**Tier 2 NMP Project Application**

BMP Demonstration Project

Inflow/Outflow Monitoring Design

Updated September 21, 2011

**Project Name:** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Project Location:**

 State: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

 County: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

 City/Township: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

 Watershed: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

***Any information already available in a form/style similar to that required in this application (i.e., concise and directly responsive) can be included by reference/attachment into this application. Identification of information by page and paragraph (as necessary) is sufficient. Hyperlinks with appropriate pointers to relevant text are also suitable and, in fact, recommended.***

**Justification for BMP Demonstration Project**

Describe concisely the reasons for conducting the best management practice (BMP) demonstration project depicted in Figure 1, including whether the BMP is innovative, the study is important for technology transfer purposes, the BMP is needed to solve an important water quality problem, or effectiveness data is sorely needed because the BMP is an important part of the state or local watershed protection program.

**BMP Description**

Describe the BMP to be tested in detail sufficient to allow others to design and implement the same BMP in other locations, including applicable standards and specifications (including inflow capacity), design drawings, and photographs as appropriate. Describe the pollutants or environmental impacts the BMP is intended to control and how (i.e., via source reduction, treatment, or transport intervention) the BMP is expected to improve ecological condition or reduce pollutant concentrations or loads.

Figure . Inflow/Outflow Monitoring of BMP Effectiveness

Inflow Station

Outflow Station

**BMP**

Inflow

Outflow

**Watershed characterization**

**Setting**

Provide a 1 page or less description of the setting in which the BMP will be tested, including inflow quality and all significant factors affecting inflow quality and BMP performance.

**Climate**

Provide monthly average precipitation totals for the nearest weather station in Table 1. Identify weather station, its distance from the BMP demonstration site, and the timeframe of record used to determine averages.

Table . Average precipitation

|  |  |  |  |
| --- | --- | --- | --- |
| **Month** | **Average Precipitation****(inches)** | **Month** | **Average Precipitation****(inches)** |
| January |  | July |  |
| February |  | August |  |
| March |  | September |  |
| April |  | October |  |
| May |  | November |  |
| June |  | December |  |

Weather station location: \_\_\_ In watershed OR \_\_\_ miles from watershed center.

Beginning \_\_\_\_\_\_ and Ending \_\_\_\_\_\_ years of data record.

**Quantitative Water Quality Objectives**

Provide a clear statement of quantitative water quality objectives for the demonstration project. Objectives must be specific to the pollutants or impacts the BMP is designed to reduce, control, or remediate and be achievable within the project timeframe.

Example: To measure total nitrogen reduction achieved by the BMP by comparing inflow and outflow weekly mean concentrations and loads over a three-year period.

**Project Management**

Each Tier 2 NMP project is required to have a designated project manager whose duty is to oversee the entire project and ensure that all activities are completed as described and on time.

Project Manager: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Describe in 1 page or less how Project Manager will ensure that project objectives are achieved within the specified timeframe.

**Monitoring Plan**

A tightly designed monitoring plan is required of all Tier 2 projects. The list of monitoring variables should be short, linked directly to the pollutants and water quality problems to be addressed by the BMP. Monitoring frequency must be sufficient to detect the minimum detectable change estimated by the project. All monitoring variables (chemistry, biology, habitat, precipitation, flow, land use/land treatment, etc.) are to be reported in Table 2, which includes an example. Additional discussion of how variables will be used in BMP evaluation should be provided under “Data Management and Analysis.”

Table . Monitoring Variables

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Variable** | **Detection Limit** | **Upper Limit** | **Method (EPA, USGS, etc.)** | **How to be used in project evaluation.** |
| Total P | 0.01 mg/L P | 20 mg/L P | EPA Method 365.4 | To measure effectiveness of BMP. Dependent variable. |
| Wetland residence time | 1 hour | n/a | Dye tracer | To characterize BMP performance and provide a design spec for future applications. Independent variable. |
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Sampling frequency (and compositing information) for each variable is reported in Table 3, which includes an example.

