	159	Limestone	100	2004	7737
6	Town of Bainbridge	Public Supply	WELL	159	Limestone	100	2005	12850
6	Town of Bainbridge	Public Supply	WELL	159	Limestone	100	2006	11300
7	Van Bibber Lake Conservancy	Public Supply	WELL	43	Sand and Gravel	100	2004	0
7	Van Bibber Lake Conservancy	Public Supply	WELL	43	Sand and Gravel	100	2005	0
7	Van Bibber Lake Conservancy	Public Supply	WELL	43	Sand and Gravel	100	2006	0
7	Van Bibber Lake Conservancy	Public Supply	WELL	46	Sand and Gravel	100	2004	24274
7	Van Bibber Lake Conservancy	Public Supply	WELL	46	Sand and Gravel	100	2005	24274
7	Van Bibber Lake Conservancy	Public Supply	WELL	46	Sand and Gravel	100	2006	24274
8	Greencastle Water Dept	Public Supply	WELL	54	Sand and Gravel	1000	2004	666800
8	Greencastle Water Dept	Public Supply	WELL	54	Sand and Gravel	1000	2005	666800
8	Greencastle Water Dept	Public Supply	WELL	54	Sand and Gravel	1000	2006	666800
8	Greencastle Water Dept	Public Supply	WELL	55	Sand and Gravel	200	2004	0
8	Greencastle Water Dept	Public Supply	WELL	55	Sand and Gravel	200	2005	0
8	Greencastle Water Dept	Public Supply	WELL	55	Sand and Gravel	200	2006	0
8	Greencastle Water Dept	Public Supply	WELL	54	Sand and Gravel	600	2004	0
8	Greencastle Water Dept	Public Supply	WELL	54	Sand and Gravel	600	2005	0

Table 6: Significant Water Withdrawal Facilities (cont)								
SITE	USER	CATEGORY	SOURCE	DEPTH (FEET)	AQUIFER/WATER SOURCE	PUMPING CAPACITY (GPM)	YEAR	PUMPED ANNUALLY
8	Greencastle Water Dept	Public Supply	WELL	54	Sand and Gravel	600	2006	0
8	Greencastle Water Dept	Public Supply	WELL	49	Sand and Gravel	1000	2004	0
8	Greencastle Water Dept	Public Supply	WELL	49	Sand and Gravel	1000	2005	0
8	Greencastle Water Dept	Public Supply	WELL	49	Sand and Gravel	1000	2006	0
8	Greencastle Water Dept	Public Supply	WELL	55	Sand and Gravel	1000	2004	0
8	Greencastle Water Dept	Public Supply	WELL	55	Sand and Gravel	1000	2005	0
8	Greencastle Water Dept	Public Supply	WELL	55	Sand and Gravel	1000	2006	0
8	Greencastle Water Dept	Public Supply	WELL	48	Sand and Gravel	650	2004	0
8	Greencastle Water Dept	Public Supply	WELL	48	Sand and Gravel	650	2005	0
8	Greencastle Water Dept	Public Supply	WELL	48	Sand and Gravel	650	2006	0
9	Lone Star Industries	Industry	INTAKE		Unnamed Quarry	850	2004	400
9	Lone Star Industries	Industry	INTAKE		Unnamed Quarry	850	2005	400
9	Lone Star Industries	Industry	INTAKE		Unnamed Quarry	850	2006	400
9	Lone Star Industries	Industry	INTAKE		Unnamed Quarry	850	2004	64700
9	Lone Star Industries	Industry	INTAKE		Unnamed Quarry	850	2005	64400
9	Lone Star Industries	Industry	INTAKE		Unnamed Quarry	850	2006	63600
9	Lone Star Industries	Industry	INTAKE		Unnamed Quarry	850	2004	65100
9	Lone Star Industries	Industry	INTAKE		Unnamed Quarry	850	2005	64500
9	Lone Star Industries	Industry	INTAKE		Unnamed Quarry	850	2006	63700
9	Lone Star Industries	Industry	INTAKE		Unnamed Quarry	850	2004	65540
9	Lone Star Industries	Industry	INTAKE		Unnamed Quarry	850	2005	65600
9	Lone Star Industries	Industry	INTAKE		Unnamed Quarry	850	2006	63400
10	Oakalla Valley Partnership	Irrigation	INTAKE		Big Walnut Creek	350	2004	0
10	Oakalla Valley Partnership	Irrigation	INTAKE		Big Walnut Creek	350	2005	0
10	Oakalla Valley Partnership	Irrigation	INTAKE		Big Walnut Creek	350	2006	0

Table 6: Significant Water Withdrawal Facilities (cont)								
SITE	USER	CATEGORY	SOURCE	DEPTH (FEET)	AQUIFER/WATER SOURCE	PUMPING CAPACITY (GPM)	YEAR	PUMPED ANNUALLY
11	City of Brazil	Public Supply	WELL	55	Sand and Gravel	600	2004	34400
11	City of Brazil	Public Supply	WELL	55	Sand and Gravel	600	2005	67400
11	City of Brazil	Public Supply	WELL	55	Sand and Gravel	60	2006	0
11	City of Brazil	Public Supply	WELL	54	Sand and Gravel	600	2004	135700
11	City of Brazil	Public Supply	WELL	54	Sand and Gravel	600	2005	134800
11	City of Brazil	Public Supply	WELL	54	Sand and Gravel	600	2006	149600
11	City of Brazil	Public Supply	WELL	54	Sand and Gravel	600	2004	135700
11	City of Brazil	Public Supply	WELL	54	Sand and Gravel	600	2005	134800
11	City of Brazil	Public Supply	WELL	54	Sand and Gravel	600	2006	149600
11	City of Brazil	Public Supply	WELL	60	Sand and Gravel	1260	2004	135700
11	City of Brazil	Public Supply	WELL	60	Sand and Gravel	1260	2005	134800
11	City of Brazil	Public Supply	WELL	60	Sand and Gravel	1260	2006	149600
11	City of Brazil	Public Supply	WELL	56	Sand and Gravel	787	2004	238400
11	City of Brazil	Public Supply	WELL	56	Sand and Gravel	787	2005	202200
11	City of Brazil	Public Supply	WELL	56	Sand and Gravel	787	2006	299300
12	A &C Products	Industry	INTAKE		Unknown Pit	2800	2004	241600
12	A &C Products	Industry	INTAKE		Unknown Pit	2800	2005	90600
12	A &C Products	Industry	INTAKE		Unknown Pit	2800	2006	271800
12	A &C Products	Industry	INTAKE		Unknown Pit	800	2004	0
12	A &C Products	Industry	INTAKE		Unknown Pit	800	2005	0
12	A &C Products	Industry	INTAKE		Unknown Pit	800	2006	0
13	Reelsville Water	Public Supply	WELL	92	Sand and Gravel	543	2006	72800
13	Reelsville Water	Public Supply	WELL	95	Sand and Gravel	543	2006	72800
13	Reelsville Water	Public Supply	WELL	62	Sand and Gravel	577	2006	72900
14	American Aggregates	Industry	INTAKE		Unnamed Quarry	1175	2004	179300
14	American Aggregates	Industry	INTAKE		Unnamed Quarry	1175	2005	124300
14	American Aggregates	Industry	INTAKE		Unnamed Quarry	1175	2006	166500
14	American Aggregates	Industry	INTAKE		Unnamed Quarry	3000	2004	35700
14	American Aggregates	Industry	INTAKE		Unnamed Quarry	3000	2005	38900
14	American Aggregates	Industry	INTAKE		Unnamed Quarry	3000	2006	26200

Creek. These SWWFs also represent important stakeholders in the protection and management of Big Walnut Creek.

5.0 WATER QUALITY ASSESSMENTS – EXISTING AND CURRENT

5.1 IDEM Data

A request was submitted to IDEM requesting both chemical and biological data that has been collected on the Big Walnut and Deer Creek Watersheds. Data was received from IDEM dating from 2002 to 2006. These sites were monitored on regular basis, but the frequency at which the site was monitored varies from site to site. Chemical and metal data was collected at four sites, fish data was collected at eight sites, and macroinvertebrate data at fifteen sites (Figure S). IDEM's Site 1 for chemical and metal data shows consistently high concentrations of nitrate. Site 1 also had high sediment concentrations. Site 1 is present in Subwatershed E. IDEM's Sites 3 and 4 for the chemical and metal data are the only sites reporting *E. coli* data from the collected data that we received from IDEM. These two sites were only sampled for *E. coli* during June of 2006 and show high *E. coli* concentrations. Site 3 is in Subwatershed D and Site 4 is in Subwatershed W. As noted in Section 4.1, twenty-nine segments of stream within the Big Walnut Watershed are listed for impairments according to the 303d list. Obviously, additional data was collected by IDEM to arrive at these listings; however, it was not made available to authors of this report as part of the data request.

