TECHNICAL MEMORANDUM:

Proposed Methods for the SET Cost Estimation Subroutine

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Prepared for the
Upper Neuse River Basin Association

Prepared by

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1 Introduction

Tetra Tech is developing a Best Management Practice (BMP) Cost Estimation Subroutine for the Upper Neuse Site Evaluation Tool. The tool will allow a user to compare the cost of stormwater BMP systems and the cost savings for reducing impervious surfaces within a site design. This memo addresses the ideas expressed at the May 12 UNRBA Site Evaluation Tool Task Group meeting. The group suggested that, during the stage of design at which the SET will be used, a designer will not have accurate estimates of BMP components like excavation, soil mixture, gravel and other materials. The group requested that the SET estimate costs based on square feet of surface area, cubic foot storage volume, or other whole BMP size units. Based on this guidance, this memorandum describes a cost subroutine that uses square foot costs and other appropriate units based on BMP size.

The SET BMP Cost Subroutine will address:

- Construction costs for BMPs, treatment train connections, additional stormwater conveyance structures, and total site pavement,
- Inspection and maintenance costs for BMPs, and
- Opportunity cost of land devoted solely to BMPs.

Preliminary maintenance cost estimates will be used as placeholders until the maintenance cost estimates being developed by NC State University researchers are available. The SET will include an opportunity cost of land estimate in which the area and cost inputs will be user-defined and optional.

Tetra Tech's goal is to design a user-friendly tool that can be easily updated as new BMP cost data are available. Continued attention to the development of the tool and input on the design of the SET Cost Subroutine by UNRBA will be greatly appreciated.

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2 Construction Cost Methods

2.1 General Methods for all BMPs

BMP cost data literature provides total construction cost estimates based on watershed area, storage volume, BMP area, or BMP length. We will use cost data primarily from the NC State Biological and Agricultural Engineering Department (NCSU-BAE), USEPA, and the Low Impact Development Center. Some sources provide regression equations estimated from actual site costs and dimensions; other sources provide approximate cost estimates or ranges by volume, area, or length of the BMP.

The subroutine uses regression equations, when available, to develop cost ranges. Approximate cost ranges from reliable sources will be used when regression equations are not available for a BMP. If no reliable cost data is available for a BMP, unit prices in RS Means (2003) will be used to estimate an approximate cost range, similar to square foot cost. It should be noted that the above sources consider labor in the cost data, but usually do not provide a separate cost estimate for labor. Table 1 lists the proposed user inputs and sources for the construction costs. User inputs will be minimized to the extent possible.

National and out of state costs will be adjusted to local prices using RS Means (2003) indices. The cost range will be limited to around 15 percent plus and minus the mean of the range. This will provide some error control and prevent unreasonably wide ranges. To evaluate the tool's accuracy, during beta-testing of the SET, the cost subroutine will be used to estimate site costs, and the output will be compared to the actual costs of the site.

Table 1. Proposed User Inputs for Construction Cost

Element	Input	Cost Data Source
BMPs		
Wet Pond	BMP Surface Area	Wossink and Hunt, 2003
Dry Detention	Storage Volume	Center for Watershed Protection, 1997
Stormwater Wetland	BMP Surface Area	Wossink and Hunt, 2003
Bioretention	BMP Surface Area	Wossink and Hunt, 2003
Sand Filter	BMP Surface Area	Wossink and Hunt, 2003
Enhanced Grass Swale	BMP Surface Area	TBD
Grass Swale	BMP Surface Area	USEPA, 2002
Infiltration Trench	Storage Volume	Center for Watershed Protection, 2000
Vegetated Filter Strip with Level Spreader	BMP Surface Area and Level Spreader Length	Filter Strip: TBD Level Spreader: Hunt, 2001
Existing Forest Buffer	BMP Surface Area (beyond 50 foot buffer)	TBD

Element	Input	Cost Data Source
Restored Forest Buffer	BMP Surface Area	TBD
Permeable Pavement	BMP Surface Area, by several types and depths	NAHB, 2004 and Low Impact Development Center, 2003
Cisterns and Rain Barrels	Number of Units of a Fixed Storage Volume	Low Impact Development Center, 2003 and Rain Water Solutions, Inc., 2004
Green Roofs (extensive)	BMP Surface Area	Hunt, personal communication
Treatment Train Components		
Piping	Length, by Several Pipe Diameters	RS Means, 2003
User Defined	(User enters total BMP cost)	NA
Other?	TBD	TBD
Additional Stormwater Conveyance		
Curb and Gutter	Length	RS Means, 2003
Catch Basins	Number	RS Means, 2003
Storm Sewer	Length, by Several Pipe Diameters	RS Means, 2003
Total Site Pavement Costs		
Parking Lot - Asphalt	Area	RS Means, 2003
Street - Asphalt	Area	RS Means, 2003
Street - Cement	Area	RS Means, 2003
Sidewalks - Cement	Area	RS Means, 2003
Driveways - Asphalt	Area*	RS Means, 2003
Driveways - Cement	Area*	RS Means, 2003
Walking Paths - Asphalt	Area*	RS Means, 2003

*Indicates that this item will be included if time permits.