Table . Sampling Frequency

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Variable** | **Preservation** | **Holding Time** | **Sampling Frequency** | **Sample Compositing** |
| Total P | H2SO4 to pH<2; Cool to 4 degrees C | 28 days | Weekly composites. | Flow-proportional sampling; weekly composites. Refrigerated sampler used for preservation. |
| Wetland residence time | n/a | n/a | Quarterly plus 4 storms per year |  |
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Sampling equipment should be described in 1 page or less. In the case of automated sampling equipment, describe in detail how the equipment will be installed and programmed to capture samples.

Report minimum detectable change (MDC) analysis results for all primary monitoring variables. For additional details regarding MDC calculations, see Tech Note 7 (Tetra Tech 2011) which can be found [***here***](http://www.bae.ncsu.edu/programs/extension/wqg/319monitoring/tech_notes.htm). The calculation MDC or the water quality concentration change required to detect significant trends requires several steps. The procedure varies slightly based upon a number of factors:

* Whether the data used are in the original scale (e.g., mg/l or kg) or log transformed.
* Addition of explanatory variables such as streamflow or season.
* Incorporation of time series to adjust for autocorrelation (See Tech Note 7).

For Tier 2 projects it is assumed that step trend is the appropriate statistical model and the information presented below is tailored to that situation. The following steps are adopted from Spooner et al. (1987 and 1988):

***Step 1. Define the Monitoring Goal and Choose the Appropriate Statistical Trend Test Approach.*** An appropriate goal for Tier 2 projects would be to detect a statistically significant change in the post-BMP period as compared to a pre-BMP period. This would require a step change statistical test such as the Student’s t-test (t-test) or analysis of covariance (ANCOVA).

***Step 2. Perform Exploratory Data Analyses.*** Preliminary data inspections are performed to determine if the residuals are distributed with a normal distribution, constant variance, and independence. Normal distribution is required in the parametric analyses; constant variance and independence are required in both parametric and nonparametric analyses. The water quality monitoring data are usually not normal, however, and often do not exhibit constant variance over the data range. Tests for autocorrelation are performed to test for independence (e.g., Durbin Watson test).

***Step 3. Perform Data Transformations.*** Water quality data typically follow log-normal distributions and the base 10 logarithmic transformation is typically used to minimize the violation of the assumptions of normality and constant variance. In this case, the MDC calculations use the log-transformed data until the last step of expressing the percent change. The natural log transformation may alternatively be used.

***Step 4. Calculate the MDC.*** For a **step trend**, the MDC is one-half of the confidence interval for detecting a change between the mean values in the pre- vs. post- BMP periods.

$$MDC= t\_{\left(n\_{pre}+n\_{post}-2\right)}\*s\_{\left(\overbar{X}\_{pre}-\overbar{X}\_{post}\right)}$$

The above equation requires an estimate of the standard error of the difference between the mean values of these two periods ($s\_{\left(\overbar{X}\_{pre}-\overbar{X}\_{post}\right)})$, a topic discussed in greater detail in Tech Note 7 (Tetra Tech 2011). In practice, an equivalent estimate is obtained using the following formula:

$$MDC= t\_{\left(n\_{pre}+n\_{post}-2\right)}\sqrt{\frac{MSE}{n\_{pre}}+\frac{MSE}{n\_{post}}}$$

Where: $t\_{\left(n\_{pre}+n\_{post}-2\right)}$ = one-sided Student’s t-value with (n*pre* + n*post* -2) degrees of freedom.

 n*pre* + n*post* = the combined number of samples in the pre- and post-BMP periods

 $ s\_{\left(\overbar{X}\_{pre}-\overbar{X}\_{post}\right)}$ = estimated standard error of the difference between the mean values in the Pre- and the Post- BMP periods.

 MSE or sp2 = Estimate of the pooled Mean Square Error (MSE) or, equivalently, variance (sp2) within each period. The variance (square of the standard deviation) of pre-BMP data can be used to estimate MSE or sp2 from running the planned statistical model of Step 1 through your statistical analysis package. Alternatively, *MSE can be estimated by using the variance of the pre-BMP data*. For log normal data calculate this value on the log transformed data.

