Exhibit C

The Lower Mississippi River Watershed Management Organization (LMRWMO) has developed the following four water quality cost allocation methods:

1. Total Area
2. Effective Impervious Area
3. Relative Pollutant Load
4. Allowable Pollutant Load

A description of each of these four methods is provided in this exhibit, including applicable formulas, and criteria for when application of each method is appropriate. In addition, four hypothetical scenarios are presented to illustrate differences between the four cost allocation methods listed above. An alternative approach to the cost allocation methods listed above is also included, referred to as the "Cost for Equivalent Treatment." This cost allocation approach is described separately, as it must be assessed on a case-by-case basis and is intended for use only when the above methods are considered unacceptable to the LMRWMO Board.

Summary of Cost Allocation Methods

Method 1: Total Area Method

The Total Area method allocates cost based on the fractions of the total tributary area within each member city. This method does not account for the variation in pollutant loading from areas of differing land use (and imperviousness). Nor does this method account for water quality treatment that may already occur upstream of the proposed project (via natural systems or past best management practice (BMP) implementation such as ponds or sedimentation basins). This is the simplest water quality cost allocation method presented, described by Equation 1:

$$Cost_i = \frac{Area_i}{Area_{total}} \qquad \text{Equation 1}$$

…where $Cost_i$ = cost to member city i

$Area_i$ = area within member city i tributary to project

$Area_{total}$ = total area tributary to project

The Total Area Method normally should not be used for projects encompassing a wide range of land use and/or various levels of upstream treatment (and therefore varying pollutant loads). The Total Area cost allocation method is most applicable when the tributary drainage areas from each member city contribute similar pollutant loads per unit area. This is likely to occur when tributary watersheds have similar land use and levels of existing water quality treatment. Criteria for application of this method include:

- Similar land uses across member cities' tributary areas
- Similar levels of existing treatment (if applicable) across member cities' tributary areas/land uses

Method 2: Effective Impervious Area Method

The Effective Impervious Area Method is similar to the Total Area Method in that costs are apportioned based on the fractions of tributary area within each member city. However, the Effective Impervious Area Method is based on the fraction of impervious area (versus total area) within each member city, to account for variation in land use (and imperviousness) throughout the tributary area. The Effective Impervious Area Method also accounts for existing upstream water quality treatment by applying a treatment effectiveness coefficient to areas already receiving treatment, in recognition that the pollutant contribution from "treated" areas will be less. The Effective Impervious Area Method is appealing because it accounts for differences in pollutant contribution from tributary areas both due to land use differences (via an assumed relationship between imperviousness and pollutant loading) and the presence of upstream treatment.

In the Effective Impervious Area Method, the cost is apportioned to each member city based on the fraction of that city's effective tributary area to the total effective tributary area. The effective tributary area includes 100% of the untreated impervious area and a fraction of the treated impervious area. This method is described by the following formulas:

$$Cost_i = \frac{Area_{effective,i}}{Area_{effective,total}} \qquad \text{Equation 2-a}$$

$$Area_{effective,i} = Area_{untreated\ imp,i} + E * Area_{treated\ imp.,i} \qquad \text{Equation 2-b}$$

…where $Cost_i$ = cost to member city i

$Area_{effective,i}$ = untreated impervious area plus fraction of treated, impervious

$Area_{effective,total}$ = sum of effective areas of each tributary member city

$Area_{untreated\ imp,i}$ = untreated impervious area within member city i tributary to project

$Area_{treated\ imp,i}$ = treated impervious area within member city i tributary to project

E = BMP treatment effectiveness (unitless value from 0 to 1.0, 0.5 proposed for total phosphorus)

As shown in Equation 2-b, the Effective Impervious Area Method incorporates treated areas using a coefficient to account for the treatment efficiency of existing Best Management Practices (BMPs). For simplicity, a single coefficient of 0.5 is proposed. This value is based on total phosphorus removal performance presented in Table L8 of the *Minnesota Stormwater Manual (*MPCA, 2008). Other coefficients may be more applicable for specific pollutants. Impervious areas (both treated and untreated) are calculated by summing the impervious area for all tributary land uses. Impervious area for each land use is calculated based on the tributary area and an assumed impervious fraction for the given land use (see Table 1 for example impervious fraction assumptions for a selection of land uses).