5.2 Hoosier Riverwatch Data

Hoosier Riverwatch is a volunteer program run through IDNR Division of Fish and Wildlife. The purpose of the program is to increase public awareness of water quality throughout the State of Indiana by training volunteers to monitor the quality of local stream's water.

There has been little data regularly collected for the Big Walnut Creek Watershed (Eel 8-digit HUC). Available data dates from 2000 to 2007 and includes chemical, biological, habitat, and stream flow data. This data can be referenced in Table 7.

5.3 Current Data

Water quality monitoring was conducted within the watershed to identify nonpoint source pollution and critical areas. The sampling site locations covered the three primary counties, Boone, Hendricks, and Putnam. A number of these monitoring locations were located along streams segments that been identified as impaired. IDEM also conducted E. coli monitoring during five events (weekly) in October, 2007. Sample locations for monitoring associated with this plan, as well as IDEM's additional *E. coli* monitoring are shown on Figure T.

Current water quality monitoring conducted as part of this project consisted of chemical and macroinvertebrate sampling. Chemical sampling was conducted quarterly, beginning in May 2007 and macroinvertebrate sampling began in April 2007. Twenty-four sites within the watershed were sampled a total of six times for chemical parameters and twice for biological parameters. The water quality criteria analyzed included dissolved oxygen, biochemical oxygen demand, pH, total phosphate, nitrates, flow, total suspended solids, and *E. coli*. Collected samples of *E. coli* were cultured in the Commonwealth Biomonitoring laboratory for analysis.

Results of each water quality criteria sampled are displayed in Subsections 5.3.2 to 5.3.7 in Table format. The tables allow side by side comparison of a single criterion/parameter across all six sampling events. Several pollutants are shown as loads, rather than concentrations. This allows for a more accurate comparison of relative impacts in each subwatershed since flow is accounted for. Raw concentration data is included in Appendix E.

Loads for the pollutants were calculated as both an individual site average and as an overall watershed average. Averages were calculated using the first five samples. The sixth sample was not included as it was a part of the major storms that occurred in June and the data would skew the numbers. The average watershed nitrate load is 2162.03 tons/year. The average watershed total phosphorus load is 49.87 tons/year. The average watershed total suspended solids load is 3780.28 tons/year. The watershed average biochemical oxygen demand load is 3.24 tons/year.

E.coli averages were calculated as well, but not on a load basis. *E.coli* counts for the watershed average below the State single grab sample standard of 235 cfu/100mL at 212 cfu/100mL. This average is based upon the data collected for the project and not the data collected by IDEM for TMDL sampling. Even though the average is below the State standard many of the segments within the Big Walnut Creek Watershed are still impaired.

Monitoring of macroinvertebrates was performed twice (spring and fall) at all twenty-four sites within the watershed. The collected samples were analyzed using the State of Indiana's macroinvertebrate Index of Biotic Integrity (mIBI). A habitat assessment was also conducted at each site using the Qualitative Habitat Evaluation Index (QHEI) method set forth by the Ohio EPA. QHEI scores were used to aid in interpreting the mIBI scores.

Aquatic macroinvertebrates samples were collected using a dip net in riffle areas where the water current was 30cm/sec. Once samples were obtained they were preserved in the field with 70% isopropanol. A subsample of 100 organisms was prepared from each site by evenly distributing the organisms among randomly selected grids until 100 organisms had been selected from the entire sample. Each organism was then identified to the lowest possible taxon, typically genus or species. The results of the macroinvertebrate study were then analyzed by calculating metrics based on information about sensitivity of individual species to changes in environmental conditions.

A Quality Assurance Project Plan (QAPP) was developed and submitted to the State on April 2, 2007 and approved by IDEM on May 3, 2007 before monitoring activities began. Monitoring followed guidelines set forth in the approved QAPP.