*If you estimate MDC using the variance of the pre-BMP data*, MDC is calculated as:

$$MDC= t\_{\left(n\_{pre}+n\_{post}-2\right)}\sqrt{\frac{s^{2}}{n\_{pre}}+\frac{s^{2}}{n\_{post}}} $$

Where: s2 is the sample variance of the pre-BMP data.

The pre- and post-periods can have different sample sizes but should have the same sampling frequency (e.g., weekly).

The following considerations should be noted:

* The choice of one- or two-sided t-statistic is based upon the question being asked. Typically, the question is whether there has been a statistically significant *decrease* in pollutant loads or concentrations and a one-sided t-statistic would be appropriate. A two-sided t-statistic would be appropriate if the question being evaluated is whether a *change* in pollutant loads or concentrations has occurred. The value of the t-statistic for a two-sided test is larger, resulting in a larger MDC value.
* At this stage in the analysis, the MDC is either in the original data scale (e.g., mg/L) if non-transformed data are used, or, more typically in the log scale if log-transformed data are use.

***Step 5. Express MDC as a Percent Decrease.*** If the data analyzed were not transformed, MDC as a percent change (MDC%) is simply the MDC from Step 5 divided by the average value in the pre-BMP period expressed as a percentage (e.g., MDC% = 100\*(MDC/mean of Pre-BMP data).

If the data were **log-transformed**, a simple calculation can be performed to express the MDC as a percent decrease in the geometric mean concentration relative to the initial geometric mean concentration or load. The calculation is:

MDC% = (1 - 10-MDC') \* 100

Where: MDC' is the MDC on the log scale and MDC% is a percentage.

MDC' is the difference required on the logarithmic scale to detect a significant decreasing trend (calculated in Step 4 using log transformed data). MDC' is a positive number if mean concentrations decrease over time. For example, for MDC'= 0.1 (10-0.1 = 0.79), the MDC% or percent reduction in water quality for required for statistical significance = 21%; MDC' = 0.2 (10-0.2 = 0.63), MDC% = 37%.

It should be noted that if the natural logarithmic transformation had been used, then:

MDC% = ((1 - exp-MDC')) \* 100

In cases where limited data are inadequate to calculate an MDC, data from similar watersheds in the area or from the literature can be used. For example, the MDC for a study with a plan for 20 samples before and after BMP installation using erosion bridges to measure change in erosion (soil altitude) was estimated using a literature-derived standard deviation of 11.0 mm. Plugging that value into the Step 4 equation (t for 38 d.f. at *p* = 0.05 is 2.0244[[1]](#footnote-1), MSE=3.025) yields a value of 7.04 mm. If the pre-BMP mean is 15 mm, the MDC% is 46.9%. Thus, a reduction in erosion rate of at least 47% was needed for the monitoring program to detect the change.

***Step 6. Compare the MDC with expected pollutant reduction.*** Compare the estimated amount of pollutant reductions expected (concentration, loads, percentages) with the planned BMPs to the estimated MDC for the water quality monitoring design.

In cases where ecological monitoring is performed, provide evidence from similar studies that the degree of improvement expected from implementing the BMPs can be measured with the proposed monitoring plan. For example, scores for the macroinvertebrate portion of Michigan Department of Environmental Quality’s P51 protocol range from -9 to +9, and are categorized as follows (Rathbun, 2007):

* < -4 = “poor”
* -4 to + 4 = “acceptable”
* > +4 = “excellent”

Background data were presented to show that substantial opportunity existed to raise current scores (most either 0 or 2) with implementation of BMPs planned for a remediation project.

**Quality Assurance/Quality Control**

This information should be prepared in accordance with either the state’s approved Quality Management Program or USEPA requirements and included by reference here.

**Data Management and Analysis**

Describe in 1 page or less how data will be managed and integrated for analysis of project effectiveness. Describe the statistical tests for which each monitoring variable will be used.

