# 5 Watershed Inventory- Part III

## 5.1 Watershed Inventory Summary

Thirty five (35) stream sites were monitored over a one year period beginning in April 2013 by IDEM to support the development of our watershed plan and a Total Maximum Daily Load (TMDL) study. IDEM field crews collected *E. coli*, fish, macroinvertebrate, habitat, and water chemistry data to help determine if the streams were meeting their designated uses (i.e. are they swimmable and fishable). *E. coli* samples were collected to evaluate full body contact recreational use while fish and macroinvertebrate communities were assessed to evaluate aquatic life uses. Habitat and water chemistry data were collected to help identify potential biotic community stressors. Through this process, IDEM identified 210 miles of stream that do not support full body contact recreational use and 225 miles of stream that do not support aquatic life use.

### 5.1.1 Patterns & Trends Affecting Full Body Contact Recreational Use

Figure 206 shows the location of the stream segments that will be included on the draft 2016 303d List of Impaired Waterbodies for *E. coli* and the median site concentrations. Figure 207 summarizes *E. coli* concentrations for all sites in the watershed. It's apparent from these figures that full body contact recreational use is threatened throughout much the watershed.

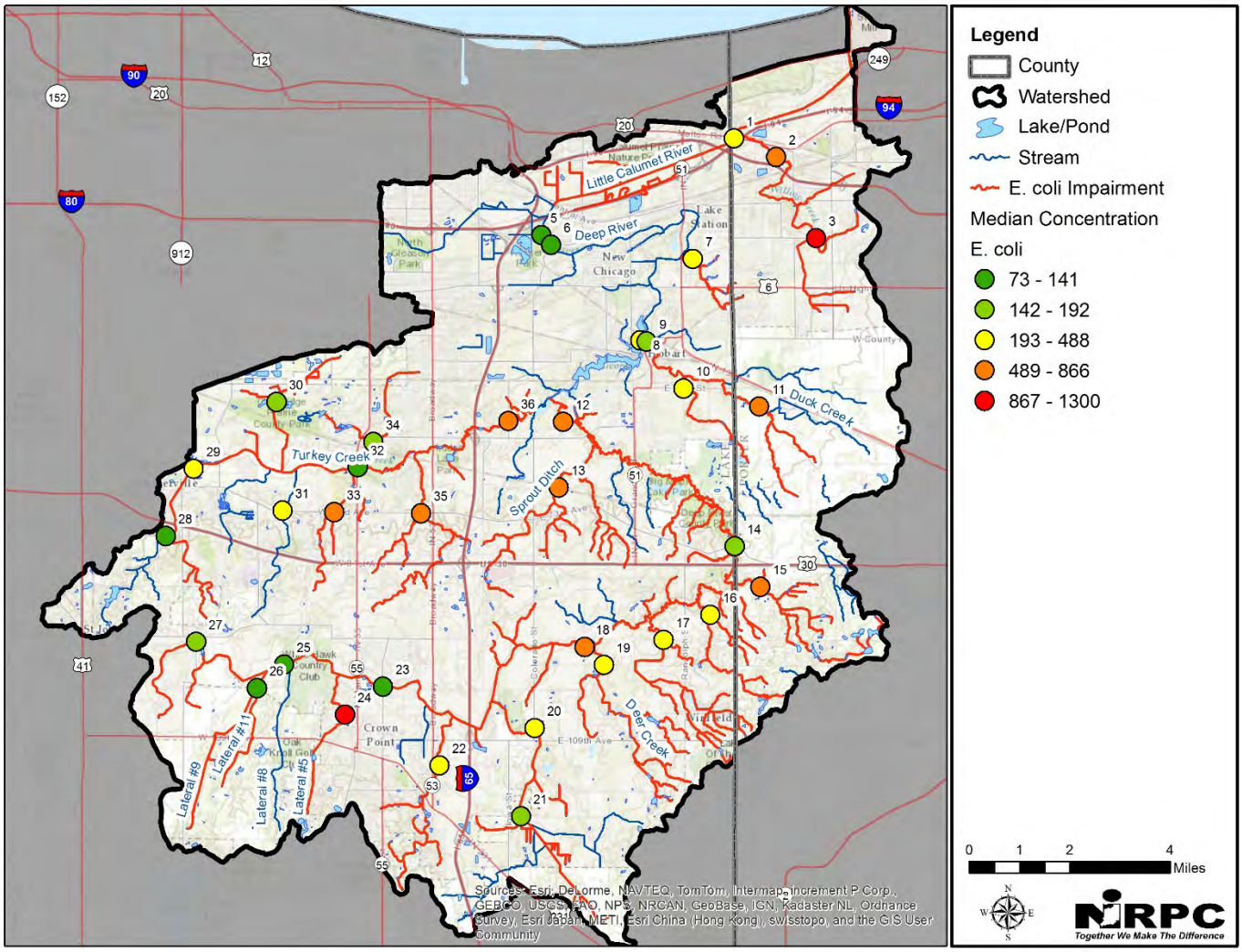



Figure 206 E. coli impaired stream reaches and sites with elevated E. coli concentrations

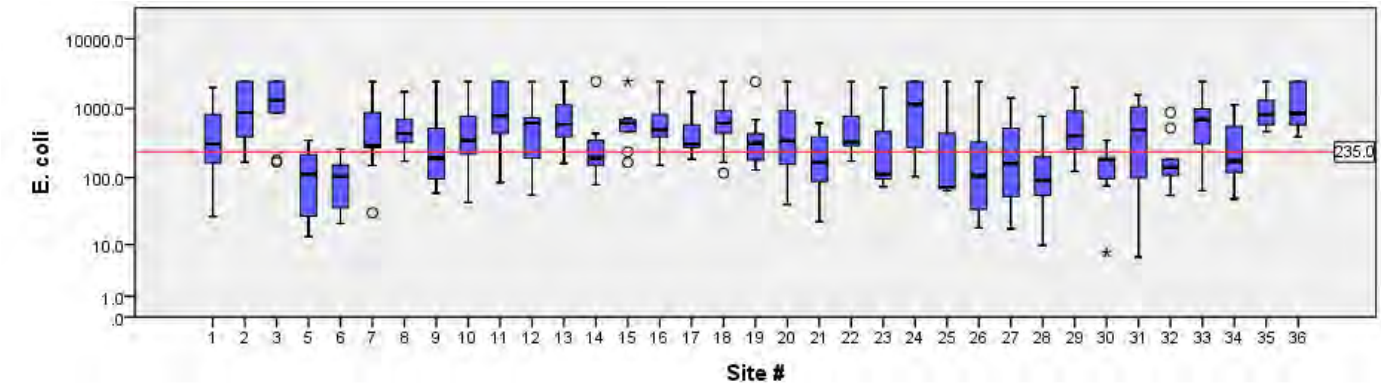



Figure 207 Box plot illustrating site E. coli concentrations within the watershed

Load duration curves for *E. coli* in the TMDL report show that many sites exceed the water quality standard across low to moderately high stream flow conditions indicating the contribution of nonpoint and at least periodic point sources. There is a strong positive correlation between *E. coli* and other water quality parameters including total solids, total dissolved solids, conductivity, and chloride (Table 83) indicating sewage as a likely source. *E. coli* is also positively correlated, although not as strongly, to riparian deciduous forest indicating wildlife sources. *E. coli* observations followed monthly/seasonal variations associated with water temperature. Median concentrations increased throughout the spring, peaking in July, before declining in the cooler fall months (Figure 208).

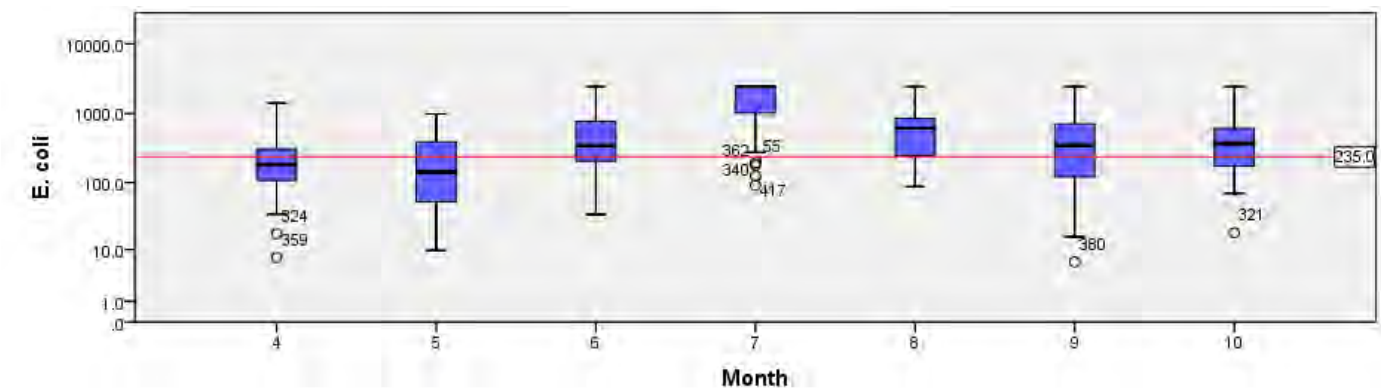



Figure 208 Box plot illustrating monthly E. coli concentrations within the watershed

### 5.1.2 Patterns & Trends Affecting Aquatic Life Use

Figure 209 shows the location of stream segments that will be included on the draft 2016 303d List for impaired biotic communities and stressors identified at each sampling site (i.e. failure to meet water quality and habitat targets, see Table 38). Impaired biotic communities is largely a watershed wide issue. Figure 210 summarizes dissolved oxygen, sediment and nutrient concentrations for all sites in the watershed and Figure 211 summarizes habitat data.

Since none of the streams in our watershed are designated as limited use by the State, they are required to be capable of supporting a well-balanced, warm water aquatic community whether the streams are naturally occurring or manmade systems (i.e. ditches). The water quality regulatory definition of a "well-balanced aquatic community" is "an aquatic community which is diverse in species composition, contains several different trophic levels, and is not composed mainly of strictly pollution tolerant species". Even the best water quality monitoring sites in our watershed are characterized as lacking sensitive fish/macroinvertebrate species and having skewed trophic

structures. Expected species are often absent and tolerant species dominate. The most heavily impacted reaches have few species and individuals present.

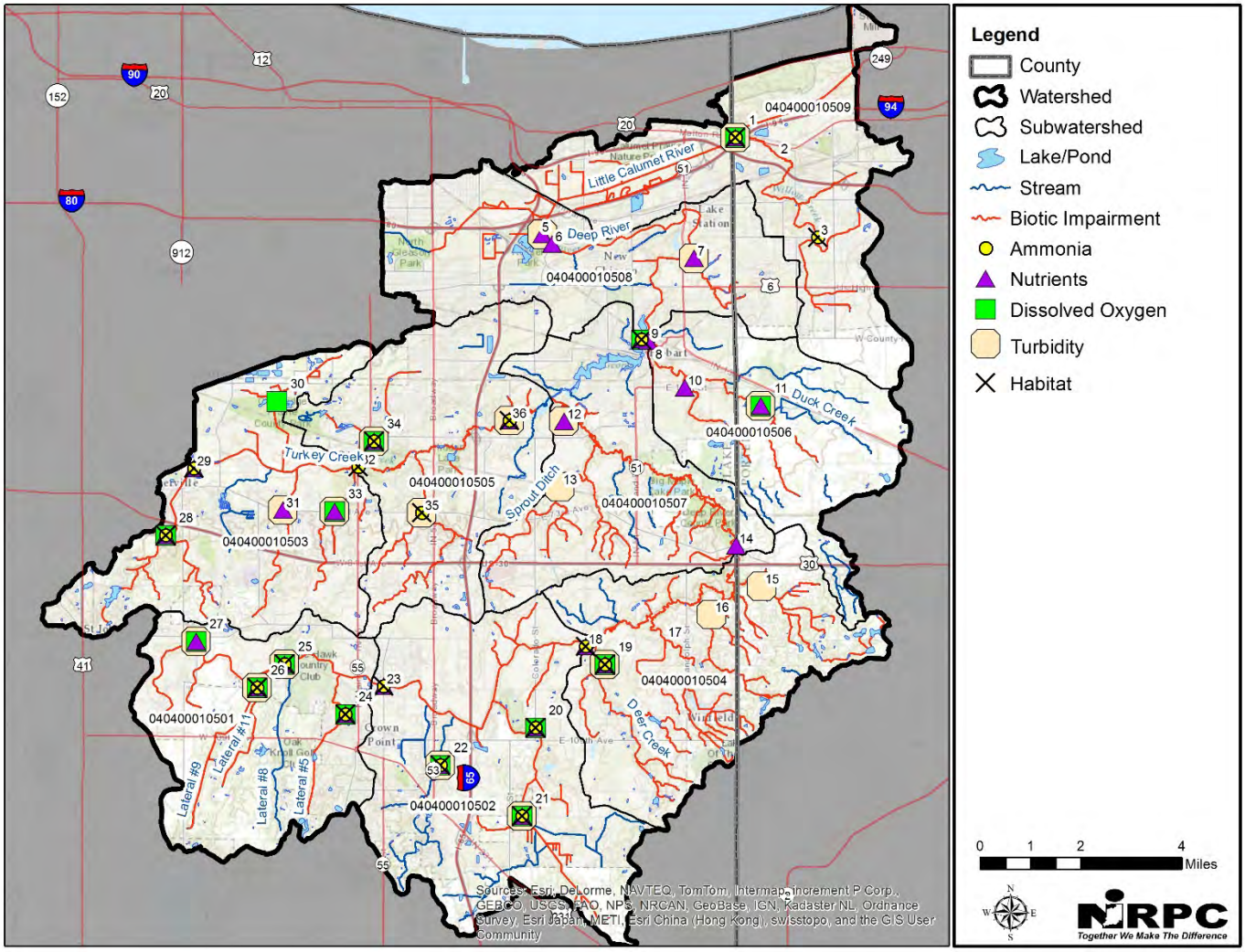
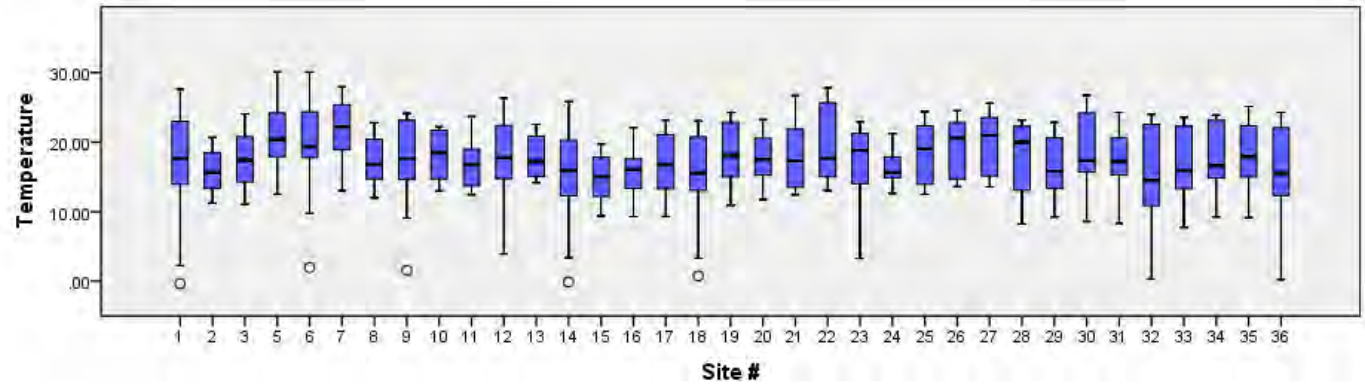
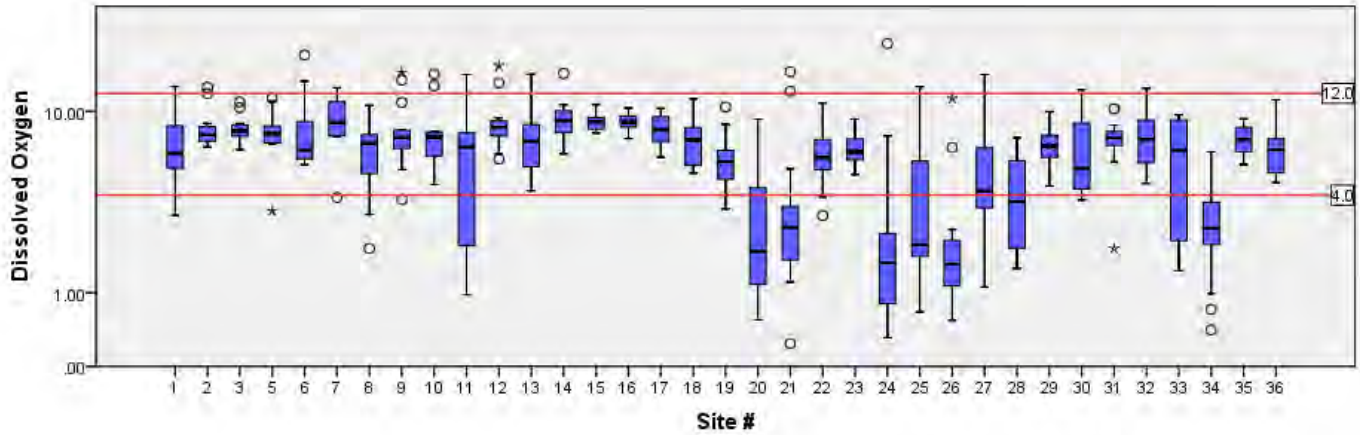
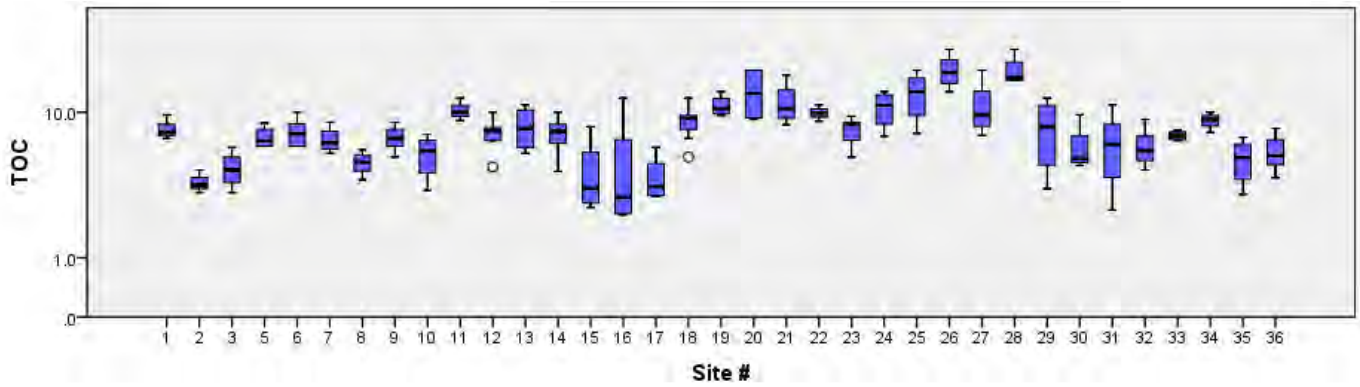
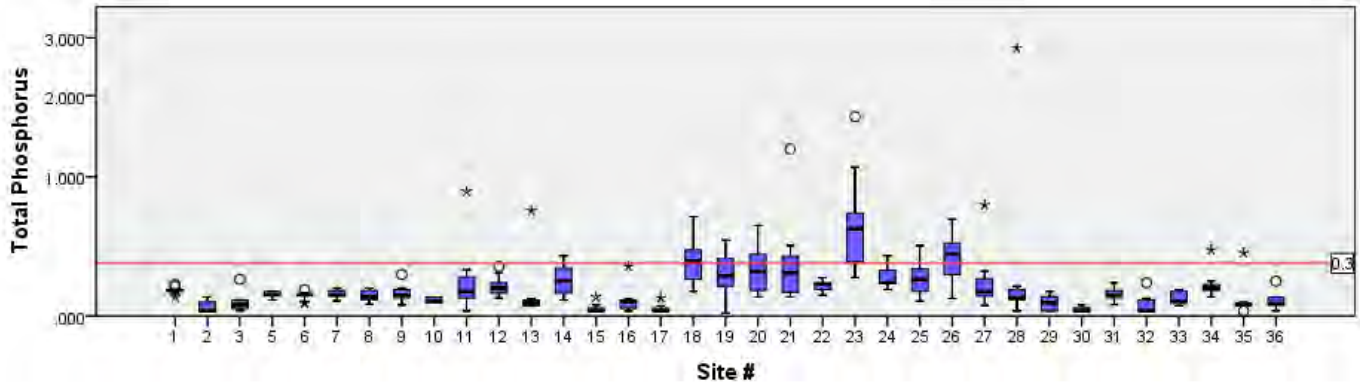


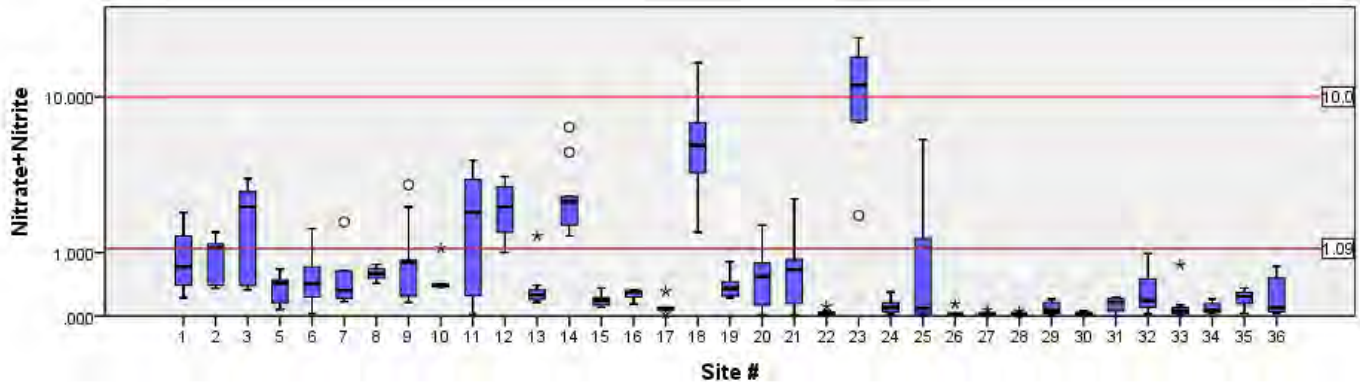

**Figure 209 Biotic impairment and stressor co-occurrences**




Dissolved Oxygen
10.00
1.00
.00
12.0
4.0
Site #


TOC
10.0
1.0
.0
Site #


Total Phosphorus
3.000
2.000
1.000
.000
0.3
Site #


Nitrate+Nitrite
10.000
1.000
.000
10.0
1.09
Site #

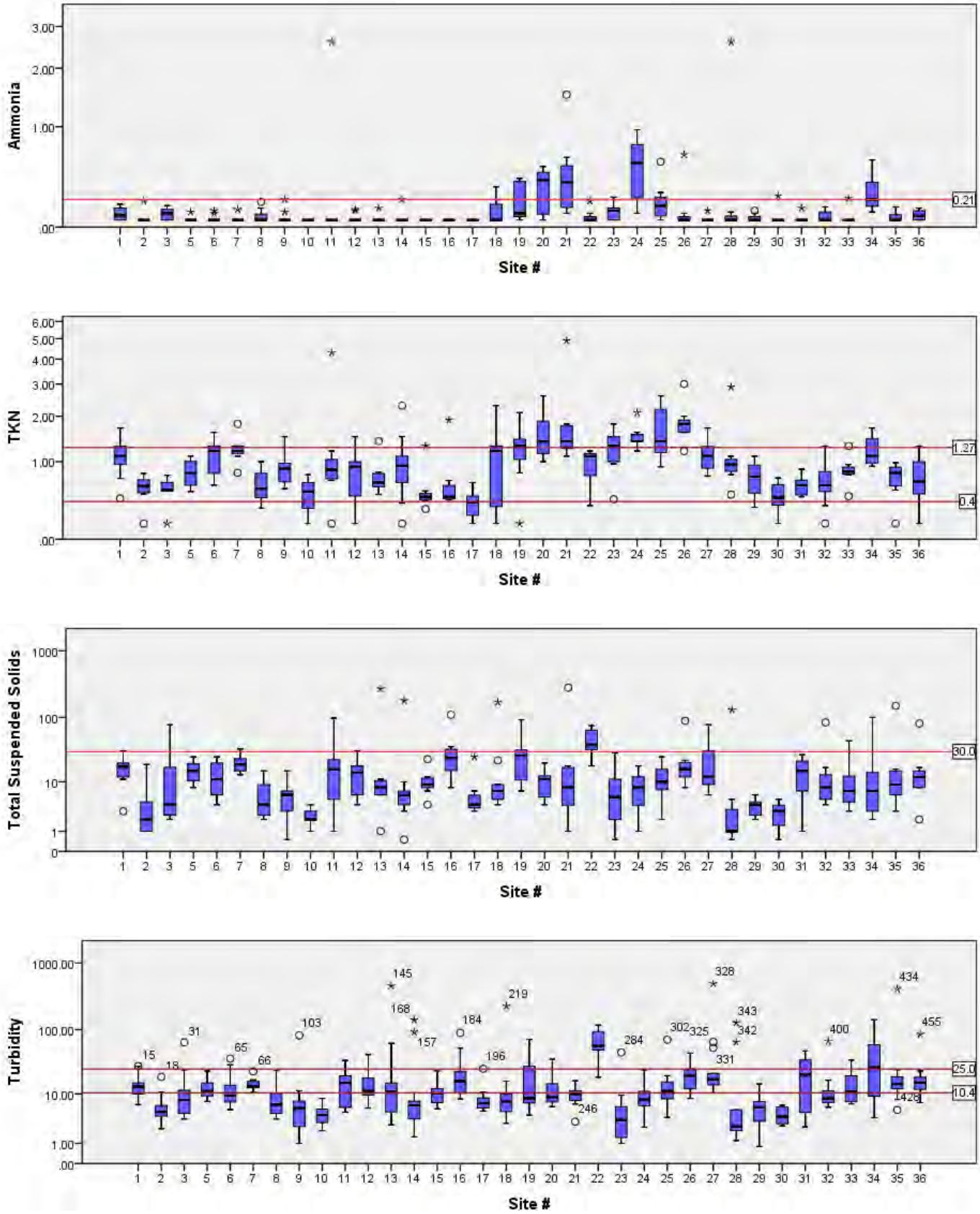



**Figure 210 Box plots illustrating site temperature, dissolved oxygen, total organic carbon, sediment, and nutrient concentrations within the watershed**

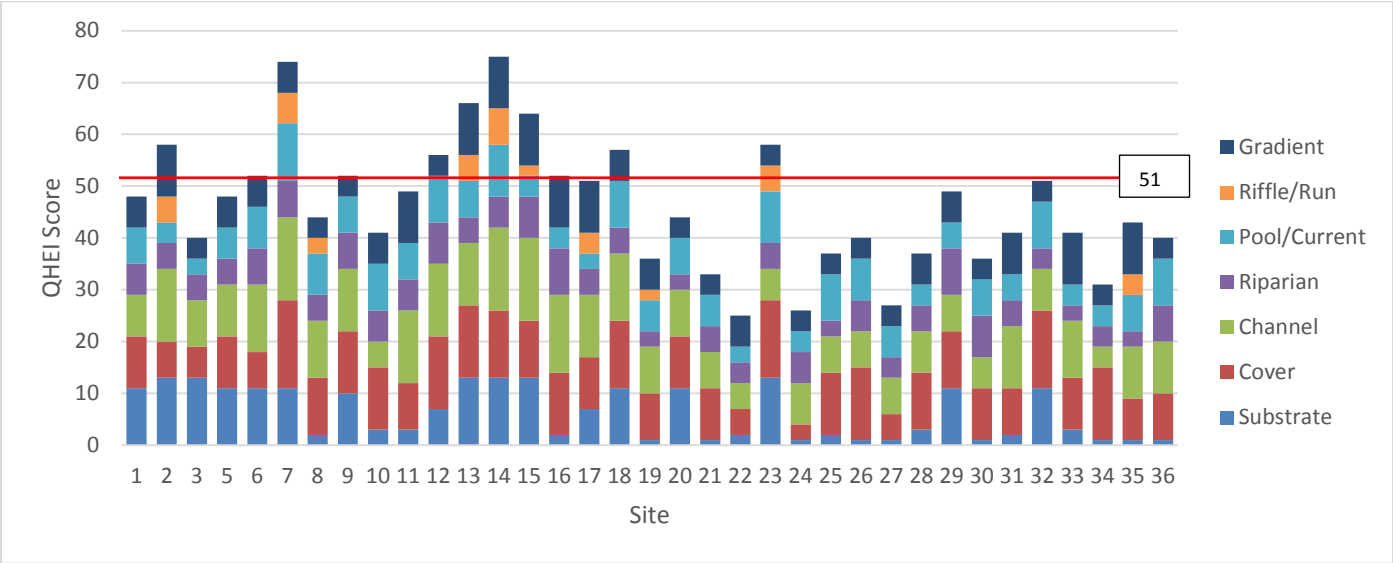



**Figure 211 Site Qualitative Habitat Evaluation Index scores within the watershed**

Several candidate causes (stressors) have been identified as potential contributors to the observed fish and/or benthic macroinvertebrate community impairments. These include elevated water temperatures, low dissolved oxygen levels, excess nutrient loading, ammonia toxicity, excess sediment loading, and habitat degradation. Table 82 provides a summary and initial evaluation of where the candidate causes co-occur with biotic impairments. This information is also spatially represented in Figure 209. Site 2 is the only site in which potential stressors are not readily apparent.

Low dissolved oxygen levels, excess nutrient loading, ammonia toxicity and habitat degradation are the stressors that most often co-occur with biotic impairments. The connection between water temperature and impaired biotic communities is ambiguous at this point. Additional data would be useful to explore the relationship further.

| Site | Biotic Impairment | | Candidate Causes/ Stressors | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | ↑Temp | ↓DO | ↑ Nutrients | | | Toxicity | ↑ Sediment | | ↓Habitat Quality | | | |
| | Fish | Macros | Temp | DO | TP | NO3 | TKN | NH3 | TSS | Turb | QHEI | Emb | Chan | Grad |
| 1 | Yes | No | 0 | 0 | + | 0 | 0 | 0 | - | + | + | + | + | 0 |
| 2 | Yes | Yes | 0 | - | - | 0 | 0 | - | - | - | - | - | - | - |
| 3 | Yes | Yes | 0 | - | + | 0 | 0 | 0 | - | 0 | + | - | + | + |
| 5 | Yes | No | 0 | - | + | - | 0 | - | - | + | + | + | + | 0 |
| 6 | No | Yes | 0 | - | + | - | 0 | - | - | 0 | - | + | + | 0 |
| 7 | Yes | Yes | 0 | - | + | - | 0 | - | - | + | - | + | - | 0 |
| 8 | Yes | Yes | 0 | 0 | + | - | 0 | 0 | - | 0 | + | + | + | 0 |
| 9 | Yes | Yes | 0 | - | + | - | 0 | - | - | - | + | + | + | + |
| 10 | Yes | Yes | 0 | - | + | - | 0 | - | - | - | + | + | + | 0 |
| 11 | Yes | Yes | 0 | + | + | 0 | 0 | - | - | + | + | + | - | - |
| 12 | No | Yes | 0 | - | + | 0 | 0 | - | - | + | - | + | - | + |
| 13 | Yes | No | 0 | - | - | - | 0 | - | - | + | - | + | + | - |
| 14 | No | No | 0 | - | + | 0 | 0 | - | - | - | - | - | - | - |
| 15 | Yes | Yes | 0 | - | - | - | - | - | - | + | - | - | - | - |
| 16 | No | Yes | 0 | - | + | - | - | - | 0 | + | - | + | - | - |
| 17 | Yes | No | 0 | - | - | - | - | - | - | - | + | + | + | - |
| 18 | No | No | 0 | - | + | 0 | 0 | 0 | - | - | - | + | + | 0 |
| 19 | Yes | Yes | 0 | + | + | - | + | + | 0 | + | + | + | + | 0 |
| 20 | No | No | 0 | + | + | - | + | + | - | 0 | + | + | + | + |

| Site | Biotic Impairment | | Candidate Causes/ Stressors | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | ↑Temp | ↓DO | ↑ Nutrients | | | Toxicity | ↑ Sediment | | ↓Habitat Quality | | | |
| | Fish | Macros | Temp | DO | TP | NO3 | TKN | NH3 | TSS | Turb | QHEI | Emb | Chan | Grad |
| 21 | Yes | Yes | 0 | + | + | - | + | + | - | + | + | + | + | + |
| 22 | No | No | 0 | + | + | - | 0 | - | + | + | + | + | + | 0 |
| 23 | No | Yes | 0 | - | + | + | + | 0 | - | 0 | - | - | + | + |
| 24 | Yes | Yes | 0 | + | + | - | + | 0 | - | 0 | + | + | + | + |
| 25 | Yes | Yes | 0 | + | + | 0 | + | 0 | - | + | + | + | + | + |
| 26 | Yes | Yes | 0 | + | + | - | + | - | - | + | + | + | + | + |
| 27 | No | Yes | 0 | + | + | - | 0 | - | 0 | + | + | + | + | + |
| 28 | Yes | NA | 0 | + | + | - | 0 | - | - | - | + | + | + | 0 |
| 29 | No | Yes | 0 | - | + | - | 0 | - | - | - | + | + | + | 0 |
| 30 | Yes | Yes | 0 | + | - | - | - | - | - | - | + | + | + | + |
| 31 | Yes | Yes | 0 | - | + | - | 0 | - | - | + | + | + | + | - |
| 32 | No | Yes | 0 | - | - | - | 0 | 0 | - | 0 | + | + | + | + |
| 33 | Yes | Yes | 0 | + | + | - | 0 | - | - | + | + | + | + | - |
| 34 | Yes | Yes | 0 | + | + | - | + | + | - | + | + | + | + | + |
| 35 | Yes | Yes | 0 | - | - | - | 0 | - | - | + | + | - | + | - |
| 36 | Yes | Yes | 0 | - | + | - | 0 | 0 | - | + | + | + | + | + |

"+" Candidate cause co-occurs with biotic impairment.
"0" Uncertain or ambiguous if the candidate cause co-occurs with biotic impairment.
"-" Candidate cause does not co-occur with biotic impairment.

**Table 82 Biotic impairment and candidate cause co-occurrence scoring**

In most cases, multiple stressors co-occur where biotic impairments are observed. Having multiple stressors co-occur where there are biotic impairments is not uncommon as was shown in the conceptual causal pathway diagrams included in Section 3.2. A correlation analysis was completed to explore the degree of relationships between these stressors. The results are shown below in Table 83. Red equals a statistically significant negative correlation and green a statistically significant positive correlation.