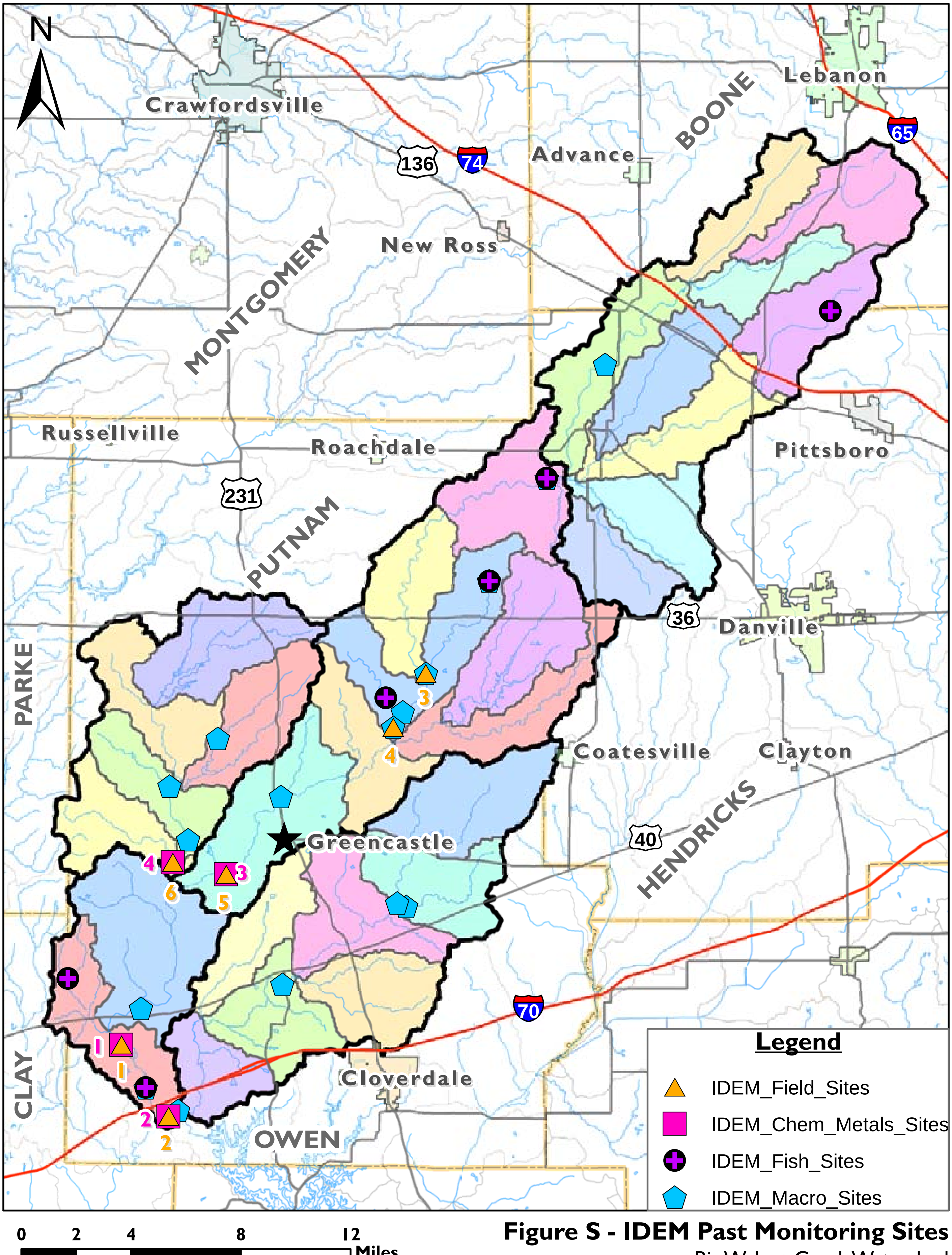

Figure S - IDEM Past Monitoring Sites

Big Walnut Creek Watershed

Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

Table 7: Hoosier Riverwatch Data

Advanced Chemical Data

Site ID	Time	Date	Weather	Past Weather	Water Quality Score	DO (ppm)	DO (%Saturation)	pH	BOD 5(mg/L)	Temp Change (c)	Total Phosphate (mg/L)	Nitrate NO3 (mg/l)	Turbidity(NTU)	EColi
118	9:30AM	9/14/2000	Clear/Sunny	Clear/Sunny	73.55	11.5	110	8.57	2	-0.1	0.78	5.03	38	
118	9:15 AM	8/30/2001	Clear/Sunny	Clear/Sunny	80.31	8.33	92	8	1	0	0.65	2.75	42	
120	12:30p.m.	10/11/2000	Clear/Sunny	Clear/Sunny	76	12.5	98	7.83	2.5	0.52	0.6	4.05	58.33	
120	9:25	2/14/2002	Clear/Sunny	Clear/Sunny	76.08	14.67	101.33	8	5	0	0.57	2.83	57	
120	9:30am	9/2/2005	Clear/Sunny	Clear/Sunny	NA	9.87	102	8.33	1.67				28.01	
210	9:30 AM	4/5/2001	Clear/Sunny	Clear/Sunny	74.01	11	96	8	2.7	-0.5	0.68	6.5	60	
210	9:30 AM	9/10/2003	Clear/Sunny	Clear/Sunny	NA	8.6		7.87	4.67	0.2	0		44.33	
211	12:45 PM	4/5/2001	Clear/Sunny	Clear/Sunny	69.54	12.67	124.67	8	3	0.3	0.8	9.5	60	
417	9:30 AM	9/11/2004	Clear/Sunny	Clear/Sunny	NA	8	86	8		1		0	10	
696	10:30am	9/25/2004	Clear/Sunny	Clear/Sunny	62.9	4	42	6	4	-2	0	2	0	200
818	5:45 PM	8/31/2004	Clear/Sunny	Clear/Sunny	NA	0	90	9		-2		4.4	61	
889	1:00 PM	1/10/2004	Overcast	Clear/Sunny	NA	19	135	8.2		2			15.01	
889	9:00 AM	4/28/2006	Clear/Sunny	Overcast	N/A	10	85	6.5		1		22	15.01	
889	1:00 PM	9/17/2006	Overcast	Clear/Sunny	N/A	9.67	105		5.5	-0.5		8.8	15.01	
889	9:30 AM	5/4/2007	Overcast	Overcast	77.44	8.67	85	8.33	4.5	0		5.13	15.01	
1046	4:00 PM	5/29/2006	Clear/Sunny	Clear/Sunny	77.42	7	85	8.67	0	0		22	15.01	
1046	12:00 PM	9/16/2006	Clear/Sunny	Stormy	N/A	8	81		1	0		22	15.01	
1046	3:25 PM	3/27/2007	Clear/Sunny	Overcast	84.04	9	95	8	0	0		8.8	15.01	
1046	123:00 PM	5/31/2007	Overcast	Overcast	N/A	8	100	9				13.2	15.01	

Stream Flow Data

Site ID	Time	Date	Weather	Past Weather	Ave Depth(ft)	Ave Width(ft)	Ave Velocity (ft/sec)	n value	Discharge (cfs)
120	9:25am	2/14/2002	Clear/Sunny	Clear/Sunny	0.87	29.08	0.88	0.8	17.81
118	9:30	8/29/2002	Clear/Sunny	Clear/Sunny	0.89	24.33	2.73	0.9	53.2
696	7:00pm	10/22/2003	Clear/Sunny	Clear/Sunny	1.35	67.4	0.61	0.8	44.4
696	5:30pm	1/1/2003	Clear/Sunny	Clear/Sunny	1.31	70	0.6	0.8	44.02
696	10:00am	4/14/2004	Clear/Sunny	Overcast	1.68	64.48	1.18	0.8	102.26
818	5:45 PM	8/31/2004	Clear/Sunny	Clear/Sunny	0.92	7.5	0.2	0.9	1.24
696	10:30am	9/25/2004	Clear/Sunny	Clear/Sunny	1.08	57.67	0.44	0.8	21.92
889	1:00 PM	1/10/2004	Overcast	Clear/Sunny	0.8	42.67	0.95	0.9	29.19
120	9:30am	9/2/2005	Clear/Sunny	Clear/Sunny	1.18	33.37	0.56	0.8	17.64
889	9:00 AM	4/28/2006	Clear/Sunny	Overcast	1.31	68.33	1.82	0.8	130.33
1046	4:00 PM	5/29/2006	Clear/Sunny	Clear/Sunny	0.36	13.17	0.5	0.8	1.9
1046	12:00 PM	9/16/2006	Clear/Sunny	Stormy	0.23	5	0.22	0.8	0.2
1046	3:25 PM	3/27/2007	Clear/Sunny	Overcast	0.45	15.77	1.45	0.8	8.23
889	9:30 AM	5/4/2007	Overcast	Overcast	1.34	75.83	0.87	0.9	79.56
889	1:00 PM	9/17/2006	Overcast	Clear/Sunny	0.69	53.67	1.62	0.8	47.99

Table 7: Hoosier Riverwatch Data (cont)

Biological Data															
Site ID	Time	Date	Weather	Past Weather	Pollution Tollerance Score	Stonefly Larvae	Mayfly Larvae	Caddis Fly Larve	Dobsonfly Larvae	Riffle Beetle	Water Penny	Right handed Snail	Damsel Fly Nymph	Dragonfly Nymph	Sowbug
118	9:30 AM	9/14/2000	Clear/Sunny	Clear/Sunny	23		12	20		3		1		1	
118	9:15	8/30/2001	Clear/Sunny	Clear/Sunny	29		77	71	3	2				3	
118	12:30pm	8/29/2002	Clear/Sunny	Clear/Sunny	24		20	3		2			3	2	
120	12:30	10/11/2000	Clear/Sunny	Clear/Sunny	29		38	17		14		1	13	1	
120	09:25am	2/14/2002	Clear/Sunny	Clear/Sunny	18	4	22	17							
120	9:30am	9/2/2005	Clear/Sunny	Clear/Sunny	26		23	13		5	10		8	1	
210	9:30 AM	4/5/2001	Clear/Sunny	Clear/Sunny	30		25	31	8				1	2	4
210	9:30	9/10/2003	Clear/Sunny	Clear/Sunny	39	5	20	1	2	11		1	2	2	
211	12:45 PM	4/5/2001	Clear/Sunny	Clear/Sunny	29		20	12	1	3				1	
364	9:30	9/27/2001	Clear/Sunny	Clear/Sunny	23		108	84	9	1			2		
417	11:00 AM	6/30/2003	Clear/Sunny	Clear/Sunny	20		5		1		8	4			
696	7:00pm	10/22/2003	Clear/Sunny	Clear/Sunny	30		6	5		7	3	1	3	2	
696	10:00am	4/14/2004	Clear/Sunny	Overcast	26	5	4	2			2				
696	10:30am	9/25/2004	Clear/Sunny	Clear/Sunny	25		1	1			1	1			
818	5:45 PM	8/31/2004	Clear/Sunny	Clear/Sunny	18		2	1					3		
889	1:00 PM	10/21/2004	Overcast	Clear/Sunny	13		16	12					1		
889	9:00 AM	4/28/2006	Clear/Sunny	Overcast	27	1	78	44	3				2		
889	1:00 PM	9/17/2006	Overcast	Clear/Sunny	17	10	10	15							
889	9:30 AM	5/4/2007	Overcast	Overcast	30	31	33	3		2					
1046	4:00 PM	5/29/2006	Clear/Sunny	Clear/Sunny	24			8		1	5	20			
1046	12:00 PM	9/16/2006	Clear/Sunny	Stormy	20		5	8			5	several			
1046	123:00 PM	5/31/2007	Overcast	Overcast	17			10			2	5			
1046	3:25 PM	3/27/2007	Clear/Sunny	Overcast	25		1	15			11	20			5

Table 7: Hoosier Riverwatch Data (cont)