**Reporting and Communications**

Tier 2 NMP projects are required to submit semi-annual and annual reports to USEPA. Brief semi-annual reports are essential to ensuring that projects inspect their data on a routine basis to allow opportunities to make mid-course corrections as needed to achieve project objectives. Annual reports are to include a summary of all project activities during the year, as well as analysis of all monitoring and BMP data collected since project startup. The final report will include a summary of all information relevant to project objectives, an analysis of all relevant data, and conclusions and recommendations.

Communication of project needs, status, and results among stakeholders is an essential part of successful water quality projects. Describe in 1 page or less the plan for such communication.

**Budget**

Relevant budget information is entered into Table 4. Budget information can be developed using the Tier 2 NMP budget spreadsheet available [***here***](http://www.bae.ncsu.edu/programs/extension/wqg/319monitoring/index.htm) (Tetra Tech, 2008).

Table 4. Project Budget

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Budget Item** | **Total Cost ($)** | **%** | **Funds in Hand ($)** | **Funds Needed ($)** |
| Salaries |  |  |  |  |
| Site Establishment |  |  |  |  |
| Equipment |  |  |  |  |
| Supplies |  |  |  |  |
| Travel/Vehicles |  |  |  |  |
| Lab and Data |  |  |  |  |
| Site Operation |  |  |  |  |
| Printing/Media |  |  |  |  |
| Contracts & Grants |  |  |  |  |
| BMPs |  |  |  |  |
| TOTAL |  |  |  |  |

Budget categories are defined as follows:

* Salaries: All in-house salaries.
* Site Establishment: Site establishment structures plus one-time fee, electricity connection, setup, etc.
* Equipment: All purchased and rented monitoring and office equipment.
* Supplies: All monitoring and office supplies.
* Travel/Vehicles: All in-house use of vehicles for travel, construction, etc.
* Lab and Data: Annual laboratory analysis plus maps, data, satellite & aerial photography
* Site Operation: All fuel and power costs to operate sites plus service, repair, and replacements of sites and equipment.
* Printing/Media: Printing and other report output media (e.g., CD, web).
* Contracts & Grants: All contracts and grants.
* BMPs: Practice implementation costs not covered in other categories (spreadsheet calculates capital plus annual costs).

For the purposes of this application, source of funds is irrelevant. The key factors are funds needed and funds in hand, regardless of source.

**Project Timeline**

Tier 2 project timelines are necessarily simple, as recorded in Table 5. Default requirements are indicated in Table 5.

 Table 5. Project Timeline

|  |  |  |  |
| --- | --- | --- | --- |
| **Activity** | **Year 1** | **Year 2** | **Year 3** |
| WQ Monitoring | X | X | X |
| LU/LT Monitoring | X | X | X |
| BMP Implementation | (1st or 2nd Year depending upon BMP type) |  |
| Semi-Annual Reports | X | X | X |
| Annual Report | X | X |  |
| Final Report |  |  | X |

**References:**

Rathbun, J. 2007. Quality assurance project plan for the Central Mine Site Stamp Sand remediation project version 1; August 8, 2007, Michigan Department of Environmental Quality Water Bureau – Nonpoint Source Unit Lansing, MI.

Spooner, J., R.P. Maas, M.D. Smolen and C.A. Jamieson. 1987. Increasing the sensitivity of nonpoint source control monitoring programs. p. 243-257. In: Symposium on Monitoring, Modeling, and Mediating Water Quality. American Water Resources Association, Bethesda, Maryland. 710p.

Spooner, J., S.L. Brichford, D.A. Dickey, R.P. Maas, M.D. Smolen, G.J. Ritter and E.G. Flaig. 1988. Determining the sensitivity of the water quality monitoring program in the Taylor Creek-Nubbin Slough, Florida project. Lake and Reservoir Management, 4(2):113- 124.

Tetra Tech. 2008. Tier 2 national monitoring program project cost estimation spreadsheet, U.S. Environmental Protection Agency, Washington, DC.

Tetra Tech. 2011. Minimum detectable change analysis, Tech Notes 7, XX 2011. Developed for U.S. Environmental Protection Agency by Tetra Tech, Inc., Fairfax, VA.

1. This is a 2-sided t-test, so t for 38d.f. and p=0.025 (0.05/2) is used in the calculation. [↑](#footnote-ref-1)