Correlation values are interpreted as follows:

- A coefficient of 0 indicates that the variables are not related.
- A negative coefficient indicates that as one variable increases, the other decreases.
- A positive coefficient indicates that as one variable increases the other also increases.
- Larger absolute values of coefficients indicate stronger associations.

| | | DO | DO % Sat | NH3 | NO3 | TKN | TP | TSS | Turb | TS | TDS | E coli | pH | Cond | Chl | TOC | COD |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **DO** | Corr. | 1.000 | .981** | -.730** | .373* | -.581** | -.539** | -.146 | -.179 | -.294 | -.055 | .190 | .845** | -.253 | -.178 | -.719** | -.632** |
| | Sig. | . | .000 | .000 | .027 | .000 | .001 | .401 | .303 | .087 | .753 | .275 | .000 | .143 | .305 | .000 | .000 |
| | N | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 |
| **DO % Sat** | Corr. | .981** | 1.000 | -.762** | .347* | -.562** | -.521** | -.143 | -.162 | -.332 | -.090 | .137 | .872** | -.299 | -.194 | -.693** | -.593** |
| | Sig. | .000 | . | .000 | .041 | .000 | .001 | .413 | .353 | .051 | .607 | .432 | .000 | .081 | .265 | .000 | .000 |
| | N | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 |
| **NH3** | Corr. | -.730** | -.762** | 1.000 | .139 | .637** | .612** | .174 | .051 | .407* | .205 | -.026 | -.727** | .373* | .385* | .622** | .520** |
| | Sig. | .000 | .000 | . | .426 | .000 | .000 | .318 | .773 | .015 | .238 | .881 | .000 | .027 | .022 | .000 | .001 |
| | N | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 |
| **NO3** | Corr. | .373* | .347* | .139 | 1.000 | .152 | .216 | -.067 | -.211 | -.052 | -.019 | .198 | .158 | .003 | .101 | -.090 | -.054 |
| | Sig. | .027 | .041 | .426 | . | .384 | .212 | .704 | .224 | .767 | .914 | .254 | .363 | .986 | .563 | .607 | .756 |
| | N | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 |
| **TKN** | Corr. | -.581** | -.562** | .637** | .152 | 1.000 | .864** | .381* | .258 | .150 | .008 | -.270 | -.539** | .095 | .161 | .865** | .876** |
| | Sig. | .000 | .000 | .000 | .384 | . | .000 | .024 | .135 | .389 | .962 | .117 | .001 | .587 | .357 | .000 | .000 |
| | N | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 |
| **TP** | Corr. | -.539** | -.521** | .612** | .216 | .864** | 1.000 | .452** | .374* | .151 | -.029 | -.241 | -.587** | .100 | .261 | .852** | .873** |
| | Sig. | .001 | .001 | .000 | .212 | .000 | . | .006 | .027 | .385 | .867 | .163 | .000 | .567 | .131 | .000 | .000 |

| | | DO | DO % Sat | NH3 | NO3 | TKN | TP | TSS | Turb | TS | TDS | E coli | pH | Cond | Chl | TOC | COD |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 |
| TSS | Corr. | -.146 | -.143 | .174 | -.067 | .381* | .452** | 1.000 | .814** | .309 | .201 | .020 | -.017 | .151 | .133 | .388* | .486** |
| | Sig. | .401 | .413 | .318 | .704 | .024 | .006 | . | .000 | .071 | .247 | .907 | .921 | .387 | .445 | .021 | .003 |
| | N | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 |
| Turb | Corr. | -.179 | -.162 | .051 | -.211 | .258 | .374* | .814** | 1.000 | .178 | .050 | .068 | -.037 | .096 | .163 | .354* | .425* |
| | Sig. | .303 | .353 | .773 | .224 | .135 | .027 | .000 | . | .305 | .774 | .698 | .832 | .585 | .349 | .037 | .011 |
| | N | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 |
| TS | Corr. | -.294 | -.332 | .407* | -.052 | .150 | .151 | .309 | .178 | 1.000 | .931** | .449** | -.412* | .931** | .757** | .200 | .087 |
| | Sig. | .087 | .051 | .015 | .767 | .389 | .385 | .071 | .305 | . | .000 | .007 | .014 | .000 | .000 | .249 | .618 |
| | N | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 |
| TDS | Corr. | -.055 | -.090 | .205 | -.019 | .008 | -.029 | .201 | .050 | .931** | 1.000 | .469** | -.181 | .899** | .680** | .017 | -.065 |
| | Sig. | .753 | .607 | .238 | .914 | .962 | .867 | .247 | .774 | .000 | . | .004 | .298 | .000 | .000 | .923 | .711 |
| | N | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 |
| E coli | Corr. | .190 | .137 | -.026 | .198 | -.270 | -.241 | .020 | .068 | .449** | .469** | 1.000 | .074 | .467** | .373* | -.330 | -.303 |
| | Sig. | .275 | .432 | .881 | .254 | .117 | .163 | .907 | .698 | .007 | .004 | . | .672 | .005 | .028 | .053 | .076 |
| | N | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 |
| pH | Corr. | .845** | .872** | -.727** | .158 | -.539** | -.587** | -.017 | -.037 | -.412* | -.181 | .074 | 1.000 | -.382* | -.369* | -.655** | -.562** |
| | Sig. | .000 | .000 | .000 | .363 | .001 | .000 | .921 | .832 | .014 | .298 | .672 | . | .023 | .029 | .000 | .000 |
| | N | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 |
| Cond | Corr. | -.253 | -.299 | .373* | .003 | .095 | .100 | .151 | .096 | .931** | .899** | .467** | -.382* | 1.000 | .771** | .132 | .018 |
| | Sig. | .143 | .081 | .027 | .986 | .587 | .567 | .387 | .585 | .000 | .000 | .005 | .023 | . | .000 | .448 | .917 |
| | N | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 |
| Chl | Corr. | -.178 | -.194 | .385* | .101 | .161 | .261 | .133 | .163 | .757** | .680** | .373* | -.369* | .771** | 1.000 | .183 | .091 |
| | Sig. | .305 | .265 | .022 | .563 | .357 | .131 | .445 | .349 | .000 | .000 | .028 | .029 | .000 | . | .293 | .604 |
| | N | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 |
| TOC | Corr. | -.719** | -.693** | .622** | -.090 | .865** | .852** | .388* | .354* | .200 | .017 | -.330 | -.655** | .132 | .183 | 1.000 | .892** |
| | Sig. | .000 | .000 | .000 | .607 | .000 | .000 | .021 | .037 | .249 | .923 | .053 | .000 | .448 | .293 | . | .000 |
| | N | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 |
| COD | Corr. | -.632** | -.593** | .520** | -.054 | .876** | .873** | .486** | .425* | .087 | -.065 | -.303 | -.562** | .018 | .091 | .892** | 1.000 |
| | Sig. | .000 | .000 | .001 | .756 | .000 | .000 | .003 | .011 | .618 | .711 | .076 | .000 | .917 | .604 | .000 | . |
| | N | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 |

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

**Table 83 Water quality correlation analysis results**

Strong negative relationships exist between dissolved oxygen (DO) and ammonia (NH3), total Kjeldahl nitrogen (TKN), total phosphorus (TP), total organic carbon (TOC), and chemical oxygen demand (COD). The breakdown of organic materials and chemical compounds, measured by TOC and COD respectively, consumes dissolved oxygen. Excess nutrient loading, measured by TKN and TP, accelerates plant and algal growth. Bacterial breakdown of dead plant material consumes oxygen. Nitrification, the conversion of ammonia to nitrate (NO3), requires oxygen. Low oxygen levels suppress this process and therefore ammonia levels build up. The correlation analysis also showed a strong positive relationship between total suspended solids (TSS) and total phosphorus and chemical oxygen demand indicating these pollutants are sediment related.

A correlation analysis was also completed to explore the degree of relationships between water quality parameters and land cover types. The results are shown below in Table 84. Red equals a statistically significant negative correlation and green a statistically significant positive correlation.

| | | HID | MID | LID | OSD | Cult. | Past. | Grass. | Decid. For. | Evergr. For. | Mix For. | Scrub / Shrub | For. Wet. | Scrub / Shrub Wet. | Emerg. Wet. | Bare Land | Open Water |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temp | Corr. | .121 | .098 | .079 | .181 | .044 | -.274 | -.114 | -.079 | -.113 | -.222 | -.198 | .047 | .021 | .103 | .015 | -.116 |
| | Sig. | .489 | .576 | .652 | .297 | .801 | .112 | .514 | .654 | .517 | .200 | .255 | .791 | .903 | .556 | .931 | .508 |
| | N | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 |
| DO | Corr. | -.006 | .022 | -.204 | .064 | .106 | .201 | .331 | .052 | .215 | .446** | .316 | -.004 | -.214 | -.514** | .229 | -.191 |
| | Sig. | .973 | .901 | .240 | .713 | .545 | .247 | .052 | .767 | .215 | .007 | .064 | .980 | .218 | .002 | .186 | .271 |
| | N | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 |
| DO % Sat | Corr. | .017 | .035 | -.173 | .076 | .086 | .176 | .351* | .062 | .218 | .430** | .314 | .001 | -.208 | -.504** | .276 | -.188 |
| | Sig. | .921 | .842 | .322 | .662 | .622 | .311 | .039 | .722 | .209 | .010 | .067 | .994 | .231 | .002 | .109 | .278 |
| | N | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 |

| | | HID | MID | LID | OSD | Cult. | Past. | Grass. | Decid. For. | Evergr. For. | Mix For. | Scrub / Shrub | For. Wet. | Scrub / Shrub Wet. | Emerg. Wet. | Bare Land | Open Water |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NH3 | Corr. | .020 | -.016 | .125 | -.220 | .016 | -.074 | -.318 | -.041 | -.276 | -.321 | -.332 | -.015 | .219 | .501** | -.377* | .066 |
| | Sig. | .908 | .927 | .475 | .204 | .929 | .674 | .063 | .815 | .109 | .060 | .051 | .933 | .205 | .002 | .025 | .707 |
| | N | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 |
| NO3 | Corr. | -.129 | -.262 | -.409* | -.397* | .633** | .359* | .033 | -.121 | -.357* | -.060 | -.160 | -.041 | .105 | .079 | .111 | -.430** |
| | Sig. | .461 | .128 | .015 | .018 | .000 | .034 | .852 | .489 | .035 | .731 | .359 | .816 | .548 | .651 | .526 | .010 |
| | N | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 |
| TKN | Corr. | -.276 | -.165 | -.079 | -.269 | .205 | .092 | -.210 | .009 | -.329 | -.413* | -.221 | -.026 | .235 | .542** | -.114 | -.121 |
| | Sig. | .109 | .344 | .651 | .119 | .238 | .601 | .225 | .961 | .053 | .014 | .202 | .883 | .174 | .001 | .516 | .487 |
| | N | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 |
| TP | Corr. | -.243 | -.218 | -.143 | -.238 | .273 | .155 | -.192 | -.014 | -.381* | -.401* | -.252 | -.080 | .312 | .623** | .030 | -.116 |
| | Sig. | .159 | .209 | .414 | .168 | .113 | .373 | .269 | .934 | .024 | .017 | .145 | .648 | .068 | .000 | .865 | .508 |
| | N | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 |
| TSS | Corr. | -.069 | .047 | -.108 | -.199 | .090 | .027 | -.054 | -.148 | -.337* | -.336* | -.123 | -.165 | -.111 | .144 | .179 | -.202 |
| | Sig. | .694 | .788 | .539 | .251 | .606 | .878 | .758 | .396 | .048 | .048 | .480 | .342 | .524 | .410 | .304 | .245 |
| | N | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 |
| Turbidity | Corr. | .056 | .206 | .098 | -.052 | -.085 | -.165 | -.110 | -.166 | -.246 | -.304 | -.112 | -.121 | -.206 | .035 | .326 | -.181 |
| | Sig. | .749 | .235 | .575 | .768 | .629 | .344 | .529 | .341 | .154 | .076 | .522 | .488 | .235 | .844 | .056 | .298 |
| | N | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 |
| TS | Corr. | .381* | .412* | .241 | -.051 | -.107 | -.266 | -.243 | -.295 | -.413* | -.060 | -.292 | -.394* | -.268 | .059 | -.235 | -.211 |
| | Sig. | .024 | .014 | .163 | .771 | .540 | .122 | .160 | .086 | .014 | .734 | .088 | .019 | .120 | .738 | .174 | .224 |
| | N | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 |
| TDS | Corr. | .395* | .450** | .212 | -.005 | -.130 | -.218 | -.155 | -.248 | -.312 | .086 | -.172 | -.435** | -.324 | -.064 | -.200 | -.212 |
| | Sig. | .019 | .007 | .221 | .978 | .456 | .209 | .375 | .150 | .068 | .623 | .322 | .009 | .058 | .714 | .249 | .221 |
| | N | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 |
| E coli | Corr. | .099 | .249 | -.006 | -.258 | .043 | -.056 | -.060 | -.459** | -.306 | .145 | -.304 | -.356* | -.465** | -.540** | -.066 | -.402* |
| | Sig. | .572 | .149 | .975 | .135 | .804 | .749 | .734 | .006 | .074 | .407 | .076 | .036 | .005 | .001 | .705 | .017 |
| | N | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 |
| pH | Corr. | .048 | .009 | -.183 | -.004 | .018 | .148 | .444** | .047 | .239 | .377* | .362* | .023 | -.252 | -.524** | .290 | -.057 |
| | Sig. | .783 | .959 | .293 | .982 | .917 | .397 | .008 | .788 | .166 | .026 | .033 | .896 | .144 | .001 | .092 | .745 |
| | N | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 |
| Cond | Corr. | .430** | .445** | .271 | -.075 | -.091 | -.283 | -.265 | -.355* | -.400* | .018 | -.373* | -.440** | -.355* | -.037 | -.166 | -.258 |
| | Sig. | .010 | .007 | .116 | .671 | .603 | .100 | .124 | .036 | .017 | .918 | .027 | .008 | .036 | .832 | .341 | .135 |
| | N | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 |
| Chl | Corr. | .542** | .494** | .350* | .146 | -.101 | -.364* | -.278 | -.391* | -.351* | .084 | -.466** | -.272 | -.370* | -.077 | -.038 | -.180 |
| | Sig. | .001 | .003 | .039 | .403 | .564 | .031 | .106 | .020 | .039 | .630 | .005 | .114 | .029 | .659 | .827 | .300 |
| | N | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 |
| TOC | Corr. | -.213 | -.185 | -.046 | -.143 | .138 | .058 | -.164 | .064 | -.284 | -.352* | -.179 | -.011 | .322 | .674** | -.078 | .032 |
| | Sig. | .218 | .288 | .792 | .412 | .429 | .742 | .346 | .715 | .099 | .038 | .303 | .952 | .059 | .000 | .656 | .854 |
| | N | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 |
| COD | Corr. | -.278 | -.176 | -.085 | -.146 | .218 | .051 | -.287 | -.004 | -.353* | -.405* | -.240 | -.041 | .253 | .547** | -.013 | -.122 |
| | Sig. | .106 | .310 | .629 | .401 | .209 | .770 | .094 | .982 | .038 | .016 | .164 | .817 | .142 | .001 | .940 | .484 |
| | N | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 |

**Table 84 Water quality land cover correlation analysis results**

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

From this analysis we can see some of the negative impacts associated with human land uses and the water quality benefits provided by natural land cover. For example strong positive correlations were observed between the percentage of agriculture land cover and nitrates and the percentage of development showed strong positive correlations with total solids (TS), total dissolved solids (TDS), conductivity, and chlorides (chl). The water quality benefit associated with forest cover was observed with a strong positive relationship with dissolved oxygen, and negative correlations with *E. coli*, conductivity, nitrate, total phosphorus, turbidity, chlorides, total organic carbon

and chemical oxygen demand. Similarly there was a strong negative correlation observed between wetlands and *E. coli*.

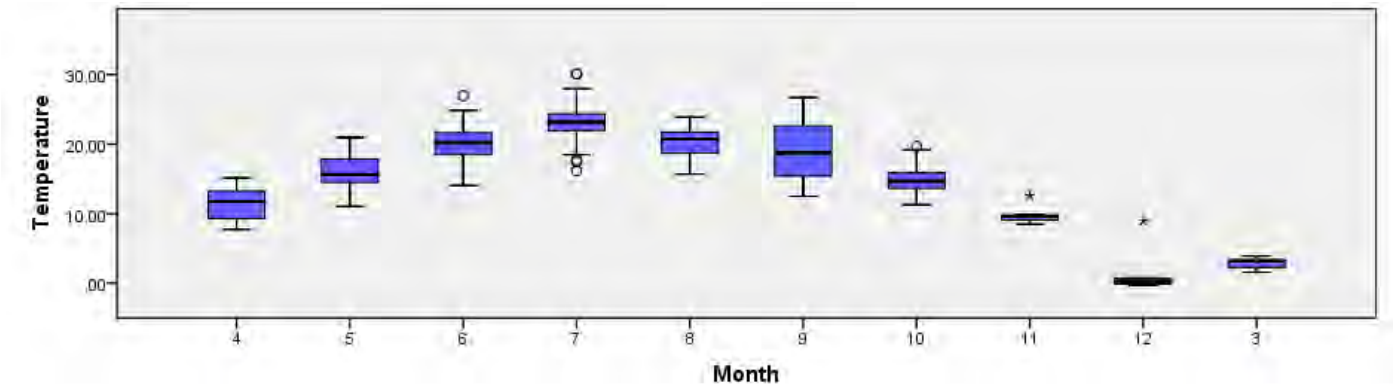
The correlation analysis indicates that wetlands in our watershed can act as sinks or sources. For example there is a strong positive correlation between the percentage of emergent wetlands and total phosphorus (source) and a strong negative correlation with E. coli concentrations (sink). A number of factors influence how the wetland will "behave" in this capacity such as wetland type, hydrologic conditions, season, and length of time the wetland has been subjected to loading. Human impacts can lead to considerable changes in chemical cycling in wetlands and their ability to assimilate these often increased inputs is not limitless.

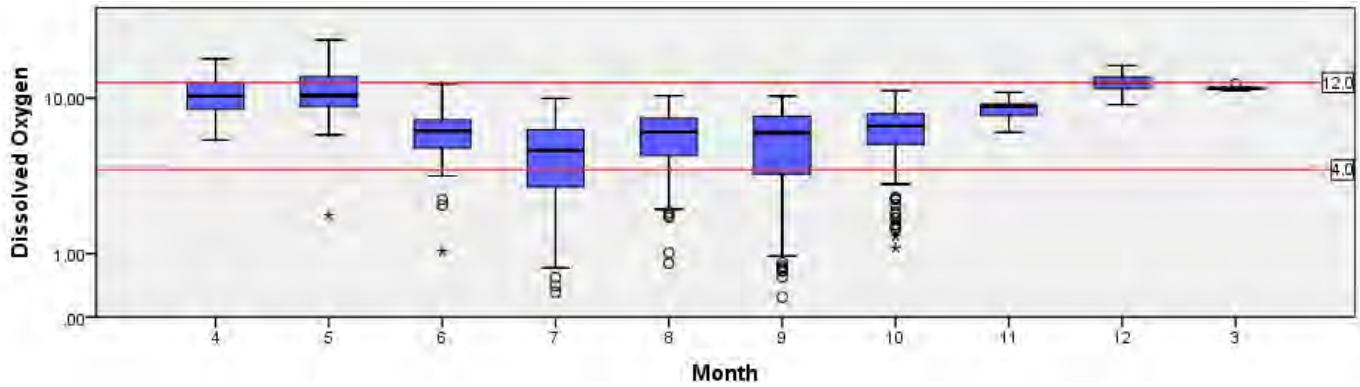
Hydrologic Condition Variability

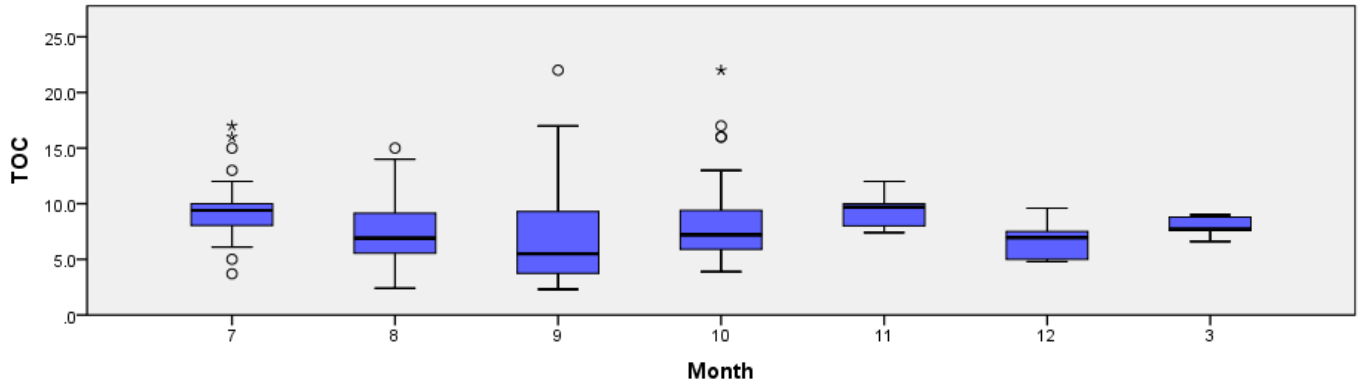
Site load duration curves for nutrients and sediment (TSS) show that water quality target values are most often exceeded during midrange to high flow conditions indicating the primary sources are runoff and streambank erosion related. Occasionally, target values are exceeded during dry stream flow conditions indicating pollutant loading from upland impervious areas and within the riparian zone. Load duration curves for each site are included in Appendix B of the Deep River-Portage Burns Waterway TMDL study http://www.in.gov/idem/nps/3893.htm.

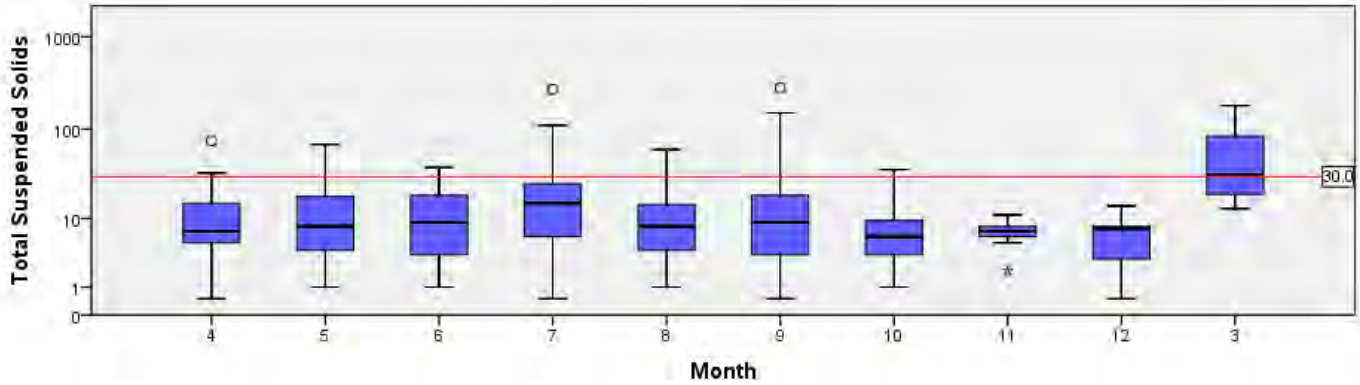
Temporal Variability

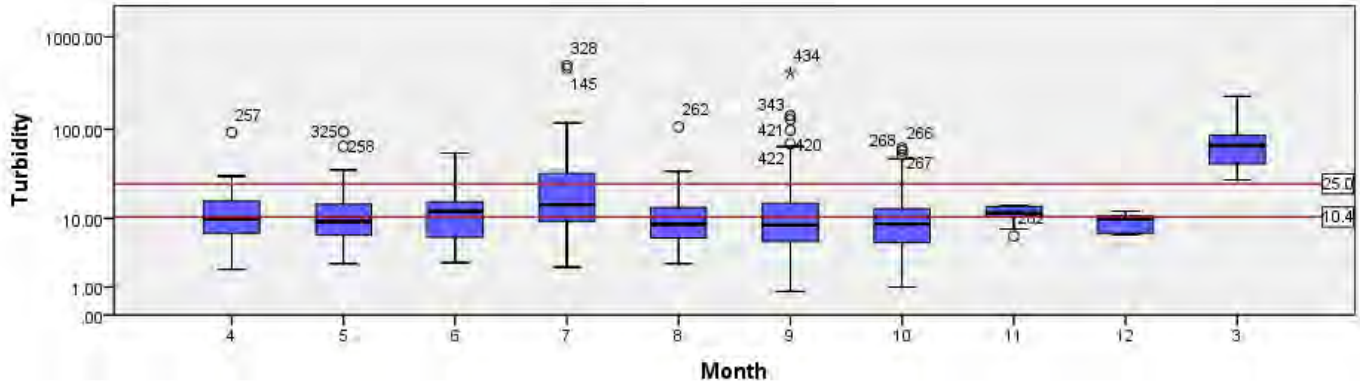
Statistically significant monthly/seasonal variations were observed in dissolved oxygen, total organic carbon, sediment, and nutrient concentrations (Figure 212). Dissolved oxygen concentrations most frequently fell below the 4 mg/L water quality standard during the summer months with warmer water temperatures and lower stream flows. Total suspended solids (TSS) and turbidity levels most frequently exceeded target values during March. This observation generally corresponds to the melting and subsequent runoff of the nearly 60 inches of snow that fell on the region between November 2013 and March 2014 (Table 5). Total phosphorus showed a small peak in July, with larger peaks being observed in September and December. Nitrate concentrations were at the highest during the fallow months of November and December. Ammonia concentration were generally highest in June and September. No water quality monitoring occurred in January or February because of ice cover at the stream sites.




Dissolved Oxygen
10.00
1.00
.00
12.0
4.0
4
5
6
7
8
9
10
11
12
3
Month


TOC
25.0
20.0
15.0
10.0
5.0
.0
7
8
9
10
11
12
3
Month


Total Suspended Solids
1000
100
10
1
0
30.0
4
5
6
7
8
9
10
11
12
3
Month


Turbidity
1000.00
100.00
10.00
1.00
.00
25.0
10.4
257
325
258
328
145
262
434
343
421
420
422
268
266
267
4
5
6
7
8
9
10
11
12
3
Month

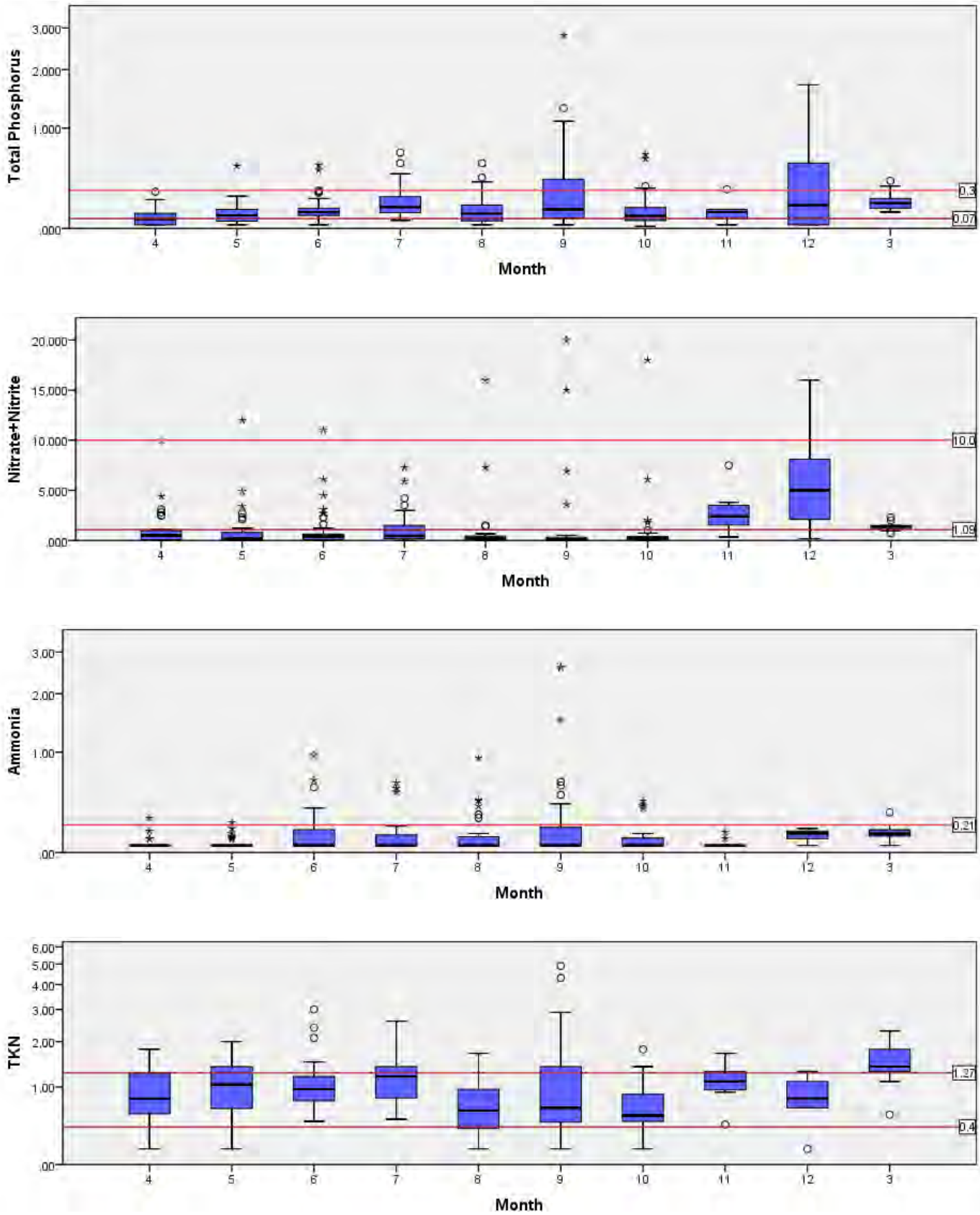



**Figure 212 Box plots illustrating monthly dissolved oxygen, sediment and nutrient concentrations within the watershed**

Stressor Linkage Analysis

A statistical analysis following methodologies outlined by Morris et al (2005) was used to further evaluate and identify the key stressors and linkages that could better explain the observed biotic impairments. The first step was to conduct a cluster analysis, grouping sites with similar fish and macroinvertebrate community structures (i.e. species and percent composition). Assuming that these community structures are the result of external driving forces and that those forces are identifiable, these groupings were used to evaluate physical and chemical variables (stressors) relative to the identified groupings. The resulting clusters (Figure 213 and Figure 214) were used as grouping variables in a Kruskal-Wallis analysis of variance (ANOVA) by ranks test to evaluate the water chemistry, habitat and land cover variables.

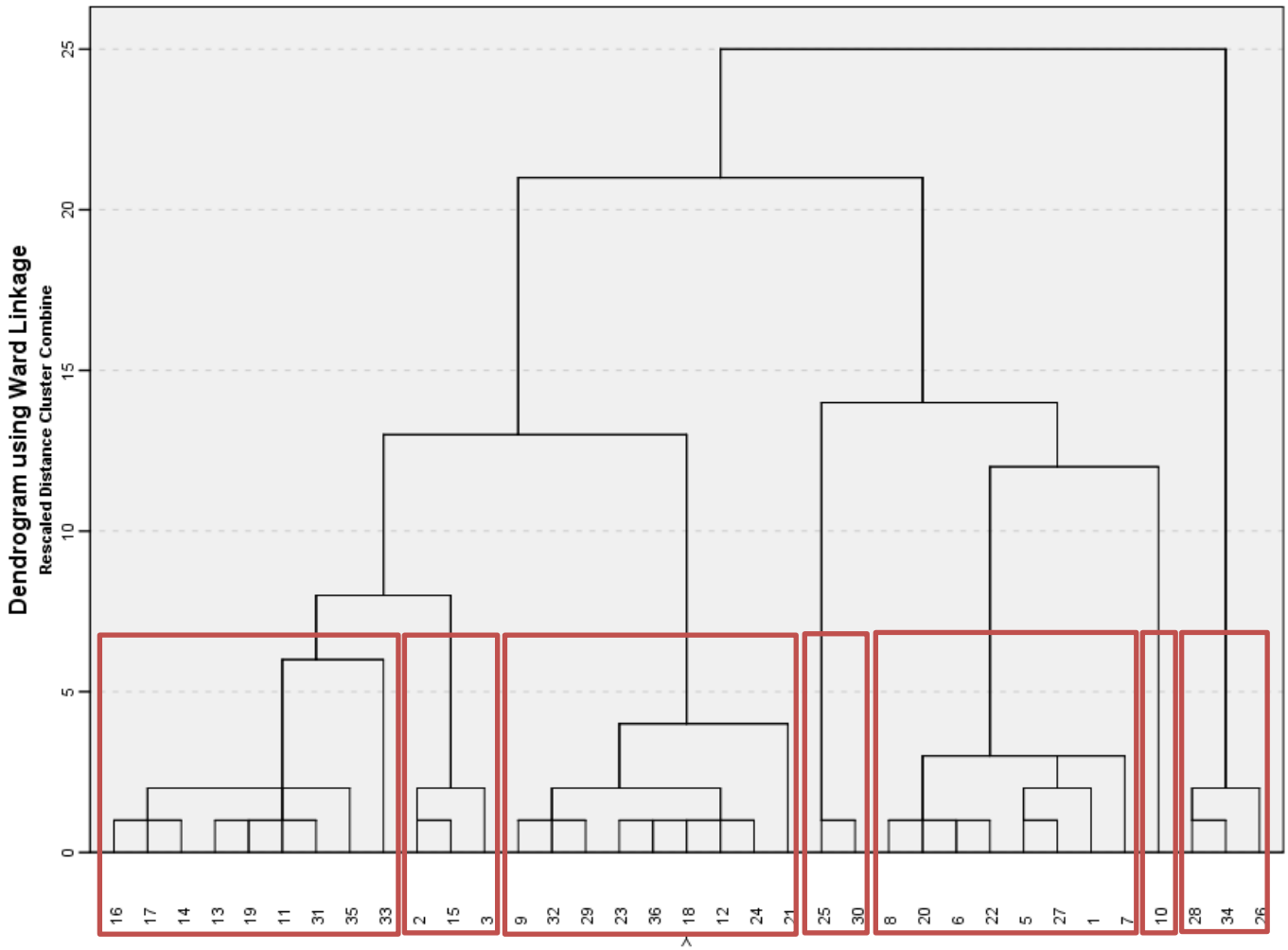



Figure 213 Fish Community Cluster Analysis

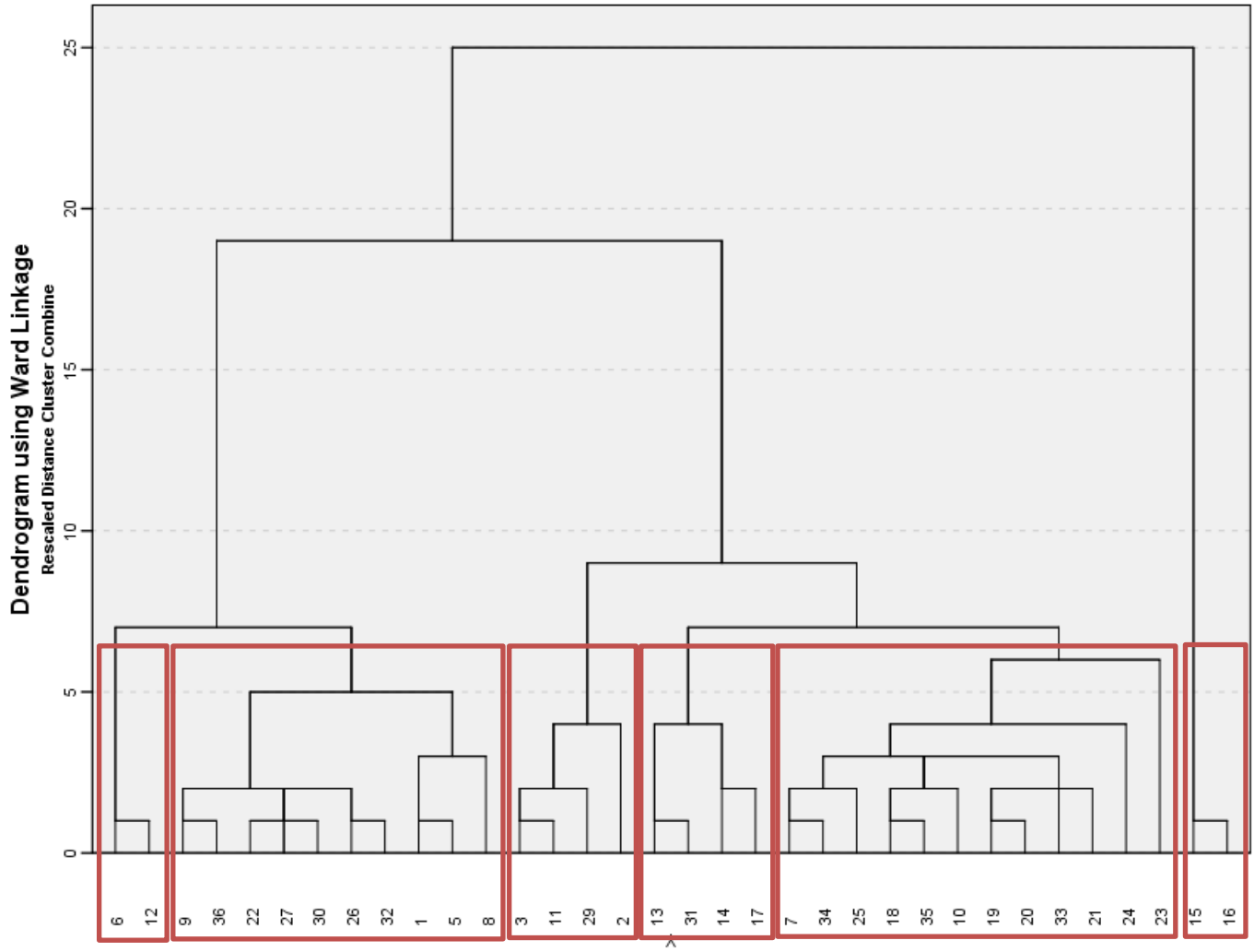



Figure 214 Macroinvertebrate community cluster analysis

The results of the Kruskal-Wallis ANOVA test (Table 85) showed that six water chemistry, one land cover, and three habitat variables (stressors) were significantly predictive of fish community structure. Four water chemistry, five land cover, and three habitat variables were significantly predictive of benthic macroinvertebrate community structure. The habitat variables effectively capture the influence of channelized streams/regulated drains on biotic communities within the watershed.

| Variable | Fish Significance (α=0.05, CL=95%) | Macroinvertebrate Significance (α=0.05, CL=95%) |
|---|---|---|
| **Water Chemistry** | | |
| Temperature | .014 | |
| Dissolved Oxygen (DO) | .036 | .019 |
| Dissolved Oxygen % Saturation | | .024 |
| Ammonia | | .019 |
| Turbidity | .036 | |
| E. coli | .026 | |
| pH | | .017 |
| Total Organic Carbon (TOC) | .028 | |

| Variable | Fish Significance (α=0.05, CL=95%) | Macroinvertebrate Significance (α=0.05, CL=95%) |
|---|---|---|
| Chemical Oxygen Demand (COD) | .046 | |
| **Land Cover** | | |
| Wetland | .022 | .026 |
| Forest | | .040 |
| Scrub/Shrub | | .021 |
| Riparian Deciduous Forest | | .003 |
| Riparian Scrub/Shrub | | .015 |
| **Physical Habitat** | | |
| Channel Morphology | .019 | .018 |
| Riparian | | .027 |
| Gradient | .001 | .010 |
| Embeddedness | .022 | |

Table 85 Variables significantly predictive of the fish and macroinvertebrate community structure

The variables found to be significantly predictive of community structures were further evaluated using a Principle Components Analysis (PCA). This type of analysis is often used to identify which factors explain most of the variance observed within a larger set of variables and to generate hypotheses regarding causal mechanisms. Variables were normalized and standardized (z-scores) and evaluated for strong correlations ($r > 0.8$) using Spearman's correlation before conducting this analysis. Chemical oxygen demand was dropped from further consideration due to its strong correlation to total organic carbon for fish while pH and dissolved oxygen percent saturation were dropped due to their strong correlation to dissolved oxygen.