Habitat Data											
Site ID	Time	Date	Weather	Past Weather	I	II	III	IV	V	VI	CQHEI
118	9:30 AM	9/14/2000	Clear/Sunny	Clear/Sunny	15	8	15	9	12	10	69
120	12:30 p.m	10/11/2000	Clear/Sunny	Clear/Sunny	20	12	15	17	12	10	86
210	9:30 AM	4/5/2001	Clear/Sunny	Clear/Sunny	19	12	9	10	7	13	70
211	12:45 PM	4/5/2001	Clear/Sunny	Clear/Sunny	15	10	12	12	11	10	70
118	9:15am	8/30/2001	Clear/Sunny	Clear/Sunny	10	10	15	8	12	10	65
120	9:25	2/14/2002	Clear/Sunny	Clear/Sunny	15	14	12	12	12	13	78
364	9:30	9/27/2001	Clear/Sunny	Clear/Sunny	15	16	12	10	14	10	77
118	9:30 a.m.	8/29/2002	Clear/Sunny	Clear/Sunny	15	16	12	8	11	10	72
417	11:00 AM	6/30/2003	Clear/Sunny	Clear/Sunny	20	14	18	19	7	9	87
211	9:30	9/10/2003	Clear/Sunny	Clear/Sunny	24	6	12	12.5	11	12	77.5
696	7:00pm	10/23/2003	Clear/Sunny	Clear/Sunny	15	16	18	15	5	12	81
696	5:30pm	1/23/2004	Clear/Sunny	Clear/Sunny	15	16	15	17	10	10	83
696	10:00am	4/14/2004	Clear/Sunny	Overcast	15	18	15	14	12	15	89
818	5:45 PM	8/31/2004	Clear/Sunny	Clear/Sunny	0	10	14	14	9	6	53
696	10:30am	9/25/2004	Clear/Sunny	Clear/Sunny	15	18	15	14	8	11	81
818	2:30 PM	11/1/2004	Clear/Sunny	Clear/Sunny	0	8	8	14	7	6	43
120	9:30am	9/2/2005	Clear/Sunny	Clear/Sunny	20	10	15	16	13	10	84
889	9:00 AM	4/28/2006	Clear/Sunny	Overcast	17	14	16.5	17	9	11.5	85
1046	4:00 PM	5/29/2006	Clear/Sunny	Clear/Sunny	17	16	20	16.5	9	13	91.5
1046	3:25 PM	3/27/2007	Clear/Sunny	Overcast	13	16	20	14.5	10	10.5	84

Site ID	**Description**
118	Big Walnut Creek - Down stream of Houck Covered Bridge
120	Deer Creek - CR 375S bridge
210	Deweese Branch - Confluence with Deer Creek
211	Big Walnut Creek - Wildwood Bridge
364	Big Walnut Creek - Crowes Bridge
417	Deweese Branch - Limestone bottom creek flowing through wooded area with limestone outcroppings
696	Big Walnut Creek - McCloud Nature Park
818	Unnamed Tributary to Ramp Run - West CR 350N, Danville
889	Big Walnut Creek - Between Pine Bluff and Rolling Stone Covered Bridges
1046	Unnamed Tributary to Big Wanut Creek - Tributary to West Fork Big Walnut Creek

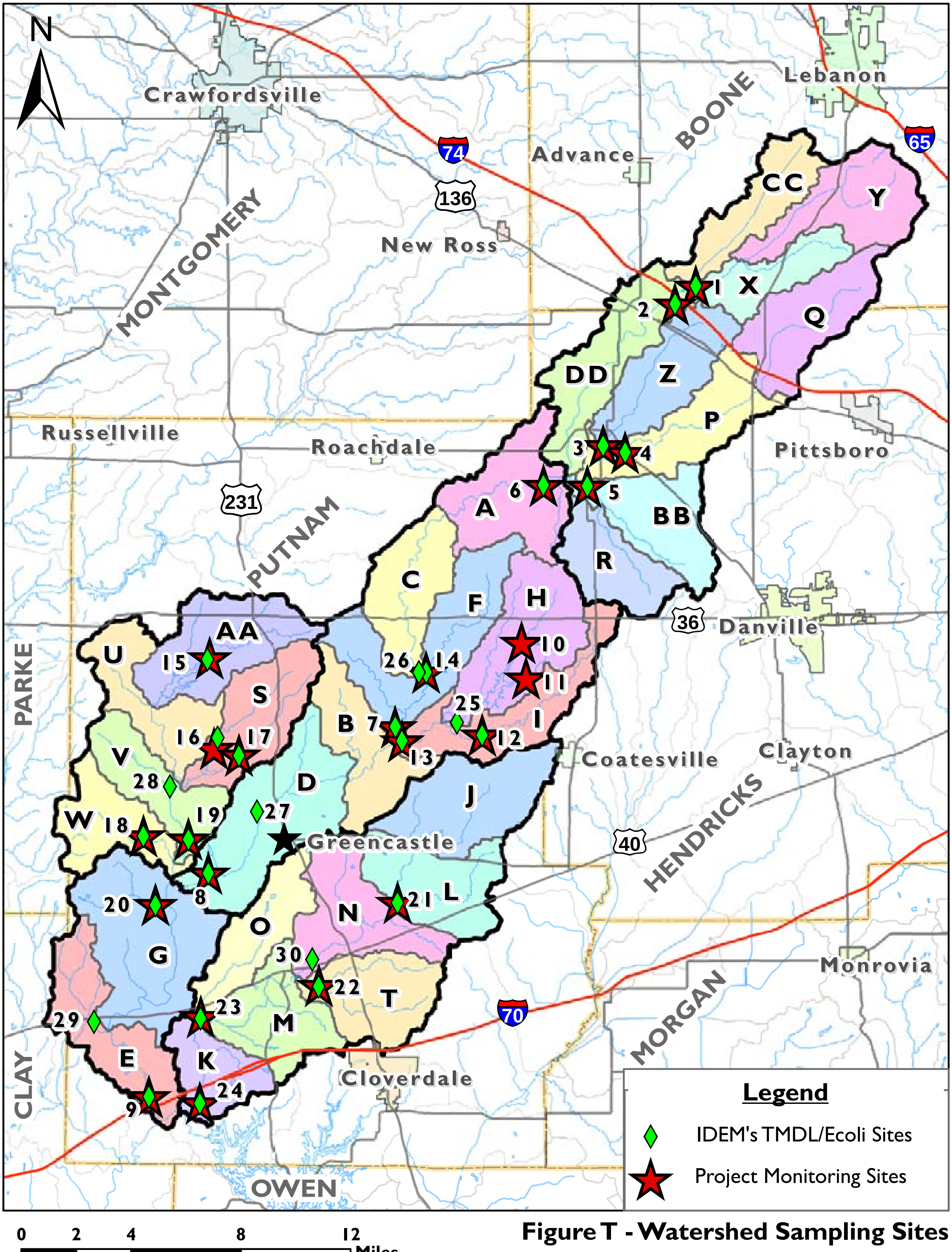

Figure T - Watershed Sampling Sites

Big Walnut Creek Watershed

Boone, Clay, Hendricks, Parke, & Putnam Counties, Indiana

5.3.1 Flow Measurements

Flow data were gathered from the USGS Gauge at Roachdale along Big Walnut Creek. Flow at this site is for a drainage area of 131 square miles. Flow at all other sites was extrapolated as a proportion of this flow. For example, if a sampling site has a drainage area of 13 square miles, the flow is ten percent of the flow at Roachdale. Changes in storm flows relative to base flow data can also demonstrate the 'flashiness' of the stream (i.e. its response to run-off events). Table 8 displays flow data for each sample site at each sample event.