$$Area_{imp,i} = \sum K_j Area_{i,j} \qquad \text{Equation 2-c}$$

…where $Area_{imp,i}$ = treated or untreated impervious area within member city *i* tributary to project

$Area_{i,j}$ = area within member city *i* of land use *j* tributary to project

K = fraction of imperviousness for land use *j* (unitless value from 0 to 1.0)

The Effective Impervious Area cost allocation method is most applicable when tributary areas are comprised of different land use types and existing water quality treatment BMPs. This method simplifies variability in treatment efficiency in order to limit method complexity. If no existing treatment BMPs are in-place, this method presents a relatively simple way to account for variability in land use. Criteria for application of this method include:

- Impervious areas are present in tributary watersheds
- Varying land uses across tributary watersheds
- Treatment BMPs are present in tributary areas

Table 1. Average impervious fraction of land use types

Land Use	Impervious Fraction
Natural/Park/Open	0.0
Low Density Residential	0.2
High Density Residential	0.4
Institutional	0.5
Highway	0.5
Commercial	0.8
Industrial/Office	0.8

Method 3: Relative Pollutant Load

Method 3 – Relative Pollutant Load allocates cost based on the fraction of the total pollutant load to the project that is contributed by each member city. This method is more detailed than Method 2 (presented above) in that it estimates pollutant loading (pounds of pollutant per year) from land used and considers variable effectiveness of existing treatment. While a detailed runoff model (e.g., P8) could be used to estimate Relative Pollutant Loading, use of a calculation based "simple" method is proposed to limit the level of computational effort required. The simple method, which is described in the Minnesota Stormwater Manual, estimates runoff volume and pollutant concentrations based on imperviousness and land use, as described in the following formulas:

$$Cost_i = \frac{W_i}{W_{total}} \qquad \text{Equation 3-a}$$

$$W_i = W_{untreated,i} + \sum W_{BMP,j,i} \qquad \text{Equation 3-b}$$

$$W_{untreated,i} = 0.2(P)(R_v)(C)(Area_{untreated,i}) \qquad \text{Equation 3-c}$$

$$W_{BMP,j,i} = 0.2(P)(R_v)(C)(Area_{BMP,j,i})(BMP_{RE}) \qquad \text{Equation 3-d}$$

…where $Cost_i$ = cost to member city i

W_i = annual load contributed by member city i (lbs/yr)

W_{total} = total annual load to the project (lbs/yr)

$W_{untreated,i,}$ = annual load contributed from untreated areas of member city i (lbs/yr)

$W_{BMP,i,j}$ = annual load contributed from areas of member city i treated by BMP j (lbs/yr)

P = annual precipitation (inches)

R_v = runoff coefficient (0.05 + 0. 9*I) (unitless)

I = average percent imperviousness of tributary area (unitless value from 0 to 1.0)

C = concentration of pollutant in runoff (0.3 mg/L for P in urban environments)

$Area_{untreated,i}$ = untreated area within city i tributary to project (acres)

$Area_{BMP,j,i}$ = area within city i tributary to treatment BMP j (acres)

BMP_{RE} = 1 – BMP treatment efficiency (unitless value from 0 to 1.0)

0.2 = unit conversion factor based on the input parameters as shown above

In the simple method, annual precipitation (P), area, and a runoff coefficient (R_v) are multiplied to create a runoff volume. That volume is multiplied by an assumed pollutant concentration (C) to determine the load (W). The runoff coefficient is an area-weighted average based on imperviousness. The fraction of imperviousness for each land use type is as described in Method 2 (see Table 1).When there is existing treatment within the tributary watershed, the pollutant removal is quantified by the removal efficiency of a given best management practice (BMP_{RE}). BMP removal efficiencies are derived from Table L8 of the *Minnesota Stormwater Manual* (MPCA, 2008). The total load from a member city to the proposed project is the sum of the untreated load and the treated load from each BMP.