The result of the principal components analysis explaining fish community structure is shown in Figure 215. Three statistically significant dimensions were identified which collectively describe 68% of the variability. Loading values greater than 0.75 signify a "strong" correlation, while values between 0.75 and 0.50 indicate "moderate" correlation and values between 0.50 and 0.30 denote "weak" correlation.

Component 1 explains 34% of the variation and shows a strong positive correlation with dissolved oxygen (DO) and a strong negative correlation with total organic carbon (TOC). Moderate, positive correlations were observed with three habitat related metrics including channel morphology, stream gradient and substrate embeddedness (inverse metric). A moderate, negative correlation was observed with emergent wetland (LC15) habitat. Component 2 explains an additional 18% of the variation and shows a strong negative correlation with wetland habitat. Moderate, positive correlations where observed with *E. coli* and turbidity and a moderate, negative correlation was observed with emergent wetland (LC15) habitat. Component 3 explains an additional 15% of the variation with a strong positive correlation with water temperature and moderate negative correlation with *E. coli*.

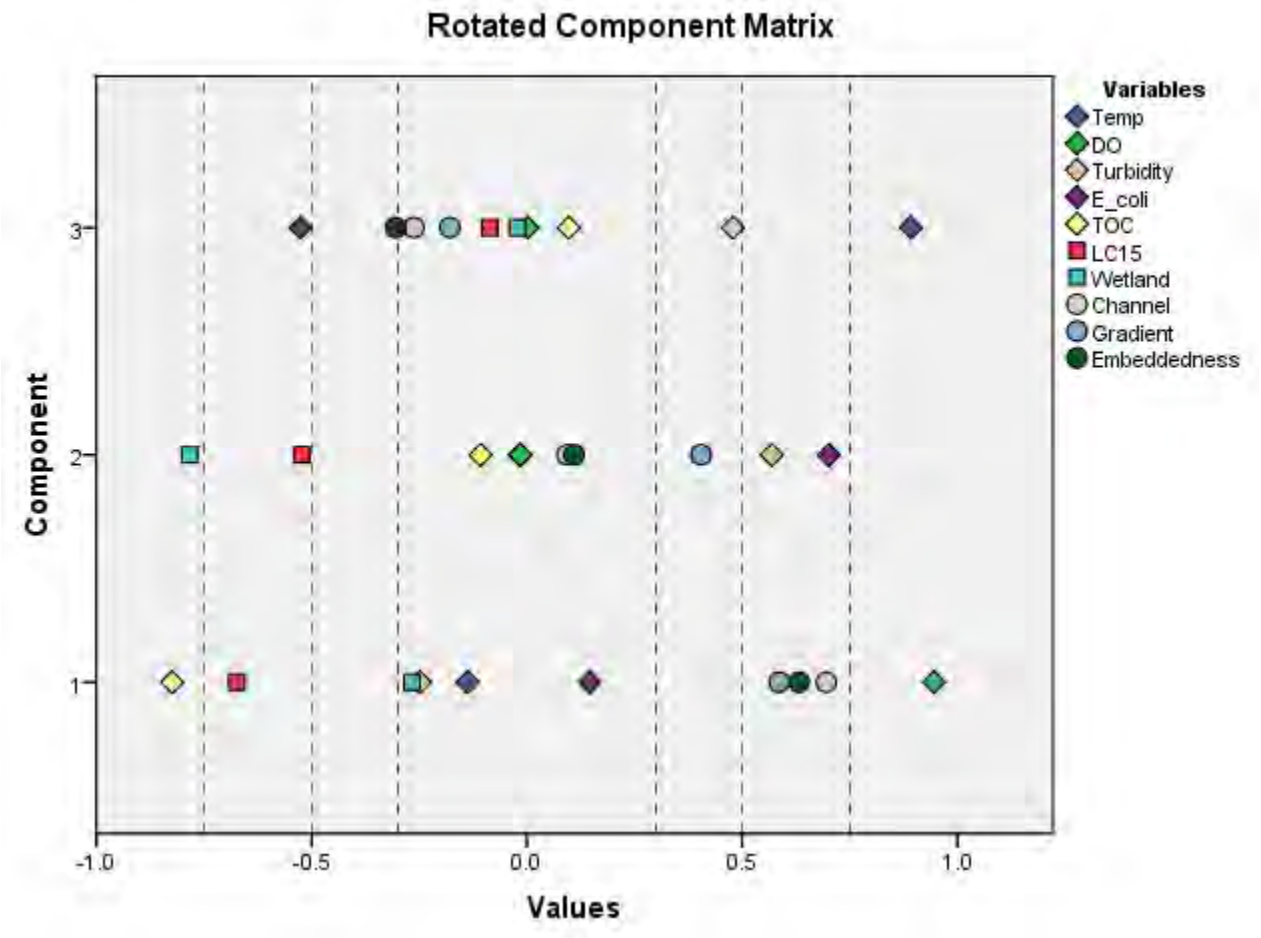



Figure 215 Fish community principle component analysis results

Results of the principal components analysis used to evaluate which factors are most influential in macroinvertebrate community structure are shown in Figure 216. Two statistically significant dimensions were identified which collectively describe 67% of the variability.

Component 1 explains 40% of the variation and shows a strong positive correlation with dissolved oxygen (DO), channel morphology, and riparian deciduous forest (Rip9). Moderate, positive correlations were observed with stream gradient and riparian scrub/shrub habitat (Rip12). A moderate, negative correlation was observed with ammonia. Component 2 explains an additional 27% of the variation and shows a strong positive correlation with forest and wetland habitat. Moderate, positive correlations where observed with forest and riparian deciduous forest (Rip9) habitat.

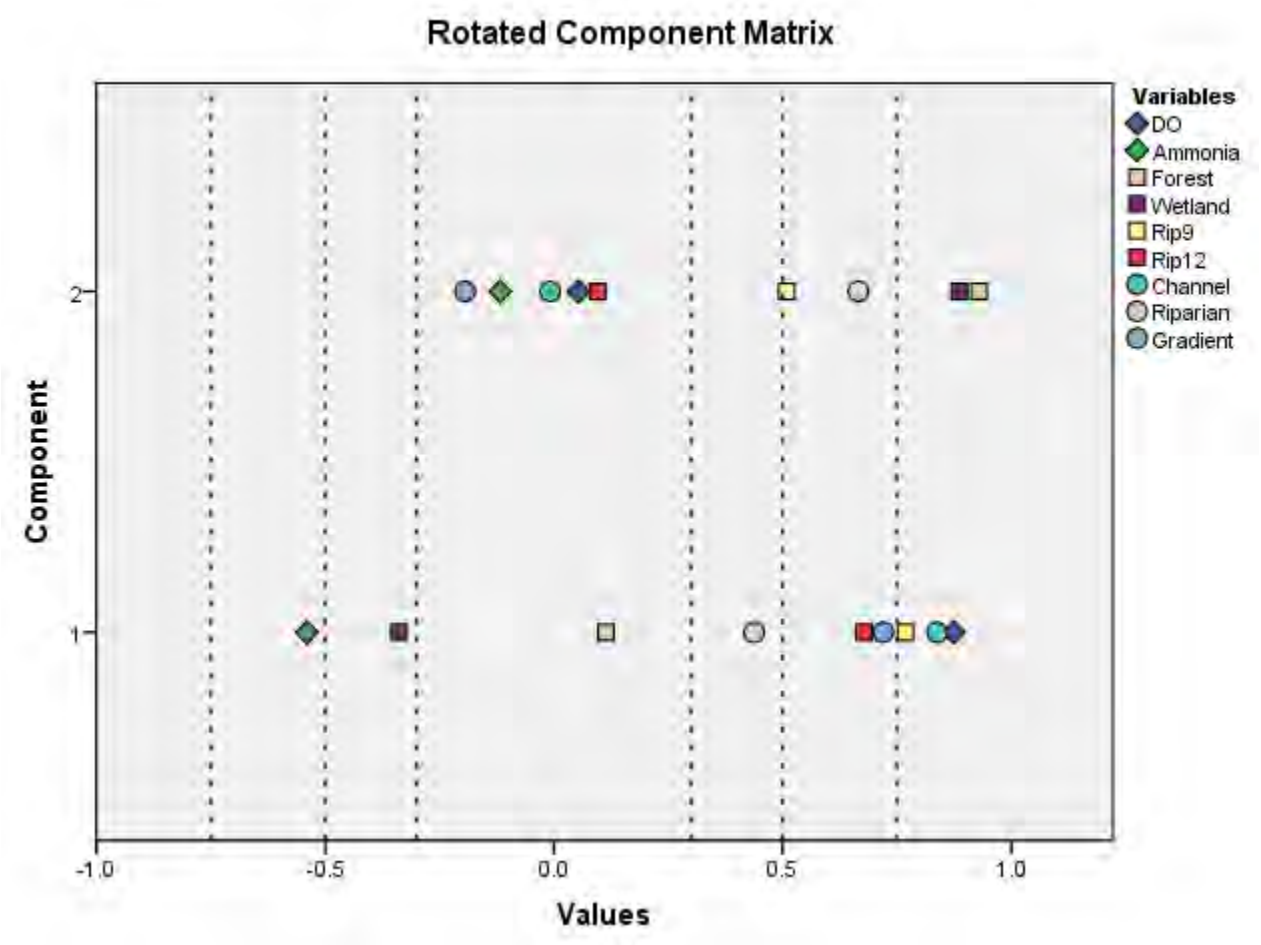



Figure 216 Macroinvertebrate community principal component analysis results

The linkage analysis shows that dissolved oxygen, channel morphology, and riparian forest are the most significant factors in explaining fish and macroinvertebrate community structure in the watershed. Restoration actions should focus heavily on these parameters. Sites that maintained good dissolved oxygen levels throughout the year (4-12 mg/L), had good channel morphology (i.e. good sinuosity, pool/riffle/run development, not channelized or had recovered, and were stable), and forested riparian zone typically had healthier fish and macroinvertebrate communities.

Healthy, functioning fish and macroinvertebrate communities occurs when the following conditions are present (Harman et al, 2012):

1. Continuous upstream streamflow sources, as removal of impoundments and excessive water consumption for human activities will provide adequate streamflow throughout the year;
2. Floodplain connectivity and bankfull channel, which dissipate energy of large storm events to prevent excessive scouring of substrates used for reproduction, and prevent sediment inundation of substrate habitat;
3. Healthy hyporheic zones (the region where shallow groundwater and surface water mix along the streambed) , which provide habitat and food resources;

4. Bed form diversity and in-stream structures, which create diverse habitats for feeding and reproduction, dissipate stormflow energy; provides opportunities for organic carbon storage and retention, provide substrates such as large woody debris, and provide scour pools for reproduction, feeding and shelter;
5. Channel stability, which prevents sediment inundation of habitat and excessive turbidity that is contributed from channel erosion;
6. Riparian community, which provides inputs for food resources, provides shade for cooler temperatures and provides vegetative roots for available habitat; and
7. Adequate dissolved oxygen, which is required for survival and health.

Based on the data that has been collected and presented, issues with conditions 1-2 and 4-7 are readily apparent, to varying degrees in watershed.

Also, when all factors are considered together an interrelated or hierarchical cause-and-effect relationship is apparent. The "stream functions pyramid" shown in Figure 217 is provided as a visual representation to help explain these relationships. The pyramid is based on a framework adopted by the US Army Corps of Engineers (USACE) for evaluating stream restoration projects. The pyramid simplifies a suite of 15 functions that the USACE determined to be critical to the health of a stream and riparian ecosystem (Harman et al, 2012).

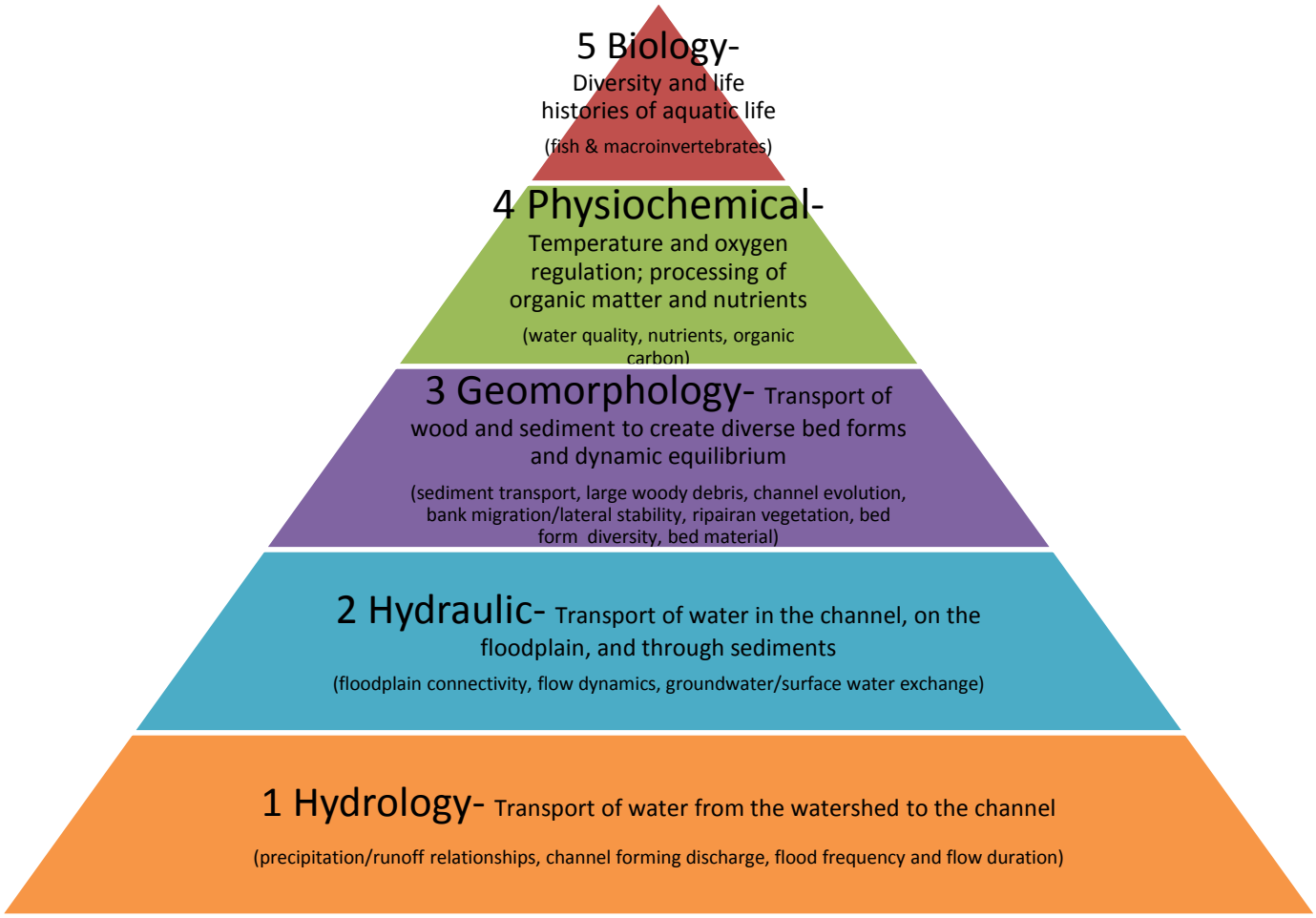



**Figure 217 Stream functions pyramid**

This functional based framework infers that restoration activities that occur at lower levels will provide a functional lift at higher levels. The pyramid also infers that the likelihood of restoring aquatic communities or water quality without also addressing lower level functions is problematic at best.

The principal components analysis results indicate that geomorphology related measures such as channel morphology, bed material, and riparian vegetation explain a significant portion of variability observed in aquatic communities. Hydraulic function parameters such as floodplain connectivity were not evaluated directly in the field during the baseline assessment. However, given the extent of stream channelization and impervious cover in the watershed it is reasonable to assume that floodplain connectivity is an issue along at least some stream reaches in the watershed such as Willow Creek and Main Beaver Dam Ditch. At the hydrology level, the shape of the flow-duration curve presented in Figure 19 indicates variable stream flows as a result of increased surface runoff and reduced watershed storage.

## 5.2 Analysis of Stakeholder Concerns

Stakeholder concerns generated through the public/ steering committee meetings are listed in Table 86. The steering committee helped evaluate whether the available data and evidence supported each concern. The steering committee also determined whether or not it was a concern they wished to focus. The only concern that the steering committee chose not to focus on at this time was the loss of cropland to development. This can be a complex issue with both positives (ex. less natural area converted) and negatives (ex. loss of productive farmland).

| Concerns | Supported by Data? | Evidence | Able to Quantify? | Within Project Scope? | Steering Committee Wants to Focus On? |
|---|---|---|---|---|---|
| Stream Habitat Loss and Riparian Encroachment | Yes | 24 of the 35 stream sites (69%) assessed by IDEM had QHEI scores <51 indicating that habitat quality in these reaches was generally not conducive to supporting a healthy warm water fish community. | Yes | Yes | Yes |
| | | The average "riparian quality" metric score from the QHEI was 5.5 with a range of 3 to 9 (12 possible points). | | | |
| | | An analysis of land cover types within a 30-meter buffer adjacent to streams showed that human land uses account for 35 to 65% of the area with an average of 52%. | | | |
| Wetland Habitat Loss and Degradation | Yes | Based on hydric soils data, nearly 28,000 acres (75%) of wetland habitat has been converted to developed or agricultural land uses. | Yes | Yes | Yes |
| Species Loss | Yes | Species metric scoring (# species) for the Index of Biotic Integrity indicates that 26 sites fall below expectations for the ecoregion. | Yes | Yes | Yes |
| Need for Conserved | Yes | The Chicago Wilderness Green Infrastructure Vision 2.1 identified | Yes | Yes | Yes |

| Concerns | Supported by Data? | Evidence | Able to Quantify? | Within Project Scope? | Steering Committee Wants to Focus On? |
|---|---|---|---|---|---|
| Open Spaces, Riparian Corridor Acquisition, Recreational Access | | 37,622 acres (58 mi²) of land as a priority for preservation. Approximately 17,000 acres (27 mi²) of land is currently protected according to DNR managed lands data. | | | |
| | | Overall, human land uses account for approximately 57% of the riparian land cover in the watershed. | | | |
| Habitat Restoration and Long-Term Management of Natural Areas | Yes | Aquatic and terrestrial invasive species have been documented in the watershed by various agencies and non-government organizations. | Yes | Yes | Yes |
| | | High quality natural areas and ETR species are documented in the watershed by Indiana Natural Heritage Data Center | | | |
| | | Local land trusts and managers such as Shirley Heinze, The Nature Conservancy, Save the Dunes, DNR and Lake County Parks Department have invested significant resources in managing natural areas. | | | |
| Terrestrial and Aquatic Invasive Species | Yes | Round goby and alewife collected by IDEM assessment crews at three sites below Deep River dam in Lake Station. | Yes | No | Yes |
| | | At least 13 terrestrial, invasive plant species have been identified in the watershed. Several others have been identified as probable. | | | |
| Negative Impact of Impaired Waterways to Recreational Use, Property Values, and Economic Development | Yes | All 35 monitoring sites have median *E. coli* concentrations that exceed the 235 CFU/100 mL single sample water quality standard. | Yes | Yes | Yes |
| | | 24 of the 35 (69%) monitoring sites have impaired fish communities. | | | |
| | | Seven (20%) sites had seven or fewer fish collected. | | | |
| | | Signs posted inside the Portage Lakefront and Riverwalk warn the public not to swim inside the harbor due to high bacteria levels. | | | |
| Coordination Between Municipalities, Business, and Residents | No | As a general observation, the level of coordination is highly variable and dependent on many factors. | Uncertain | Yes | Yes |

| Concerns | Supported by Data? | Evidence | Able to Quantify? | Within Project Scope? | Steering Committee Wants to Focus On? |
|---|---|---|---|---|---|
| Enforcement of Existing Regulations Protective of Stream Health | Yes | Over 160 unauthorized wetland impact violations have been investigated by the U.S. Army Corps of Engineers between 2000 and March 2015 in the watershed. | Yes | Yes | Yes |
| Reconciling Need for Drainage While Also Protecting Water Quality and Aquatic Life | Yes | Of the approximate 112 miles of regulated drain within the watershed, 110 miles are listed with an impairment.<br>Significantly negative correlations exist between regulated drains and:<br>• dissolved oxygen<br>• pH<br>• QHEI, channel quality, riffle/run, and gradient metrics<br>• Silt and embeddedness QHEI sub-metrics<br>• Simple lithophils IBI metric<br>• Intolerant species and sprawler mIBI metrics<br>Significantly positive correlations exist between regulated drains and:<br>• Ammonia<br>• Total Kjeldahl nitrogen<br>• Total phosphorus<br>• Total organic carbon<br>• Chemical oxygen demand<br>• Insectivore IBI metric | Yes | Yes | Yes |
| Maintenance of Existing Plans | Yes | No organizational structure was put in place to implement the Deep River-Turkey Creek and West Branch Little Calumet River WMP's once they were completed. Projects were largely independent of group effort. | Yes | Yes | Yes |
| Loss of Cropland to Development | Yes | Between 1985 and 2010, 6,644 acres of agricultural land (-17%) was converted to other uses while development expanded by nearly 10,578 acres (26%). | Yes | Yes | No |
| Some Absentee Agricultural Landowners Seem to be Land Speculators with Less | No | Agricultural parcels posted/listed for sale near prime development areas. However due to privacy requirements associated with the Farm Bill program, operator or site information is restricted to the general public so | No | Uncertain | Yes |

| Concerns | Supported by Data? | Evidence | Able to Quantify? | Within Project Scope? | Steering Committee Wants to Focus On? |
|---|---|---|---|---|---|
| Interest in Investing in BMPs to Protect Water Quality | | there is a degree of uncertainty associated with BMP implementation. | | | |
| Ability of Watershed to Store and Filter Storm Water Runoff While Providing Habitat | Yes | In a Wisconsin DNR publication that focused on small wetlands and wetland loss, Trochlell and Bernthal (1998) compiled research that showed there was a threshold in which watersheds with less than 10% wetland area often experienced pronounced negative hydrological and water quality impacts, including deceased stream stability, higher peak flows, lower base flows and increased suspended solid loading rates. Only 8% of the land area in our watershed is wetland habitat. Historically it would have been closer to 32%. | Yes | Yes | Yes |
| | | The approximate value of ecosystem services provided by the Green Infrastructure Vision within our watershed is:<br>• $31 million in water purification<br>• $493 million in water flow regulation/ flood control<br>• $126 million in groundwater recharge | | | |
| Excessive Sediment and Nutrient Loading from Urban and Agricultural Land Uses | Yes | Biotic impairments co-occur where the data indicates sediment and nutrients are at an intensity and duration that could result in a change in the ecological condition. | Yes | Yes | Yes |
| | | Median concentrations of sediment and nutrient target values protective of fish and macroinvertebrate communities exceeded.<br>• TSS- 1 site (2.9% of sites)<br>• Turbidity- 16 sites (45.7% of sites)<br>• TP- 24 sites (68.6% of sites)<br>• Nitrate- 6 sites (17.1% of sites)<br>• TKN- 23 sites (65.7% of sites) | | | |

| Concerns | Supported by Data? | Evidence | Able to Quantify? | Within Project Scope? | Steering Committee Wants to Focus On? |
|---|---|---|---|---|---|
| | | • Ammonia- 10 sites (28.6% of sites) | | | |
| | | There is a significant correlation between nutrient concentrations and agricultural land uses. | | | |
| | | There is a significant correlation between chloride concentrations and developed land uses. | | | |
| Increased Storm Water Runoff Volume Causing Streambank and Shoreline Erosion | Yes | USGS stream gage at Lake George outlet indicates increasing trends for annual peak discharge and precipitation. However, annual peak discharge is increasing at a much higher rate (57%) than annual total precipitation (11%) over period of record (1947-2009). | Yes | Yes | Yes |
| | | The flow-duration curve suggests a system influenced by increased runoff and loss of storage. | | | |
| | | Impervious surface cover analysis shows that seven of the nine subwatersheds are impacted by impervious cover, exceeding the 10% threshold classification for a sensitive stream. | | | |
| | | 31 of the 34 (91%) monitoring sites had moderate levels of streambank erosion documented on the QHEI | | | |
| Sedimentation of Lake George and Burns Ditch | Yes | In 1993 the U.S. Army Corps of Engineers (USACE), Chicago District, initiated an extensive evaluation of Lake George and its major tributaries and later published a 1995 Planning/ Engineering feasibility report for the dredging of Lake George. | Yes | Yes | Yes |
| | | In 2000, the City of Hobart proceeded with a limited dredging of Lake George that removed 590,000 cubic yards of sediment at a cost of over two million dollars. | | | |
| | | In 2003, the USACE released the Burns Ditch/ Waterway Sediment Transport Modeling Phase I Report with the following findings:<br>• Sediment reduced the average depth of water in Lake George | | | |

| Concerns | Supported by Data? | Evidence | Able to Quantify? | Within Project Scope? | Steering Committee Wants to Focus On? |
|---|---|---|---|---|---|
| | | from approximately 6-8 ft. to 1-3 ft.<br>• Sediment in the lake is mostly from intensive agriculture and development construction in the upstream watershed.<br>• Sediment on the lake bottom is formed by fine silt and clay (90-98%).<br>• Channel erosion on the river reach downstream of Lake George appears to be an important source of sediment that ultimately settles at mouth of Burns Ditch. | | | |
| | | Bathymetric mapping of Lake George for the Deep River Flood Risk Management Plan shows that 70,000 cubic yards of sediment have accumulated over the past 14 years (2001-2014). This translates to approximately 5,000 cubic yards/year. | | | |
| | | Median TSS concentrations drop from 14 mg/L at Site 12 on Deep River upstream of Lake George to 4 mg/L at Site 8 immediately downstream of the Lake George dam (71% reduction) indicating sediment deposition in the lake. | | | |
| Failing Septic Systems | Yes | City of Hobart and Indiana State Department of Health confirm several houses have failed septic systems with absorption fields located within Deep River floodplain. | Yes | Yes | Yes |
| | | Strong positive correlation observed between *E. coli* and total dissolved solids, conductivity and chloride median concentrations indicating presence of human sources. | | | |
| Flooding, Floodplain Encroachment, and Stream Flashiness | Yes | Analysis of land cover types within the 100-yr. floodplain show that agriculture accounts for 22% of the floodplain land area, development 21%, and developed open space 9%. | Yes | Yes | Yes |
| | | Impervious surface cover analysis shows that seven of the nine | | | |

| Concerns | Supported by Data? | Evidence | Able to Quantify? | Within Project Scope? | Steering Committee Wants to Focus On? |
|---|---|---|---|---|---|
| | | subwatersheds are impacted by impervious cover. | | | |
| | | USGS stream gage data shows a steady increase in annual peak flows. | | | |
| | | Flow duration curve points towards a system influenced by runoff and loss of storage. | | | |
| Negative Impacts Associated with Dams | Yes | Streambank erosion downstream of Lake George and Deep River dams documented in IDEM habitat assessments. | Yes | Yes | Yes |
| | | Findings from the USACE Burns Ditch/ Waterway Sediment Transport Modeling Phase I Report state that channel erosion on the river reach downstream of Lake George appears to be an important source of sediment due to rapid fluctuation in discharge. | | | |
| | | Impaired biotic impairments in upstream and downstream reaches of the Lake George and Deep River dams. | | | |
| | | Deep River dam is an obstacle for recreational use of the river as a water trail. | | | |
| Public Involvement | No | Attendance at public/stakeholder meeting. | Yes | Yes | Yes, as overall stakeholder awareness and collaboration |
| | | Participation in Hoosier Riverwatch training workshops. | | | |
| Soil Health | Yes | In 2103, approximately 45% of the acreage in corn production in Lake and Porter Counties still used conventional tillage. | Yes | Yes | Yes |
| | | In 2013, no-till was only used on 20% of the acreage in corn production in Lake County and 5% in Porter County. | | | |
| Combined Sewer and Sanitary Sewer Overflows | Yes | Crown Point WWTP CSO Events<br>• 2009- 10 events<br>• 2010- 10 events<br>• 2011- 20 events<br>• 2012- 5 events<br>• 2013- 15 events<br><br>Gary Sanitary District WWTP CSO Events | Yes | Yes | Yes |

| Concerns | Supported by Data? | Evidence | Able to Quantify? | Within Project Scope? | Steering Committee Wants to Focus On? |
|---|---|---|---|---|---|
| | | • 2009- 64 events<br>• 2010- 80 events<br>• 2011- 44 events<br>• 2012- 24 events<br>• 2013- 48 events | | | |
| Litter Left Behind After Floodwaters Recede | Yes | Litter deposited in floodplains after floodwaters receded. Litter accumulated in woody debris within stream channel. | Yes | Yes | Yes |
| | | Litter collected by volunteers during stream clean up (NWI Paddlers Association event on Deep River below Lake George). | | | |
| | | Litter accumulated on beach inside Burns Waterway harbor. | | | |

Table 86 Analysis of stakeholder concerns

# 6 Problems & Causes

The stakeholder concerns which the steering committee has chosen to focus on have been carried forward into Table 87 which relates concerns to problems in the watershed. Problems are conditions or actions that need to be changed, improved or investigated further.

| Concern | Problem |
|---|---|
| • Need for Conserved Open Spaces, Riparian Corridor Acquisition, Recreational Access Stream Habitat Loss and Riparian Encroachment<br>• Wetland Habitat Loss and Degradation<br>• Ability of Watershed to Store and Filter Storm Water Runoff While Providing Habitat<br>• Habitat Restoration and Long-Term Management of Natural Areas | The degradation and loss of upland and riparian habitats is negatively affecting our watershed's ability to store and filter storm water runoff while also providing important habitat and recreation opportunities. |
| • Negative Impact of Impaired Waterways to Recreational Use, Property Values, and Economic Development | Some of our streams are frequently turbid and have nuisance levels of aquatic plant growth and algal blooms. |
| • Negative Impact of Impaired Waterways to Recreational Use, Property Values, and Economic Development<br>• Failing Septic Systems<br>• Combined Sewer and Sanitary Sewer Overflows | Elevated pathogens levels pose a health risk to full body contact recreational use of our streams. |
| • Negative Impact of Impaired Waterways to Recreational Use, Property Values, and Economic Development | Poor quality fish community structure and numbers limit recreational use of our streams and lakes. |

| Concern | Problem |
|---|---|
| • Coordination Between Municipalities, Business, and Residents<br>• Enforcement of Existing Regulations Protective of Stream Health<br>• Maintenance of Existing Plans<br>• Public Involvement<br>• Litter Left Behind After Floodwaters Recede<br>• Some Absentee Agricultural Landowners Seem to be Land Speculators with Less Interest in Investing in BMPs to Protect Water Quality<br>• Soil Health | Awareness of watershed issues and collaboration need to be increased to protect our streams, lakes and natural areas. |
| • Reconciling Need for Drainage While Also Protecting Water Quality and Aquatic Life<br>• Negative Impacts Associated with Dams | Hydromodification is negatively affecting aquatic life and recreational use of our streams and lakes. |
| • Excessive Sediment and Nutrient Loading from Urban and Agricultural Land Uses<br>• Sedimentation of Lake George and Burns Ditch | Excessive sediment and nutrient loading threaten aquatic life and recreational use of our streams and lakes. |
| • Increased Storm Water Runoff Volume Causing Streambank and Shoreline Erosion<br>• Flooding, Floodplain Encroachment, and Stream Flashiness | Losses of upland, riparian and wetland habitats, and increases in impervious surface cover exacerbate streambank erosion and downstream flooding. |

Table 87 Problems reflecting stakeholder concerns

Table 88 relates problems to potential causes. A cause is considered an event or actions that produce an effect which in this case is the problem statement.

| Problem | Potential Cause(s) |
|---|---|
| The degradation and loss of upland and riparian habitats is negatively affecting our watershed's ability to store and filter storm water runoff while also providing important habitat and recreation opportunities. | Encroachment on and conversion of upland, riparian and wetland habitat for development and agricultural land uses. |
| Some of our streams and lakes are frequently turbid and have nuisance levels of aquatic plant growth and algal blooms. | • Nutrient concentrations often exceed the protective water quality target values established by this watershed restoration plan.<br>• Sediment concentrations often exceed the protective water quality target values established by this watershed restoration plan. |
| Elevated pathogens levels pose a health risk to full body contact recreational use of our streams. | *E. coli* concentrations often exceed state water quality standards. |
| Poor quality fish community structure and numbers limit recreational use of our streams and lakes. | • Streams lack the habitat quality that is conducive to supporting a healthy warm water fishery as indicated by QHEI scores. |

| Problem | Potential Cause(s) |
|---|---|
| | • Dissolved oxygen concentrations fall below state water quality standards.<br>• Nutrient concentrations often exceed the protective water quality target values established by this watershed restoration plan.<br>• Ammonia concentrations often exceed the protective water quality target values established by this watershed restoration plan.<br>• Sediment concentrations often exceed the protective water quality target values established by this watershed restoration plan. |
| Awareness of watershed issues and collaboration need to be increased to protect our streams, lakes and natural areas. | • Limited resources and/or awareness of need.<br>• Communities/organizations have other issues that are a higher priority than water quality and aquatic habitats |
| Hydromodification activities are negatively affecting aquatic life and recreational use of our streams and lakes. | Hydromodification activities disrupts hydraulic, geomorphic, physiochemical, and biotic stream functions. |
| Excessive sediment and nutrient loading threaten aquatic life and recreational use of our streams and lakes. | • Nutrient concentrations often exceed the protective water quality target values established by this watershed restoration plan.<br>• Sediment concentrations often exceed the protective water quality target values established by this watershed restoration plan.<br>• Channelized streams disassociated the stream from their floodplain. |
| Losses of upland, riparian and wetland habitats, and increases in impervious surface cover exacerbate streambank erosion and downstream flooding. | • Conversion of forest, grassland and wetland habitats for human land uses such as development and agriculture.<br>• Development siting and implementation of post-development practices not sufficiently protective of environmental features and ecosystem functions. |

Table 88 Potential causes for identified problems

# 7 Pollutant Sources and Pollutant Loads

The following section provides information on potential pollutant sources in the watershed and an approximation of existing pollutant loads and reductions needed based on pollutant thresholds/target values.