Table 8: Flow Data

Flow Data (cfs) Flow data is calculated from USGS Roachdale Gauge						
	5/29/07	**7/11/07**	**8/28/07**	**1/8/08**	**4/10/08**	**6/4/08***
	Storm	Base	Base	Storm	Base	Storm
USGS Gauge Flow	42	8.5	6.5	35	100	7000
Site 1 - Watershed X, Y	7.1	1.4	1.1	6.0	17.0	1190.0
Site 2 - Watershed CC	3.4	0.7	0.5	2.8	8.0	560.0
Site 3 - Watershed Z	4.6	0.9	0.7	3.9	11.0	770.0
Site 4 - Watershed P, Q	8.0	1.6	1.2	6.7	19.0	1330.0
Site 5 - Watershed BB, R	7.6	1.5	1.2	6.3	18.0	1260.0
Site 6 - Watershed DD	38.2	7.7	5.9	31.9	91.0	6370.0
Site 7 - Watersheds A, C, F	46.6	9.4	7.2	38.9	111.0	7770.0
Site 8 - Watershed B, D	72.2	14.6	11.2	60.2	172.0	12040.0
Site 9 - Watershed E, G	107.5	21.8	16.6	89.6	256.0	17920.0
Site 10 - Watershed H	2.9	0.6	0.5	2.5	7.0	490.0
Site 11 - Watershed H	1.7	0.3	0.0	1.4	4.0	280.0
Site 12 - Watershed I	3.4	0.7	0.5	2.8	8.0	560.0
Site 13 - Watershed I	9.7	2.0	1.5	8.1	23.0	1610.0
Site 14 - Watershed F	3.4	0.7	0.5	2.8	8.0	560.0
Site 15 - Watershed AA	4.6	0.9	0.7	3.9	11.0	770.0
Site 16 - Watershed S	2.1	0.4	0.3	1.8	5.0	350.0
Site 17 - Watershed S	2.1	0.4	0.0	1.8	5.0	350.0
Site 18 - Watershed W	2.9	0.6	0.5	2.5	7.0	490.0
Site 19 - Watershed U, V	15.5	3.1	2.4	13.0	37.0	2590.0
Site 20 - Watershed G	2.5	0.5	0.4	2.1	6.0	420.0
Site 21 - Watershed L, J	6.7	1.4	1.0	5.6	16.0	1120.0
Site 22 - Watershed T	3.8	0.8	0.6	3.2	9.0	630.0
Site 23 - Watershed O	3.4	0.7	0.5	2.8	8.0	560.0
Site 24 - Watershed K, M, N	27.3	5.5	4.2	22.8	65.0	4550.0

*Approximately 1.5 inches of rain was received June 3-June 4, representing an above average storm event sampling.

5.3.2 Dissolved Oxygen (DO)

Dissolved oxygen is a measure of the amount of oxygen available in the water for fish, macroinvertebrates and other wildlife. When excessive nutrients from sources such as fertilizers and wastewaters enter the water, plants and algae will flourish. When excess aquatic plants and algae begin to decay or die they remove a significant amount of oxygen from the water which can often cause a fish kill or degraded conditions for other wildlife. Low DO levels often signal non-point source pollution problems. There are several factors that influence dissolved oxygen levels. They include: temperature, plant growth and photosynthesis, and amount of decaying organic matter.

Sites that displayed DO levels at or below the State water quality standard of 5 mg/L during each sampling event were highlighted to assist in the identification of consistent water quality concerns and the development of critical areas and watershed "hotspots."

Table 9: Dissolved Oxygen

Dissolved Oxygen (DO) mg/L						
	5/29/07	**7/11/07**	**8/28/07**	**1/8/08**	**4/10/08**	**6/4/08**
	Storm	Base	Base	Storm	Base	Storm
Site 1 - Watershed X, Y	8.1	7.3	6.7	9.5	10.5	7.0
Site 2 - Watershed CC	12	6.3	5.0	10.5	10.6	6.7
Site 3 - Watershed Z	9.1	8.4	9.4	10.5	11.9	7.8
Site 4 - Watershed P, Q	9.1	7.5	8.0	9.6	11.6	6.8
Site 5 - Watershed BB, R	8.6	5.7	6.4	10.0	10.5	8.0
Site 6 - Watershed DD	9.0	8.2	8.4	10.0	10.9	7.9
Site 7 - Watersheds A, C, F	8.7	6.8	7.0	9.8	10.6	8.0
Site 8 - Watershed B, D	11.1	8.6	7.8	12.4	11.9	8.1
Site 9 - Watershed E, G	9.7	8.1	8.2	12.8	11.7	9.7
Site 10 - Watershed H	6.7	7.8	7.5	9.8	10.7	8.2
Site 11 - Watershed H	8.1	5.0	3.6	9.9	10.2	8.1
Site 12 - Watershed I	8.9	4.2	4.4	8.1	10.5	8.2
Site 13 - Watershed I	8.0	8.4	4.7	9.4	10.2	7.9
Site 14 - Watershed F	10.6	8.2	7.3	9.8	10.5	8.4
Site 15 - Watershed AA	9.8	6.2	6.6	11.2	13.1	12.4
Site 16 - Watershed S	10.1	7.7	6.7	12.5	13.4	15.2
Site 17 - Watershed S	8.7	6.7	3.3	12.6	13.9	14.8
Site 18 - Watershed W	9.8	7.4	6.5	13.1	13.7	8.7
Site 19 - Watershed U, V	11.3	8.5	7.0	11.7	12.7	14.2
Site 20 - Watershed G	8.9	7.6	8.1	12.7	13.6	7.8
Site 21 - Watershed L, J	10.1	6.4	6.8	12.2	13.1	9.4
Site 22 - Watershed T	9	8.1	6.8	14.2	12.5	10.2
Site 23 - Watershed O	10.2	6.7	6.8	12.2	12.0	9.2
Site 24 - Watershed K, M, N	8.6	6.1	7.3	13.1	11.6	9.3

Percent saturation is the result of comparing the level of dissolved oxygen present in water to the total amount of dissolved oxygen that water is able to hold at a given temperature and pressure. Sites that displayed percent saturation values lower than 70% were highlighted to assist in identification of sites experiencing conditions stressful to aquatic life. Sites with percent saturation values higher than 115% were highlighted to assist in identification of sites likely experiencing algal bloom, as indicator of nutrient enrichment.

Table 10: Percent Saturation

Percent Saturation						
	5/29/07	**7/11/07**	**8/28/07**	**1/8/08**	**4/10/08**	**6/4/08**
	Storm	Base	Base	Storm	Base	Storm
Site 1 - Watershed X, Y	94.2	86.9	82.7	94.1	100.0	89.7
Site 2 - Watershed CC	148.2	73.3	61.7	104.0	98.2	82.7
Site 3 - Watershed Z	108.3	97.7	111.9	104.0	110.2	94.0
Site 4 - Watershed P, Q	105.8	89.3	85.2	93.2	104.4	84.0
Site 5 - Watershed BB, R	100.0	66.3	74.4	97.1	100.0	95.2
Site 6 - Watershed DD	104.7	98.8	101.2	99.0	101.0	94.1
Site 7 - Watersheds A, C, F	101.2	81.9	84.3	93.3	96.4	92.0
Site 8 - Watershed B, D	129.1	103.6	91.8	95.4	103.9	87.1
Site 9 - Watershed E, G	112.1	96.4	95.4	103.2	104.9	105.4
Site 10 - Watershed H	79.8	89.7	87.2	95.2	99.1	95.4
Site 11 - Watershed H	93.1	60.2	41.9	96.1	94.4	94.2
Site 12 - Watershed I	100.0	48.8	50.6	77.1	100.0	92.1
Site 13 - Watershed I	86.0	101.2	54.7	89.5	94.4	90.8
Site 14 - Watershed F	121.8	95.4	83.9	93.3	95.5	96.9
Site 15 - Watershed AA	112.6	77.0	80.6	103.7	111.7	129.2
Site 16 - Watershed S	112.2	89.5	75.3	105.9	110.7	156.7
Site 17 - Watershed S	103.6	77.0	39.3	101.6	115.7	152.6
Site 18 - Watershed W	119.7	84.1	72.2	104.8	116.1	90.2
Site 19 - Watershed U, V	132.9	101.2	79.6	91.4	108.3	147.2
Site 20 - Watershed G	97.8	86.4	92.1	105.0	115.3	80.8
Site 21 - Watershed L, J	114.8	74.0	77.3	109.4	114.4	101.1
Site 22 - Watershed T	96.8	92.1	77.3	127.4	105.9	110.9
Site 23 - Watershed O	117.2	74.4	75.6	105.2	101.7	101.1
Site 24 - Watershed K, M, N	96.6	74.5	83.0	109.1	101.0	101.1

5.3.3 Nitrate (NO3)

Nitrate is a form of nitrogen. Nitrogen is present in all living things and composes about 80% of the air we breathe. Nitrogen is a source of pollution to water when it becomes present in excessive amounts. Increased nitrogen leads to increased plant growth resulting in algal blooms in lakes and streams. Nitrate is a common inorganic nutrient found in commercial fertilizer, septic system waste, animal feed lot runoff, agricultural fertilizers, manure, industrial waste waters, and sanitary waste water including landfill leachate.