This method is more technical than area-based methods and requires detailed user inputs. This method accounts for varying degrees of treatment. This method is identical to Method 2 (Impervious Area Method) if all BMP treatment efficiencies are the same. The benefit of this method is the calculation of annual load from each area, which may be required for grant reporting or demonstrating waste load allocation (WLA) compliance. Criteria for application of this method include:

- Varying land uses across tributary watersheds
- Significant treatment BMPs are present in tributary areas
- Wide range in effectiveness of existing treatment

Method 4: Allowable Pollutant Load

Method 4 – Allowable Pollutant Load, apportions cost for water quality improvements similar to the existing allowable flow method, but based on pollutant load rather than flow. In this method, an upstream member city's portion of the project cost is based on the percentage of the upstream city's "excess" load relative to the total load to the project. Excess load is the total load from the upstream member city less an "allowable" load. Thus, the upstream city receives a credit for that allowable pollutant load. The credit is paid by the downstream city in which the project is located. The cost assigned to the city in which the project is located is based on the ratio of that city's total load (including the allowable pollutant loads from all upstream member cities) to the total load to the project.

The total load from areas tributary to the project is calculated using the simple method as described in Method 3 – Relative Pollutant Load. There are many ways that the "allowable" pollutant load could be defined. Allowable pollutant load is calculated by multiplying a member city's tributary area by an export coefficient (pollutant loading per unit area) corresponding to natural conditions. For simplicity, a single export coefficient is proposed for each pollutant. An export coefficient of 0.15 kg/ha/year (or 0.17 lbs/acre/year) is proposed for total phosphorus generated from natural areas. This value represents a combination of forested, mixed, and idle land export coefficients summarized in the *Review of Published Export Coefficients and Event Mean Concentration Data* (Lin, 2004). Excess load is calculated as the difference between the total load and the allowable pollutant load. This method is described by the formulas shown below:

$$Cost_{up.\ i} = \frac{W_{excess,up.\ i}}{W_{total}} \qquad \text{Equation 4-a}$$

$$W_{excess,up.\ i} = W_{up.\ i} - W_{allowable,up.\ i} \qquad \text{Equation 4-b}$$

$$W_{allowable,up.\ i} = (C_{nat})(Area_{up.\ i}) \qquad \text{Equation 4-c}$$

$$Cost_{host} = Cost_{total} - \sum Cost_{up.\ i} = \frac{W_{total} - \sum W_{excess,up.\ i}}{W_{total}} \qquad \text{Equation 4-d}$$

…where $Cost_{up.\ i}$ = cost to upstream member city *i*

$Cost_{host}$ = cost to member city in which the project is located

W_{total} = annual total load to project (lbs, see Method 3 – Relative Pollutant Load)

$W_{up.\ i}$ = annual total load from upstream member city *i* tributary to project (lbs, see Method 3 – Relative Pollutant Load)

$W_{allowable,up.\ i,}$ = annual allowable pollutant load from upstream member city *i* tributary to project (lbs)

$W_{excess,up.\ i}$ = annual excess load from upstream member city *i* tributary to project (lbs)

$Area_{up.\ i}$ = area within upstream member city *i* tributary to project (acres)

C_{nat} = pollutant-specific export coefficient (lbs/acre/yr, 0.17 proposed for total phosphorus)

The allowable pollutant load calculation shown above is provided as a simple method applicable to most situations. In some cases (e.g., TMDL waste load allocations) it may be useful to define allowable pollutant load through other methods. Relative to Method 3 – Relative Pollutant Load, Method 4 rewards member cities that have taken steps to reduce their loading towards pre-development levels. Criteria for application of this method are similar to Method 3 and include:

- Varying land uses across tributary watersheds
- Significant treatment BMPs are present in tributary areas
- Wide range in effectiveness of existing treatment

Alternative Approach: Cost for Equivalent Treatment

Cost for Equivalent Treatment apportions the cost for water quality improvements located downstream of a member city based on the cost to achieve the same level of treatment through other means. In this method, an upstream city would contribute to a downstream city's water quality improvement project based on the cost of implementing other equally-effective BMPs, and the share of the improvement (or pounds of loading reduction) that they get credit for. This method implies that a pollutant reduction target has been established for each city (i.e., improving the quality of a downstream lake requires a certain level of treatment throughout the watershed). Desired load reductions could be estimated using the simple method described in Method 3 (Relative Pollutant Load).