## 7.1 Potential Pollutant Sources

Information about watershed problems and potential causes listed above in Table 88 have been linked to potential sources in the following tables. The Indiana Department of Environmental Management defines a sources as an activity, material, or structure that results in a cause of nonpoint source pollution.

| Problem | The degradation and loss of upland, wetland and riparian habitats is negatively affecting our watershed's ability to store and filter storm water runoff while also providing important habitat and recreation opportunities. |
|---|---|

| | |
|---|---|
| **Potential Cause(s)** | Encroachment on and conversion of upland, riparian and wetland habitat for development and agricultural land uses. |
| **Potential Sources** | • Between 1985 and 2010 approximately 759 acres of forest, 2,430 acres of grassland, 1,079 acres of scrub/shrub, and 563 acres of wetland habitat has been converted.<br>• Nearly 220 acres (3%) of core forest habitat was lost between 1996 and 2006.<br>• Percentage of human land uses occurring within 100-foot riparian buffer: 53% Headwaters Main Beaver Dam Ditch, 63% Main Beaver Dam Ditch, 65% Headwaters Turkey Creek, 40% Deer Creek, 60% City of Merrillville, 44% Duck Creek, 35% Lake George, 45% Little Calumet River, and 57% Willow Creek subwatersheds.<br>• Subwatershed wetland loss: Headwaters Main Beaver Dam Ditch 75%, Main Beaver Dam Ditch 86%, Headwaters Turkey Creek 76%, Deer Creek 71%, City of Merrillville 76%, Duck Creek 81%, Lake George 61%, Little Calumet River 69%, and Willow Creek 74%.<br>• Subwatershed drainage area 10% or less wetland: Headwaters Main Beaver Dam Ditch 10% , Main Beaver Dam Ditch 5%, Headwaters Turkey Creek 9%, Deer Creek 7%, City of Merrillville 8%, Duck Creek 5%, Lake George 10%, Little Calumet River 10%, and Willow Creek 9% subwatersheds. |

Table 89 Potential causes and sources of habitat degredation

| **Problem** | Some streams and lakes are frequently turbid and have nuisance levels of aquatic plant growth and algal blooms. |
|---|---|
| **Potential Cause(s)** | • Nutrient concentrations often exceed the protective water quality target values established by this watershed plan.<br>• Sediment concentrations often exceed the protective water quality target values established by this watershed plan.<br>• Streams are disassociated from their floodplains |
| **Potential Sources** | • CSO communities: Crown Point and Gary (4 Headwaters Main Beaver Dam Ditch subwatershed, 1 Main Beaver Dam Ditch subwatershed, 5 Little Calumet River subwatershed).<br>• SSOs: Merrillville and Portage (1 Headwaters Turkey Creek subwatershed, 1 City of Merrillville subwatershed and 1 Willow Creek subwatershed).<br>• Pasture and livestock operations (# animal units/subwatershed: 208 Headwaters Main Beaver Dam Ditch, 299 Main Beaver Dam Ditch, 242 Headwaters Turkey Creek, 420 Deer Creek, 325 City of Merrillville, 311 Duck Creek, 290 Lake George, 328 Little Calumet River, 411 Willow Creek).<br>• 26,000 acres of row crop production in the watershed<br>• Approximately 2,600 acres (10%) of row crop production occur on HEL soils<br>• Approximately 18,500 acres (71%) of row crop are tile drained<br>• Approximately 45% of row crop in corn is conventional tillage<br>• There are approximately 23,000 septic systems in the watershed based on number of rural households. The highest densities are located in the Headwaters Main Beaver Dam Ditch (402 households/mi$^2$), Headwaters Turkey Creek (280 households/mi$^2$), and Duck Creek (243 households/mi$^2$).<br>• Domestic pets in population centers (# dogs/subwatershed: 8,500 Headwaters Main Beaver Dam Ditch, 13,000 Main Beaver Dam Ditch, 19,000 Headwaters Turkey Creek, 5,000 Deer Creek, 29,000 City of Merrillville, 6,000 Duck Creek, 13,000 Lake George, 37,000 Little Calumet River, 20,000 Willow Creek).<br>• MS4 entities (#/subwatershed: 6 Headwaters Main Beaver Dam Ditch, 3 Main Beaver Dam Ditch, 6 Headwaters Turkey Creek, 5 Deer Creek, 4 City of Merrillville, 4 Duck Creek, 4 Lake George, 7 Little Calumet River, 4 Willow Creek). |

| | |
|---|---|
| | • Percentage of human land uses occurring within 100-foot riparian buffer: 53% Headwaters Main Beaver Dam Ditch, 63% Main Beaver Dam Ditch, 65% Headwaters Turkey Creek, 40% Deer Creek, 60 City of Merrillville, 44% Duck Creek, 35% Lake George, 45% Little Calumet River, and 57% Willow Creek subwatersheds.<br>• Moderate to high levels of streambank erosion was documented at 28 of the 35 stream monitoring sites.<br>• 24 of the 35 stream monitoring sites are located on stream reaches that have been channelized.<br>• Streams that are disassociated from there floodplain or ditches that were not designed with benchs.<br>• Approximately 112 miles of stream are maintained as regulated drains.<br>• Flow-duration curves point to streams flows being strongly influenced by runoff and as a result are flashy. |

Table 90 Potential causes and sources of turbid streams and algal blooms

| **Problem** | Elevated pathogens levels pose a health risk to full body contact recreational use of streams. |
|---|---|
| **Potential Cause(s)** | *E. coli* concentrations often exceed state water quality standards. |
| **Potential Sources** | • NPDES permitted WWTPs (1 Headwaters Main Beaver Dam Ditch subwatershed, 4 Deer Creek subwatershed, 1 Little Calumet River subwatershed, 1 Willow Creek subwatershed).<br>• CSO communities: Crown Point and Gary (4 Headwaters Main Beaver Dam Ditch subwatershed, 1 Main Beaver Dam Ditch subwatershed, 5 Little Calumet River subwatershed).<br>• SSOs: Merrillville and Portage (1 Headwaters Turkey Creek subwatershed, 1 City of Merrillville subwatershed and 1 Willow Creek subwatershed).<br>• Pasture and livestock operations (# animal units/subwatershed: 208 Headwaters Main Beaver Dam Ditch, 299 Main Beaver Dam Ditch, 242 Headwaters Turkey Creek, 420 Deer Creek, 325 City of Merrillville, 311 Duck Creek, 290 Lake George, 328 Little Calumet River, 411 Willow Creek).<br>• There are approximately 23,000 septic systems in the watershed based on number of rural households. The estimated failure rate is somewhere between 1-2% which equates to 230 to 460 failing systems. The highest densities of systems are located in the Headwaters Main Beaver Dam Ditch (402 households/mi2), Headwaters Turkey Creek (280 households/mi2), and Duck Creek (243 households/mi2).<br>• Domestic pets in population centers (# dogs/subwatershed: 8,500 Headwaters Main Beaver Dam Ditch, 13,000 Main Beaver Dam Ditch, 19,000 Headwaters Turkey Creek, 5,000 Deer Creek, 29,000 City of Merrillville, 6,000 Duck Creek, 13,000 Lake George, 37,000 Little Calumet River, 20,000 Willow Creek).<br>• An estimated 20% of dog owners do not pick up their pet's waste.<br>• Nuisance level urban goose populations because of suitable habitat and feeding (ex. below Lake George dam)<br>• MS4 entities (#/subwatershed: 6 Headwaters Main Beaver Dam Ditch, 3 Main Beaver Dam Ditch, 6 Headwaters Turkey Creek, 5 Deer Creek, 4 City of Merrillville, 4 Duck Creek, 4 Lake George, 7 Little Calumet River, 4 Willow Creek). |

Table 91 Potential causes and sources of pathogens

| **Problem** | Poor quality fish community structure and numbers limit recreational use of streams and lakes. |
|---|---|
| **Potential Cause(s)** | • Streams lack the habitat quality that is conducive to supporting a healthy warm water fishery as indicated by QHEI scores.<br>• Dissolved oxygen concentrations fall below state water quality standards. |

| | |
|---|---|
| | • Nutrient concentrations often exceed the protective water quality target values established by this watershed restoration plan.<br>• Ammonia concentrations often exceed the protective water quality target values established by this watershed plan.<br>• Sediment concentrations often exceed the protective water quality target values established by this watershed plan. |
| **Potential Sources** | • Sites 1, 3, 5, 8, 10, 11, 17, 19-22, and 24-36 have habitat quality that is generally not conducive of supporting a healthy warm water fishery (QHEI <51).<br>• There are seven dams located in the watershed.<br>• There are 112 miles of channel that are managed as regulated drains, representing approximately 39% of the total stream miles, in the watershed.<br>• 24 of the 35 stream monitoring sites are located on stream reaches that have been channelized.<br>• Flow-duration curves point to streams flows being strongly influenced by runoff and as a result are flashy.<br>• Percentage of human land uses occurring within 100-foot riparian buffer: 53% Headwaters Main Beaver Dam Ditch, 63% Main Beaver Dam Ditch, 65% Headwaters Turkey Creek, 40% Deer Creek, 60% City of Merrillville, 44% Duck Creek, 35% Lake George, 45% Little Calumet River, and 57% Willow Creek subwatersheds. |

Table 92 Potential causes and sources resulting in poor quality fish communities

| **Problem** | Hydromodification activities are negatively affecting aquatic life and recreational use of streams and lakes. |
|---|---|
| **Potential Cause(s)** | Hydromodification activities disrupts hydraulic, geomorphic, physiochemical, and biotic stream functions |
| **Potential Sources** | • Seven dams located in the watershed.<br>• There are 112 miles of channel that are managed as county regulated drains, representing approximately 39% of the total stream miles, in the watershed.<br>• 24 of the 35 stream monitoring sites are located on stream reaches that have been channelized.<br>• Flow-duration curves point to streams flows being strongly influenced by runoff and as a result are flashy. |

Table 93 Potential causes and sources of hydromodication negatively affecting aquatic life and recreational use

| **Problem** | Excessive sediment and nutrient loading threaten aquatic life and recreational use of streams and lakes. |
|---|---|
| **Potential Cause(s)** | • Nutrient concentrations often exceed the protective water quality target values established by this watershed restoration plan.<br>• Sediment concentrations often exceed the protective water quality target values established by this watershed restoration plan. |
| **Potential Sources** | • CSO communities: Crown Point and Gary (4 Headwaters Main Beaver Dam Ditch subwatershed, 1 Main Beaver Dam Ditch subwatershed, 5 Little Calumet River subwatershed).<br>• SSOs: Merrillville and Portage (1 Headwaters Turkey Creek subwatershed, 1 City of Merrillville subwatershed and 1 Willow Creek subwatershed).<br>• Pasture and livestock operations (# animal units/subwatershed: 208 Headwaters Main Beaver Dam Ditch, 299 Main Beaver Dam Ditch, 242 Headwaters Turkey Creek, 420 Deer Creek, 325 City of Merrillville, 311 Duck Creek, 290 Lake George, 328 Little Calumet River, 411 Willow Creek). |

| | |
|---|---|
| | • 26,000 acres of row crop production in the watershed<br>• Approximately 2,600 acres (10%) of row crop production occur on HEL soils<br>• Approximately 18,500 acres (71%) of row crop are tile drained<br>• Approximately 45% of row crop in corn is conventional tillage<br>• There are approximately 23,000 septic systems in the watershed based on number of rural households. The highest densities are located in the Headwaters Main Beaver Dam Ditch (402 households/mi$^2$), Headwaters Turkey Creek (280 households/mi$^2$), and Duck Creek (243 households/mi$^2$).<br>• Domestic pets in population centers (# dogs/subwatershed: 8,500 Headwaters Main Beaver Dam Ditch, 13,000 Main Beaver Dam Ditch, 19,000 Headwaters Turkey Creek, 5,000 Deer Creek, 29,000 City of Merrillville, 6,000 Duck Creek, 13,000 Lake George, 37,000 Little Calumet River, 20,000 Willow Creek).<br>• MS4 entities (#/subwatershed: 6 Headwaters Main Beaver Dam Ditch, 3 Main Beaver Dam Ditch, 6 Headwaters Turkey Creek, 5 Deer Creek, 4 City of Merrillville, 4 Duck Creek, 4 Lake George, 7 Little Calumet River, 4 Willow Creek).<br>• Percentage of human land uses occurring within 100-foot riparian buffer: 53% Headwaters Main Beaver Dam Ditch, 63% Main Beaver Dam Ditch, 65% Headwaters Turkey Creek, 40% Deer Creek, 60 City of Merrillville, 44% Duck Creek, 35% Lake George, 45% Little Calumet River, and 57% Willow Creek subwatersheds.<br>• Moderate to high levels of streambank erosion was documented at 28 of the 35 stream monitoring sites.<br>• 24 of the 35 stream monitoring sites are located on stream reaches that have been channelized.<br>• Flow-duration curves point to streams flows being strongly influenced by runoff and as a result are flashy. |

**Table 94 Potential causes and sources of sediment and nutrient loading**

| **Problem** | Losses of upland, riparian and wetland habitats, and increases in impervious surface cover exacerbate streambank erosion and downstream flooding. |
|---|---|
| **Potential Cause(s)** | • Conversion of forest, grassland and wetland habitats for human land uses such as development and agriculture.<br>• Development siting and implementation of post-development practices not sufficiently protective of environmental features and ecosystem functions. |
| **Potential Sources** | • Percentage of human land uses occurring within 100-foot riparian buffer: 53% Headwaters Main Beaver Dam Ditch, 63% Main Beaver Dam Ditch, 65% Headwaters Turkey Creek, 40% Deer Creek, 60% City of Merrillville, 44% Duck Creek, 35% Lake George, 45% Little Calumet River, and 57% Willow Creek subwatersheds.<br>• Impervious surface cover exceeds 10% in the Headwaters Main Beaver Dam Ditch (16%), Main Beaver Dam Ditch (15%), Headwaters Turkey Creek (21%), City of Merrillville (26%), Lake George (18%), Little Calumet River (28%) and Willow Creek subwatersheds (25%).<br>• Subwatershed wetland loss: Headwaters Main Beaver Dam Ditch 75%, Main Beaver Dam Ditch 86%, Headwaters Turkey Creek 76%, Deer Creek 71%, City of Merrillville 76%, Duck Creek 81%, Lake George 61%, Little Calumet River 69%, and Willow Creek 74%.<br>• Subwatershed drainage area 10% or less wetland: Headwaters Main Beaver Dam Ditch 10% , Main Beaver Dam Ditch 5%, Headwaters Turkey Creek 9%, Deer Creek 7%, City of Merrillville 8%, Duck Creek 5%, Lake George 10%, Little Calumet River 10%, and Willow Creek 9% subwatersheds. |

**Table 95 Potential sources streambank erosion and downstream flooding related to habitat loss**

## 7.2 Current Runoff Volume & Pollutant Loads

Storm water runoff is the volume of water generated by a storm that does not infiltrate into the ground or is not retained in storage as surface water. A pollutant load is the mass of a pollutant (ex. pounds of sediment or nutrients) that passes a particular point (ex. monitoring station) of a river in specific amount of time (ex. annually). *E. coli* has no mass and its "load" is expressed as a concentration of colony forming units (CFU) or most probable number (MPN).

### 7.2.1 Pollutant Load Modeling

A number of models were considered and used during the development of this watershed plan to estimate pollutant loads and storm water runoff volume. The models included the Spreadsheet Tool for Estimating Pollutant Loads (STEPL), Region 5, Hydrologic Simulation Program- FORTRAN (HSPF), Nonpoint Source Pollution & Erosion Comparison Tool (NSPECT), and the Kentucky Nutrient models. STEPL and Region 5 are both fairly simple spreadsheet based models that were run by NIRCP. Because of the complexity and time intensity, NIRPC contracted with Purdue University Calumet- Department of Mechanical Engineering to setup and run the HSPF, NSPECT and Kentucky Nutrient models.

The STEPL model was used to estimate annual runoff volume and nutrient and sediment pollutant loads for each site catchment area. The Kentucky Nutrient Model was used to estimate nitrate and total phosphorus loads. The nitrate data was incorporated in the HSPF model as well. Later, NIRPC decided to also use HSPF to estimate nutrient loading with data processed using the Kentucky Nutrient Model. The Region 5 model was used to estimate load reductions anticipated through best management practice implementation (See Section 11.6). The NSPECT model was setup to evaluate landscape scale restoration activities such as reforestation and future land use/land cover changes.

Ultimately the STEPL model was selected to estimate the load reductions needed (Section 7.3) because data was calculated and available at the smaller catchment scale as opposed to the subwatershed scale with HSPF.

Additional information about the models used is available from the following websites.

STEPL & Region 5: http://it.tetratech-ffx.com/steplweb/default.htm
HSPF: http://water.usgs.gov/software/HSPF/
Kentucky Nutrient Model: https://www.uky.edu/WaterResources/assets/docs/pdf/The%20Kentucky%20Nutrient%20Model%20Report%2010-06-14.pdf
NSPECT: https://coast.noaa.gov/digitalcoast/tools/opennspect.html

### 7.2.2 HSPF Modeling Results

Failing septic systems, livestock and CSO were identified as specific sources in the HSPF model. General nonpoint sources were allocated between permeable and impermeable land cover types (Table 96). Permeable land use-land cover includes some urban development, agriculture, forest, wetlands, and barren land. Impermeable land is solely urban development.

The HSPF model indicated that the highest E. coli loads occur in the Little Calumet-Deep River and Headwaters Main Beaver Dam Ditch subwatersheds followed by the Headwaters Turkey Creek subwatershed.

The HSPF model indicated that CSOs are a major contributor of *E. coli* loading where they exist and when CSO events occur in the watershed. CSOs contribute at least an order of magnitude more to *E. coli* loading than failing septic systems or livestock. The largest loads originate from CSOs located in the Little Calumet-Deep River subwatershed.

The HSPF model also indicates that livestock is a slightly greater contributor to *E. coli* loads than failing septic systems in 7 of the 9 subwatersheds. However, it is important to note that the numbers and locations of either is an approximation based on agricultural census data from 2007 and populated unsewered areas respectively. A failure rate of 1.5% was assumed in estimating the contribution from failing septic systems.

| Subwatershed | Failing Septic Systems (counts/day) | Livestock (counts/day) | Combined Sewer Overflow (counts/day) | Average NPS Load Permeable (counts/ac./day) | Average NPS Load Impermeable (counts/ac./day) |
|---|---|---|---|---|---|
| Headwaters Main Beaver Dam Ditch | 2.86E+10 | 4.19E+10 | 2.55E+11 | 3.84E+11 | 4.8E+08 |
| Main Beaver Dam Ditch-Deep River | 1.85E+10 | 5.34E+10 | 0 | 3.84E+11 | 4.8E+08 |
| Headwaters Turkey Creek | 2.86E+10 | 4.19E+10 | 0 | 3.84E+11 | 4.8E+08 |
| Deer Creek-Deep River | 1.63E+10 | 5.03E+10 | 0 | 3.84E+11 | 4.8E+08 |
| City of Merrillville-Turkey Creek | 4.94E+10 | 3.86E+10 | 0 | 3.84E+11 | 4.8E+08 |
| Duck Creek | 3.27E+10 | 3.33E+10 | 0 | 3.84E+11 | 4.8E+08 |
| Lake George-Deep River | 4.18E+10 | 3.55E+10 | 0 | 3.84E+11 | 4.8E+08 |
| Little Calumet River-Deep River | 2.37E+09 | 3.62E+10 | 1.59E+12 | 3.84E+11 | 4.8E+08 |
| Willow Creek-Burns Ditch | 4.79E+10 | 5.22E+10 | 0 | 3.84E+11 | 4.8E+08 |

Table 96 Estimated E. coli loads by subwatershed (HSPF)

Agricultural land was shown to have an average *E. coli* load two orders of magnitude greater than the next highest land use type which was urban land uses (Table 97).

| Land Use Type | Average E. coli Load (counts/ac./day) |
|---|---|
| Urban or Built-up Land | 1.61E+11 |
| Agricultural Land | 2.37E+13 |
| Forest Land | 1.31E+11 |
| Wetlands/Water | 4.82E+07 |
| Barren Land | 4.82E+07 |

Table 97 Estimated E. coli load by land use (HSPF)

The HSPF model indicated that the highest nitrate loads occur in the Headwaters Main Beaver Dam Ditch and Little Calumet-Deep River subwatersheds followed by the Main Beaver Dam Ditch-Deep River subwatershed (Table 98).

As with *E. coli*, the HSPF model indicated that CSOs are a major contributor of nitrate loading where they exist in the watershed. The largest nitrate loads originate from CSOs located in the Headwaters Main Beaver Dam Ditch subwatershed. The HSPF model also indicates that failing septic systems are another important contributor of nitrate loading.

| Subwatershed | Failing Septic Systems (lbs./day) | Livestock (lbs./day) | Combined Sewer Overflow (lbs./day) | Average NPS Load Permeable (lbs./ac./day) | Average NPS Load Impermeable (lbs./ac./day) |
|---|---|---|---|---|---|
| Headwaters Main Beaver Dam Ditch | 0.0048 | 0.0066 | 49.3326 | 0.0011 | 0.0012 |
| Main Beaver Dam Ditch-Deep River | 0.2429 | 0.0084 | 0 | 0.0011 | 0.0012 |
| Headwaters Turkey Creek | 0.0040 | 0.0074 | 0 | 0.0011 | 0.0012 |
| Deer Creek-Deep River | 0.0277 | 0.0079 | 0 | 0.0011 | 0.0012 |
| City of Merrillville-Turkey Creek | 0.0840 | 0.0061 | 0 | 0.0011 | 0.0012 |
| Duck Creek | 0.0556 | 0.0053 | 0 | 0.0011 | 0.0012 |
| Lake George-Deep River | 0.0711 | 0.0056 | 0 | 0.0011 | 0.0012 |
| Little Calumet River-Deep River | 0.0045 | 0.0057 | 6.7875 | 0.0011 | 0.0012 |
| Willow Creek-Burns Ditch | 0.0815 | 0.0082 | 0 | 0.0011 | 0.0012 |

Table 98 Estimated nitrate loads by subwatershed (HSPF)

### 7.2.3 STEPL Modeling Results

Urban land cover contributes approximately 66% of the annual runoff volume in the watershed (Figure 218). Table 99 presents runoff volume, expressed in acre-feet, by land cover type for each site's catchment area. No BMPs were applied to the model for these estimates.

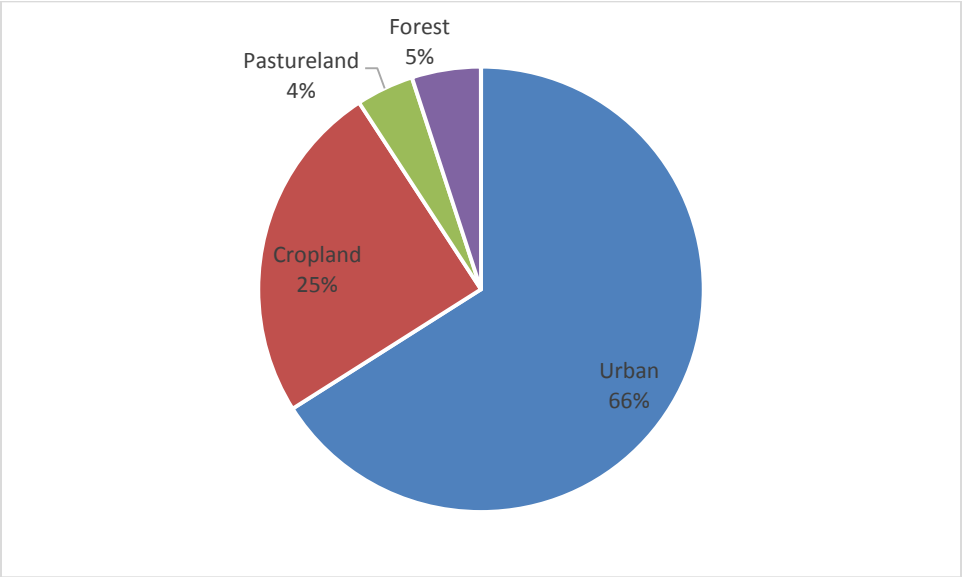



Figure 218 Percent land cover contribution to runoff volume (STEPL)

| Site # | Urban (ac-ft) | Cropland (ac-ft) | Pastureland (ac-ft) | Forest (ac-ft) | Tot Runoff Vol (ac-ft) |
|---|---|---|---|---|---|
| 1 | 3,930 | 243 | 5 | 29 | 4,208 |
| 2 | 926 | 1 | - | 28 | 955 |
| 3 | 1,643 | 1,003 | 48 | 24 | 2,717 |
| 5 | 32 | - | - | 3 | 35 |
| 6 | 1,675 | 19 | 6 | 47 | 1,748 |
| 7 | 1,649 | 258 | 14 | 80 | 2,001 |
| 8 | 2,225 | 491 | 41 | 269 | 3,026 |
| 9 | 1,090 | 982 | 322 | 227 | 2,620 |
| 10 | 1,131 | 388 | 58 | 55 | 1,632 |
| 11 | 472 | 1,491 | 195 | 200 | 2,358 |
| 12 | 54 | 151 | 194 | 228 | 627 |
| 13 | 239 | 149 | 141 | 113 | 642 |
| 14 | 941 | 363 | 109 | 80 | 1,492 |
| 15 | 3,881 | 1,908 | 198 | 71 | 6,058 |
| 16 | 1,204 | 946 | 150 | 111 | 2,411 |
| 17 | 141 | 631 | 129 | 61 | 961 |
| 18 | 372 | 1,749 | 251 | 154 | 2,525 |
| 19 | 1,341 | 33 | 19 | 100 | 1,492 |
| 20 | 2,741 | 177 | 36 | 162 | 3,116 |
| 21 | 1,515 | 4 | 14 | 43 | 1,577 |
| 22 | 302 | 647 | 36 | 19 | 1,005 |
| 23 | 535 | 506 | 144 | 277 | 1,463 |
| 24 | 774 | 437 | 5 | 2 | 1,218 |
| 25 | 3,254 | 228 | 36 | 165 | 3,682 |

| | | | | | |
|---|---|---|---|---|---|
| **26** | 2,824 | 738 | 79 | 166 | 3,806 |
| **27** | 1,130 | 53 | 70 | 74 | 1,326 |
| **28** | 1,173 | 1 | 31 | 107 | 1,312 |
| **29** | 384 | 2 | 1 | 30 | 417 |
| **30** | 1,174 | 118 | 24 | 53 | 1,369 |
| **31** | 935 | 226 | 11 | 31 | 1,203 |
| **32** | 2,734 | 88 | 11 | 100 | 2,933 |
| **33** | 1,953 | 197 | 25 | 31 | 2,205 |
| **34** | 1,658 | 602 | 109 | 196 | 2,566 |
| **35** | 435 | 827 | 98 | 79 | 1,438 |
| **36** | 449 | 1,962 | 371 | 153 | 2,935 |

Table 99 Estimated annual runoff (STEPL)

Estimated annual pollutant loads for nitrogen, phosphorus, biological oxygen demand, and sediment for each site's catchment area is provided in Table 100. No BMPs were applied to the model for these estimates. Annual loading was also calculated on a per acre basis to help identify which catchments were contributing a higher proportion of pollutant loads.

| Site # | Nitrogen Load | | Phosphorus Load | | BOD Load | | Sediment Load | |
|---|---|---|---|---|---|---|---|---|
| | (lb/yr) | (lb/ac/yr) | (lb/yr) | (lb/ac/yr) | (lb/yr) | (lb/ac/yr) | (t/yr) | (lb/ac/yr) |
| **1** | 27,827 | 3.0 | 5,532 | 0.6 | 95,185 | 10.2 | 630 | 135.7 |
| **2** | 5,334 | 0.6 | 847 | 0.1 | 20,085 | 2.2 | 122 | 26.2 |
| **3** | 27,034 | 2.9 | 6,914 | 0.7 | 64,140 | 6.9 | 404 | 87.1 |
| **5** | 191 | 0.0 | 32 | 0.0 | 721 | 0.1 | 4 | 0.9 |
| **6** | 10,529 | 1.1 | 1,860 | 0.2 | 39,195 | 4.2 | 229 | 49.3 |
| **7** | 13,559 | 1.5 | 2,915 | 0.3 | 42,597 | 4.6 | 245 | 52.8 |
| **8** | 20,988 | 2.3 | 4,707 | 0.5 | 61,733 | 6.6 | 363 | 78.3 |
| **9** | 27,392 | 2.9 | 6,833 | 0.7 | 64,137 | 6.9 | 342 | 73.6 |
| **10** | 13,801 | 1.5 | 3,267 | 0.4 | 37,740 | 4.1 | 214 | 46.1 |
| **11** | 31,976 | 3.4 | 8,990 | 1.0 | 61,711 | 6.6 | 379 | 81.6 |
| **12** | 5,308 | 0.6 | 1,146 | 0.1 | 12,893 | 1.4 | 43 | 9.3 |
| **13** | 5,627 | 0.6 | 1,221 | 0.1 | 14,772 | 1.6 | 62 | 13.3 |
| **14** | 13,035 | 1.4 | 3,062 | 0.3 | 35,338 | 3.8 | 188 | 40.4 |
| **15** | 56,826 | 6.1 | 14,011 | 1.5 | 142,545 | 15.3 | 857 | 184.6 |
| **16** | 25,589 | 2.8 | 6,618 | 0.7 | 60,014 | 6.5 | 344 | 74.1 |
| **17** | 13,681 | 1.5 | 3,773 | 0.4 | 26,386 | 2.8 | 154 | 33.1 |
| **18** | 36,623 | 3.9 | 10,332 | 1.1 | 68,789 | 7.4 | 423 | 91.1 |
| **19** | 7,865 | 0.8 | 1,387 | 0.1 | 29,527 | 3.2 | 162 | 34.8 |
| **20** | 18,030 | 1.9 | 3,433 | 0.4 | 63,488 | 6.8 | 354 | 76.2 |
| **21** | 8,167 | 0.9 | 1,337 | 0.1 | 31,811 | 3.4 | 175 | 37.6 |
| **22** | 13,800 | 1.5 | 3,914 | 0.4 | 26,922 | 2.9 | 174 | 37.6 |
| **23** | 13,970 | 1.5 | 3,586 | 0.4 | 32,510 | 3.5 | 175 | 37.6 |
| **24** | 12,099 | 1.3 | 3,122 | 0.3 | 29,380 | 3.2 | 183 | 39.3 |
| **25** | 21,095 | 2.3 | 3,947 | 0.4 | 73,405 | 7.9 | 423 | 91.2 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **26** | 28,915 | 3.1 | 6,577 | 0.7 | 82,470 | 8.9 | 484 | 104.3 |
| **27** | 7,598 | 0.8 | 1,325 | 0.1 | 27,234 | 2.9 | 142 | 30.6 |
| **28** | 6,413 | 0.7 | 1,023 | 0.1 | 24,924 | 2.7 | 136 | 29.3 |
| **29** | 2,523 | 0.3 | 470 | 0.1 | 9,448 | 1.0 | 52 | 11.2 |
| **30** | 8,343 | 0.9 | 1,618 | 0.2 | 27,803 | 3.0 | 160 | 34.5 |
| **31** | 8,943 | 1.0 | 2,009 | 0.2 | 25,707 | 2.8 | 156 | 33.6 |
| **32** | 15,773 | 1.7 | 2,774 | 0.3 | 58,547 | 6.3 | 333 | 71.7 |
| **33** | 13,638 | 1.5 | 2,640 | 0.3 | 45,418 | 4.9 | 266 | 57.3 |
| **34** | 20,954 | 2.3 | 4,951 | 0.5 | 56,450 | 6.1 | 322 | 69.4 |
| **35** | 18,180 | 2.0 | 4,788 | 0.5 | 36,802 | 4.0 | 194 | 41.7 |
| **36** | 41,786 | 4.5 | 11,196 | 1.2 | 80,366 | 8.7 | 416 | 89.6 |
| **Total** | 603,411 | | 142,153 | | 1,610,195 | | 9,310 | |