Sites that displayed the highest NO3 levels (upper third of the 24 sites, eight (8) sites) during each sampling event were highlighted to assist in the identification of consistent water quality concerns and the development of critical areas and watershed “hotspots.” There is nothing scientific about the values highlighted, rather they represent a simple, relative comparison across sites to help determine rough trends.

Table 11: Nitrate

Nitrates (NO3) tons/year							
	5/29/07	**7/11/07**	**8/28/07**	**1/8/08**	**4/10/08**	**6/4/08**	**Average**
	Storm	Base	Base	Storm	Base	Storm	1st 5 events
Site 1 - Watershed X, Y	8.44	0.97	1.63	44.32	100.46	4453.78	31.16
Site 2 - Watershed CC	9.93	0.48	1.48	22.06	59.09	1544.34	18.51
Site 3 - Watershed Z	11.83	2.13	1.24	24.97	56.34	3185.21	19.30
Site 4 - Watershed P, Q	14.93	1.10	1.42	49.49	112.28	4584.77	35.84
Site 5 - Watershed BB, R	15.64	0.59	1.54	40.33	106.37	2357.88	32.89
Site 6 - Watershed DD	67.76	3.03	6.97	175.94	537.76	12547.79	158.29
Site 7 - Watersheds A, C, F	82.65	3.70	5.67	214.55	524.76	26784.70	166.27
Site 8 - Watershed B, D	135.19	15.82	14.34	260.88	338.81	22530.86	153.01
Site 9 - Watershed E, G	137.67	8.59	11.44	335.34	806.84	38829.20	259.98
Site 10 - Watershed H	2.03	0.12	0.34	7.39	19.30	1930.43	5.84
Site 11 - Watershed H	5.29	0.18	0.00	8.96	20.49	1323.72	1071.73
Site 12 - Watershed I	2.98	0.14	0.34	11.58	18.91	2095.89	6.79
Site 13 - Watershed I	24.74	1.18	1.48	35.10	72.49	3805.70	27.00
Site 14 - Watershed F	2.98	0.28	0.30	9.65	19.70	1930.43	6.58
Site 15 - Watershed AA	13.65	0.53	0.62	23.05	20.58	3033.53	11.69
Site 16 - Watershed S	7.24	0.24	0.24	8.86	24.62	827.33	8.24
Site 17 - Watershed S	4.96	0.35	0.00	10.28	32.99	758.38	9.72
Site 18 - Watershed W	4.05	0.47	0.34	5.42	10.34	1158.26	4.12
Site 19 - Watershed U, V	42.86	3.36	3.07	28.17	87.46	4081.48	32.98
Site 20 - Watershed G	2.98	0.25	0.20	1.45	4.14	537.76	1.80
Site 21 - Watershed L, J	12.58	0.55	0.98	22.06	55.16	3199.00	18.27
Site 22 - Watershed T	37.23	0.71	0.77	9.46	21.27	1799.44	13.89
Site 23 - Watershed O	8.60	0.41	0.49	6.07	9.46	882.48	5.01
Site 24 - Watershed K, M, N	94.11	4.33	4.14	78.60	134.44	7170.16	63.12
Overall (sum sites 1-24)	6074.03	49.03	59.04	1433.98	3194.06	151352.5	2162.03

5.3.4 Total Phosphorus (TP)

Phosphorus is an essential element for plant and animal life. It is a naturally occurring element found in rocks that is often mined for commercial fertilizer production. Aquatic life develops with low levels of phosphorus, but phosphorus becomes a problem in water quality when its presence becomes excessive. Excessive amounts of phosphorus can lead to problematic algal blooms causing depleted dissolve oxygen supplies and leading to eutrophication (aging/degradation) of lakes and other water bodies. Total Phosphorus includes inorganic and organic types of phosphorus. Increased phosphorus levels result from discharge of phosphorus-containing pollutants into surface waters. Sources of phosphorus include naturally occurring organic matter such as leaf litter, grass clipping and decaying plants and animals, as well as human and domestic animal waste and commercial and agricultural fertilizers.

Sites that displayed the highest TP levels (upper third of the 24 sites, eight (8) sites) during each sampling event were highlighted to assist in the identification of consistent water quality concerns and the development of critical areas and watershed "hotspots." There is nothing scientific about the values highlighted, rather they represent a simple, relative comparison across sites to help determine rough trends.

Table 12: Phosphorus

Total Phosphorus (TP) tons/year							
	5/29/07	**7/11/07**	**8/28/07**	**1/8/08**	**4/10/08**	**6/4/08**	**Average**
	Storm	Base	Base	Storm	Base	Storm	1st 5 events
Site 1 - Watershed X, Y	1.55	0.36	0.14	.24	0.5	468.82	0.56
Site 2 - Watershed CC	0.13	0.07	0.04	.11	0.39	523.97	0.15
Site 3 - Watershed Z	1.18	0.09	0.17	.12	0.98	606.71	0.51
Site 4 - Watershed P, Q	1.34	0.55	0.22	.40	2.99	681.17	1.10
Site 5 - Watershed BB, R	1.27	0.30	0.11	.37	1.06	1178.94	0.62
Site 6 - Watershed DD	16.19	2.43	1.10	1.57	4.48	2635.04	5.15
Site 7 - Watersheds A, C, F	11.02	0.74	1.13	1.92	8.75	3979.44	4.71
Site 8 - Watershed B, D	17.79	2.59	2.10	2.96	13.55	6166.34	7.80
Site 9 - Watershed E, G	42.36	5.15	4.25	4.41	32.78	10589.78	17.79
Site 10 - Watershed H	0.69	0.06	0.04	0.15	0.41	386.09	0.27
Site 11 - Watershed H	0.99	0.06	0.00	0.08	0.51	261.99	0.33
Site 12 - Watershed I	1.85	0.17	0.10	0.14	0.55	523.97	0.56
Site 13 - Watershed I	1.81	0.22	0.21	0.80	2.04	1427.14	1.02
Site 14 - Watershed F	0.10	0.08	0.16	0.17	0.55	286.81	0.21
Site 15 - Watershed AA	1.09	0.17	0.15	0.27	0.76	288.19	0.49
Site 16 - Watershed S	0.50	0.06	0.05	0.11	0.98	144.78	0.34
Site 17 - Watershed S	0.25	0.09	0.00	0.12	0.44	82.73	0.18
Site 18 - Watershed W	1.01	0.08	0.11	0.17	0.21	106.17	0.32
Site 19 - Watershed U, V	1.38	0.27	0.57	1.28	1.09	459.17	0.92
Site 20 - Watershed G	0.15	0.16	0.06	0.19	0.18	99.28	0.15
Site 21 - Watershed L, J	0.79	0.15	0.28	0.33	0.63	882.48	0.44
Site 22 - Watershed T	0.56	0.12	0.07	0.38	1.51	235.79	0.53
Site 23 - Watershed O	0.50	0.15	0.07	0.28	0.55	121.34	0.31
Site 24 - Watershed K, M, N	24.17	0.98	0.99	1.80	3.20	1075.52	5.43
Overall (sum sites 1-24)	124.67	15.1	12.12	18.37	79.09	33211.66	49.87

5.3.5 Total Suspended Solids (TSS)

Total Suspended Solids (TSS) are solid materials suspended in water and include such things as soil particles and industrial waste. TSS lower water quality by absorbing light resulting in warmer waters that have less ability to hold oxygen. Less light also decreases the amount of photosynthesis by plants and thus reduces the amount of oxygen produced by the plants. TSS can also have an impact on life by clogging fish gills, suffocating eggs and larvae, and obstructing habitats of microinvertebrates (aquatic insects).

Sites that displayed the highest TSS levels (upper third of the 24 sites, eight (8) sites) during each sampling event were highlighted to assist in the identification of consistent water quality concerns and the development of critical areas and watershed "hotspots." There is nothing scientific about the values highlighted, rather they represent a simple, relative comparison across sites to help determine rough trends.