2.2 BMPS WITH ECONOMIES OF SCALE

Most BMP cost regression equations contain an exponent that accounts for economies of scale. If the SET tool used these equations alone, the tool might be difficult to update when new information on BMP costs is available, but not in the form of a regression equation. For BMPs that exhibit economies of scale, incremental costs will be estimated so that the BMP tool can be updated easily. For example, Table 2 lists ranges of surface area that can be used to estimate wet pond cost. If the surface area of a wet pond is greater than 1.5 acres but less than 3 acres, then the SET will estimate the wet pond cost as between $416,551 and $661,224. As noted above, the

increments will range from about minus 15 percent to plus 15 percent of the mean cost in each interval.

The estimates in Table 2 use two equations. With Equation 1, watershed area is used to estimate the cost of a wet pond draining a certain watershed area. This equation was estimated with data from 13 wet ponds. With Equation 2, the watershed area is used to estimate the surface area associated with that watershed area. This equation was developed by NCSU-BAE and based on typical impervious surface distributions and rules of thumb (Wossink and Hunt, 2003).

Equation 1. Relationship of Wet Pond Construction Cost to Watershed Area (Wossink and Hunt, 2003)

$C = 14{,}326x^{0.67}$ where C = *cost of wet pond construction*

x = *watershed area draining to wet pond*

Equation 2. Relationship of Wet Pond Surface to Watershed Area (Wossink and Hunt, 2003)

$SA = 0.015x$ where SA = *surface area of wet pond;*

x = *watershed area draining to wet pond*

Table 2. Example of Wet Pond Surface Area Intervals that Will Be Used to Estimate a Range of Construction Costs

Surface Area of Pond (acres)[1]		Cost	
Min	**Max**	**Min**	**Max**
0.02	0.04	$18,909	$38,652
0.05	0.07	$39,542	$54,971
0.08	0.15	$55,722	$88,153
0.15	0.29	$88,750	$136,569
0.30	0.44	$141,355	$181,413
0.45	0.59	$185,590	$221,344
0.60	0.74	$225,140	$258,009
0.75	1.12	$261,533	$343,070
1.13	1.50	$343,378	$416,523
1.50	2.99	$416,551	$661,224
3.00	4.49	$663,453	$869,124
4.50	5.99	$871,075	$1,054,926
6.00	7.49	$1,056,700	$1,225,866
7.50	11.25	$1,227,515	$1,611,641
11.25	14.99	$1,611,655	$1,953,785

[1]Ranges area rounded to the nearest hundredth and will be continuous within the programming.

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3 Maintenance and Inspection Cost Methods

Bill Hunt at NC State University is researching BMP maintenance requirements and will be drafting updated requirements and estimated annual costs by December 2004. When Bill Hunt's final estimates are available, the preliminary maintenance costs will be updated. The lists of BMP maintenance requirements will be updated based on available information from NC State researchers. Based on current guidance from Bill Hunt, the following rule of thumb approach will be used: 50 percent of the construction cost will be used as a preliminary estimate of maintenance and inspection costs over a BMP's 20-year lifetime (Hunt, 2004).

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4 Approach to Opportunity Cost of Land

SET users may benefit from estimating the opportunity cost of land devoted to BMPs. This cost is defined as the value of the foregone development on the BMP land. When estimating this cost, the user would distinguish between BMPs that are incorporated into the landscape and building features and those that require land with sole use as a BMP. Examples of BMPs incorporated into the landscape include bioretention cells located in yards, parking medians, landscaped areas, green roofs, and underground parking storage. Examples of BMPs that do not share land with other uses include large wet ponds, large bioretention areas, or stormwater wetlands. To estimate the opportunity cost, one estimates the revenue that could have been realized if that land was available for another use.

Since land values vary considerably geographically and over time, it would be difficult to program a spreadsheet that would predict accurate land values for every user. Therefore, this portion of the SET will allow a user to enter their estimate of land value; the use of this portion will be optional.

User inputs will include the total area of land with sole use as a BMP and the estimated opportunity cost of this land. The output will display the total area devoted solely to BMPs and the total opportunity cost, if specified.

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5 Structure and Programming of Tool

The Cost Subroutine will add two additional tabs to the SET: 1) Cost Inputs and 2) Cost Data and References. The Cost Inputs worksheet will collect all of the inputs required for the cost estimation, but this sheet will only show inputs for BMPs that were selected in the "BMPs" sheet of the SET. An example of this worksheet is provided in Figure 1 and Figure 2. This example shows all the possible inputs; while using the tool, the users would only see the inputs pertaining to their selected BMPs.