Table 100 Estimated annual pollutant loading by catchment (STEPL)

Estimated total annual pollutant loads by source are present in Table 101 and Figure 219. Table 101 also includes area loads which show that cropland contributes higher nutrient and sediment loads on a per acre basis.

| Sources | N Load (lb/yr) | N Load (lb/ac/yr) | P Load (lb/yr) | P Load (lb/ac/yr) | BOD Load (lb/yr) | BOD Load (lb/ac/yr) | Sed Load (t/yr) | Sed Load (t/ac/yr) |
|---|---|---|---|---|---|---|---|---|
| **Urban** | 239,763 | 4.86 | 37,188 | 0.75 | 942,489 | 19.12 | 5,478 | 0.11 |
| **Cropland** | 318,784 | 12.36 | 97,011 | 3.76 | 516,213 | 20.02 | 3,735 | 0.14 |
| **Pastureland** | 32,845 | 5.59 | 2,846 | 0.48 | 106,199 | 18.07 | 55 | 0.01 |
| **Forest** | 2,280 | 0.22 | 1,294 | 0.13 | 5,530 | 0.54 | 43 | 0.00 |
| **Septic** | 9,738 | - | 3,814 | - | 39,765 | - | - | - |
| **Total** | 603,411 | - | 142,153 | - | 1,610,195 | - | 9,310 | - |

Table 101 Estimated total annual pollutant load by source

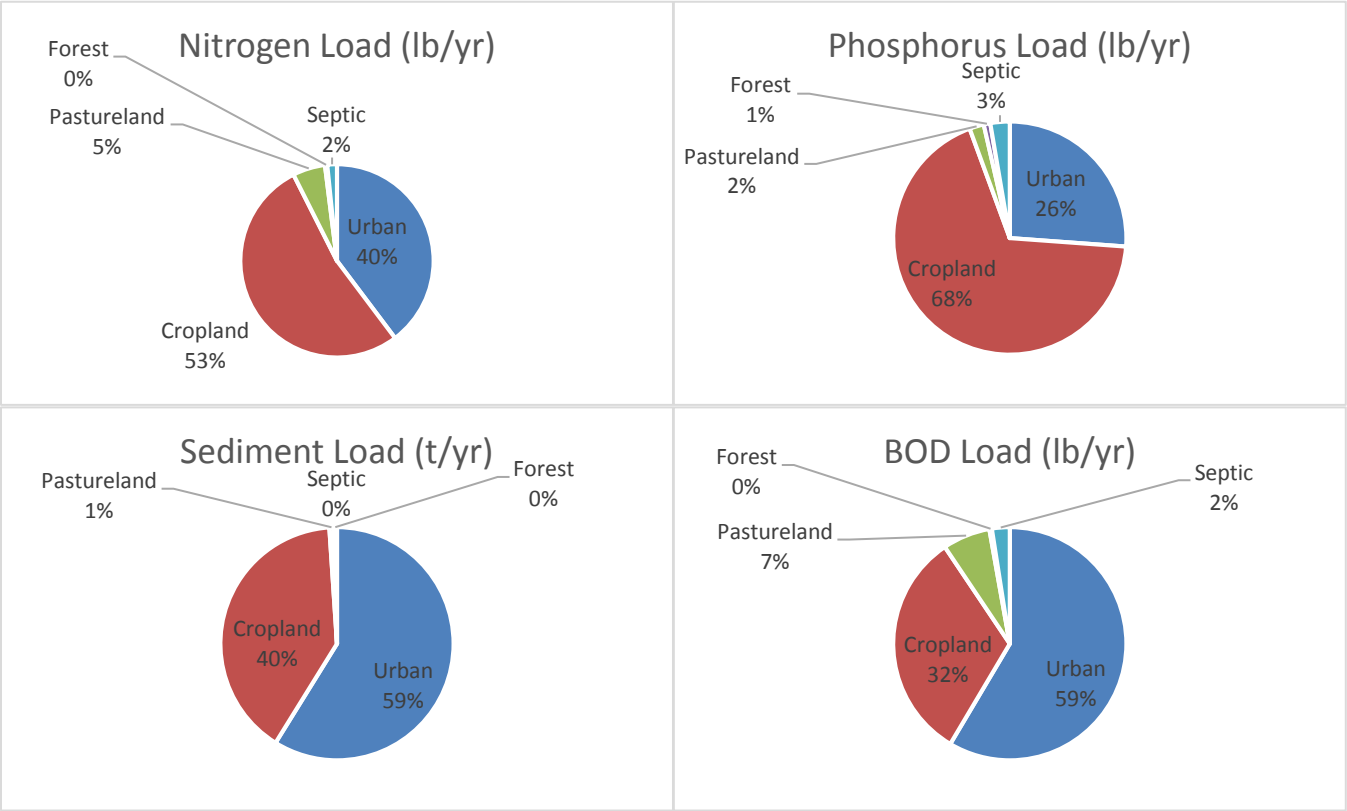



Figure 219 Estimated total annual pollutant load by source (STEPL)

The following table provides a summary of *E. coli* data from the Deep River-Portage Burns Waterway TMDL.

| Site | # of Samples | % Samples Violating Target | Maximum MPN/100mL | Average MPN/100mL |
|---|---|---|---|---|
| 1 | 10 | 60% | 1986.3 | 551.9 |
| 2 | 10 | 90% | 2419.6 | 1340.4 |
| 3 | 10 | 80% | 2419.6 | 1240.2 |
| 5 | 10 | 20% | 344.8 | 132.6 |
| 6 | 10 | 10% | 260.3 | 107.3 |
| 7 | 10 | 90% | 1732.9 | 656.1 |
| 8 | 10 | 80% | 2419.6 | 612.9 |
| 9 | 10 | 40% | 2419.6 | 622.2 |
| 10 | 10 | 60% | 2419.6 | 661.2 |
| 11 | 10 | 80% | 2419.6 | 1216 |
| 12 | 10 | 70% | 2419.6 | 669.7 |
| 13 | 10 | 80% | 2419.6 | 957.8 |
| 14 | 10 | 40% | 2419.6 | 438.5 |
| 15 | 10 | 90% | 2419.6 | 699.3 |
| 16 | 10 | 80% | 2419.6 | 720 |
| 17 | 10 | 80% | 1732.9 | 501.6 |

| Site | # of Samples | % Samples Violating Target | Maximum MPN/100mL | Average MPN/100mL |
|---|---|---|---|---|
| 18 | 10 | 80% | 2419.6 | 785.8 |
| 19 | 10 | 50% | 2419.6 | 511.5 |
| 20 | 10 | 60% | 2419.6 | 629.9 |
| 21 | 10 | 40% | 613.1 | 233.2 |
| 22 | 10 | 80% | >2419.6 | 687.6 |
| 23 | 10 | 30% | 1986.3 | 372 |
| 24 | 10 | 80% | >2419.6 | 1,297.50 |
| 25 | 10 | 40% | 2419.6 | 414.3 |
| 26 | 10 | 29% | 770.1 | 207.6 |
| 27 | 10 | 50% | 1413.6 | 360 |
| 28 | 7 | 29% | 770.1 | 207.6 |
| 29 | 10 | 80% | 1986.3 | 668.9 |
| 30 | 10 | 20% | 344.8 | 168.8 |
| 31 | 10 | 60% | 1553.1 | 564.9 |
| 32 | 10 | 20% | 866.4 | 238 |
| 33 | 10 | 80% | 2419.6 | 810.9 |
| 34 | 10 | 40% | 1119.9 | 351.8 |
| 35 | 10 | 100% | 2419.6 | 1001.3 |
| 36 | 10 | 100% | 2419.6 | 1301.9 |

Table 102 Summary of E. coli site data from TMDL

## 7.3 Pollutant Load Reductions Needed

The US EPA's Spreadsheet Tool for Estimating Pollutant Load (STEPL) model was also used to estimate pollutant loads reductions needed for each catchment area and the watershed as a whole. The watershed restoration plan targets listed below were used as STEPL model inputs. The steering committee ultimately decided to use more stringent nutrient targets than chosen by IDEM for the TMDL study. Total suspended solids and *E. coli* targets from the TMDL were retained. The watershed plan water quality targets are the same or more stringent than those used for the TMDL. Therefore meeting the reductions listed in the tables below would also meet the load reductions called for in the TMDL.

| Parameter | TMDL Target Value | Watershed Plan Target Value |
|---|---|---|
| Total Phosphorus | No value should exceed 0.30 mg/L | No value should exceed 0.07 mg/L |
| Total Nitrogen | NA | No value should exceed 3.3 mg/L |
| Biological Oxygen Demand | NA | No value should exceed 2 mg/L |
| Total Suspended Solids | No value should exceed 30.0 mg/L | No value should exceed 30.0 mg/L |
| *E. coli* | No value should exceed 125 counts/100 mL (geometric mean) | No value should exceed 125 counts/100 mL (geometric mean) |

Table 103 TMDL water quality targets compared to the watershed restoration plan targets

The following four tables show the overall reductions needed to meet the water quality targets for total nitrogen, total phosphorus, biological oxygen demand, and sediment as measured by total suspended solids.

| Site # | N Current Load (lb/year) | N Target Load (lb/year) | N Load Reduction (lb/year) | % N Load Reduction |
|---|---|---|---|---|
| **1** | 27,827 | 34,676 | NA | NA |
| **2** | 5,334 | 7,627 | NA | NA |
| **3** | 27,034 | 23,594 | 3,439 | 13 |
| **5** | 191 | 282 | NA | NA |
| **6** | 10,529 | 14,071 | NA | NA |
| **7** | 13,559 | 15,903 | NA | NA |
| **8** | 20,988 | 24,625 | NA | NA |
| **9** | 27,392 | 23,596 | 3,796 | 14 |
| **10** | 13,801 | 13,608 | 193 | 1 |
| **11** | 31,976 | 23,043 | 8,932 | 28 |
| **12** | 5,308 | 5,834 | NA | NA |
| **13** | 5,627 | 5,675 | NA | NA |
| **14** | 13,035 | 12,615 | 421 | 3 |
| **15** | 56,826 | 51,738 | 5,088 | 9 |
| **16** | 25,589 | 21,469 | 4,120 | 16 |
| **17** | 13,681 | 9,509 | 4,172 | 30 |
| **18** | 36,623 | 25,132 | 11,491 | 31 |
| **19** | 7,865 | 11,419 | NA | NA |
| **20** | 18,030 | 24,114 | NA | NA |
| **21** | 8,167 | 11,852 | NA | NA |
| **22** | 13,800 | 9,676 | 4,124 | 30 |
| **23** | 13,970 | 13,226 | 744 | 5 |
| **24** | 12,099 | 10,505 | 1,594 | 13 |
| **25** | 21,095 | 28,471 | NA | NA |
| **26** | 28,915 | 31,137 | NA | NA |
| **27** | 7,598 | 10,280 | NA | NA |
| **28** | 6,413 | 9,991 | NA | NA |
| **29** | 2,523 | 3,373 | NA | NA |
| **30** | 8,343 | 10,696 | NA | NA |
| **31** | 8,943 | 9,753 | NA | NA |
| **32** | 15,773 | 22,306 | NA | NA |
| **33** | 13,638 | 17,134 | NA | NA |
| **34** | 20,954 | 21,561 | NA | NA |
| **35** | 18,180 | 13,592 | 4,588 | 25 |
| **36** | 41,786 | 28,775 | 13,011 | 31 |
| **Total** | 603,411 | 600,857 | 2,554 | <1 |

**Table 104 Nitrogen load reductions needed by catchment (STEPL)**

| Site # | P Current Load (lb/year) | P Target Load (lb/year) | P Load Reduction (lb/year) | % P Load Reduction |
|---|---|---|---|---|
| 1 | 5,532 | 1,942 | 3,590 | 65 |
| 2 | 847 | 245 | 602 | 71 |
| 3 | 6,914 | 2,310 | 4,604 | 67 |
| 5 | 32 | 9 | 22 | 70 |
| 6 | 1,860 | 513 | 1,347 | 72 |
| 7 | 2,915 | 900 | 2,015 | 69 |
| 8 | 4,707 | 1,550 | 3,156 | 67 |
| 9 | 6,833 | 2,313 | 4,520 | 66 |
| 10 | 3,267 | 1,036 | 2,231 | 68 |
| 11 | 8,990 | 3,091 | 5,899 | 66 |
| 12 | 1,146 | 448 | 698 | 61 |
| 13 | 1,221 | 427 | 794 | 65 |
| 14 | 3,062 | 973 | 2,089 | 68 |
| 15 | 14,011 | 4,613 | 9,398 | 67 |
| 16 | 6,618 | 2,169 | 4,448 | 67 |
| 17 | 3,773 | 1,301 | 2,472 | 66 |
| 18 | 10,332 | 3,562 | 6,770 | 66 |
| 19 | 1,387 | 409 | 978 | 71 |
| 20 | 3,433 | 1,029 | 2,403 | 70 |
| 21 | 1,337 | 371 | 966 | 72 |
| 22 | 3,914 | 1,323 | 2,591 | 66 |
| 23 | 3,586 | 1,235 | 2,351 | 66 |
| 24 | 3,122 | 1,011 | 2,111 | 68 |
| 25 | 3,947 | 1,243 | 2,704 | 69 |
| 26 | 6,577 | 2,133 | 4,443 | 68 |
| 27 | 1,325 | 407 | 918 | 69 |
| 28 | 1,023 | 317 | 706 | 69 |
| 29 | 470 | 118 | 352 | 75 |
| 30 | 1,618 | 517 | 1,101 | 68 |
| 31 | 2,009 | 658 | 1,351 | 67 |
| 32 | 2,774 | 827 | 1,947 | 70 |
| 33 | 2,640 | 837 | 1,804 | 68 |
| 34 | 4,951 | 1,632 | 3,319 | 67 |
| 35 | 4,788 | 1,451 | 3,337 | 70 |
| 36 | 11,196 | 3,534 | 7,662 | 68 |
| Total | 142,153 | 46,453 | 95,699 | 67 |

Table 105 Phosphorus load reductions needed by catchment (STEPL)

| Site # | BOD Current Load (lb/year) | BOD Target Load (lb/year) | BOD Load Reduction (lb/year) | % BOD Load Reduction |
|---|---|---|---|---|
| 1 | 95,185 | 22,433 | 72,752 | 76 |
| 2 | 20,085 | 4,660 | 15,425 | 77 |
| 3 | 64,140 | 16,749 | 47,392 | 74 |
| 5 | 721 | 173 | 549 | 76 |
| 6 | 39,195 | 8,687 | 30,507 | 78 |
| 7 | 42,597 | 10,304 | 32,294 | 76 |
| 8 | 61,733 | 16,187 | 45,547 | 74 |
| 9 | 64,137 | 16,744 | 47,393 | 74 |
| 10 | 37,740 | 9,215 | 28,526 | 76 |
| 11 | 61,711 | 17,601 | 44,110 | 71 |
| 12 | 12,893 | 3,948 | 8,946 | 69 |
| 13 | 14,772 | 3,831 | 10,941 | 74 |
| 14 | 35,338 | 8,559 | 26,780 | 76 |
| 15 | 142,545 | 36,048 | 106,496 | 75 |
| 16 | 60,014 | 15,337 | 44,677 | 74 |
| 17 | 26,386 | 7,301 | 19,085 | 72 |
| 18 | 68,789 | 19,484 | 49,305 | 72 |
| 19 | 29,527 | 7,042 | 22,485 | 76 |
| 20 | 63,488 | 15,122 | 48,366 | 76 |
| 21 | 31,811 | 7,232 | 24,580 | 77 |
| 22 | 26,922 | 7,431 | 19,492 | 72 |
| 23 | 32,510 | 9,291 | 23,219 | 71 |
| 24 | 29,380 | 7,432 | 21,948 | 75 |
| 25 | 73,405 | 17,895 | 55,510 | 76 |
| 26 | 82,470 | 20,730 | 61,740 | 75 |
| 27 | 27,234 | 6,397 | 20,837 | 77 |
| 28 | 24,924 | 6,100 | 18,825 | 76 |
| 29 | 9,448 | 2,074 | 7,374 | 78 |
| 30 | 27,803 | 6,799 | 21,005 | 76 |
| 31 | 25,707 | 6,478 | 19,229 | 75 |
| 32 | 58,547 | 13,801 | 44,746 | 76 |
| 33 | 45,418 | 10,904 | 34,514 | 76 |
| 34 | 56,450 | 14,583 | 41,867 | 74 |
| 35 | 36,802 | 9,822 | 26,980 | 73 |
| 36 | 80,366 | 21,483 | 58,882 | 73 |
| Total | 1,610,195 | 407,876 | 1,202,319 | 75 |

Table 106 BOD load reductions needed by catchment (STEPL)

| Site # | Sed Current Load (t/year) | Sed Target Load (t/year) | Sed Load Reduction (t/year) | % Sed Load Reduction |
|---|---|---|---|---|
| **1** | 630 | 263 | 367 | 58 |
| **2** | 122 | 35 | 86 | 71 |
| **3** | 404 | 272 | 132 | 33 |
| **5** | 4 | 1 | 3 | 70 |
| **6** | 229 | 72 | 157 | 68 |
| **7** | 245 | 113 | 133 | 54 |
| **8** | 363 | 185 | 179 | 49 |
| **9** | 342 | 254 | 88 | 26 |
| **10** | 214 | 123 | 91 | 42 |
| **11** | 379 | 341 | 38 | 10 |
| **12** | 43 | 39 | 4 | 10 |
| **13** | 62 | 43 | 19 | 31 |
| **14** | 188 | 112 | 76 | 40 |
| **15** | 857 | 545 | 312 | 36 |
| **16** | 344 | 247 | 97 | 28 |
| **17** | 154 | 142 | 11 | 7 |
| **18** | 423 | 393 | 30 | 7 |
| **19** | 162 | 54 | 108 | 67 |
| **20** | 354 | 133 | 220 | 62 |
| **21** | 175 | 53 | 122 | 70 |
| **22** | 174 | 150 | 24 | 14 |
| **23** | 175 | 132 | 43 | 25 |
| **24** | 183 | 120 | 62 | 34 |
| **25** | 423 | 162 | 262 | 62 |
| **26** | 484 | 257 | 227 | 47 |
| **27** | 142 | 51 | 91 | 64 |
| **28** | 136 | 42 | 94 | 69 |
| **29** | 52 | 16 | 36 | 69 |
| **30** | 160 | 66 | 94 | 59 |
| **31** | 156 | 81 | 75 | 48 |
| **32** | 333 | 113 | 220 | 66 |
| **33** | 266 | 109 | 157 | 59 |
| **34** | 322 | 189 | 133 | 41 |
| **35** | 194 | 157 | 37 | 19 |
| **36** | 416 | 378 | 38 | 9 |
| **Total** | 9,310 | 5,444 | 3,866 | 42 |

**Table 107 Sediment load reductions needed by catchment (STEPL)**

| Site | # of Samples | % Samples Violating Target | Maximum MPN/100mL | Average MPN/100mL | % Reduction |
|---|---|---|---|---|---|
| 1 | 10 | 60% | 1986.3 | 551.9 | 57.40% |
| 2 | 10 | 90% | 2419.6 | 1340.4 | 82.50% |
| 3 | 10 | 80% | 2419.6 | 1240.2 | 81.10% |
| 5 | 10 | 20% | 344.8 | 132.6 | 0% |
| 6 | 10 | 10% | 260.3 | 107.3 | 0% |
| 7 | 10 | 90% | 1732.9 | 656.1 | 64.20% |
| 8 | 10 | 80% | 2419.6 | 612.9 | 61.70% |
| 9 | 10 | 40% | 2419.6 | 622.2 | 62.20% |
| 10 | 10 | 60% | 2419.6 | 661.2 | 64.50% |
| 11 | 10 | 80% | 2419.6 | 1216 | 80.70% |
| 12 | 10 | 70% | 2419.6 | 669.7 | 64.90% |
| 13 | 10 | 80% | 2419.6 | 957.8 | 75.50% |
| 14 | 10 | 40% | 2419.6 | 438.5 | 46.40% |
| 15 | 10 | 90% | 2419.6 | 699.3 | 66.40% |
| 16 | 10 | 80% | 2419.6 | 720 | 67.40% |
| 17 | 10 | 80% | 1732.9 | 501.6 | 53.20% |
| 18 | 10 | 80% | 2419.6 | 785.8 | 70.10% |
| 19 | 10 | 50% | 2419.6 | 511.5 | 54.10% |
| 20 | 10 | 60% | 2419.6 | 629.9 | 62.70% |
| 21 | 10 | 40% | 613.1 | 233.2 | 0% |
| 22 | 10 | 80% | >2419.6 | 687.6 | 65.80% |
| 23 | 10 | 30% | 1986.3 | 372 | 36.80% |
| 24 | 10 | 80% | >2419.6 | 1,297.50 | 81.90% |
| 25 | 10 | 40% | 2419.6 | 414.3 | 43.30% |
| 26 | 10 | 29% | 770.1 | 207.6 | 69.50% |
| 27 | 10 | 50% | 1413.6 | 360 | 34.70% |
| 28 | 7 | 29% | 770.1 | 207.6 | 69.50% |
| 29 | 10 | 80% | 1986.3 | 668.9 | 64.90% |
| 30 | 10 | 20% | 344.8 | 168.8 | 0% |
| 31 | 10 | 60% | 1553.1 | 564.9 | 58.40% |
| 32 | 10 | 20% | 866.4 | 238 | 1.20% |
| 33 | 10 | 80% | 2419.6 | 810.9 | 71.00% |
| 34 | 10 | 40% | 1119.9 | 351.8 | 33.20% |
| 35 | 10 | 100% | 2419.6 | 1001.3 | 76.50% |
| 36 | 10 | 100% | 2419.6 | 1301.9 | 81.90% |

Table 108 E. coli load reductions needed by catchment (TMDL)

The following table summarizes the current loads, target loads, load reductions, and percent reductions for the watershed. In order to calculate the overall watershed geomean (average) for *E. coli*, the site geomeans were averaged together and then an overall percent reduction was calculated from this value.

| Pollutant | Current Load | Target Load | Load Reduction | % Reduction |
|---|---|---|---|---|
| **Nitrogen (lb/year)** | 603,411 | 600,857 | 2,554 | <1 |
| **Phosphorus (lb/year)** | 142,153 | 46,453 | 95,699 | 67 |
| **BOD (lb/year)** | 1,610,195 | 407,876 | 1,202,319 | 75 |
| **Sediment (t/year)** | 9,310 | 5,444 | 3,866 | 42 |
| | **Average** | **Target Value** | **-** | **% Reduction** |
| ***E. coli* (CFU/100mL)** | 627 | 125 | - | 80 |

Table 109 Overall current and target loads and load reductions needed for the watershed

# 8 Watershed Restoration Goals

The following goals and supporting objectives have been developed based on public concerns, watershed inventory and pollutant loading data, and guidance from steering committee members.

## 8.1 Recreational Use

***Existing Condition:***

Water quality data collected during the baseline assessment shows that 60% of the 327 samples collected for *E. coli* exceeded the single sample water quality standard of 235 CFU/100 mL with a median concentration of 344 CFU/100mL and a maximum >2,419 CFU/100 mL.

***Goal 1:*** Reduce watershed *E. coli* loads by 80% so that all waterways meet the state water quality standard of 235 CFU/100 mL (single sample) and 125 CFU/100mL (geomean) during the recreational season (April 1 – October 31) by 2050.

- 10-years: Reduce E. coli loading by 20%
- 20-years: Reduce E. coli loading by 50%
- 30-years: Reduce *E. coli* loading by 70%

***Indicators:*** Water quality will be used as the indicator towards meeting this goal. The environmental indicator will be *E. coli* testing conducted at each impaired site at least monthly during the recreational season following 5 years of implementation.

## 8.2 Aquatic Life Use

***Existing Condition:*** Biological monitoring data collected during the baseline assessment indicate that the overall biological integrity of the watershed is poor to very poor. More than 94% of the 35 sample sites failed established criteria for aquatic life support during each sampling event with a median Index of Biotic Integrity score of 30 for fish and 28 for macroinvertebrates.

***Goal 2:*** Restore warmwater fish and macroinvertebrate communities so that all waterways meet their aquatic life use designations with natural waterways maintaining at least a "good" integrity class rating and modified waterways maintaining at least a "fair" integrity class rating by 2050.

To achieve this goal, functional lifts are necessary at the hydrology, hydraulic, geomorphology, and physiochemical levels. The following supporting objectives are anticipated to provide this lift. Lower function levels must be addressed to realize functional lift of higher levels.

***Indicators:*** Biological monitoring will be used as the indicator towards meeting this goal. The environmental indicator will be a macroinvertebrate assessment (Hoosier Riverwatch methodology). Ideally, both the fish and

macroinvertebrate communities can revaluated by IDEM using their methodologies. Monitoring will be conducted annually at each impaired site once the implementation phase is complete.

***Objective 2.1:*** Improve dissolved oxygen levels so that all waterways are capable of supporting a well balance, warm water community.

- All waterways should maintain a daily average dissolved oxygen concentration >5 mg/L and no less than 4 mg/L at any time.

***Indicators:*** Water quality and streamflow will be used as the indicators towards meeting this goal. The environmental indicators will include dissolved oxygen, temperature, BOD testing and stream flow (Hoosier Riverwatch methodologies) conducted at each impaired site at least monthly following 5 years of implementation.

***Objective 2.2:*** Reduce nutrient and sediment loads from urban and agricultural land uses.

- All waterways should maintain a median total phosphorus concentration of <0.08 mg/L, nitrate concentration <1.09 mg/L, and total suspended solids concentration <30 mg/L.
  - Reduce phosphorus loading from 142,153 lb/year to 46,453 lb/year (67%) and nitrogen loading from 603,411 lb/year to 600,857 lb/year.
    - 10-Years: Reduce nitrogen loading by 128 lb/year (0.02%) and phosphorus loading by 4,785 lb/year (3%).
    - 20-Years: Reduce nitrogen loading by 638 lb/year (0.11%) and phosphorus loading by 23,925 lb/year (17%).
    - 30-Years: Reduce nitrogen loading by 1,915 lb/year (0.32%) and phosphorus loading by 71,774 lb/year (50%).

  - Reduce sediment loads from 9,310 t/year to 5,444 t/year (42%).
    - 10-Years: Reduce sediment loading by 193 t/year (2%).
    - 20-Years: Reduce sediment loading by 966 t/year (10%).
    - 30-Years: Reduce sediment loading by 2,899 t/year (31%).

***Indicators:*** Water quality and pollutant load modeling will be used as the indicators towards meeting this goal. The environmental indicators will include orthophosphate, nitrate and turbidity testing (Hoosier Riverwatch methodologies) at each impaired site at least monthly following 5 years of implementation. Pollutant load models will be run on a project by project basis.

***Objective 2.3:*** Restore riparian vegetation to improve channel stability, nutrient processing, sediment capture, and landscape habitat connectivity.

***Indicators:*** Physical measurement and qualitative measures will be used as the indicators towards meeting this goal. The environmental indicators will be buffer width and length and qualitative visual assessments to assess functioning condition (ex. IDEM QHEI and NRCS SVA). Buffer length and width restored/enhanced will be determined following practice installation. Qualitative visual assessments will be conducted annually for 5 years thereafter.

***Objective 2.4:*** Improve bed form diversity within channelized/incised or dammed stream reaches to increase depth variability and substrate quality.

***Indicator:*** Physical measurement and qualitative measures will be used as the indicators towards meeting this goal. The environmental indicators will be bed material characterization (material size), pool-to-pool spacing and depth variability, and qualitative visual assessments to assess functioning condition (ex. IDEM QHEI and NRCS SVA). Bed material, pool-to-pool spacing and depth variability will be characterized and qualitative visual assessments will be conducted prior to any in-channel implementation activity and continued annually over a total of 5 years.

***Objective 2.5:*** Improve channel stability to reduce suspended and bedded sediments.

***Indicators:*** Physical measurement and qualitative measures will be used as the indicators towards meeting this goal. The environmental indicators will be channel evolution stage/stream succession type and channel profile and cross sections. Channel stage/type and channel profile and cross section will be assessed prior to any in-channel implementation activity and ideally will be reevaluated annually over a total of 5 years.

***Objective 2.6:*** Provide floodplain connectivity for channelized/incised stream reaches to improve channel stability and facilitate sediment storage and nutrient processing outside of the channel.

***Indicators:*** Physical measurement qualitative measures will be used as the indicators towards meeting this goal. The environmental indicators will be bank height and entrenchment ratios and qualitative visual assessments to assess channel condition (ex. NRCS SVA). Bank height and entrenchment ratios will be characterized and qualitative visual assessments will be conducted prior to any in-channel implementation activity and continued annually over a total of 5 years.

***Objective 2.7:*** Reduce storm water runoff volume and rates to improve flow-duration conditions and flow dynamics.

***Indicators:*** Models and flow-duration curves will be used as indicators towards meeting this goal. The environmental indicators will include volume reduction from practice implementation and flow-duration curves. Models that evaluate runoff volume and reductions will be run on a project by project basis. Flow-duration curves will be evaluated after 5 years of implementation.

# 9 Watershed Critical Areas

IDEM identifies “Critical Areas” as areas where watershed management plan implementation can remediate nonpoint pollution sources in order to improve water quality and/or can mitigate the impact of future sources in order to protect water quality. Because storm water delivers additional pollutants and flow to streams, and excess flow has been shown to destabilize stream banks and add to pollutant loads, the reduction of flow may be designated as a critical activity if that reduction will reduce a nonpoint source pollutant in a critical area. IDEM requires the use of inventoried data, current pollutant loads, and potential sources to identify critical areas.

## 9.1 Identification Process

Site catchment drainage areas were used as the geographical extent in evaluating critical areas. The decision to use catchment areas over the larger HUC-12 subwatersheds was based on the fact that there are 35 sites in the watershed with water chemistry, biological, and habitat monitoring data available from IDEM’s baseline assessment in 2013. A two-step process was used in the evaluation:

1. The first step was to consider data that was shown to be statistically significant in describing the reasons behind existing stream impairments.

2. The second step was to consider data that represented stakeholder concerns.

A "weight of evidence" approach was used to prioritize which catchments would be deemed the most critical for implementation actions. Water quality data was prioritized over data that represented stakeholder concerns since that data captured real conditions.

### 9.1.1 Loads & Stressors

The first step of the critical area identification process was to consider data from the stressor linkage analysis completed in Section 5: Watershed Inventory- Part III and STEPL pollutant loading data from Section 7.2: Current Pollutant Loads. Based on this review, eighteen different indicators were chosen for consideration (Table 110).