This method could be considered when an upstream city believes the proposed downstream water quality improvement project is too expensive as a result of BMP selection and/or other design factors, and a less expensive option exists to achieve the expected results of the downstream project. However, this method is only applicable if the less expensive option is feasible and can be demonstrated to achieve similar results, through comparison of estimated load reductions for the proposed project and the alternative, equivalent treatment. The inherent difficulty of the Cost for Equivalent Treatment approach is assessing an appropriate cost for equivalent treatment. The cost of achieving a given load reduction may vary based on many factors, including treatment location (i.e., upstream versus downstream), further complicating the estimation of a cost for equivalent treatment. Given the number of variables involved, this cost allocation approach is less structured than the other methods.

Ultimately, the cost for equivalent treatment allocation method must be applied on a case-by-case basis and should be limited to situations where other cost allocation methods are not applicable or acceptable to the LMRWMO Board.

Method Comparison via Hypothetical Scenarios

Four hypothetical scenarios involving three contributing cities were developed to illustrate the differences between cost allocation Methods 1 through 4 (Method 5 – Cost of Equivalent Treatment must be considered on a case-by-case basis and cannot be evaluated in the hypothetical situations presented here). Characteristics of the three contributing cities were varied to create the following four scenarios (see Figure 1):

- Scenario 1 – Identical land use with no treatment
- Scenario 2 – Different land use with no treatment
- Scenario 3 – Identical land use with varying levels of treatment
- Scenario 4 – Different land use with varying levels of treatment

For simplicity, all four scenarios include three contributing cities, with equal land area contributions. The contributing areas include:

- City A – 10 acres located in member city A, upstream of the project
- City B – 10 acres located in member city B, upstream of the project
- City C – 10 acres located in member city C, in which the project is located

Each scenario and the resulting relative cost distributions are summarized in the following sections.