Table 13: Total Suspended Solids

Total Suspended Solids (TSS) tons/year							
	5/29/07	**7/11/07**	**8/28/07**	**1/8/08**	**4/10/08**	**6/4/08**	**Average**
	Storm	Base	Base	Storm	Base	Storm	1st 5 events
Site 1 - Watershed X, Y	31.65	9.65	5.42	88.64	133.95	632904.90	53.86
Site 2 - Watershed CC	62.88	2.76	6.65	26.20	114.25	247094.90	42.55
Site 3 - Watershed Z	13.65	3.55	3.79	13.44	21.67	183528.63	11.22
Site 4 - Watershed P, Q	15.72	4.73	10.05	19.80	74.85	241027.84	25.03
Site 5 - Watershed BB, R	29.78	58.36	5.32	15.51	70.91	488950.06	35.98
Site 6 - Watershed DD	112.93	64.46	31.96	172.80	1971.80	1693951.36	470.79
Site 7 - Watersheds A, C, F	137.75	60.18	42.55	421.44	765.28	4101885.63	285.44
Site 8 - Watershed B, D	355.75	136.61	55.16	681.86	1863.45	10672514.03	618.57
Site 9 - Watershed E, G	794.23	203.98	130.80	970.73	5799.17	16555358.21	1579.78
Site 10 - Watershed H	169.40	2.95	0.98	1.23	34.47	162156.03	41.81
Site 11 - Watershed H	20.68	1.18	0.00	6.20	82.73	153882.76	22.16
Site 12 - Watershed I	16.55	6.20	3.20	5.52	48.85	616634.14	16.06
Site 13 - Watershed I	71.36	54.17	6.65	127.64	215.20	716740.67	95.00
Site 14 - Watershed F	4.96	8.27	2.71	5.52	35.46	516251.84	11.38
Site 15 - Watershed AA	4.55	12.41	10.69	21.13	124.59	517217.06	34.67
Site 16 - Watershed S	4.14	0.79	0.59	0.89	22.16	116515.17	5.71
Site 17 - Watershed S	5.17	3.15	0.00	1.77	22.16	121341.24	6.45
Site 18 - Watershed W	1.45	3.25	1.48	13.54	41.37	209451.54	12.22
Site 19 - Watershed U, V	22.96	32.06	23.64	76.82	127.55	1270360.10	56.61
Site 20 - Watershed G	1.24	0.98	0.20	3.10	11.82	121617.02	3.47
Site 21 - Watershed L, J	9.93	28.27	2.46	8.27	70.91	425797.46	23.97
Site 22 - Watershed T	78.18	21.27	4.14	9.46	84.21	174979.59	39.45
Site 23 - Watershed O	14.89	3.79	2.71	9.65	66.97	132372.27	19.60
Site 24 - Watershed K, M, N	416.77	151.68	95.14	134.74	544.16	3405828.12	268.50
Overall (sum sites 1-24)	2396.57	874.7	446.29	2835.90	12347.9	43478361	3780.28

5.3.6 Biochemical Oxygen Demand (BOD)

Biochemical Oxygen Demand (BOD) is a measure of the quantity of oxygen used by microorganisms (aerobic bacteria) in the oxidation (break-down) of organic matter. Streams with high quantities of plant growth and decay generally have high levels of biochemical oxygen levels. The higher the number, the more indicative the site is of higher pollution loads.

Sites that displayed the highest BOD levels (upper third of the 24 sites, eight (8) sites) during each sampling event were highlighted to assist in the identification of consistent water quality concerns and the development of critical areas and watershed "hotspots." There is nothing scientific about the values highlighted, rather they represent a simple, relative comparison across sites to help determine rough trends.

Table 14: Biochemical Oxygen Demand

Biochemical Oxygen Demand (BOD) tons/year							
	5/29/07	**7/11/07**	**8/28/07**	**1/8/08**	**4/10/08**	**6/4/08**	**Average**
	Storm	Base	Base	Storm	Base	Storm	1st 5 events
Site 1 - Watershed X, Y	12.66	4.00	3.25	4.73	10.05	3281.73	1.10
Site 2 - Watershed CC	3.97	1.03	1.77	3.86	3.15	3309.31	0.16
Site 3 - Watershed Z	6.83	1.51	1.65	6.53	4.33	6370.42	0.67
Site 4 - Watershed P, Q	12.58	3.47	3.55	7.92	14.97	7859.60	1.60
Site 5 - Watershed BB, R	13.40	4.58	3.43	9.93	19.50	8935.13	3.13
Site 6 - Watershed DD	56.47	15.93	17.43	47.13	134.44	20076.46	9.68
Site 7 - Watersheds A, C, F	82.65	18.52	19.86	53.64	10.93	33672.20	6.50
Site 8 - Watershed B, D	106.73	28.76	40.81	83.01	101.64	75893.43	12.03
Site 9 - Watershed E, G	158.85	47.24	49.05	158.85	25.21	84718.25	22.92
Site 10 - Watershed H	9.56	0.83	1.28	2.71	0.69	2895.64	0.62
Site 11 - Watershed H	4.30	3.01	0.00	1.52	1.18	1654.65	0.80
Site 12 - Watershed I	5.96	1.65	1.48	3.03	6.30	4191.79	1.07
Site 13 - Watershed I	12.37	5.52	5.76	15.16	49.84	13954.24	2.26
Site 14 - Watershed F	2.65	0.55	1.03	3.86	4.73	3088.69	0.24
Site 15 - Watershed AA	5.92	1.77	2.62	8.45	14.08	5157.00	0.91
Site 16 - Watershed S	2.48	0.16	0.68	2.30	2.95	2481.98	0.34
Site 17 - Watershed S	3.10	0.91	0.00	2.30	2.95	1654.65	0.23
Site 18 - Watershed W	4.63	0.24	1.03	3.45	6.20	2123.47	0.54
Site 19 - Watershed U, V	32.14	4.27	5.44	26.89	0.00	13264.84	1.69
Site 20 - Watershed G	3.97	0.30	0.95	2.48	0.00	1820.12	0.16
Site 21 - Watershed L, J	33.09	1.24	2.17	6.07	1.58	6618.61	1.19
Site 22 - Watershed T	7.07	0.08	1.60	4.41	2.66	2730.18	0.50
Site 23 - Watershed O	5.29	0.41	1.13	3.59	3.94	2868.07	0.39
Site 24 - Watershed K, M, N	53.78	4.88	11.17	31.44	0.37	5487.23	10.84
Overall (sum site 1-24)	10.02	1.47	1.76	1.39	1.55	314107.7	3.24

5.3.7 E. coli

E. coli is a specific species of fecal coliform bacteria, which are found in the feces of warm-blooded animals. *E. coli* enter our waters from combined sewer overflows (CSOs), failing septic systems, livestock in streams, agricultural feedlot runoff, wildlife, and urban runoff from domestic pet waste. Not all, but certain strains of *E. coli* can cause illness in humans. Those that are not pathogenic may occur with other intestinal pathogens and cause health problems.
Sites that displayed *E. coli* levels at or below the State water quality standard of 235 cfu/100mL during each sampling event were highlighted to assist in the identification of consistent water quality concerns and the development of critical areas and watershed "hotspots."

Table 15: *E. coli*

E. coli cfu/100mL							
	5/29/07	**7/11/07**	**8/28/07**	**1/8/08**	**4/10/08**	**6/4/08**	**Average**
	Storm	Base	Base	Storm	Base	Storm	1st 5 events
Site 1 - Watershed X, Y	218	494	441	262	182	2975	319.4
Site 2 - Watershed CC	87	117	170	103	67	1510	108.80
Site 3 - Watershed Z	281	247	226	136	136	1450	205.20
Site 4 - Watershed P, Q	155	514	103	164	120	5250	211.20
Site 5 - Watershed BB, R	174	190	376	152	546	3015	287.60
Site 6 - Watershed DD	175	131	181	205	155	1535	169.40
Site 7 - Watersheds A, C, F	124	72	137	80	91	5140	100.80
Site 8 - Watershed B, D	146	40	98	146	103	7205	106.60
Site 9 - Watershed E, G	64	74	112	48	61	6010	71.80
Site 10 - Watershed H	237	79	241	255	187	3075	199.80
Site 11 - Watershed H	822	2	889	421	106	2260	448.00
Site 12 - Watershed I	441	184	128	327	516	11250	319.20
Site 13 - Watershed I	48	155	65	210	52	10700	106.00
Site 14 - Watershed F	403	1353	285	187	208	2115	487.20
Site 15 - Watershed AA	110	223	125	75	120	6750	130.60
Site 16 - Watershed S	382	133	169	68	98	4450	170.00
Site 17 - Watershed S	269	117	31	243	399	775	211.80
Site 18 - Watershed W	152	123	295	228	112	6075	182.00
Site 19 - Watershed U, V	161	225	155	89	35	2010	133.00
Site 20 - Watershed G	902	483	83	327	38	210	366.60
Site 21 - Watershed L, J	228	209	256	47	87	1885	165.40
Site 22 - Watershed T	43	380	132	46	180	3035	156.20
Site 23 - Watershed O	230	290	310	122	103	13500	211.00
Site 24 - Watershed K, M, N	406	169	73	336	71	5555	211.00
Overall	260.75	250.17	211.71	178.21	157.21	107735	211.61