Site data for each indicator were sorted and ranked from worst to best. The top nine worst sites (upper 25%) were recorded. In the instance of a tie, site selection was inclusive of all tie values. These data were combined to come up with a cumulative score which was used to rank sites based on number of occurrences documented.

| **STEPL Loads (adjusted for catchment area)** |
|---|
| • Nitrogen load<br>• Phosphorus load<br>• Biological oxygen demand load<br>• Sediment load<br>• Runoff volume |
| **Water Chemistry (% observations exceeding target value or water quality standard)** |
| • Dissolved oxygen<br>• Ammonia<br>• Nitrate<br>• Total Kjeldahl nitrogen<br>• Total phosphorus<br>• Total suspended solids<br>• Turbidity<br>• E. coli |
| **Habitat Quality** |
| • Qualitative Habitat Evaluation Index scores |
| **Fish & Macroinvertebrate Community Health** |
| • Index of biotic integrity scores<br>• Macroinvertebrate Index of Biotic Integrity scores |
| **Land Cover (% of land cover in catchment area)** |
| • Forest<br>• Agriculture |

Table 110 Pollutant load and stressor indicators used in critical area identification process

### 9.1.2 Stakeholder Concerns

The second step considered stakeholder concerns identified in Section 6: Problems and Causes that could be measured and were not captured by the previous step. Based on this review, seven different indicators were chosen for consideration (Table 111).

| **Stakeholder Concerns** |
|---|
| • Percent wetland loss<br>• Percent Green Infrastructure Vision lands not protected<br>• Recreational sites located on or adjacent to impaired waterways<br>• Approximate percentage of impaired streams that are regulated drains |

- Percent human land cover
- Percent riparian human land cover
- Percent impervious cover

**Table 111 Stakeholder concern indicators used in critical area identification process**

Data for each indicator was evaluated and the top 25% worst values for each indicator were identified. In the instance of a tie, the data was inclusive of all tie values.

| Site | % Exceedance DO | % Exceedance Ammonia | % Exceedace Nitrate | % Exceedance TKN | % Exceedance TP | % Exceedance TSS | % Exceedance Turbidity | % Exceedance E coli | QHEI Score | IBI Score | mIBI Score | STEPL N Load | STEPL P Load | STEPL BOD Load | STEPL Sed Load | STEPL Runoff Volume | % Ag Land Cover | % Forest Cover |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 7 | 50 | 30 | 90 | 100 | 10 | 67 | 67 | 48 | 16 | 36 | 3.00 | 0.60 | 10.25 | 135.71 | 0.45 | 29 | 9 |
| 2 | 0 | 14 | 57 | 29 | 29 | 0 | 17 | 89 | 58 | 12 | 22 | 0.57 | 0.09 | 2.16 | 26.24 | 0.47 | 29 | 6 |
| 3 | 0 | 57 | 57 | 17 | 43 | 14 | 25 | 78 | 40 | 30 | 26 | 2.91 | 0.74 | 6.91 | 87.08 | 0.80 | 47 | 2 |
| 5 | 8 | 14 | 0 | 14 | 100 | 0 | 50 | 22 | 48 | 34 | 38 | 0.02 | 0.00 | 0.08 | 0.93 | 0.33 | 30 | 10 |
| 6 | 0 | 22 | 22 | 89 | 89 | 0 | 43 | 11 | 52 | 36 | 30 | 1.13 | 0.20 | 4.22 | 49.26 | 0.42 | 30 | 10 |
| 7 | 8 | 14 | 14 | 100 | 100 | 14 | 100 | 78 | 74 | 18 | 30 | 1.46 | 0.31 | 4.59 | 52.78 | 0.81 | 17 | 9 |
| 8 | 17 | 29 | 0 | 33 | 71 | 0 | 25 | 89 | 44 | 32 | 28 | 2.26 | 0.51 | 6.65 | 78.27 | 0.64 | 30 | 10 |
| 9 | 7 | 22 | 22 | 67 | 89 | 0 | 14 | 33 | 52 | 30 | 30 | 2.95 | 0.74 | 6.91 | 73.57 | 0.48 | 50 | 10 |
| 10 | 0 | 0 | 14 | 29 | 100 | 0 | 17 | 33 | 41 | 12 | 28 | 1.49 | 0.35 | 4.06 | 46.07 | 0.70 | 56 | 8 |
| 11 | 33 | 14 | 57 | 86 | 86 | 14 | 67 | 78 | 49 | 24 | 30 | 3.44 | 0.97 | 6.65 | 81.62 | 0.49 | 69 | 7 |
| 12 | 0 | 22 | 89 | 56 | 100 | 11 | 64 | 67 | 56 | 42 | 28 | 0.57 | 0.12 | 1.39 | 9.27 | 0.34 | 39 | 10 |
| 13 | 0 | 14 | 14 | 43 | 43 | 14 | 58 | 78 | 66 | 30 | 42 | 0.61 | 0.13 | 1.59 | 13.35 | 0.43 | 30 | 6 |
| 14 | 0 | 10 | 100 | 60 | 100 | 10 | 13 | 44 | 75 | 36 | 40 | 1.40 | 0.33 | 3.81 | 40.42 | 0.67 | 40 | 10 |
| 15 | 0 | 0 | 0 | 14 | 14 | 0 | 50 | 89 | 64 | 30 | 28 | 6.12 | 1.51 | 15.35 | 184.58 | 0.76 | 33 | 32 |
| 16 | 0 | 0 | 0 | 29 | 57 | 29 | 75 | 78 | 52 | 40 | 30 | 2.76 | 0.71 | 6.46 | 74.08 | 0.64 | 34 | 20 |
| 17 | 0 | 0 | 0 | 0 | 14 | 0 | 17 | 78 | 51 | 34 | 38 | 1.47 | 0.41 | 2.84 | 33.11 | 0.54 | 34 | 9 |
| 18 | 0 | 40 | 100 | 60 | 100 | 10 | 20 | 78 | 57 | 36 | 40 | 3.94 | 1.11 | 7.41 | 91.12 | 0.55 | 38 | 8 |
| 19 | 8 | 71 | 0 | 86 | 86 | 29 | 45 | 56 | 36 | 32 | 28 | 0.85 | 0.15 | 3.18 | 34.82 | 0.79 | 45 | 8 |
| 20 | 75 | 71 | 14 | 100 | 100 | 0 | 33 | 67 | 44 | 38 | 38 | 1.94 | 0.37 | 6.84 | 76.16 | 0.76 | 67 | 9 |
| 21 | 77 | 100 | 14 | 100 | 100 | 14 | 42 | 40 | 33 | 12 | 20 | 0.88 | 0.14 | 3.43 | 37.63 | 0.88 | 67 | 9 |
| 22 | 17 | 29 | 0 | 71 | 100 | 71 | 100 | 80 | 25 | 38 | 38 | 1.49 | 0.42 | 2.90 | 37.55 | 0.62 | 5 | 14 |
| 23 | 0 | 70 | 100 | 90 | 100 | 0 | 6 | 33 | 58 | 36 | 26 | 1.50 | 0.39 | 3.50 | 37.60 | 0.46 | 25 | 11 |
| 24 | 85 | 100 | 100 | 100 | 100 | 0 | 25 | 80 | 26 | 14 | 24 | 1.30 | 0.34 | 3.16 | 39.32 | 0.81 | 2 | 6 |
| 25 | 62 | 71 | 38 | 100 | 100 | 0 | 62 | 40 | 37 | 28 | 26 | 2.27 | 0.43 | 7.90 | 91.15 | 0.80 | 43 | 13 |
| 26 | 85 | 29 | 0 | 100 | 100 | 14 | 77 | 30 | 40 | 12 | 26 | 3.11 | 0.71 | 8.88 | 104.30 | 0.70 | 33 | 23 |
| 27 | 46 | 14 | 0 | 100 | 86 | 29 | 92 | 50 | 27 | 40 | 28 | 0.82 | 0.14 | 2.93 | 30.59 | 0.73 | 44 | 0 |
| 28 | 56 | 29 | 0 | 86 | 86 | 14 | 22 | 29 | 37 | 12 | 0 | 0.69 | 0.11 | 2.68 | 29.25 | 0.73 | 4 | 16 |
| 29 | 0 | 29 | 0 | 67 | 43 | 0 | 8 | 80 | 49 | 36 | 26 | 0.27 | 0.05 | 1.02 | 11.17 | 0.31 | 8 | 13 |
| 30 | 15 | 14 | 0 | 29 | 0 | 0 | 0 | 20 | 36 | 28 | 34 | 0.90 | 0.17 | 2.99 | 34.55 | 0.81 | 1 | 22 |
| 31 | 8 | 14 | 0 | 29 | 86 | 0 | 69 | 60 | 41 | 12 | 28 | 0.96 | 0.22 | 2.77 | 33.60 | 0.84 | 13 | 8 |
| 32 | 0 | 40 | 0 | 40 | 30 | 10 | 31 | 20 | 51 | 44 | 30 | 1.70 | 0.30 | 6.30 | 71.67 | 0.82 | 16 | 11 |
| 33 | 38 | 14 | 0 | 86 | 71 | 14 | 54 | 80 | 41 | 30 | 28 | 1.47 | 0.28 | 4.89 | 57.33 | 0.87 | 25 | 6 |
| 34 | 77 | 100 | 0 | 100 | 100 | 14 | 69 | 40 | 31 | 12 | 30 | 2.26 | 0.53 | 6.08 | 69.43 | 0.65 | 4 | 7 |
| 35 | 0 | 86 | 0 | 57 | 14 | 14 | 85 | 100 | 43 | 20 | 30 | 1.96 | 0.52 | 3.96 | 41.74 | 0.73 | 14 | 3 |
| 36 | 0 | 50 | 0 | 40 | 40 | 10 | 88 | 100 | 40 | 16 | 30 | 4.50 | 1.21 | 8.65 | 89.63 | 0.71 | 13 | 9 |

**Table 112 Top 25% worst values for each water quality indicator highlighted in red**

| Site | % Wetland Loss | Ratio Managed Lands / GIV | Recreational Sites on 303d Stream | % 303d Streams Regulated Drains | % Human Land Cover | % Impervious Cover | % Human Riparian Land Cover |
|---|---|---|---|---|---|---|---|
| 1 | 85 | 100 | 0 | 0 | 76 | 39 | 82 |
| 2 | 93 | 100 | 1 | 75 | 86 | 23 | 80 |
| 3 | 89 | 100 | 0 | 100 | 71 | 17 | 70 |
| 5 | 81 | 84 | 0 | 75 | 71 | 5 | 65 |
| 6 | 86 | 100 | 0 | 100 | 82 | 5 | 63 |
| 7 | 92 | 60 | 0 | 0 | 76 | 6 | 57 |
| 8 | 82 | 99 | 0 | 25 | 50 | 28 | 56 |
| 9 | 93 | 88 | 1 | 0 | 87 | 24 | 56 |
| 10 | 87 | 96 | 2 | 75 | 79 | 24 | 55 |
| 11 | 90 | 67 | 0 | 50 | 93 | 31 | 55 |
| 12 | 83 | 100 | 1 | 50 | 77 | 20 | 54 |
| 13 | 83 | 100 | 0 | 100 | 75 | 15 | 53 |
| 14 | 64 | 61 | 0 | 100 | 48 | 21 | 53 |
| 15 | 78 | 61 | 0 | 100 | 76 | 10 | 50 |
| 16 | 93 | 72 | 0 | 0 | 74 | 16 | 49 |
| 17 | 91 | 98 | 3 | 100 | 79 | 21 | 47 |
| 18 | 80 | 100 | 0 | 50 | 68 | 25 | 46 |
| 19 | 72 | 98 | 0 | 50 | 49 | 17 | 45 |
| 20 | 95 | 100 | 1 | 100 | 92 | 19 | 45 |
| 21 | 95 | 93 | 1 | 100 | 75 | 13 | 45 |
| 22 | 75 | 83 | 3 | 100 | 62 | 17 | 44 |
| 23 | 75 | 100 | 0 | 75 | 79 | 18 | 44 |
| 24 | 78 | 85 | 0 | 0 | 72 | 12 | 44 |
| 25 | 61 | 99 | 4 | 0 | 70 | 17 | 43 |
| 26 | 0 | 100 | 4 | 0 | 51 | 17 | 43 |
| 27 | 76 | 94 | 0 | 0 | 36 | 13 | 43 |
| 28 | 71 | 97 | 0 | 25 | 63 | 5 | 42 |
| 29 | 63 | 98 | 0 | 0 | 60 | 9 | 41 |
| 30 | 85 | 100 | 0 | 25 | 82 | 23 | 37 |
| 31 | 50 | 99 | 0 | 0 | 75 | 22 | 36 |
| 32 | 82 | 76 | 1 | 100 | 65 | 22 | 31 |
| 33 | 81 | 100 | 1 | 100 | 73 | 7 | 28 |
| 34 | 85 | 94 | 0 | 0 | 76 | 7 | 26 |
| 35 | 92 | 65 | 0 | 0 | 87 | 5 | 25 |
| 36 | 97 | 91 | 0 | 0 | 80 | 24 | 25 |

**Table 113 Top 25% worst values for each stakeholder concern indicator highlighted in red**

In order to better understand where the worst problems existed throughout the watershed, the number of times a site was identified as having a value in the top 25% worst was recorded (Table 114). Thirty-two out of the thirty-five

sites had at least one data record in the top 25% worst values for water quality, loads, and stressors. Twenty-eight out of the thirty-five sites had at least one data record in the top 25% worst values relating to stakeholder concerns.

| Site | Pollutant Load & Stressor Indicators # of Times Site Identified | Stakeholder Concern Indicator # of Times Site Identified | Site | Pollutant Load & Stressor Indicators # of Times Site Identified | Stakeholder Concern Indicators # of Times Site Identified |
|---|---|---|---|---|---|
| **1** | 7 | 2 | **20** | 6 | 1 |
| **2** | 5 | 0 | **21** | 10 | 4 |
| **3** | 11 | 5 | **22** | 4 | 3 |
| **5** | 0 | 2 | **23** | 5 | 0 |
| **6** | 0 | 1 | **24** | 11 | 3 |
| **7** | 5 | 3 | **25** | 11 | 1 |
| **8** | 2 | 2 | **26** | 11 | 3 |
| **9** | 4 | 0 | **27** | 7 | 3 |
| **10** | 2 | 2 | **28** | 5 | 2 |
| **11** | 7 | 0 | **29** | 2 | 1 |
| **12** | 1 | 0 | **30** | 2 | 3 |
| **13** | 2 | 2 | **31** | 3 | 5 |
| **14** | 1 | 3 | **32** | 1 | 2 |
| **15** | 5 | 2 | **33** | 5 | 6 |
| **16** | 4 | 0 | **34** | 9 | 2 |
| **17** | 0 | 1 | **35** | 5 | 3 |
| **18** | 5 | 2 | **36** | 7 | 3 |
| **19** | 4 | 0 | | | |

Table 114 Number of times site identified

The information on number of times a site was identified (Table 114) was used to populate an attribute table in GIS so that the data could be expressed spatially. GIS shapefile layers were created to display the Pollutant Load & Stressor Indicators data and Stakeholder Concern Indicators data (Figure 220). An "equal interval" classification scheme with four classes was chosen to classify the dataset for priority ranking. Equal interval classification divides the range of attribute values into equal-sized subranges. This allows the user to specify the number of intervals, four in this case, and ArcGIS automatically determines the class breaks based on the value range (Table 115). Equal interval is best applied to familiar data ranges, such as percentages. This method emphasizes the amount of an attribute value relative to other values. Additionally, the data was linear in distribution and had no outliers that would skew the results, thereby making equal interval classification an appropriate method.

| Load & Stressor Indicators | Rank | Stakeholder Indicators | Rank |
|---|---|---|---|
| 0 - 2.750000 | 4 - Low Priority | 0 – 1.500000 | 4 - Low Priority |
| 2.750001 – 5.500000 | 3 – Moderately Low Priority | 1.500001 – 3.00000 | 3 – Moderately Low Priority |
| 5.500001 – 8.250000 | 2 – Moderately High Priority | 3.00001 – 4.500000 | 2 – Moderately High Priority |

| | | | |
|---|---|---|---|
| 8.250001 - 11 | 1 – High Priority | 4.500001 - 6 | 1 – High Priority |

Table 115 Classification scoring breaks

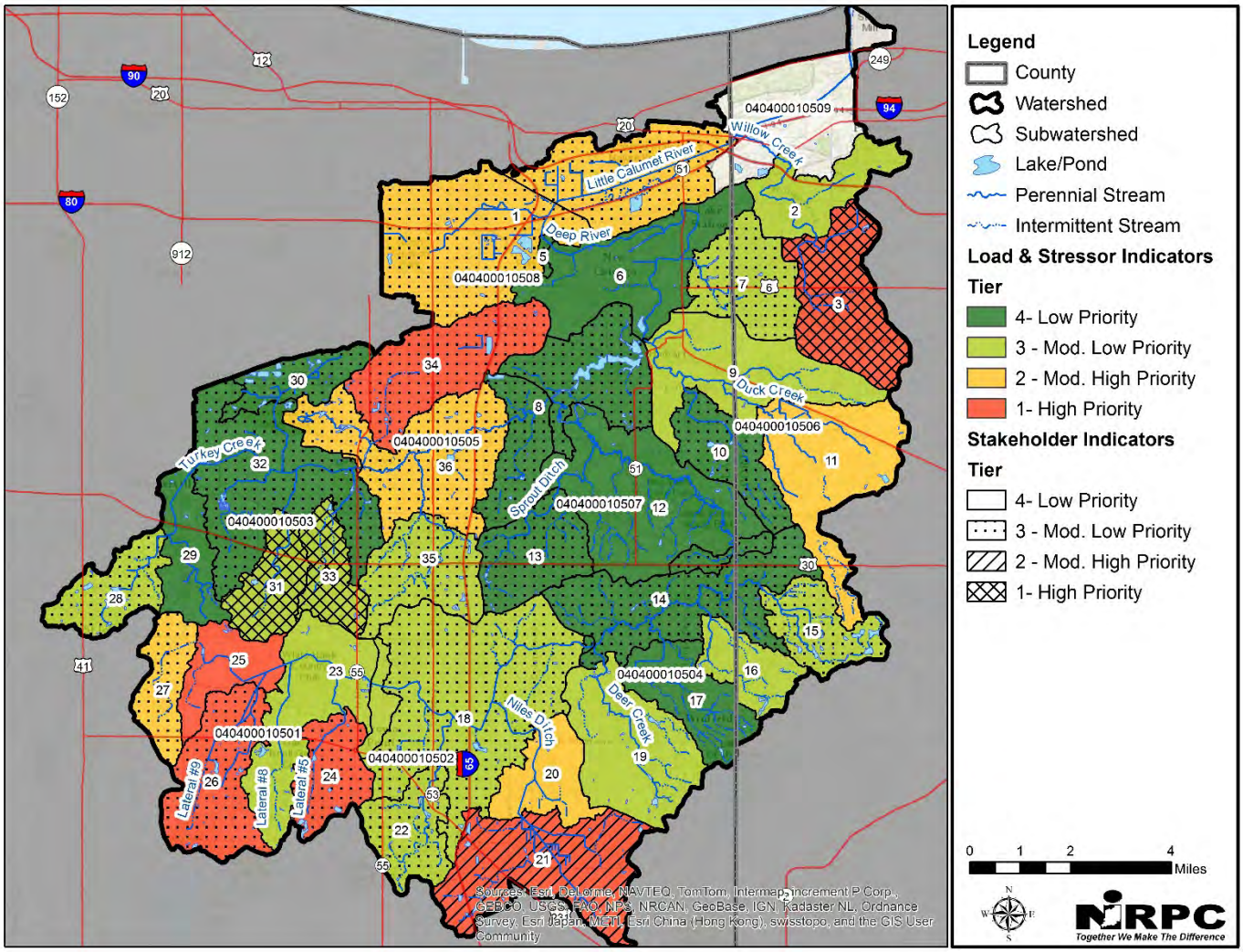



Figure 220 Pollutant load and stressor indicators with stakeholder indicators overlay

Since further prioritization is necessary, we counted the number of times each site had at least one data record in the top 25% worst values for the water quality, loads, and stressors and at least one data record in the top 25% worst values related to stakeholder concerns.

### 9.1.3 Final Determination

As previously stated, water quality data was prioritized over data that represented stakeholder concerns since that data captured real conditions. However, one last step was taken to further prioritize critical areas. Any site that had an occurrence of five or more stakeholder concerns received a higher priority ranking. In Table 116, below, note that both sites 33 and 31 are considered moderately low priority for water quality. However, since the data shows that there are a lot of stakeholder concerns that need to be addressed in these areas, they are moved from moderately low priority to moderately high priority critical areas.

| Site | Water Quality Indicator # of Times Site Identified | Stakeholder Concern Indicator # of Times Site Identified | Site | Water Quality Indicator # of Time Site Identified | Stakeholder Concern Indicator # of Times Site Identified |
|---|---|---|---|---|---|
| 3 | 11 | 5 | 23 | 5 | 0 |
| 24 | 11 | 3 | 22 | 4 | 3 |
| 26 | 11 | 3 | 9 | 4 | 0 |
| 25 | 11 | 1 | 16 | 4 | 0 |
| 21 | 10 | 4 | 19 | 4 | 0 |
| 34 | 9 | 2 | 31 | 3 | 5 |
| 27 | 7 | 3 | 30 | 2 | 3 |
| 36 | 7 | 3 | 8 | 2 | 2 |
| 1 | 7 | 2 | 10 | 2 | 2 |
| 11 | 7 | 0 | 13 | 2 | 2 |
| 20 | 6 | 1 | 29 | 2 | 1 |
| 33 | 5 | 6 | 14 | 1 | 3 |
| 7 | 5 | 3 | 32 | 1 | 2 |
| 35 | 5 | 3 | 12 | 1 | 0 |
| 15 | 5 | 2 | 5 | 0 | 2 |
| 18 | 5 | 2 | 6 | 0 | 1 |
| 28 | 5 | 2 | 17 | 0 | 1 |
| 2 | 5 | 0 | | | |

Table 116 Final step in critical area determination

The results of this last step are a shown in Figure 221 . Catchments identified as Tier 1 critical areas will be a priority for 319 grant cost-share program implementation at this time. This includes catchments areas 3, 21, 24, 25, 26, 27 and 36.

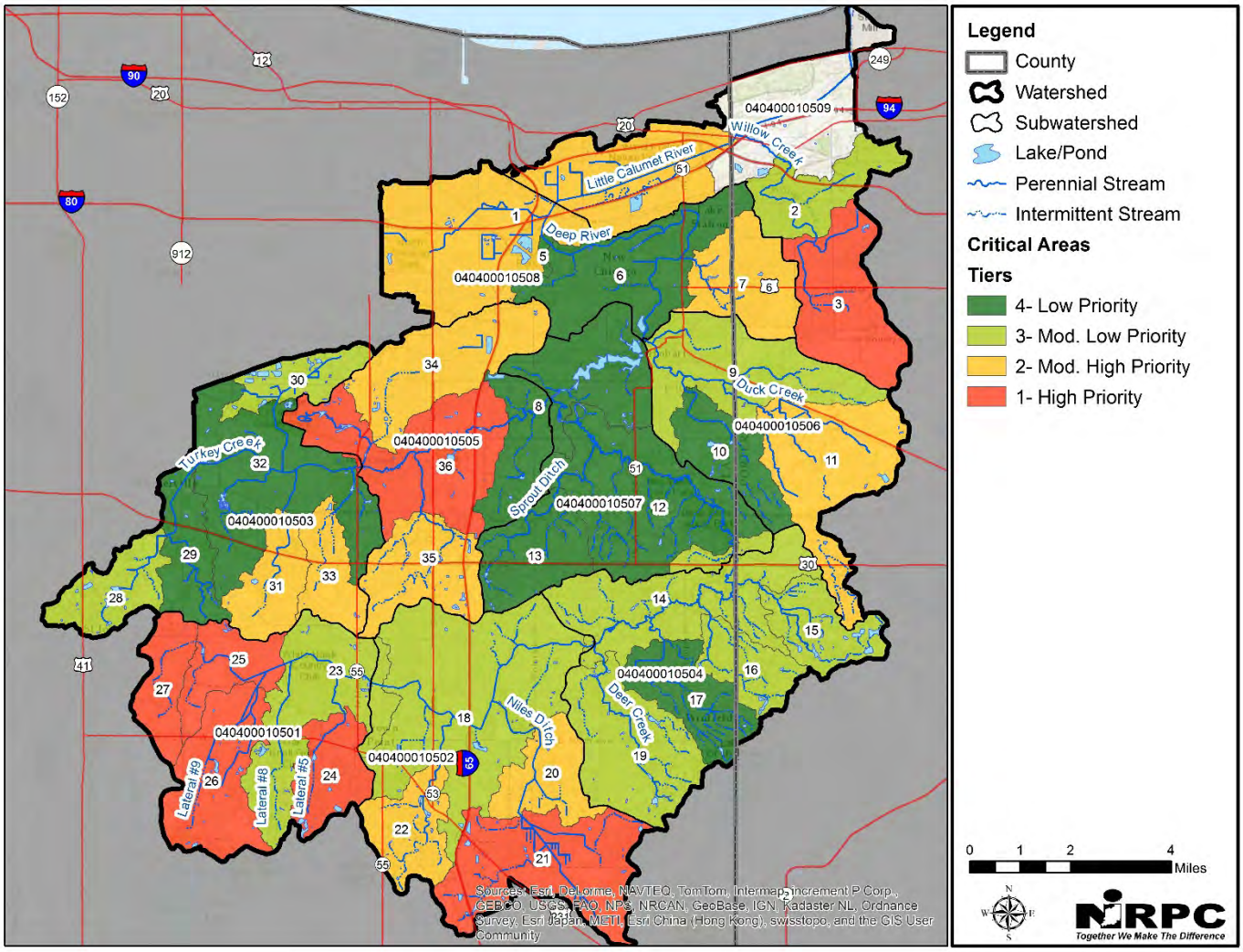



Figure 221 Critical areas

## 9.2 Critical Area Summary of Potential Problems & Sources

Table 117 lists the water quality, physical habitat, and aquatic life problems documented for the Tier 1 critical areas. These are the issues that will need to be addressed through implementation actions.

| Tier 1- High Priority Critical Areas | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Catchment Area** | *E. coli* | Dissolved Oxygen | Nutrients | Sediment | Ammonia Toxicity | Physical Habitat | Aquatic Life |
| **3** | X | | X | X | | X | X |
| **21** | X | X | X | X | X | X | X |
| **24** | X | X | X | X | X | X | X |
| **25** | X | X | X | X | X | X | X |
| **26** | X | X | X | X | | X | X |
| **27** | X | X | X | X | | X | X |
| **36** | X | | X | X | | X | X |

Table 117 Tier 1 critical area problems

The following four tables are based on the conceptual diagrams presented earlier in Section 3.2. They outline the casual pathways, from sources to the observed biotic impairments. Multiple stressors exist in each critical area and contribute to the observed impairment in most of the catchments. Each table includes information on the human activities, sources, and site evidence contributing to the biotic impairment. Human activity and source information included in the tables was gathered from a desktop GIS assessment using data such as aerial imagery, land cover, and NPDES facility (point source) outfalls. Information on site evidence was gathered from IDEM's field notes, data sheets and site pictures.

| | Human Activity | | | Source | | | | | | Site Evidence | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Site** | Agriculture | Urbanization | Channel Alteration | Impoundments | Septic Systems | Point Sources | Agricultural & Urban Runoff | Devegetated Riparian Areas | Channel Alteration | High Plant Abundance | Slow Moving Water | Reduced Water Volume | Organic Wastes | Turbidity | Color | Embedded Substrate |
| 21 | X | | X | | X | | X | X | X | X | X | | X | X | X | X |
| 24 | | X | X | X | | X | X | | X | X | X | | | X | X | X |
| 25 | X | X | X | | X | | X | X | X | X | X | | | X | X | X |
| 26 | X | X | X | | X | | X | | X | X | X | | | X | X | X |
| 27 | X | X | X | | X | | X | X | X | X | X | | | X | X | X |

Table 118 Human activities, sources and site evidence tied to dissolved oxygen problems in tier 1 critical areas

| | Human Activity | | | Source | | | | | | Site Evidence | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Site** | Agriculture | Urbanization | Channel Alteration | Waste Water Treatment Plants/CSO/SSO | Landfills & Waste Disposal Sites | Confined Animal Feeding Operations | Agricultural & Urban Runoff | Pasture Runoff | Septic Systems | Proliferation of Filamentous or Algae Mats | Phytoplankton Blooms (Green Water) | High Plant Abundance |
| 3 | X | X | X | | | | X | | X | X | | |
| 21 | X | | X | | | X | X | X | X | X | X | X |
| 24 | X | X | X | X | | | X | X | X | X | X | X |
| 25 | X | X | X | | | | X | X | X | X | X | X |
| 26 | X | X | X | | X | | X | X | X | X | X | X |
| 27 | | X | X | | | | X | X | X | X | | X |
| 36 | X | X | X | X | | | X | | X | | | X |

Table 119 Human activities, sources and site evidence tied to nutrient problems in tier 1 critical areas

| | Human Activity | Source | Site Evidence |
|---|---|---|---|

| Site | Land Cover Alteration | Riparian Alteration | Channel Alteration | Autumn Plowing | Road Maintenance | Channel Modification | Eroding Streambanks | Impoundments | Impervious Surfaces | Turbid Water | Deposited or Embedded Substrate | Slow Moving Water |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | X | X | X | | X | X | X | | X | X | | X |
| 21 | X | X | X | X | X | X | X | | | X | X | X |
| 24 | X | X | X | | X | X | X | | X | X | X | X |
| 25 | X | X | X | X | X | X | | | | X | X | X |
| 26 | X | X | X | X | X | X | | | | X | X | X |
| 27 | X | X | X | X | X | X | | | | X | X | X |
| 36 | X | X | X | X | X | X | | | X | X | X | X |

Table 120 Human activities, sources and site evidence tied to sediment problems in tier 1 critical areas

| | Human Activity | | | Source | | | | | | | | | Site Evidence | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Site | Agriculture | Urbanization | Channel Alteration | Impoundments | Septic Systems | Point Sources | Agricultural & Urban Runoff (Fertilizer) | Manure Application | Concentrated Animal Feeding Operations | Piped/Buried Streams | Devegetated Riparian Areas | High Plant Production | Slow Moving or Stagnant Water | Organic Wastes | Suspended Solids | Alkaline, Anoxic, or Warm Water |
| 21 | X | | X | | X | | X | X | X | | X | X | X | X | X | X |
| 24 | | X | X | X | | X | X | | | | | X | X | | | X |
| 25 | X | X | X | | X | | X | | | | X | X | X | | | X |

Table 121 Human activities, sources and site evidence tied to ammonia toxicity problems in tier 1 critical areas

| | Human Activity | | Source | | | | | | | Site Evidence | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Site | Agriculture | Urbanization | Channelization | Impervious Surfaces | Levees or Walls | Agricultural Drainage | Devegetated Riparian Areas | Dredging | Burried/ Piped Stream | Concrete or Rip-Rap | Embedded Substrates | Bridge or Culvert | Channelization | Predominance of Runs, Glides, or Pools | Eroded Streambanks | Lack or Alteration of Riparian Vegetation | Lack of Habitat Features |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **3** | X | X | X | X | | X | X | X | X | X | | X | X | X | X | X | X |
| **21** | X | X | X | | | X | X | X | | | X | X | X | X | X | X | X |
| **24** | | X | X | X | | | X | X | | X | X | X | X | X | | X | X |
| **25** | X | X | X | | | X | X | X | | | X | X | X | X | X | X | |
| **26** | X | X | X | | | X | X | X | | | X | X | X | X | X | X | |
| **27** | X | X | X | X | | X | X | X | | | X | X | X | X | X | X | X |
| **36** | X | X | X | X | | X | X | X | | | X | X | X | X | X | X | X |

Table 122 Human activities, sources and site evidence tied to physical habitat problems in tier 1 critical areas

# 10 Watershed Priority Preservation Areas

Priority preservation areas have been identified for our watershed because these areas were shown to have:

- higher water quality compared to other locations
- healthier fish and macroinvertebrate assemblages
- higher quality stream and riparian habitat
- land area included in the Green Infrastructure Vision ecological network
- concentrations of natural habitat features that provide important ecosystem functions (ex. water purification, groundwater recharge, and stream flow regulation)
- concentrations of high quality natural areas and Heritage Database species
- habitats most at risk to invasive species

Data analysis shows that the Deep River Outstanding River reach is generally healthier than any of the other streams assessed in our watershed. Monitoring sites located on this reach had significantly (statistically) higher IBI scores; greater number of fish species; lower number of tolerant species; better QHEI channel morphology sub-metric scores; higher dissolved oxygen concentrations and lower *E. coli* and ammonia concentrations. The higher quality of this reach can likely be attributed to its natural, meandering river channel upstream of Lake George and the contiguous tracts of forest, wetland and floodplain buffering it from adjacent human land uses.

The Hobart Marsh Area encompasses nearly 750 acres of permanently protected land, which includes, wet forest, oak woodland, tall grass prairie, emergent marsh, savanna, and fens. A preliminary review of the Indiana Natural Heritage Database shows that 79 unique element occurrences exist within this area. The site provides critical habitat for nine state threatened or rare plant species, Blanding's turtle (state endangered), over 40 state endangered, threatened and rare insect species, four state endangered bird species, and five high quality natural communities. Several different entities (federal, state, municipal and NGO) own conservation lands within this area.

A half-mile buffer was established around the Deep River outstanding river reach using GIS to identify the Deep River Outstanding River Corridor. This buffer width effectively captured a high percentage of natural land cover areas, core forests, documented high quality natural communities and ETR species, and managed lands along Deep River. The boundary used for the Hobart Marsh Area was the same boundary identified in the Hobart Marsh Plan.

These preservation areas will also be a priority for 319 grant cost-share program implementation at this time in order to protect and maintain the higher quality natural resources.

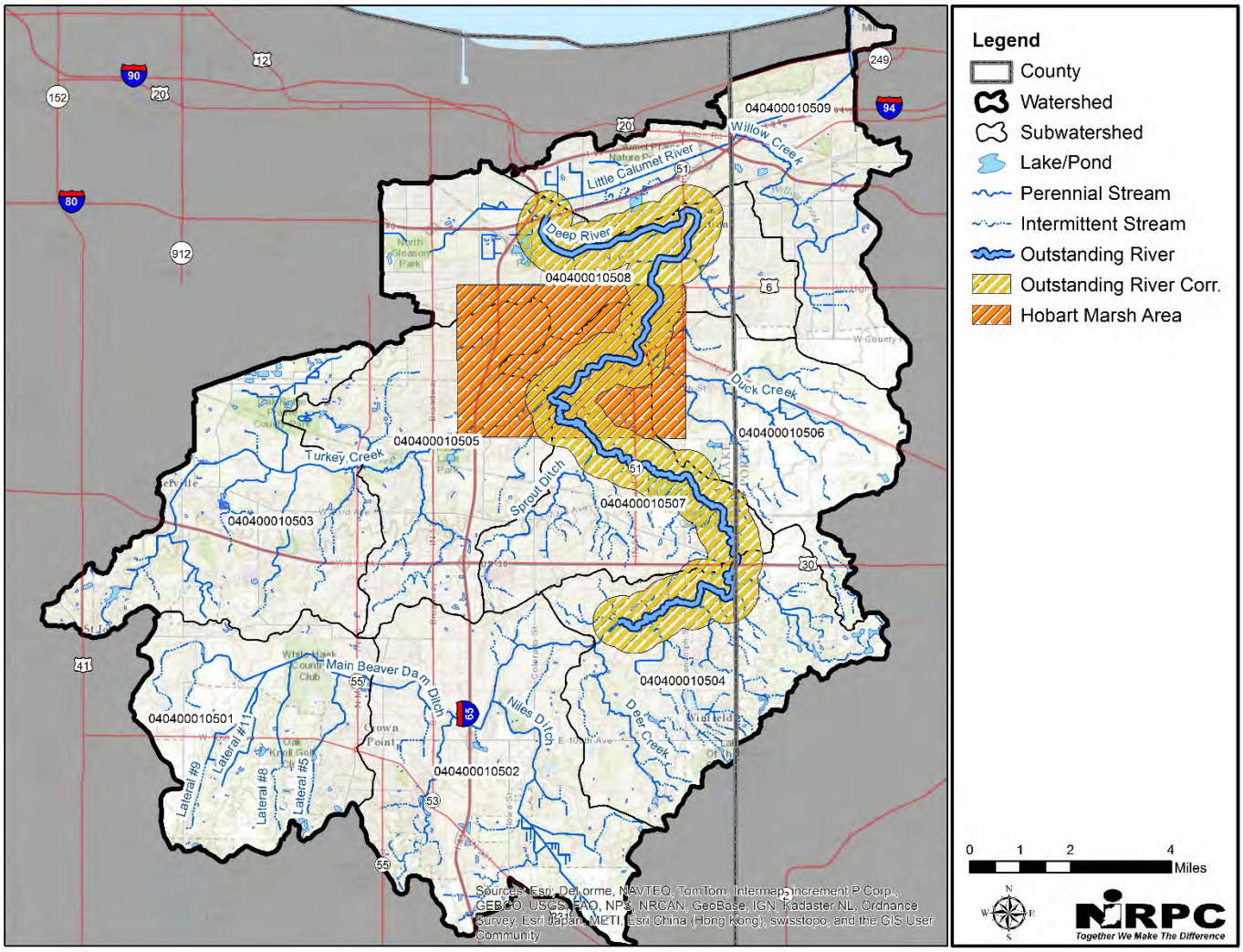



Figure 222 Deep River-Hobart Marsh Conservation Corridor

# 11 Best Management Practices

A wide variety of structural and non-structural implementation practices exist that we can select to help us protect and restore our watershed. A list of potential strategies was reviewed by the steering committee to help identify which practices were deemed the most appropriate and likely to succeed in addressing the watershed goals. The list of implementation strategies is not meant to be static or exhaustive as new approaches or practices may come to our attention over time and evaluation may show that certain practices were not as effective as we originally thought they would be.

## 11.1 Urban Area BMPs

Urban development is the most common human land use in the watershed, accounting for nearly 45% of its land area. The highest concentrations of development are located in the north western half of the watershed around Crown Point, Gary, Hobart, Merrillville and Portage. Urban development contributes an estimated 66% of the runoff volume, 40% of the nitrogen loads, 26% of the phosphorus loads, 59% of the biological oxygen demand loads, and 59% of the sediment loads in the watershed.

The following list of BMPs have been identified for implementation in the watershed. Descriptions of the individual practices are included in the appendices. The focus is to 1) Encourage the use of Low Impact Development (LID) design principles with new development or redevelopment; 2) Retrofit existing sites or practices to provide or improve water quality benefits and enhance storage for downstream channel protection (i.e. erosion) using LID practices; and 3) restore riparian corridors and native vegetation in upland areas to improve storage, water quality and habitat benefits.

- Bioretention (Rain Gardens)
- Capture Reuse (Rain Barrels & Cisterns)
- Constructed Filter
- Detention Basin
- Infiltration Practices
- Low Impact Development Site Design
- Native Revegetation
- Pervious Pavement w/ Infiltration
- Planter Boxes
- Riparian Buffer Restoration
- Vegetated Filter Strip
- Vegetated Roof (Green Roof)
- Vegetated Swale
- Water Quality Devices

Two resources were primarily consulted in identifying urban BMP list above and BMP selection considerations below: The Center for Watershed Protection's URBAN SUBWATERSHED RESTORATION MANUAL SERIES and the LOW IMPACT DEVELOPMENT MANUAL FOR MICHIGAN. Low Impact Development (LID) is a comprehensive land planning and engineering design approach with a goal of maintaining and enhancing the pre-development hydrologic regime of urban and developing watersheds. Low Impact Development mimics a site's pre-development hydrology by using design techniques that infiltrate, filter, store, evaporate, and detain runoff close to its source. Because LID utilizes a variety of useful techniques for controlling runoff, designs can be customized according to local regulatory and resource protection requirements, as well as site constraints.