Figure 1. Schematic of scenarios used to evaluate cost allocation methods

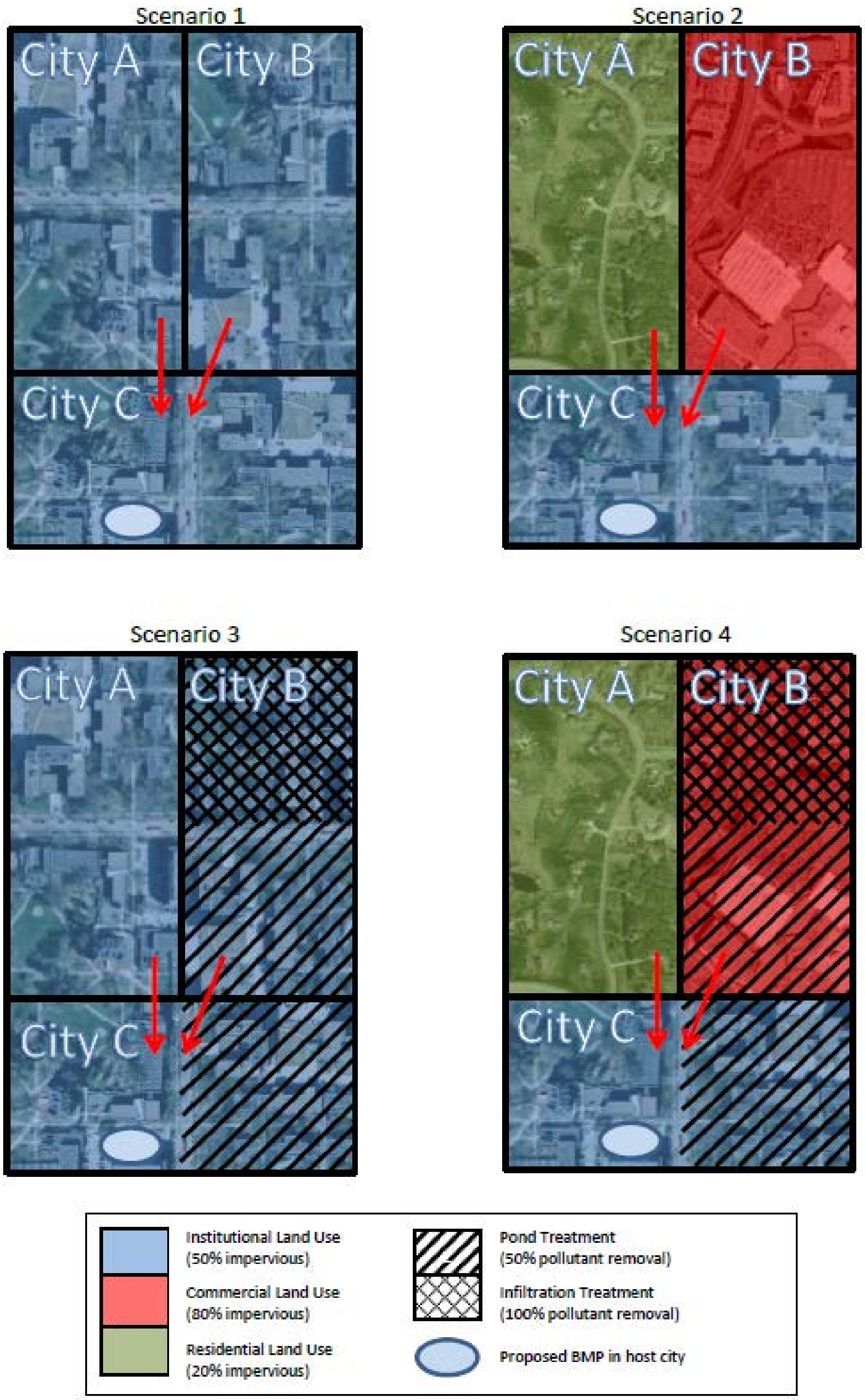

Figure 1. Schematic of scenarios used to evaluate cost allocation methods

Scenario 1 – Identical Land Use with No Treatment

Scenario 1 assumes institutional land use (50 percent impervious area) for all areas within each contributing city. All land within each contributing city is assumed to be untreated. This scenario is illustrated in Figure 1. The relative cost breakdown between cities A, B, and C is illustrated for each of the four cost allocation methods in Figure 2.

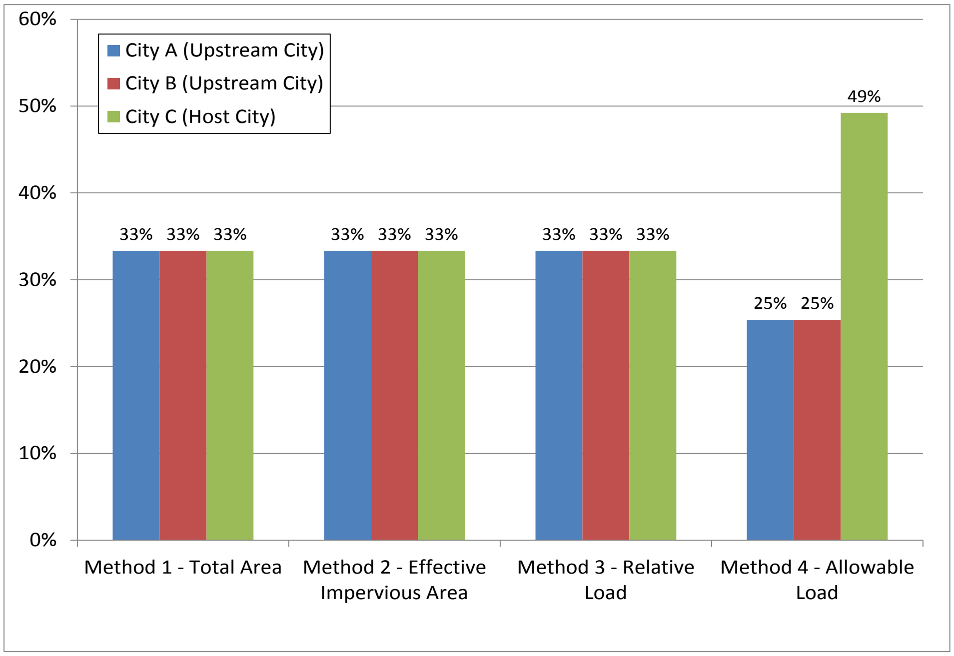

Figure 2. Cost allocation results for Scenario 1 – Identical land use

Costs are equally distributed amongst all cities according to cost allocation Methods 1 through 3 in Scenario 1. As each city's contributing area has identical characteristics, each has the same area, impervious area, and load, resulting in equivalent cost distribution for those methods. In Method 4 – Allowable Pollutant Load, upstream cities A and B receive a credit for an allowable pollutant load, reducing their relative cost from 33 percent of the total to 25 percent of the total. City C, as the host city, bears the cost for that credit; the cost to city C increases from 33 percent to 49 percent.