Existing SET inputs will be used to the extent possible so that new user inputs are minimized. If the user has already entered the inputs in the previous worksheets, the program will enter the values automatically in the Cost Inputs sheet. Once the user inputs the appropriate units, the cost of each BMP or component will appear to the right of the input. For BMPs that exhibit economies of scale, the user will be allowed to enter inputs for multiple BMPs of the same type. For example, building one large pond is less expensive than building several ponds of the same volume. Additional features will include:

- A year's input will be required and the costs will automatically be increased by 3 percent each year to account for inflation.
- A warning message will appear if the user enters too few or too many inputs.
- A user will be able to enter user-defined costs for each BMP.
- Overhead and profits may be added to each BMP cost with a toggle switch (not shown in figure). If a developer plans to use subcontractors to construct a BMP, the user may want to add overhead and profit to estimate the subcontractors' price. These costs will be added as a percent of the construction cost.

The Cost Data and References worksheet will list the sources used for each BMP cost estimate and allow the user to adjust the cost assumptions based on new data. When new cost data are entered, the user will be prompted to update the source information as well. The program will use the year of the new cost data to adjust for future inflation.

Cost output will be incorporated into the water quality and volume output reports. The program will calculate and display the following in the output sheets:

- Total Stormwater Control System cost, including BMPs and stormwater conveyance
- Maintenance Costs
- Pavement Cost
- Land Area and Land Opportunity Cost (if entered by user)
- Ratio of Cost to Pollutant Removal

3. Input Cost Estimation Quantities

Year	

Site Element	Unit	Input*	SET Cost	User-Defined Cost*
BMPs				
Wet Pond				
a. Wet Pond 1	Surface area in SF			
b. Wet Pond 2	Surface area in SF			
c. Wet Pond 3	Surface area in SF			
d. Wet Pond 4	Surface area in SF			
Dry Detention (Extended)				
a. Dry Pond 1	Storage volume in CF			
b. Dry Pond 2	Storage volume in CF			
c. Dry Pond 3	Storage volume in CF			
d. Dry Pond 4	Storage volume in CF			
Stormwater Wetland (including Pocket Wetland)				
a. Wetland 1	Surface area in SF			
b. Wetland 2	Surface area in SF			
c. Wetland 3	Surface area in SF			
d. Wetland 4	Surface area in SF			
Sand Filter				
a. Sand Filter 1	Surface area in SF			
b. Sand Filter 2	Surface area in SF			
c. Sand Filter 3	Surface area in SF			
d. Sand Filter 4	Surface area in SF			
Veg. Filter Strip with Level Spreader				
a. Veg. Filter Strip	Surface area in SF			
b. Level Spreader	Length in LF			
Forest Buffer				
a. Surface area beyond 50 feet buffer	Surface area in SF			
b. Restored Buffer	Surface area in SF			
Permeable pavement				
a. Grass parking reinforced with plastic grid	Surface area in SF			
b. Porous Concrete	Surface area in SF			
c. Porous Asphalt	Surface area in SF			
d. Honeycomb Pavers	Surface area in SF			
Green Roofs				
a. Extensive: no public access	Surface area in SF			
b. Intensive: public access	Surface area in SF			
Cisterns and Rain Barrels	(enter number of fixed volume units)			
a. Galvanized Steel	27 CF units			
	267 CF units			
b. Polyethylene	22 CF units			
	241 CF units			
c. Fiberglass	47 CF units			
	1337 CF units			
d. Fiberglass/Steel Composite	40 CF units			
	668 CF units			
e. Rainbarrels	9 CF units			
Bioretention	Surface area in SF			
Enhanced Grass Swale ("dry swale " in MD manual)	Swale surface area in SF			
Grass Swale	Swale surface area in SF			
Infiltration Trench	Storage volume in CF			

*Indicates columns for user input.

Figure 1. Draft of Inputs Worksheet for SET Cost Subroutine (blue cells indicate user inputs)

Site Element	Unit	Input*	SET Cost	User-Defined Cost*
Treatment Train Components				
Piping	Length in LF			
User Defined				
Other?				
Additional Stormwater Conveyance				
Curb and Gutter	Length in LF			
Catch Basins	Number			
Storm Sewer	Length in LF			
Total Site Pavement Costs				
Parking Lot - asphalt	Surface area in SF			
Street - asphalt	Surface area in SF			
Street - cement	Surface area in SF			
Driveways - asphalt	Surface area in SF			
Driveways - cement	Surface area in SF			
Sidewalks - cement	Surface area in SF			
Walking Paths - asphalt	Surface area in SF			
User-Defined BMPs				
a. BMP 1				
b. BMP 2				
c. BMP 3				
d. BMP 4				
Opportunity Cost of Land				
Land are devoted solely to BMPs	SF			
Land are that shares	SF			
Estimated opportunity cost of land (optional)	$/SF			

*Indicates columns for user input.

Figure 2. Draft of Inputs Worksheet for SET Cost Subroutine (continued; blue cells indicate user inputs)

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6 References

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