### 11.1.1 LID BEST MANAGEMENT PRACTICE SELECTION CONSIDERATIONS

Selecting which BMPs accomplish as many storm water functions as possible is important. At the same time, meeting a certain function or level of pollution or storm water volume control can require multiple BMPs integrated at the site, creating a "treatment train." Treatment trains direct storm water to or through multiple BMPs in order to achieve quantity and/or quality storm water management objectives. Additionally, implementing BMPs as part of a treatment train can also provide a level of backup, which provides additional assurance if one BMP does not work as designed (e.g., maintenance problems, large storm event).

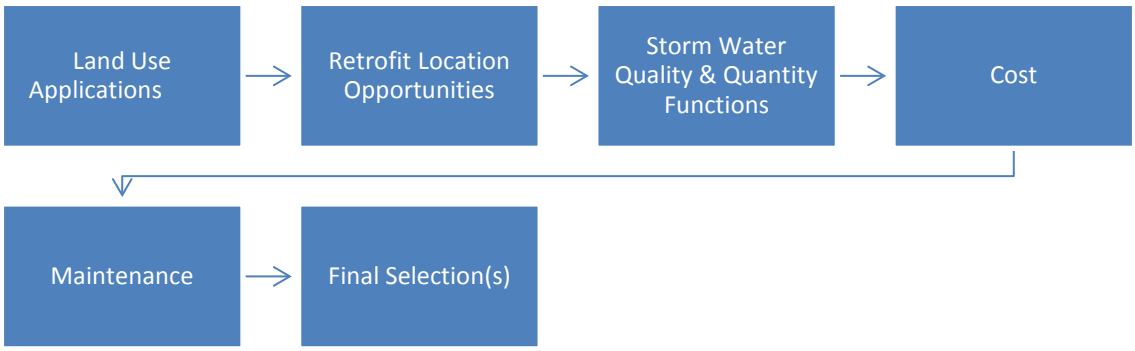



**Figure 223 Decision making process for BMP selection**

The following table, adapted from the LID Manual for Michigan, is intended to help identify which BMP(s) would be most suitable for a given land use. In many instances a combination of BMPs can be used at a site to improve pollutant removal and storm water volume reduction efficiency. Typical applications include modifying existing detention ponds, storage in transportation rights-of-way, parking lot retrofits, and landscapes/hardscapes.

| Best Management Practice | Residential | Commercial | Ultra-Urban | Industrial | Transportation Rights-of-Way | Recreational | Retrofit |
|---|---|---|---|---|---|---|---|
| Bioretention | Yes | Yes | No | No | Yes | Yes | Yes |
| Capture Reuse | Yes | Yes | Yes | Yes | No | Yes | Yes |
| Constructed Filter | Limited | Yes | Yes | Yes | Yes | Yes | Yes |
| Detention- Dry Pond | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Detention- Wet Pond | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Detention- Constructed Wetland | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Infiltration- Dry Well | Yes | Yes | Yes | Limited | No | No | Yes |
| Infiltration- Basin | Yes | Yes | Limited | Yes | Limited | No | Limited |
| Infiltration- Berm | Yes | Yes | Limited | Yes | Yes | Yes | Yes |
| Infiltration- Trench | Yes | Yes | Yes | Yes | Yes | No | Yes |
| Infiltration- Subsurface Bed | Yes | Yes | Yes | Yes | Limited | No | Yes |
| Native Revegetation | Yes | Yes | No | Yes | Limited | Yes | Yes |
| Pervious Pavement | Yes | Yes | Yes | Yes | Limited | Yes | Yes |
| Planter Box | Yes | Yes | Yes | Limited | No | Limited | Yes |
| Riparian Buffer Restoration | Yes | Yes | Yes | Yes | Limited | Yes | Yes |
| Vegetated Filter Strip | Yes | Yes | Limited | Limited | Yes | Yes | Yes |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Vegetated Roof | Limited | Yes | Yes | Yes | No | Yes | Yes |
| Vegetated Swale | Yes | Yes | Limited | Yes | Yes | Yes | Yes |
| Water Quality Device | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

**Table 123 Suitability of LID practices in various urban land uses**

The following list of retrofit opportunities comes from the Center for Watershed Protection's URBAN SUBWATERSHED RESTORATION MANUAL SERIES- 3. URBAN STORMWATER RETROFIT PRACTICES. Opportunities can be broadly categorized as either storage or onsite retrofits. In general storage retrofits treat larger drainage areas, typically are constructed on public land, and tend to be more cost effective.

Retrofit location opportunities:

- Existing storm water ponds (SR-1)
- Storage above roadway crossings (SR-2)
- New storage below outfalls (SR-3)
- Treatment in conveyance system (SR-4)
- Transportation rights-of-way (SR-5)
- Large parking lots (SR-6)
- Hotspot operations (OS-7)
- Small parking lot retrofits (OS-8)
- Individual streets (OS-9)
- Individual rooftops (OS-10)
- Little retrofits (OS-11)
- Landscapes-hardscapes (OS-12)

SR = storage retrofit, treat drainage areas ranging from 5-500 acres

OS = onsite retrofit, treat drainage areas < 5 acres

Table 125 , primarily adapted from the LID Manual for Michigan, compares storm water quantity and quality functions, cost and maintenance for the various structural LID BMPs recommended. The ability of a practice to treat pathogens is based on a literature review conducted by Schueler (2000). As noted previously a combination of BMPs can be used at a site to improve pollutant removal and storm water volume reduction efficiency.

| Best Management Practice | Volume | Peak Rate | Sediment | Phosphorus | Nitrogen | Pathogens* | Cost | Maintenance |
|---|---|---|---|---|---|---|---|---|
| Bioretention | M/H | M | H | M | M | X | M | M |
| Capture Reuse | H | L | M | M | M | | L/M | M |
| Constructed Filter | L | L | H | M | M | | M/H | H |
| Detention- Dry Pond | L | H | M | M | L | | H | L/H |
| Detention- Wet Pond | L | H | H | M | M | X | H | L/M |
| Detention- Constructed Wetland | L | H | H | M | M | X | H | L/M |
| Infiltration- Dry Well | M | M | H | M/H | L/M | X | M | L/M |
| Infiltration- Basin | H | H | H | M/H | M | X | L/M | L/M |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Infiltration- Berm | L/M | M | M/H | M | M | X | L/M | L/M |
| Infiltration- Trench | M | L/M | H | M/H | L/M | X | M | L/M |
| Infiltration- Subsurface Bed | H | H | H | M/H | L | X | H | M |
| Native Revegetation | L/M/H | L/M | H | H | M/H | | L/M | L |
| Pervious Pavement | H | M/H | H | M/H | L | | M | H |
| Planter Box | L/M | M | M | L/M | L/M | | M | M |
| Riparian Buffer Restoration | L/M | L/M | M/H | M/H | M/H | | L/M | L |
| Vegetated Filter Strip | L | L | M/H | M/H | M/H | | L | L/M |
| Vegetated Roof | M/H | M | H | H | H | | H | M |
| Vegetated Swale | L/M | L/M | M/H | L/H | M | | L/M | L/M |
| Water Quality Device | NA | NA | Varies | Varies | Varies | | Varies | Varies |

**Table 124 Function, cost, and maintenance of LID practices**

L= Low, M= Medium, H= High, X= Yes

## 11.2 Agricultural Area BMPs

Agriculture is the second common human land use in the watershed, accounting for nearly 28% of its land area. The highest concentrations of agricultural land are located in the southeastern portion of the watershed. An estimated 53% of the nitrogen loads, 68% of the phosphorus loads, 32% of the biological oxygen demand loads, and 40% of the sediment loads in the watershed originate from agricultural production.

The following best management practices have been identified from the NRCS Field Office Technical Guide (FOTG) for Indiana to control sediment, nutrients, and pathogens from row crop production and livestock operations on agricultural lands. The selection of which BMPs are most appropriate for a field or site is based on a Conservation Plan which is developed between the NRCS district conservationist and landowner. A Conservation Plan must be in place for a landowner to eligible for Farm Bill programs or Section 319 Cost-Share program funding.

- Access Control
- Alternative Watering Systems
- Conservation Cover
- Cover Crops
- Critical Area Planting
- Denitrifying Bioreactor
- Drainage Water Management
- Fencing
- Field Border
- Filter Strips
- Forage and Biomass Planting
- Stabilization Structures
- Grassed Waterway
- Manure Management Planning
- Manure Storage Facilities
- Nutrient Management
- Open Channel (Two-Stage Ditch)
- Prescribed Grazing
- Riparian Herbaceous Cover
- Riparian Forest Cover
- Residue and Tillage Management, No Till
- Residue and Tillage Management, Reduced Till
- Saturated Buffer

## 11.3 Priority Preservation Areas BMPs

The priority preservation area includes a mix of urban and agricultural land uses adjacent to or near sensitive natural areas. All of the BMPs referenced above for urban and agricultural areas still apply to the priority preservation area. However there are some additional measures that are very important and specific to this area.

### *Conservation Planning*

Conservation planning includes identifying key natural areas within the landscape, assessing the conservation value of each parcel identified, establishing conservation targets for the parcel, landowner education on the value of land preservation, and identifying conservation options to landowners.

### *Dam Removal or Modification*

Dam removal or modification can help restore fish passage, sediment and nutrient transport, riverine habitat characteristics, and stream flows.

### *Natural Area Preservation*

Natural area preservation can include acquisition, conservation easements, or land donation of key natural area parcels.

### *Natural Area Restoration*

Natural area restoration can vary greatly depending on the level of disturbance at a site. For more heavily disturbed sites, or portions of sites, restoration activities may include more intensive measures such as conversion back to natural land cover (ex. agricultural to forest or grassland) or restoring hydrology (ex. wetland or floodplain restoration). Natural area restoration can also include ongoing activities such as invasive species control, fire reintroduction for fire-dependent communities (ex. prairies), or opening the tree canopy (ex. oak savanna).

## 11.4 Watershed-Wide BMPs

These practices can be used throughout the watershed.

- Education and Outreach
- Floodplain Reconnection/Two-Stage Ditch
- Native Revegetation
- Riparian Buffer Restoration
- Septic system maintenance
- Streambank Stabilization & Shoreline Protection
- Wetland Restoration

## 11.5 BMP Recommendations for Critical Areas

The following table includes recommended BMPs for Tier 1 critical areas in the watershed. The table also includes information on why the catchment area was critical and the human land cover area potentially available for treatment by the BMPs. The recommendations are not intended to be exhaustive or prescriptive. Any number or combination of implementation activities might contribute to water quality improvement, whether applied at sites where the actual impairment was noted or other locations where sources contribute indirectly to the water quality impairment.

| Catchment Area | Reasons for Being Critical | Urban (ac.) | Cropland (ac.) | Pasture (ac.) | Suggested BMP |
|---|---|---|---|---|---|
| 3 | E. coli<br>Nutrients<br>Sediment<br>Physical Habitat<br>Aquatic Life | 1,556 | 1,490 | 97 | Floodplain reconnection |
| | | | | | Streambank stabilization |
| | | | | | Riparian buffer restoration |
| | | | | | Native revegetation |
| | | | | | Bioretention |
| | | | | | Capture Reuse |
| | | | | | Infiltration practices |
| | | | | | Vegetated swale |
| | | | | | Constructed wetland |
| | | | | | Wet pond |
| | | | | | Pervious pavement |
| | | | | | Cover crop |
| | | | | | Conservation tillage |
| | | | | | Grassed waterway |
| | | | | | Filter strips/Field border |
| | | | | | Nutrient management |
| | | | | | Septic system maintenance |

| Catchment Area | Reasons for Being Critical | Urban (ac.) | Cropland (ac.) | Pasture (ac.) | Suggested BMP |
|---|---|---|---|---|---|
| | | | | | Education and outreach |
| 21 | E. coli<br>Dissolved Oxygen<br>Nutrients<br>Sediment<br>Ammonia<br>Physical Habitat<br>Aquatic Life | 351 | 2,605 | 509 | Floodplain reconnection |
| | | | | | Streambank stabilization |
| | | | | | Riparian buffer restoration |
| | | | | | Native revegetation |
| | | | | | Wetland restoration |
| | | | | | Bioretention |
| | | | | | Capture Reuse |
| | | | | | Cover crop |
| | | | | | Conservation tillage |
| | | | | | Grassed waterway |
| | | | | | Filter strips/Field border |
| | | | | | Conservation cover |
| | | | | | Nutrient management |
| | | | | | Manure management |
| | | | | | Drainage water management |
| | | | | | Septic system maintenance |
| | | | | | Education and outreach |
| 24 | E. coli<br>Dissolved Oxygen<br>Nutrients<br>Sediment<br>Ammonia<br>Physical Habitat<br>Aquatic Life | 1,437 | 6 | 29 | Floodplain reconnection |
| | | | | | Streambank stabilization |
| | | | | | Riparian buffer restoration |
| | | | | | Native revegetation |
| | | | | | Bioretention |
| | | | | | Capture reuse |
| | | | | | Detention basin |
| | | | | | Pervious pavement |
| | | | | | Planter boxes |
| | | | | | Dry wells |
| | | | | | Infiltration trenches |
| | | | | | Subsurface infiltration beds |
| | | | | | Septic system maintenance |
| | | | | | Education and outreach |
| 25 | E. coli<br>Dissolved Oxygen<br>Nutrients<br>Sediment<br>Ammonia<br>Physical Habitat<br>Aquatic Life | 282 | 964 | 73 | Floodplain reconnection |
| | | | | | Streambank stabilization |
| | | | | | Riparian buffer restoration |
| | | | | | Native revegetation |
| | | | | | Wetland restoration |
| | | | | | Detention basin |
| | | | | | Cover crop |
| | | | | | Conservation tillage |

| Catchment Area | Reasons for Being Critical | Urban (ac.) | Cropland (ac.) | Pasture (ac.) | Suggested BMP |
|---|---|---|---|---|---|
| | | | | | Grassed waterway |
| | | | | | Filter strip/Field border |
| | | | | | Conservation cover |
| | | | | | Nutrient management |
| | | | | | Manure management |
| | | | | | Drainage water management |
| | | | | | Saturated buffer |
| | | | | | Septic system maintenance |
| | | | | | Education and outreach |
| 26 | E. coli<br>Dissolved Oxygen<br>Nutrients<br>Sediment<br>Physical Habitat<br>Aquatic Life | 513 | 745 | 291 | Floodplain reconnection |
| | | | | | Streambank stabilization |
| | | | | | Riparian buffer restoration |
| | | | | | Native revegetation |
| | | | | | Wetland restoration |
| | | | | | Detention basin |
| | | | | | Cover crop |
| | | | | | Conservation tillage |
| | | | | | Grassed waterway |
| | | | | | Filter strip/Field border |
| | | | | | Conservation cover |
| | | | | | Nutrient management |
| | | | | | Manure management |
| | | | | | Drainage water management |
| | | | | | Saturated buffer |
| | | | | | Septic system maintenance |
| | | | | | Education and outreach |
| 27 | E. coli<br>Dissolved Oxygen<br>Nutrients<br>Sediment<br>Physical Habitat<br>Aquatic Life | 733 | 651 | 11 | Floodplain reconnection |
| | | | | | Streambank stabilization |
| | | | | | Riparian buffer restoration |
| | | | | | Native revegetation |
| | | | | | Wetland restoration |
| | | | | | Detention basin |
| | | | | | Cover crop |
| | | | | | Conservation tillage |
| | | | | | Grassed waterway |
| | | | | | Filter strip/Field border |
| | | | | | Conservation cover |
| | | | | | Nutrient management |
| | | | | | Manure management |
| | | | | | Drainage water management |

| Catchment Area | Reasons for Being Critical | Urban (ac.) | Cropland (ac.) | Pasture (ac.) | Suggested BMP |
|---|---|---|---|---|---|
| | | | | | Saturated buffer |
| | | | | | Septic system maintenance |
| | | | | | Education and outreach |
| 36 | E. coli<br>Dissolved Oxygen<br>Nutrients<br>Sediment<br>Ammonia<br>Physical Habitat<br>Aquatic Life | 3,081 | 338 | 73 | Floodplain reconnection |
| | | | | | Streambank stabilization |
| | | | | | Riparian buffer restoration |
| | | | | | Wetland restoration |
| | | | | | Native revegetation |
| | | | | | Bioretention |
| | | | | | Capture reuse |
| | | | | | Detention basin |
| | | | | | Pervious pavement |
| | | | | | Planter boxes |
| | | | | | Dry wells |
| | | | | | Infiltration trenches |
| | | | | | Subsurface infiltration beds |
| | | | | | Cover crop |
| | | | | | Conservation tillage |
| | | | | | Grassed waterway |
| | | | | | Filter strip/Field border |
| | | | | | Conservation cover |
| | | | | | Septic system maintenance |
| | | | | | Education and outreach |

Table 125 BMP recommendations for tier 1 critical areas

## 11.6 Estimated Load Reductions from BMPs

The following table provides a general overview of the load reductions anticipated from implementing some of the various practices recommended in the previous sections. These load reductions were estimated using the EPA Region 5 spreadsheet model. This model likely be used the most frequently in assessing site specific load reductions during implementation.

| Practice (Contributing Area) | Estimated Load Reduction | | | |
|---|---|---|---|---|
| | Nitrogen (lb/year) | Phosphorus (lb/year) | BOD (lb/year) | Sediment (t/year) |
| **Urban/Rural Development Areas** | | | | |
| Bioretention | 179 | 44 | 2,274 | 31 |
| Detention- Dry Pond (100 ac.) | 269 | 26 | 975 | 23 |
| Detention- Wet Pond | 492 | 69 | 2,599 | 34 |
| Detention- Constructed Wetland (100 ac.) | 179 | 44 | 2,274 | 31 |
| Infiltration- Basin | 537 | 66 | NA | 30 |
| Infiltration- Trench | 492 | 60 | NA | 30 |

| | | | | |
|---|---|---|---|---|
| Pervious Pavement | 761 | 66 | NA | 36 |
| Vegetated Filter Strip (100 ac.) | 358 | 46 | 1,823 | 29 |
| Vegetated Swale (100 ac.) | 90 | 25 | 1,083 | 26 |
| Water Quality Device | NA | NA | NA | NA |
| **Agricultural Areas** | | | | |
| No-Till/Strip-Till (100 ac.) | 435 | 218 | NA | 167 |
| Cover Crops (100 ac.) | 271 | 136 | NA | 94 |
| Filter Strips (100 ac.) | 340 | 171 | NA | 110 |
| Grassed Waterway (100 ft.) | 34 | 17 | NA | 17 |
| Critical Area Planting (100 ac.) | 324 | 162 | NA | 107 |
| **Watershed-Wide** | | | | |
| Conservation Cover | 324 | 162 | NA | 107 |
| Two-Stage Ditch | 46 | 23 | NA | 23 |
| Wetland Restoration (10 ac.) | 252 | 126 | NA | 89 |
| Riparian Forest Buffer (100 ac.) | 148 | 74 | NA | 56 |
| Riparian Herbaceous Cover (100 ac.) | 324 | 162 | NA | 107 |
| Streambank Stabilization (100 ft.) | 46 | 23 | NA | 23 |

**Table 126 Summary of load reductions anticipated with each BMP**

The STEPL model was used to approximate load reductions and progress towards meeting load reduction goals anticipated from a few of the key recommend BMPs watershed wide and within each catchment area. The BMPs selected for this general analysis were considered to have broad applicability throughout the watershed and their pollutant removal efficiencies were readily available in the model. The following tables are formatted to show progress (increasing rates) in implementation over time. For example, the first table shows increasing adaptation of cover crops on cultivated land. Rows highlighted in red correspond to the Tier 1 critical areas.

| | | 10% Coverage (~2,500 ac) | | | 25% Coverage (~6,500 ac) | | | 50% Coverage (~13,000 ac) | | | 75% Coverage (~19,500) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Site | Row Crop | N | P | S | N | P | S | N | P | S | N | P | S |
| | Acres | lb/year | lb/year | t/year | lb/year | lb/year | t/year | lb/year | lb/year | t/year | lb/year | lb/year | t/year |
| 1 | 825 | 198 | 79 | 5 | 495 | 197 | 12 | 989 | 395 | 24 | 1,484 | 592 | 36 |
| 2 | 5 | 2 | 1 | 0 | 6 | 2 | 0 | 12 | 4 | 0 | 18 | 5 | 0 |
| 3 | 1,499 | 731 | 243 | 9 | 1,828 | 607 | 22 | 3,656 | 1,214 | 43 | 5,483 | 1,821 | 65 |
| 5 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 6 | 66 | 16 | 6 | 0 | 40 | 16 | 1 | 79 | 32 | 2 | 119 | 48 | 3 |
| 7 | 384 | 187 | 62 | 2 | 469 | 156 | 6 | 937 | 311 | 11 | 1,406 | 467 | 17 |
| 8 | 729 | 356 | 118 | 4 | 889 | 295 | 11 | 1,778 | 590 | 21 | 2,666 | 886 | 32 |
| 9 | 898 | 438 | 145 | 5 | 1,095 | 364 | 13 | 2,190 | 727 | 26 | 3,285 | 1,091 | 39 |
| 10 | 968 | 472 | 157 | 6 | 1,180 | 392 | 14 | 2,360 | 784 | 28 | 3,540 | 1,176 | 42 |
| 11 | 2,289 | 1,116 | 371 | 13 | 2,791 | 927 | 33 | 5,582 | 1,854 | 66 | 8,373 | 2,781 | 99 |
| 12 | 1,456 | 710 | 236 | 8 | 1,775 | 589 | 21 | 3,549 | 1,179 | 42 | 5,324 | 1,768 | 63 |
| 13 | 576 | 281 | 93 | 3 | 703 | 233 | 8 | 1,405 | 467 | 17 | 2,108 | 700 | 25 |
| 14 | 2,215 | 1,080 | 359 | 13 | 2,700 | 897 | 32 | 5,401 | 1,794 | 64 | 8,101 | 2,691 | 96 |
| 15 | 221 | 108 | 36 | 1 | 270 | 90 | 3 | 540 | 179 | 6 | 809 | 269 | 10 |
| 16 | 222 | 108 | 36 | 1 | 270 | 90 | 3 | 540 | 179 | 6 | 810 | 269 | 10 |
| 17 | 541 | 264 | 88 | 3 | 660 | 219 | 8 | 1,320 | 438 | 16 | 1,980 | 658 | 24 |
| 18 | 2,840 | 1,385 | 460 | 16 | 3,463 | 1,150 | 41 | 6,926 | 2,300 | 82 | 10,389 | 3,450 | 123 |
| 19 | 1,403 | 684 | 227 | 8 | 1,710 | 568 | 20 | 3,421 | 1,136 | 41 | 5,131 | 1,704 | 61 |
| 20 | 938 | 457 | 152 | 5 | 1,143 | 380 | 14 | 2,287 | 760 | 27 | 3,430 | 1,139 | 41 |
| 21 | 2,605 | 1,270 | 422 | 15 | 3,176 | 1,055 | 38 | 6,352 | 2,110 | 75 | 9,528 | 3,164 | 113 |
| 22 | 49 | 24 | 8 | 0 | 60 | 20 | 1 | 120 | 40 | 1 | 181 | 60 | 2 |
| 23 | 262 | 128 | 42 | 2 | 319 | 106 | 4 | 639 | 212 | 8 | 958 | 318 | 11 |
| 24 | 6 | 4 | 1 | 0 | 10 | 3 | 0 | 20 | 6 | 0 | 30 | 9 | 0 |
| 25 | 964 | 470 | 156 | 6 | 1,175 | 390 | 14 | 2,350 | 780 | 28 | 3,525 | 1,171 | 42 |
| 26 | 745 | 363 | 121 | 4 | 908 | 302 | 11 | 1,816 | 603 | 22 | 2,724 | 905 | 32 |
| 27 | 651 | 317 | 105 | 4 | 793 | 263 | 9 | 1,587 | 527 | 19 | 2,380 | 790 | 28 |
| 28 | 2 | 2 | 1 | 0 | 6 | 2 | 0 | 12 | 3 | 0 | 17 | 5 | 0 |
| 29 | 78 | 19 | 7 | 0 | 47 | 19 | 1 | 94 | 37 | 2 | 140 | 56 | 3 |
| 30 | 6 | 6 | 2 | 0 | 15 | 4 | 0 | 29 | 8 | 0 | 44 | 12 | 0 |
| 31 | 176 | 86 | 28 | 1 | 214 | 71 | 3 | 428 | 142 | 5 | 643 | 213 | 8 |
| 32 | 1,096 | 534 | 178 | 6 | 1,336 | 444 | 16 | 2,672 | 888 | 32 | 4,009 | 1,331 | 48 |
| 33 | 336 | 164 | 54 | 2 | 410 | 136 | 5 | 820 | 272 | 10 | 1,230 | 408 | 15 |
| 34 | 130 | 63 | 21 | 1 | 158 | 53 | 2 | 317 | 105 | 4 | 475 | 158 | 6 |
| 35 | 292 | 178 | 57 | 2 | 444 | 142 | 4 | 888 | 283 | 8 | 1,331 | 425 | 13 |
| 36 | 338 | 206 | 66 | 2 | 514 | 164 | 5 | 1,028 | 328 | 10 | 1,542 | 492 | 15 |
| Total | 25,810 | 12,428 | 4,138 | 149 | 31,071 | 10,344 | 374 | 62,142 | 20,688 | 747 | 93,213 | 31,033 | 1,121 |
| Reduction Needed | | 2,554 | 95,699 | 3,866 | 2,554 | 95,699 | 3,866 | 2,554 | 95,699 | 3,866 | 2,554 | 95,699 | 3,866 |
| % Meet | | >100% | 4% | 4% | >100% | 11% | 10% | >100% | 22% | 19% | >100% | 32% | 29% |

**Table 127 Anticipated load reductions from cover crops**

| | | 10% Coverage (~2,500 ac) | | | 25% Coverage (~6,500 ac) | | | 50% Coverage (~13,000 ac) | | | 75% Coverage (~19,500) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Site | Row Crop | N | P | S | N | P | S | N | P | S | N | P | S |
| | Acres | lb/year | lb/year | t/year | lb/year | lb/year | t/year | lb/year | lb/year | t/year | lb/year | lb/year | t/year |
| 1 | 825 | 291 | 111 | 9 | 728 | 277 | 22 | 1,455 | 554 | 45 | 2,183 | 830 | 67 |
| 2 | 5 | 3 | 1 | 0 | 8 | 2 | 0 | 17 | 5 | 0 | 25 | 7 | 0 |
| 3 | 1,499 | 1,040 | 301 | 16 | 2,600 | 751 | 41 | 5,200 | 1,503 | 81 | 7,800 | 2,254 | 122 |
| 5 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 6 | 66 | 23 | 9 | 1 | 58 | 22 | 2 | 117 | 44 | 4 | 175 | 67 | 5 |
| 7 | 384 | 267 | 77 | 4 | 666 | 193 | 10 | 1,333 | 385 | 21 | 1,999 | 578 | 31 |
| 8 | 729 | 506 | 146 | 8 | 1,264 | 365 | 20 | 2,529 | 731 | 40 | 3,793 | 1,096 | 59 |
| 9 | 898 | 623 | 180 | 10 | 1,557 | 450 | 24 | 3,115 | 900 | 49 | 4,672 | 1,350 | 73 |
| 10 | 968 | 671 | 194 | 11 | 1,679 | 485 | 26 | 3,357 | 970 | 53 | 5,036 | 1,455 | 79 |
| 11 | 2,289 | 1,588 | 459 | 25 | 3,970 | 1,147 | 62 | 7,941 | 2,295 | 124 | 11,911 | 3,442 | 186 |
| 12 | 1,456 | 1,010 | 292 | 16 | 2,524 | 730 | 40 | 5,049 | 1,459 | 79 | 7,573 | 2,189 | 119 |
| 13 | 576 | 400 | 116 | 6 | 999 | 289 | 16 | 1,999 | 578 | 31 | 2,998 | 866 | 47 |
| 14 | 2,215 | 1,536 | 444 | 24 | 3,841 | 1,110 | 60 | 7,682 | 2,220 | 120 | 11,524 | 3,330 | 180 |
| 15 | 221 | 154 | 44 | 2 | 384 | 111 | 6 | 768 | 222 | 12 | 1,151 | 333 | 18 |
| 16 | 222 | 154 | 44 | 2 | 384 | 111 | 6 | 768 | 222 | 12 | 1,152 | 333 | 18 |
| 17 | 541 | 376 | 109 | 6 | 939 | 271 | 15 | 1,878 | 543 | 29 | 2,816 | 814 | 44 |
| 18 | 2,840 | 1,970 | 569 | 31 | 4,926 | 1,424 | 77 | 9,852 | 2,847 | 154 | 14,779 | 4,271 | 231 |
| 19 | 1,403 | 973 | 281 | 15 | 2,433 | 703 | 38 | 4,866 | 1,406 | 76 | 7,299 | 2,109 | 114 |
| 20 | 938 | 651 | 188 | 10 | 1,626 | 470 | 25 | 3,253 | 940 | 51 | 4,879 | 1,410 | 76 |
| 21 | 2,605 | 1,807 | 522 | 28 | 4,518 | 1,306 | 71 | 9,035 | 2,611 | 141 | 13,553 | 3,917 | 212 |
| 22 | 49 | 34 | 10 | 1 | 86 | 25 | 1 | 171 | 49 | 3 | 257 | 74 | 4 |
| 23 | 262 | 182 | 53 | 3 | 454 | 131 | 7 | 909 | 263 | 14 | 1,363 | 394 | 21 |
| 24 | 6 | 6 | 1 | 0 | 14 | 4 | 0 | 28 | 7 | 0 | 42 | 11 | 0 |
| 25 | 964 | 668 | 193 | 10 | 1,671 | 483 | 26 | 3,342 | 966 | 52 | 5,014 | 1,449 | 78 |
| 26 | 745 | 517 | 149 | 8 | 1,292 | 373 | 20 | 2,583 | 747 | 40 | 3,875 | 1,120 | 61 |
| 27 | 651 | 451 | 130 | 7 | 1,129 | 326 | 18 | 2,257 | 652 | 35 | 3,386 | 978 | 53 |
| 28 | 2 | 3 | 1 | 0 | 8 | 2 | 0 | 16 | 4 | 0 | 24 | 5 | 0 |
| 29 | 78 | 28 | 10 | 1 | 69 | 26 | 2 | 138 | 52 | 4 | 207 | 79 | 6 |
| 30 | 6 | 8 | 2 | 0 | 20 | 4 | 0 | 41 | 9 | 0 | 61 | 13 | 0 |
| 31 | 176 | 122 | 35 | 2 | 305 | 88 | 5 | 609 | 176 | 10 | 914 | 264 | 14 |
| 32 | 1,096 | 760 | 220 | 12 | 1,901 | 549 | 30 | 3,801 | 1,099 | 59 | 5,702 | 1,648 | 89 |
| 33 | 336 | 233 | 67 | 4 | 583 | 169 | 9 | 1,166 | 337 | 18 | 1,750 | 506 | 27 |
| 34 | 130 | 90 | 26 | 1 | 225 | 65 | 4 | 450 | 130 | 7 | 676 | 195 | 11 |
| 35 | 292 | 251 | 68 | 3 | 627 | 170 | 8 | 1,254 | 340 | 16 | 1,882 | 509 | 24 |
| 36 | 338 | 291 | 79 | 4 | 727 | 197 | 9 | 1,453 | 393 | 18 | 2,180 | 590 | 28 |
| Total | 25,810 | 17,687 | 5,132 | 280 | 44,217 | 12,829 | 701 | 88,435 | 25,658 | 1,401 | 132,652 | 38,487 | 2,102 |
| Reduction Needed | | 2,554 | 95,699 | 3,866 | 2,554 | 95,699 | 3,866 | 2,554 | 95,699 | 3,866 | 2,554 | 95,699 | 3,866 |
| % Meet | | >100% | 5% | 7% | >100% | 13% | 18% | >100% | 27% | 36% | >100% | 40% | 54% |

**Table 128 Anticipated load reductions from reduced tillage**

| | | 1% Coverage | | | 5% Coverage | | | 10% Coverage | | | 15% Coverage | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Site | Commercial | N | P | S | N | P | S | N | P | S | N | P | S |
| | Acres | lb/year | lb/year | t/year | lb/year | lb/year | t/year | lb/year | lb/year | t/year | lb/year | lb/year | t/year |
| 1 | 524 | 5 | 1 | 704 | 24 | 5 | 3,518 | 48 | 11 | 7,035 | 7 | 2 | 1,082 |
| 2 | 92 | 1 | 0 | 135 | 5 | 1 | 676 | 8 | 2 | 1,218 | 13 | 3 | 1,894 |
| 3 | 186 | 3 | 1 | 391 | 12 | 3 | 1,760 | 24 | 5 | 3,520 | 38 | 8 | 5,475 |
| 5 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 6 | 221 | 2 | 0 | 271 | 10 | 2 | 1,488 | 20 | 5 | 2,976 | 31 | 7 | 4,465 |
| 7 | 47 | 1 | 0 | 98 | 3 | 1 | 391 | 7 | 1 | 978 | 9 | 2 | 1,369 |
| 8 | 84 | 1 | 0 | 196 | 5 | 1 | 782 | 11 | 2 | 1,564 | 17 | 4 | 2,542 |
| 9 | 109 | 1 | 0 | 196 | 7 | 1 | 978 | 15 | 3 | 2,151 | 22 | 5 | 3,129 |
| 10 | 103 | 1 | 0 | 196 | 7 | 1 | 978 | 13 | 3 | 1,955 | 20 | 4 | 2,933 |
| 11 | 32 | 0 | 0 | 59 | 2 | 0 | 293 | 4 | 1 | 587 | 7 | 1 | 978 |
| 12 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 13 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 14 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 15 | 10 | 0 | 0 | 20 | 1 | 0 | 98 | 1 | 0 | 196 | 1 | 0 | 196 |
| 16 | 5 | - | - | - | - | - | - | - | - | - | - | - | - |
| 17 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 18 | 1,948 | 26 | 6 | 3,715 | 131 | 29 | 18,967 | 261 | 57 | 37,933 | 393 | 86 | 57,095 |
| 19 | 11 | 0 | 0 | 20 | 1 | 0 | 98 | 1 | 0 | 196 | 2 | 0 | 293 |
| 20 | 5 | - | - | - | 0 | 0 | 59 | 1 | 0 | 98 | 1 | 0 | 98 |
| 21 | 11 | 0 | 0 | 20 | 1 | 0 | 98 | 1 | 0 | 196 | 1 | 0 | 196 |
| 22 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 23 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 24 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 25 | 34 | 0 | 0 | 59 | 2 | 0 | 293 | 4 | 1 | 587 | 7 | 1 | 978 |
| 26 | 15 | 0 | 0 | 20 | 1 | 0 | 147 | 2 | 0 | 293 | 3 | 1 | 391 |
| 27 | 37 | 0 | 0 | 59 | 3 | 1 | 391 | 5 | 1 | 704 | 7 | 1 | 978 |
| 28 | 78 | 1 | 0 | 156 | 5 | 1 | 782 | 10 | 2 | 1,525 | 16 | 4 | 2,346 |
| 29 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 30 | 26 | 0 | 0 | 39 | 2 | 0 | 244 | 3 | 1 | 489 | 5 | 1 | 782 |
| 31 | 155 | 2 | 0 | 293 | 10 | 2 | 1,515 | 20 | 4 | 2,933 | 31 | 7 | 4,497 |
| 32 | 54 | 1 | 0 | 98 | 4 | 1 | 518 | 7 | 2 | 1,036 | 11 | 2 | 1,564 |
| 33 | 425 | 5 | 1 | 782 | 28 | 6 | 4,106 | 57 | 12 | 8,212 | 86 | 19 | 12,514 |
| 34 | 26 | 0 | 0 | 39 | 2 | 0 | 244 | 3 | 1 | 489 | 4 | 1 | 587 |
| 35 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 36 | 31 | 0 | 0 | 64 | 2 | 0 | 320 | 4 | 1 | 640 | 7 | 1 | 960 |
| Total | 25,810 | 52 | 12 | 7,626 | 267 | 59 | 38,744 | 533 | 117 | 77,509 | 739 | 163 | 107,340 |
| Reduction Needed | | 2,554 | 95,699 | 3,866 | 2,554 | 95,699 | 3,866 | 2,554 | 95,699 | 3,866 | 2,554 | 95,699 | 3,866 |
| % Meet | | 2% | <1% | >100% | 10% | <1% | >100% | 21% | <1% | >100% | 29% | <1% | >100% |