Scenario 2 – Different land use with no treatment

Scenario 2 assumes a unique land use type for each contributing city. City A is classified as low density residential land use (20 percent impervious). City B is classified as commercial land use (80 percent impervious). City C, the host city, is designated as institutional land use (50 percent impervious), as in Scenario 1. No treatment is assumed for any of the contributing area. This scenario is illustrated in Figure 1. The relative cost breakdown between cities A, B, and C is illustrated for each of the four cost allocation methods in Figure 3.

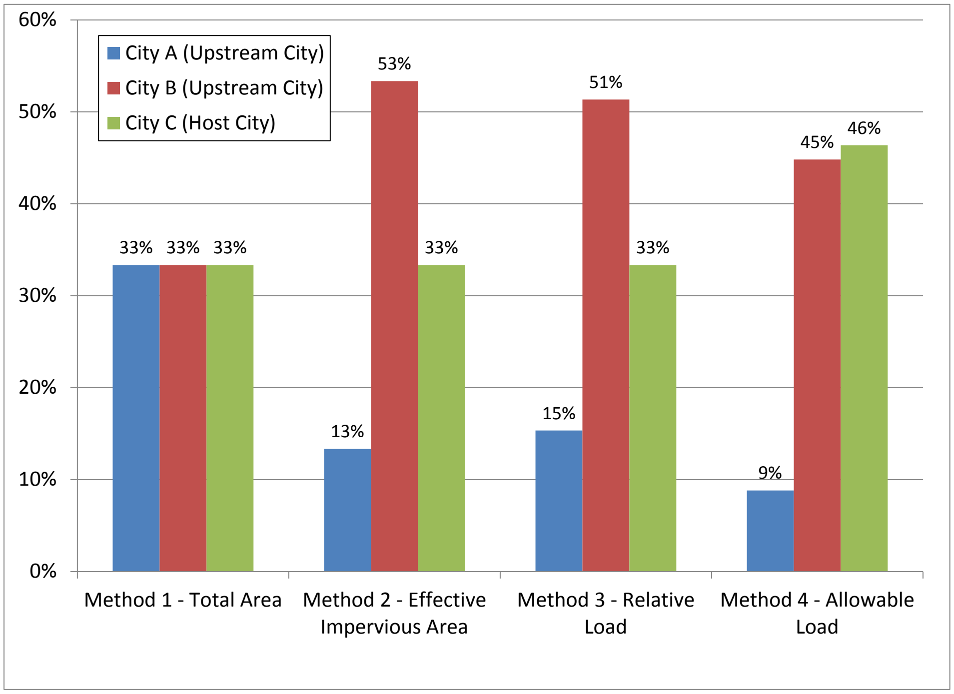

Figure 3. Cost allocation results for Scenario 2 – Different land use

In Scenario 2, the different land uses result in significantly different cost allocations for Method 2 – Effective Impervious Area as compared to Method 1 – Total area. Method 3 – Relative Pollutant Load returns a cost allocation approximately equal to Method 2, as there is no treatment in any of the contributing areas. The small difference between Methods 2 and 3 is due to the runoff coefficient used in the simple method formula to calculate pollutant load. In Scenario 2, the load from city B is much greater than its allowable pollutant load, resulting in a smaller cost difference between Method 3 and Method 4 – Allowable Pollutant Load. Thus, the additional allowable pollutant load borne by the host city (city C) is smaller than in Scenario 1.

Scenario 3 – Similar land use with varying treatment

Scenario 3 assumes the same land use as in Scenario 1, but adds various levels of existing water quality treatment. City A has no treatment. In city B, half of the tributary area is treated via a pond; the other half is treated by infiltration. Half city C's contributing area is treated by a pond and the remaining half of the area is untreated. Pollutant removal efficiency is assumed to be 50 percent for a pond and 100 percent for infiltration. This scenario is illustrated in Figure 1. The cost breakdown between cities A, B, and C is illustrated for each of the four cost allocation methods in Figure 4.