The Indiana Water Pollution Control Board (327 IAC 2-1-6 Section 6(d)) set forth water quality targets for *E. coli* for any one sample in a 30-day period. Concentrations for a one-time *E. coli* sample are not to exceed 235 cfu/100 ml. Data in Table 15 was collected as one sample in a 30-day period and concentrations are not to exceed 235cfu/mL. The Indiana Water Pollution Control Board also set forth water quality targets for *E. coli* that are not to exceed concentrations greater than 125 cfu/100 ml as a geometric mean based on no less than five samples spaced equally over a 30-day period (327 IAC 2-1-6 Section 6(d)). Table 16 shows *E. coli* data collected by IDEM using five samples equally spaced over 30-days. The geometric mean of these samples must not exceed 125 cfu/100mL concentration sampling. This data was collected by IDEM for the purpose of investigating if any currently listed segments could be removed from the 303d list. Several of the IDEM *E. coli* sample sites (22) overlapped the sample sites of this project. IDEM sample sites 17-30 all exceeded the State's geometric mean standard for *E. coli*.

Table 16: *E. coli* - IDEM

E. coli cfu/100mL – IDEM Sampling						
	10/1/07	**10/9/07**	**10/15/07**	**10/22/07**	**10/29/07**	
	Week 1	Week 2	Week 3	Week 4	Week 5	GeoMean
Site 1 - Watershed X, Y	12	82	17.3	40.4	21.3	27.1
Site 2 - Watershed CC	72.7	77.6	13.2	38.2	6.3	28.2
Site 3 - Watershed Z	23.3	40.8	75.4	29.8	14.5	31.5
Site 4 - Watershed P, Q	16.6	29.2	78.4	38.2	50.4	37.4
Site 5 - Watershed BB, R	57.6	48.7	50.4	75.4	16	44.3
Site 6 - Watershed DD	365.4	25.9	6.3	108.6	81.3	55.5
Site 7 - Watersheds A, C, F	74.9	77.1	46.5	88.4	33.6	60.3
Site 8 - Watershed B, D	36.8	104.3	72.3	64.4	95.9	70.3
Site 9 - Watershed E, G	108.1	160.7	70.8	71.2	19.7	70.4
Site 12 - Watershed I	96	55.4	66.3	117.8	49.6	72.9
Site 13 - Watershed I	109.2	84.2	57.6	74.9	121.1	86.4
Site 14 - Watershed F	79.4	198.9	231	88.4	44.1	107.3
Site 15 - Watershed AA	238.2	149.7	261.3	146.7	16.7	117.9
Site 16 - Watershed S	167.4	209.8	172.3	82	58.1	123.6
Site 17 - Watershed S	2419.2	111.2	41.3	185	20.3	133.1
Site 18 - Watershed W	127.4	178.5	325.5	101.7	57.3	134.0
Site 19 - Watershed U, V	133.3	290.9	461.1	101.7	30.5	140.9
Site 20 - Watershed G	218.7	248.9	69.7	248.9	77.1	148.7
Site 21 - Watershed L, J	26.5	1553.1	82	22.8	980.4	149.8
Site 22 - Watershed T	307.6	285.1	95.8	222.4	101	180.0
Site 23 - Watershed O	613.1	275.5	325.5	135.4	26.2	181.1
Site 24 - Watershed K, M, N	686.7	143.9	290.9	172.3	66.3	201.0
Site 25 – Watershed H	290.9	156.5	313	410.6	121.1	234.5
Site 26 – Watershed C	137.4	816.4	325.5	218.7	106.7	243.3
Site 27 – Watershed D	248.1	365.4	579.4	224.7	77.1	246.5
Site 28 – Watershed V	1732.9	648.8	48	124.6	307.6	290.5
Site 29 – Watershed E	613.1	727	547.5	435.2	154.1	439.3
Site 30 – Watershed N	1119.9	410.6	1119.9	488.4	109.5	487.5

5.3.8 Other Parameters

In addition to the sampling of dissolved oxygen, nitrates, total phosphorus, total suspended solids, biochemical oxygen demand, and *E. coli,* other in-situ parameters such as pH, conductivity, and temperature readings were also taken at each sampling event.

pH is estimated by the concentration of H^+ ions present in a solution. Aquatic organisms are sensitive to pH, so it is therefore an important measurement of water quality. A range of 6.5 to 8.2 is best for most aquatic organisms. pH for Big Walnut Creek and its tributaries did not fall outside of this optimal range.

Conductivity is the ability of a solution to carry an electrical current. The presence of ions allows a current to be carried. Conductivity is higher in low or base flow conditions since water moves more slowly across soils and substrates that contain ions. Other ions also dissolve easier into slower moving water which increases conductivity levels.

Temperature is an important indicator of overall water quality. Temperature affects dissolved oxygen, photosynthesis, and metabolism of aquatic organisms. Aquatic life in Indiana streams are protected by the Indiana Administrative Code (IAC) (327 IAC 2-1-6). The code sets maximum water temperature limits in order to protect aquatic life for Indiana streams. For example, stream temperatures during the months of June, July, August, and September should not exceed 90°F (23.7°C) by more than 1% of the hours in a twelve month period. And at no time should a waters temperature exceed this same maximum limit by more than 3°F (1.7°C). Several of the sample sites were above the 90°F temperature during the time of sampling in the months of May, July, and August 2007, and June 2008. It is not know if the sites exceeded 90°F by more than 1% of the hours in 12 month period. One site did exceed the maximum limit of 90°F at any one time by 3°F.

5.3.9 Biological Data – Aquatic Macroinvertebrates

Biological data in the form of macroinvertebrate analysis was conducted twice as part of this project. Sampling efforts resulted in collecting 50 different macroinvertebrate genera during the spring collection and 65 genera during the fall collection. Dominant species collected during the spring and fall differed among the seasons. The spring dominant species included midges (Chironomidae), blackfly larvae (Simuliidae), and riffle beetles (primarily *Stenelmis*). Fall dominant species included caddisflies (Trichoptera), mayflies (Ephemeroptera) and midges (Chironomidae). The sediment-tolerant midge *Orthocladius obumbratus* was common amongst many of the sites at both spring and fall collections. An uncommon caddisfly (*Helicopsyche borealis*) was abundant during the fall collection sample at Miller Creek (Site 12).

Bioassessment of macroinvertebrates can indicate impairment of sites, while the organisms present at the site can indicate what type of impairment is present. Poor habitat quality can be one type of impairment that affects aquatic life. Figure 1a of the Aquatic Macroinvertebrate Report (Appendix F) shows the relationship between the mean Ohio EPA bioassessment score and QHEI habitat scores. The correlation between habitat and the bioassessment score should be within ten percent of the expected score in order to rule out low biological scores due to habitat impairments. If the biological score is low in the presence of good habitat, then water quality problems are suspected.

There are two sites that fall farthest from the expected scores. They are Limestone Creek (Site 22) and Jones Creek (Site 17). Both sites had good QHEI scores, but low biotic index scores. There was a low diversity of the organisms that were collected at these sites. Low diversity in the presence of good habitat indicates a water quality concern at these locations.

Due to an overall a lack of biotic integrity, four other sites are also of concern based on macroinvertebrate sampling. These are mainstem Sites 7 and 8, Site 10, and Site 24. In addition to these four sites, the headwaters of the watershed are also of interest since both biotic index and habitat scores are low. In this general location the macroinvertebrate analysis proves to be a limited diagnostic tool, since habitat impairments dictate low diversity, regardless of pollution