**Table 129 Anticipated load reductions from bioretention**

| | | 1% Coverage | | | 5% Coverage | | | 10% Coverage | | | 15% Coverage | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Site | Row Crop | N | P | S | N | P | S | N | P | S | N | P | S |
| | Acres | lb/year | lb/year | t/year | lb/year | lb/year | t/year | lb/year | lb/year | t/year | lb/year | lb/year | t/year |
| 1 | 825 | 34 | 13 | 1 | 171 | 65 | 4 | 341 | 130 | 8 | 512 | 195 | 12 |
| 2 | 5 | 0 | 0 | 0 | 2 | 1 | 0 | 4 | 1 | 0 | 6 | 2 | 0 |
| 3 | 1,499 | 127 | 40 | 1 | 635 | 201 | 7 | 1,271 | 402 | 14 | 1,906 | 603 | 21 |
| 5 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 6 | 66 | 3 | 1 | 0 | 14 | 5 | 0 | 27 | 10 | 1 | 41 | 16 | 1 |
| 7 | 384 | 33 | 10 | 0 | 163 | 52 | 2 | 326 | 103 | 4 | 489 | 155 | 5 |
| 8 | 729 | 62 | 20 | 1 | 309 | 98 | 3 | 618 | 195 | 7 | 927 | 293 | 10 |
| 9 | 898 | 76 | 24 | 1 | 381 | 120 | 4 | 761 | 241 | 8 | 1,142 | 361 | 13 |
| 10 | 968 | 82 | 26 | 1 | 410 | 130 | 5 | 820 | 259 | 9 | 1,231 | 389 | 14 |
| 11 | 2,289 | 194 | 61 | 2 | 970 | 307 | 11 | 1,941 | 614 | 22 | 2,911 | 921 | 32 |
| 12 | 1,456 | 123 | 39 | 1 | 617 | 195 | 7 | 1,234 | 390 | 14 | 1,851 | 585 | 21 |
| 13 | 576 | 49 | 15 | 1 | 244 | 77 | 3 | 488 | 154 | 5 | 733 | 232 | 8 |
| 14 | 2,215 | 188 | 59 | 2 | 939 | 297 | 10 | 1,877 | 594 | 21 | 2,816 | 891 | 31 |
| 15 | 221 | 19 | 6 | 0 | 94 | 30 | 1 | 188 | 59 | 2 | 281 | 89 | 3 |
| 16 | 222 | 19 | 6 | 0 | 94 | 30 | 1 | 188 | 59 | 2 | 282 | 89 | 3 |
| 17 | 541 | 46 | 15 | 1 | 229 | 73 | 3 | 459 | 145 | 5 | 688 | 218 | 8 |
| 18 | 2,840 | 241 | 76 | 3 | 1,204 | 381 | 13 | 2,408 | 762 | 27 | 3,612 | 1,142 | 40 |
| 19 | 1,403 | 119 | 38 | 1 | 595 | 188 | 7 | 1,189 | 376 | 13 | 1,784 | 564 | 20 |
| 20 | 938 | 79 | 25 | 1 | 397 | 126 | 4 | 795 | 251 | 9 | 1,192 | 377 | 13 |
| 21 | 2,605 | 221 | 70 | 2 | 1,104 | 349 | 12 | 2,208 | 698 | 25 | 3,312 | 1,048 | 37 |
| 22 | 49 | 4 | 1 | 0 | 21 | 7 | 0 | 42 | 13 | 0 | 63 | 20 | 1 |
| 23 | 262 | 22 | 7 | 0 | 111 | 35 | 1 | 222 | 70 | 2 | 333 | 105 | 4 |
| 24 | 6 | 1 | 0 | 0 | 3 | 1 | 0 | 7 | 2 | 0 | 10 | 3 | 0 |
| 25 | 964 | 82 | 26 | 1 | 408 | 129 | 5 | 817 | 258 | 9 | 1,225 | 388 | 14 |
| 26 | 745 | 63 | 20 | 1 | 316 | 100 | 4 | 631 | 200 | 7 | 947 | 300 | 11 |
| 27 | 651 | 55 | 17 | 1 | 276 | 87 | 3 | 552 | 174 | 6 | 827 | 262 | 9 |
| 28 | 2 | 0 | 0 | 0 | 2 | 1 | 0 | 4 | 1 | 0 | 6 | 2 | 0 |
| 29 | 78 | 3 | 1 | 0 | 16 | 6 | 0 | 32 | 12 | 1 | 48 | 18 | 1 |
| 30 | 6 | 1 | 0 | 0 | 5 | 1 | 0 | 10 | 3 | 0 | 15 | 4 | 0 |
| 31 | 176 | 15 | 5 | 0 | 74 | 24 | 1 | 149 | 47 | 2 | 223 | 71 | 2 |
| 32 | 1,096 | 93 | 29 | 1 | 464 | 147 | 5 | 929 | 294 | 10 | 1,393 | 441 | 15 |
| 33 | 336 | 29 | 9 | 0 | 143 | 45 | 2 | 285 | 90 | 3 | 428 | 135 | 5 |
| 34 | 130 | 11 | 3 | 0 | 55 | 17 | 1 | 110 | 35 | 1 | 165 | 52 | 2 |
| 35 | 292 | 31 | 9 | 0 | 154 | 47 | 1 | 309 | 94 | 3 | 463 | 141 | 4 |
| 36 | 338 | 36 | 11 | 0 | 179 | 54 | 2 | 358 | 109 | 3 | 537 | 163 | 5 |
| Total | 25,810 | 2,160 | 685 | 24 | 10,800 | 3,424 | 121 | 21,600 | 6,849 | 243 | 32,400 | 10,273 | 364 |
| Reduction Needed | | 2,554 | 95,699 | 3,866 | 2,554 | 95,699 | 3,866 | 2,554 | 95,699 | 3,866 | 2,554 | 95,699 | 3,866 |
| % Meet | | 85% | 1% | 1% | >100% | 4% | 3% | >100% | 7% | 6% | >100% | 11% | 9% |

**Table 130 Anticipated load reductions from conservation cover**

| | 1/4-Mile | 1-Mile | 3-Miles | 5-Miles |
|---|---|---|---|---|
| Site | S | S | S | S |
| | t/year | t/year | t/year | t/year |
| 1 | 38 | 151 | 453 | 755 |
| 2 | 34 | 137 | 412 | 686 |
| 3 | 29 | 117 | 350 | 583 |
| 5 | 34 | 137 | 412 | 686 |
| 6 | 34 | 137 | 412 | 686 |
| 7 | 31 | 124 | 371 | 618 |
| 8 | 29 | 117 | 350 | 583 |
| 9 | 29 | 117 | 350 | 583 |
| 10 | 29 | 117 | 350 | 583 |
| 11 | 29 | 117 | 350 | 583 |
| 12 | 29 | 117 | 350 | 583 |
| 13 | 29 | 117 | 350 | 583 |
| 14 | 29 | 117 | 350 | 583 |
| 15 | 29 | 117 | 350 | 583 |
| 16 | 29 | 117 | 350 | 583 |
| 17 | 29 | 117 | 350 | 583 |
| 18 | 29 | 117 | 350 | 583 |
| 19 | 29 | 117 | 350 | 583 |
| 20 | 29 | 117 | 350 | 583 |
| 21 | 29 | 117 | 350 | 583 |
| 22 | 29 | 117 | 350 | 583 |
| 23 | 29 | 117 | 350 | 583 |
| 24 | 29 | 117 | 350 | 583 |
| 25 | 29 | 117 | 350 | 583 |
| 26 | 29 | 117 | 350 | 583 |
| 27 | 29 | 117 | 350 | 583 |
| 28 | 29 | 117 | 350 | 583 |
| 29 | 38 | 151 | 453 | 755 |
| 30 | 29 | 117 | 350 | 583 |
| 31 | 29 | 117 | 350 | 583 |
| 32 | 27 | 110 | 329 | 549 |
| 33 | 29 | 117 | 350 | 583 |
| 34 | 31 | 124 | 371 | 618 |
| 35 | 31 | 124 | 371 | 618 |
| 36 | 29 | 117 | 350 | 583 |
| Total | 1,057 | 4,228 | 12,685 | 21,141 |
| Reduction Needed | 3,866 | 3,866 | 3,866 | 3,866 |
| % Meet | 27% | >100% | >100% | >100% |

**Table 131 Anticipated load reductions from streambank stabilization**

# 12 Watershed Restoration Action Register

Goal and objectives were developed based on stakeholder concerns and information collected through the watershed characterization process. Each action register table, presented below, identifies the strategies, target audiences, timeframes, milestones, estimated costs, possible partners, and technical assistance to reach these goals. The action register is set up as five year work plan. Progress will be evaluated, modifications considered, and new work plans developed in subsequent 5-year cycles. The greatest focus over the next five to ten years will occur in the Tier 1 critical areas and priority preservation areas.

Goal 1: Reduce *E. coli* concentrations by 80% so that all waterways meet the state water quality standard of 235 CFU/100 mL (single sample) and 125 CFU/100mL (geomean) during the recreational season (April 1 – October 31).

Goal 2: Restore warmwater fish and macroinvertebrate communities so that all waterways meet their aquatic life use designations with natural waterways maintaining at least a "good" integrity class rating and modified waterways maintaining at least a "fair" integrity class rating.

Objectives:

- Improve dissolved oxygen levels so that all waterways maintain a concentration > 4 mg/L.
- Reduce nutrient and sediment loads from urban and agricultural land uses.
- Restore riparian vegetation to improve channel stability, nutrient processing, sediment capture, and landscape habitat connectivity.
- Improve bed form diversity within channelized/incised or dammed stream reaches to increase depth variability and substrate quality.
- Improve channel stability to reduce suspended and bedded sediments.
- Provide floodplain connectivity for channelized/incised stream reaches to improve channel stability and facilitate sediment storage and nutrient processing outside of the channel.
- Reduce storm water runoff volume and rates to improve flow-duration conditions and flow dynamics.

## 12.1 Recreational Use

### 12.1.1 Reduce E. coli Loads

| Strategy | Target Audience | Time Frame | Milestone | Cost | Potential Partners | Technical Assistance |
|---|---|---|---|---|---|---|
| Restrict livestock access to streams and reduce runoff from pastures<br><br>Long-term target: 75% of livestock owners & facility operators will have and implement provisions of conservation plan | Livestock Owners & Facility Operators | 2016-2017 | Coordinate with NRCS and ISDA to do site visits at identified facilities to determine if livestock have unrestricted livestock access to waterway or if pastures are in near proximity to potential conveyances. | *See Note | Watershed Group, SWCD, ISDA, NRCS | TSPs, SWCD, NRCS, ISDA, Purdue Extension |
| | | 2016-2020 | Market conservation programs to owners and operators. | **See Note | | |
| | | 2016-2020 | Develop individual conservation plans as needed. Plans may include provisions for alternate water systems, livestock fencing, conservation buffers, and rotational grazing. | **See Note | | |
| | | 2016 | Develop a 319 cost-share program. | *See Note | | |
| | | 2016-2020 | Install alternate water systems, livestock fencing and conservation buffers as needed | | | |
| Implement manure management and application BMPs<br><br>Long-term target: 75% owners and operators that have fields to which manure is applied will have and implement provisions of conservation plan | Livestock Owners & Facility Operators | 2016-2017 | Coordinate with NRCS and ISDA to do site visits at identified facilities to determine if manure from facilities is being field applied. | *See Note | Watershed Group, SWCD, ISDA, NRCS | TSPs, SWCD, NRCS, ISDA, Purdue Extension |
| | | 2016-2020 | Market conservation programs to owners and operators. | **See Note | | |
| | | 2016-2020 | Develop individual conservation plans as needed. Plans may include provisions for manure management, nutrient management, cover crops, and conservation buffers. | **See Note | | |
| | | 2016 | Develop a 319 cost-share program. | *See Note | | |
| | | 2016-2020 | Install cover crops, conservation buffers as needed. Implement manure and nutrient management practices as needed. | | | |

| Strategy | Target Audience | Time Frame | Milestone | Cost | Potential Partners | Technical Assistance |
|---|---|---|---|---|---|---|
| Increase public awareness of proper septic system maintenance | Septic system owners | 2016-2020 | Collaborate with NWI Septic System Working Group in promoting SepticSmart Week. | *See Note | Watershed Group, NWI Septic System Working Group | ISDH, County Health Department |
| | | 2016-2017 | Collaborate with NWI Septic System Working Group to develop outreach program strategy and materials | *See Note | | |
| | | 2018-2020 | Implement outreach program | *See Note | | |
| Support the adoption of ordinances that improve county health department oversight of septic system operation and maintenance<br><br>Long-term target: Lake & Porter Counties will have an O&M program and/or point-of-sale inspection ordinance | County Health Departments | 2016-2020 | Collaborate with NWI Septic System Working Group to support development of an operation and maintenance program ordinance and/or point-of-sale inspection ordinance | *See Note | Watershed Group, NWI Septic System Working Group | ISDH, County Health Department |
| Increase use of LID practices | Municipalities & Urban Landowners | 2016-2020 | See 12.2.2 Reduce Nutrient & Sediment Loads | -- | Municipalities Watershed Group | MS4 Communities, IDEM, Consulting Firms |

Table 132 Action register to reduce pathogen loading from agricultural areas

## 12.2 Aquatic Life Use

### 12.2.1 Improve Dissolved Oxygen Levels

| Strategy | Target Audience | Time Frame | Milestone | Cost | Potential Partners | Technical Assistance |
|---|---|---|---|---|---|---|
| Reduce nutrient and sediment loads | -- | 2016-2020 | See 12.2.2 Reduce Nutrient & Sediment Loads | -- | -- | -- |
| Restore riparian vegetation | -- | 2016-2020 | See 12.2.3 Restore Riparian Vegetation | -- | -- | -- |

| Strategy | Target Audience | Time Frame | Milestone | Cost | Potential Partners | Technical Assistance |
|---|---|---|---|---|---|---|
| Improve bed form diversity | -- | 2016-2020 | See 12.2.4 Improve Bed Form Diversity | -- | -- | -- |
| Improve channel stability | -- | 2016-2020 | See 12.2.5 Improve Channel Stability | -- | -- | -- |
| Provide floodplain connectivity | -- | 2016-2020 | See 12.2.5 Provide Floodplain Connectivity | -- | -- | -- |
| Reduce storm water runoff volume & rates | -- | 2016-2020 | See 12.2.6 Reduce Storm Water Runoff Volume & Rates | -- | -- | -- |

**Table 133 Action register to improve dissolved oxygen levels**

### 12.2.2 Reduce Nutrient & Sediment Loads

| Strategy | Target Audience | Time Frame | Milestone | Cost | Potential Partners | Technical Assistance |
|---|---|---|---|---|---|---|
| Increase awareness of lawn and yard care pollution prevention practices | Urban/ Rural Landowners | 2016-2018 | Distribute Lawn to Lake & NWI Rain Garden Manuals at public events | $1,000/ event | Watershed Group, IL-IN Sea Grant | IL-IN Sea Grant, Purdue Extension |
| | | 2016-2017 | Include information on DRPBWI webpage | $500 | | |
| | | 2016-2020 | Occasionally post information on DRPBWI Facebook page | $1,000 annually | | |
| Increase use of conservation cropping system (no-till, cover crops, adaptive nutrient and pest management, and precision farming)<br><br>Long-term target: 75% of row crop fields | Agricultural Landowners & Operators | 2016-2020 | Host/promote regional conservation cropping system workshops and field day events. | $3,000 annually | Watershed Group | SWCD, NRCS, ISDA, Purdue Extension |
| | | 2016 | Develop 319 cost-share program. | *See Note | | |
| | | 2016-2020 | Annually identify additional funding options. | *See Note | | |
| | | 2016-2020 | Market conservation cropping systems to owners and operators. | **See Note | | |
| | | 2016-2020 | Continue to develop conservation plans as needed. | **See Note | | |
| | | 2016-2020 | Annually implement 500 acres of conservation cropping system. | No-till: $20/ac<br>Cover crop: $35/ac<br>Nutr./Pest mgt.: $20/ac | | |
| | | 2016 | Develop 319 cost-share program. | *See Note | | |

| Strategy | Target Audience | Time Frame | Milestone | Cost | Potential Partners | Technical Assistance |
|---|---|---|---|---|---|---|
| Increase use of conservation cover and critical area planting on areas retired from agricultural production<br><br>Long-term target: 1% of agricultural fields | Agricultural Landowners & Operators | 2016-2020 | Annually identify additional funding options. | *See Note | Watershed Group | SWCD, NRCS, ISDA, Purdue Extension |
| | | 2016-2020 | Market conservation cover and critical area planting to owners and operators. | **See Note | | |
| | | 2016-2020 | Continue to develop conservation plans as needed. | **See Note | | |
| | | 2016-2020 | Annually implement 50 acres of conservation cover and critical area planting. | $2,250 | | |
| Increase the use of conservation buffers (ex. filter strips, riparian buffer, field borders) | Agricultural Landowners & Operators, Urban/ Rural Landowners | 2016 | Develop 319 cost-share program. | *See Note | Watershed Group | SWCD, NRCS, ISDA, Purdue Extension |
| | | 2016-2020 | Annually identify additional funding options. | *See Note | | |
| | | 2016-2020 | Market conservation buffers to landowners and operators. | *See Note<br>**See Note | | |
| | | 2016-2020 | Continue to develop conservation plans as needed. | **See Note | | |
| | | 2017-2018 | Host conservation buffer workshop and field day event for urban areas. | $5,000/ event | | |
| | | 2016-2020 | Host/promote regional conservation buffer workshops and field day events for agricultural areas. | $5,000 | | |
| | | 2016-2020 | Annually implement 50 acres of conservation buffers | $10,000-$25,000 | | |
| Increase use of grassed waterways | Agricultural Landowners & Operators | 2016 | Develop 319 cost-share program. | *See Note | Watershed Group | SWCD, NRCS, ISDA, Purdue Extension |
| | | 2016-2020 | Annually identify additional funding options. | *See Note | | |
| | | 2016-2020 | Market grassed waterways to landowners and operators. | **See Note | | |
| | | 2016-2020 | Continue to develop conservation plans as needed. | **See Note | | |
| | | 2016-2020 | Annually implement 1,000 feet of grassed waterway | $10,000 | | |
| | | 2016-2017 | Develop an education plan including promotional materials and | $5,000-$10,000 | Watershed Group | |

| Strategy | Target Audience | Time Frame | Milestone | Cost | Potential Partners | Technical Assistance |
|---|---|---|---|---|---|---|
| Increase awareness of drainage water management practices | Agricultural Landowners & Operators | | demonstration day for drainage water management | | | SWCD, NRCS, ISDA, Purdue Extension |
| | | 2016 | Develop 319 cost-share program. | *See Note | | |
| | | 2016-2017 | Identify a drainage water management highlight project location. Installation target by 2020. | *See Note | | |
| | | 2017-2020 | Annually identify additional funding options. | *See Note | | |
| | | 2017-2020 | Market drainage water management to landowners and operators. | **See Note | | |
| Restrict livestock access to streams and reduce runoff from pastures | Livestock Owners & Facility Operators | 2016-2020 | See 12.1.1 Reduce E. coli Loads | -- | Watershed Group, SWCD, ISDA, NRCS | TSPs, SWCD, NRCS, ISDA, Purdue Extension |
| Implement manure management and application BMPs | Livestock Owners & Facility Operators | 2016-2020 | See 12.1.1 Reduce E. coli Loads | -- | Watershed Group, SWCD, ISDA, NRCS | TSPs, SWCD, NRCS, ISDA, Purdue Extension |
| Increase use of LID practices and development<br><br>Long-term target: 5% of existing developed lands treated | Municipalities & Urban Landowners | 2016 | Develop 319 cost-share program. | *See Note | Municipalities Watershed Group | MS4 Communities, IDEM, Consulting Firms |
| | | 2016-2020 | Annually identify additional funding options. | *See Note | | |
| | | 2016-2020 | Market LID to municipalities and landowners. | *See Note | | |
| | | 2016-2020 | Host an LID development workshop. | $5,000-$10,000 | | |
| | | 2017-2020 | Develop a web-based LID tour and update at least annually. (See Nashville LID Tour on ArcGIS.com for example) | $5,000-$10,000 initial, $2,500 annually thereafter | | |
| | | 2016-2020 | Annually retrofit and treat an additional 100 acres of urban land uses with LID practices. | $300,000-$500,000 | | |

**Table 134 Action register to reduce nutrient and sediment loading**

### 12.2.3 Restore Riparian Vegetation

| Strategy | Target Audience | Time Frame | Milestone | Cost | Potential Partners | Technical Assistance |
|---|---|---|---|---|---|---|
| Increase conservation buffers area along waterways<br><br>Long-term target: 75% of waterway length | Riparian Landowners | 2016 | Develop 319 cost-share program | *See Note | MS4 Communities, County Surveyors Office, Watershed Group | SWCD, NRCS, ISDA, Purdue Extension |
| | | 2016-2020 | Annually identify additional funding options. | *See Note | | |
| | | 2016-2020 | Market riparian restoration to municipalities and landowners. | *See Note<br>**See Note | | |
| | | 2016-2020 | Continue to develop conservation plans as needed. | **See Note | | |
| | | 2016-2020 | Restore 20 acres of conservation buffer annually. | $19,000 - $50,000 | | |

Table 135 Action register to restore riparian vegetation

### 12.2.4 Improve Bed Form Diversity

| Strategy | Target Audience | Time Frame | Milestone | Cost | Potential Partners | Technical Assistance |
|---|---|---|---|---|---|---|
| Remove/modify the Deep River dam located in Lake Station | Property Owners | 2016-2018 | Complete engineering feasibility study for dam's removal or modification. | $30,000 | City of Lake Station, School Corporation of Gary, Little Calumet River Basin Development Commission, Watershed Group | DNR LARE, Consulting Firms |
| | | 2017-2018 | Identify funding options for construction. | *See Note | | |
| | | 2018-2020 | Begin construction once funding and permits have been secured. | TBD | | |
| Re-meander formerly channelized/incised streams through excavated floodplain | Landowners, County Surveyors Office, Municipalities | 2016-2017 | Identify potential reaches where re-meandering stream channel and excavating a new floodplain is possible. | *See Note | County Surveyors Office, Municipalities, Little Calumet River Basin Development Commission, Watershed Group | NRCS, DNR, IDEM, USACE, Consulting Firms |
| | | 2017-2018 | Meet with landowners to discuss willingness | *See Note<br>**See Note | | |
| | | 2018-2020 | Conducted engineering feasibility study as sites are identified. | $30,000-$50,000 | | |
| | | 2020 | Identify funding options for construction | *See Note | | |

| Strategy | Target Audience | Time Frame | Milestone | Cost | Potential Partners | Technical Assistance |
|---|---|---|---|---|---|---|
| | | -- | Construct as possible | TBD | | |
| Incorporate large woody debris and/or other in-stream structures into restoration designs where feasible | Project designers, permitting agencies | 2016-2020 | Coordinate with project designers and permitting agencies. | *See Note | County Surveyors Office, Municipalities | NRCS, DNR, IDEM, USACE, Consulting Firms |

Table 136 Action register to improve bed form diversity

### 12.2.5 Improve Channel Stability

| Strategy | Target Audience | Time Frame | Milestone | Cost | Potential Partners | Technical Assistance |
|---|---|---|---|---|---|---|
| Remove or modify the Deep River dam located in Lake Station | Property Owners | 2016-2020 | See 12.2.4 Improve Bed Form Diversity | -- | City of Lake Station, School Corporation of Gary, Little Calumet River Basin Development Commission, Watershed Group | DNR LARE, Consulting Firm |
| Stabilize eroding streambanks downstream impacted by in-channel infrastructure or where infrastructure is threatened | Lake County Parks Department | 2017-2018 | Complete an engineering design study for the severely eroding streambank on Deep River in Deep River County Park adjacent to County Line Road | $20,000-30,000 | Lake County Parks, Lake County Highway Dept., Watershed Group | DNR LARE Program, Consulting Firms |
| | | 2019-2020 | Stabilize project reach based on recommendations from engineering design study. | TBD | | |
| | Landowners | 2016-2018 | Coordinate with partners to identify additional opportunities and create list of sites where stabilization is most needed | *See Note | County Surveyors Office, Municipalities | NRCS, DNR LARE, Consulting Firms |

| Strategy | Target Audience | Time Frame | Milestone | Cost | Potential Partners | Technical Assistance |
|---|---|---|---|---|---|---|
| | | 2018 | Identify funding options for construction | *See Note | | |
| | | 2016-2020 | Stabilize streambanks and shorelines as possible | $22 - $100 / foot | | |
| Reconstruct conventional drainage ditches/incised channels to include floodplain benches or terraces. | Landowners | 2016-2020 | See 12.2.6 Provide Floodplain Connectivity | -- | County Surveyors Office, Municipalities, Little Calumet River Basin Development Commission | NRCS, ISDA, SWCD, DNR LARE Program, TNC, Consulting Firms |
| Incorporate channel protection standards into storm water ordinances | Municipalities | 2016-2020 | Update municipal storm water ordinances to incorporate channel protection standards | $5,000-$10,000 | MS4 Communities | MS4 Communities, Consulting Firms |
| Increase conservation buffers area along waterways | Riparian Landowners | 2016-2020 | See 12.2.3 Restore Riparian Vegetation | -- | MS4 Communities, County Surveyors Office, Watershed Group | SWCD, NRCS, ISDA, Purdue Extension |

Table 137 Action register to improve channel stability

### 12.2.6 Provide Floodplain Connectivity

| Strategy | Target Audience | Time Frame | Milestone | Cost | Potential Partners | Technical Assistance |
|---|---|---|---|---|---|---|
| Reconstruct conventional drainage ditches/incised channels to include floodplain benches or terraces. | Landowners | 2016-2017 | Create a priority list and GIS layer of conventional drainage ditch reaches that could be reconstructed with floodplain benches or terraces. | *See Note | County Surveyors Office, Municipalities, Little Calumet River Basin | NRCS, ISDA, SWCD, DNR LARE Program, TNC, Consulting Firms |
| | | 2017-2018 | Conduct geomorphic surveys and hydrologic surveys of priority project reaches. | $5,000 - $10,000 per reach | | |

| Strategy | Target Audience | Time Frame | Milestone | Cost | Potential Partners | Technical Assistance |
|---|---|---|---|---|---|---|
| | | 2016-2017 | Identify funding options for construction | *See Note | Development Commission | |
| | | 2017-2018 | Install ½- mile of two-stage ditch along Turkey Creek (previously identified project) or other appropriate location as a showcase project in the watershed. | $55,000 | | |
| | | 2019-2020 | Host workshop highlighting the benefits of two-stage ditches. | $5,000 | | |
| | | 2017-2018 | Conduct an engineering feasibility study for floodplain connectivity along Willow Creek south of Stone Avenue. | $30,000-$50,000 | | |
| | | 2018 | Identify funding options for construction. | *See Note | | |
| | | 2018-2020 | Begin construction once funding and permits have been secured. | TBD | | |

Table 138 Action register to increase floodplain connectivity

### 12.2.7 Reduce Storm Water Runoff Volume & Rates

| Strategy | Target Audience | Time Frame | Milestone | Cost | Potential Partners | Technical Assistance |
|---|---|---|---|---|---|---|
| Reestablish natural upland habitats<br><br>Long-term target additional 2,300 acres for 30% watershed coverage | Landowners | 2016 | Develop 319 cost-share program. | *See Note | MS4 Communities, DNR, Land Trusts, Watershed Group | NRCS, ISDA, SWCD, DNR, Land Trusts |
| | | 2016-2020 | Annually identify additional funding options. | *See Note | | |
| | | 2016-2020 | Market upland habitat reestablishment to landowners. | *See Note<br>**See Note | | |
| | | 2016-2020 | Continue to develop conservation plans as needed for agricultural owners and operators. | **See Note | | |
| | | | Develop conservation & coordinated management plan for the Hobart Marsh Area & Develop long-term vision and strategy for the Deep River Conservation Corridor | $60,000 | | |

| Strategy | Target Audience | Time Frame | Milestone | Cost | Potential Partners | Technical Assistance |
|---|---|---|---|---|---|---|
| | | 2016-2020 | Annually convert 25 acres of turf grass or row crop to natural upland habitat. | $125,000-$625,000 | | |
| Reestablish depressional wetlands and rehabilitate hydraulic function of wetland drained by ditches<br><br>Long-term target additional 2,300 acres for 10% watershed coverage | Landowners | 2016 | Develop 319 cost-share program. | *See Note | Watershed Group | NRCS, ISDA, SWCD, DNR, USACE, IDEM, Consulting Firms |
| | | 2016-2020 | Annually identify additional funding options. | *See Note | | |
| | | 2016-2020 | Market wetland restoration to landowners | *See Note<br>**See Note | | |
| | | 2016-2020 | Continue to develop conservation plans as needed. | **See Note | | |
| | | 2016-2020 | Annually implement 5 acres of wetland restoration. | $10,000-$50,000 | | |
| Increase use of LID practices and development | Municipalities & Urban Landowners | 2016-2020 | See 12.2.2 Reduce Nutrient & Sediment Loads | -- | Watershed Group, Municipalities | MS4 Communities, IDEM, Consulting Firms |
| Increase urban tree canopy density<br><br>Long-term target 30% average UTC | Municipalities & Landowners | 2016 | Develop 319 cost-share program. | *See Note | Watershed Group, Municipalities | Urban Waters Partnership, USFS, DNR, NIPSCO |
| | | 2016-2020 | Annually identify additional funding options. | *See Note | | |
| | | 2016-2020 | Market urban forestry and promote Tree City USA program to municipalities. | *See Note | | |
| | | 2017-2018 | Host urban forestry workshop and field day event. | $5,000 | | |
| | | 2016-2020 | Public tree inventory completed by two municipalities. | $90,000 | | |
| | | 2016-2020 | Urban forestry master plan completed by one municipality. | $5,000-$10,000 | | |
| | | 2017-2018 | Develop one community engagement program. | $30,000 annually | | |
| | | 2016-2020 | Plant 1,000 native trees annually. | $200,000-$300,000 annually | | |

**Table 139 Action register to reduce storm water runoff volume and rates**

Notes:

* Annual salary of watershed coordinator

** Personnel from NRCS/SWCD/ISDA

# 13 Tracking Effectiveness

The success of this watershed plan depends upon the implementation of the strategies outlined above. Periodic adjustments to the strategies will need to be made as restoration targets are met or unforeseen challenges dictate a different approaches. The following indicators that will be used to track overall effectiveness of plan implementation and stream function functional-lift over time.

## 13.1 Pollutant Load Modelling

Pollutant load reductions anticipated through BMP implementation will be estimated using STEPL, Region 5 or other appropriate models. Modeling will be conducted prior to any 319 funded project implementation to evaluate and maximize cost-benefit. Modeling will also be done for partner projects that do not use Section 319 funding to greatest extent possible (ex. projects funded through Farm Bill programs).

## 13.2 Water Quality & Biological Assessment

Water quality and biological monitoring will begin following five years of implementation at the critical area sampling points. Water quality monitoring will occur at least monthly over a one year period to capture seasonal variability. Biological monitoring will occur once during the sampling year. Monitoring will follow Hoosier Riverwatch methodologies. Parameters to be monitored include benthic macroinvertebrates, temperature, pH, DO, BOD, orthophosphate, nitrate, and turbidity. Flow data will either be collected in the field using Hoosier Riverwatch methodologies or estimated using the Deep River USGS gaging station. The estimated cost is $1,000-$2,000 for supplies. Monitoring will be completed by trained partners and/or NIRPC.

## 13.3 Hydrologic & Geomorphology Assessment

Hydrology, hydraulics, and geomorphology assessments will be conducted as part of stream restoration design to help evaluate pre- and post- restoration functional lift. Hydrology parameters such as precipitation/runoff relationship, flood frequency, and flow duration will be assessed. Hydraulic parameters such as floodplain connectivity and flow dynamics will be evaluated. Geomorphology parameters such as channel evolution, bank stability, riparian vegetation, and bed form diversity, and bed material characterization will also be evaluated.

## 13.4 Administrative Indicators

Administrative indicators provide information that water quality data cannot. These indicators are used to track program participation, strategy completion, and goal attainment. Administrative indicators will be used to track the following:

- Funds secured and leveraged
- Attendance at workshops and field day events.
- Conservation practice installation and anticipated load reduction.
- Acres of natural area conserved.
- Photo monitoring of installed practices.
- Media coverage.
- Number and types of educational materials distributed.
- Number of goals met.
- Delisting of streams included on the 303d List (impairment type, # of segments, miles of stream)

## 13.5 Implementation Tracking

Implementation strategies will be tracked on a quarterly basis. Work completed towards each strategy will be documented in a spreadsheet which will include scheduled and completed activities, numbers of individuals attending or efforts completed toward each objective, and load calculations or monitoring results for each goal, objective, and strategy. Overall project progress will be tracked by measureable items such as workshops held, BMPs installed, meetings held, etc. Load reductions will be calculated for each BMP installed. These values and associated project details including BMP type, location, length of conservation commitment, easement, size, cost, installer, and more will be tracked over time using spreadsheets and GIS where appropriate.

# 14 Future Considerations

Watershed plans are intended to be living documents that require updates as water quality and land use change and BMPs are implemented.

The steering committee will continue to meet on a regular basis for the purpose of plan implementation. Annually, this committee will review findings of any subcommittees that have been formed to help implement the watershed restoration plan. The action register, which serves as a work plan, will be updated every five years. The steering committee will review project efforts according to the management plan's goals, objectives, and strategies no less than every five years. The Northwestern Indiana Regional Planning Commission will be responsible for holding and revising the Deep River-Portage Burns Waterway Watershed Restoration Plan as appropriate based on stakeholder feedback. The plan may be adapted or blended with other watershed management plans to effectively create living documents which cover larger-scale projects and capitalize on potential shared resources.

Questions pertaining to the Deep River-Portage Burns Waterway Watershed Plan can be directed to:

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