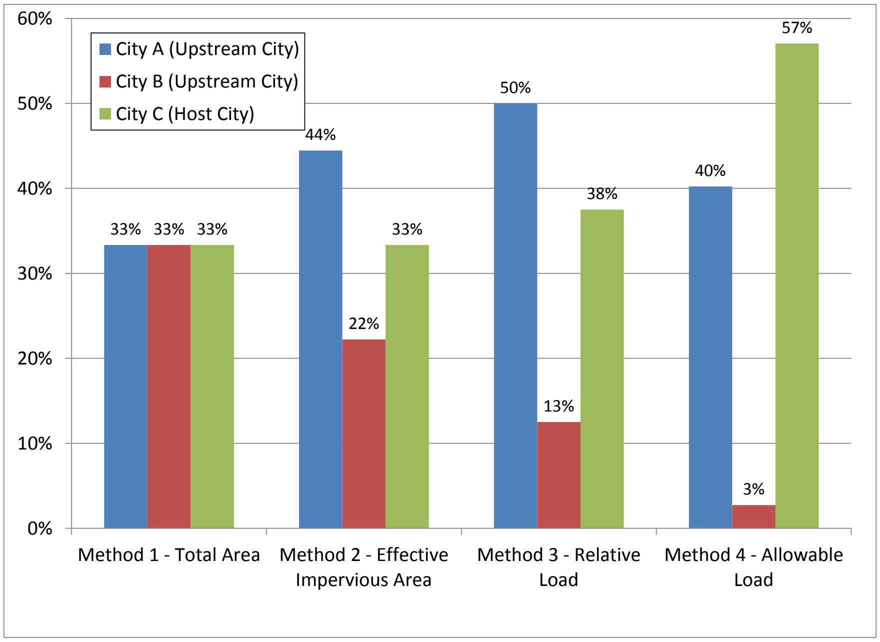

Figure 4. Cost allocation results for Scenario 3 – Identical land use with treatment

As with Scenarios 1 and 2, Method 1 – Total Area results in an equal cost allocation among each city. In Method 2 – Effective Impervious Area, the cost to city A is increased due to the lack of existing treatment BMPs within its contributing area. City B has the lowest "effective" imperviousness because 100% of the contributing area receives some kind of treatment. The cost to city C is higher than city B because only half of the area in city C receives treatment. In Scenario 3, Method 3 – Relative Pollutant Load results in a reduced cost for city B relative to Method 2 because the average treatment efficiency for the two BMPs is greater than the overall efficiency assumed in method 2 (50% pollutant removal). The relative cost to city C between Method 2 and Method 3 is similar, as the assumed treatment efficiency in Method 2 is the same as the treatment efficiency of the single pond in Method 3. The relative cost to city A is similar between Methods 2 and 3 because there is no treatment in city A. Using Method 4 – Allowable Pollutant Load, the cost assigned to city A decreases because city A gets a credit for the load expected under natural watershed conditions ("allowable" load). City B receives the same credit; the cost assigned to city B is minimal because the treatment present in city B reduces the total load to a value close to the allowable pollutant load. The cost to city C increases relative to the other methods, as city C must bear the cost of the allowable pollutant load credited to city A and city B.

Scenario 4 – Different land use with varying treatment

Scenario 4 is the most complex scenario and a scenario likely to occur in the LMRWMO. This scenario combines the differing land use types in Scenario 2 with the varying levels of existing water quality treatment of Scenario 3. This scenario is illustrated in Figure 1. The cost breakdown between cities A, B, and C is illustrated for each of the four cost allocation methods in Figure 5.

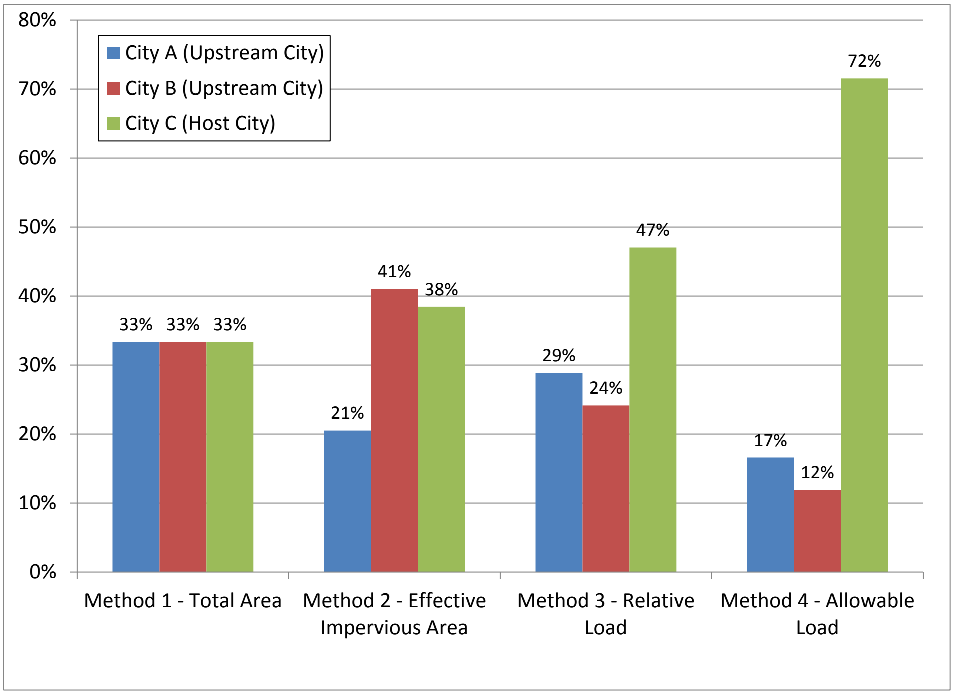

Figure 5. Cost allocation results for Scenario 4 – Different land use with treatment

Method 1 – Total Area results in the same cost breakdown as the other scenarios. In Method 2 – Effective Impervious Area, the lower imperviousness of city A reduces its cost share relative to Method 1. For city B and city C, the costs are approximately the same, as the more intense land use in city B is offset my more treatment. Like Scenario 3, the cost to city B is reduced in Method 3 – Relative Pollutant Load relative to Method 2 because the treatment efficiencies for the two BMPs in city B are greater than the assumed treatment efficiency in Method 2. As in Scenario 3, the reduction in relative cost to city B when moving from Method 2 to Method 3 results in increased relative costs to city A and city C. Method 4 – Allowable Pollutant Load, provides credit to city A and city B for their allowable pollutant loads, resulting in decreased relative costs to those cities and increased relative cost to city C as compared to the other methods.

Summary and Recommendations

Several potential cost allocation methods are presented in this memorandum. The four scenarios described in this memo provide an opportunity to compare and contrast potential water quality project cost allocation methods. Table 2 includes a summary of the cost breakdown between the three hypothetical cities for all cost allocation methods and scenarios. The cost to each city as a fraction of the total project cost is also presented in Figure 6 for all methods and all scenarios. The inputs used in these scenarios are summarized in Table 3.

Table 2. Summary of cost allocation results for all methods and scenarios

Method	Cost to City A / B / C as Percent of Total			
	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Method 1 – Total Area	33 / 33 / 33	33 / 33 / 33	33 / 33 / 33	33 / 33 / 33
Method 2 – Impervious Area	33 / 33 / 33	13 / 53 / 33	44 / 22 / 33	21 / 41 / 38
Method 3 – Relative Pollutant Load	33 / 33 / 33	15 / 51 / 33	50 / 13 / 38	29 / 24 / 47
Method 4 – Allowable Pollutant Load	25 / 25 / 49	9 / 45 / 46	40 / 3 / 57	17 / 12 / 72

Method 2 – Total Area, Method 3 – Relative Pollutant Load, and Method 4 – Allowable Pollutant Load all possess a wide range of applicability, as these methods account for differing land use and existing treatment in tributary watershed areas.

Method 4 – Allowable Pollutant Load is unique among the cost allocation methods in that it applies an "allowable load" credit to the upstream cities, resulting in increased relative cost to city C. This trend is apparent in each hypothetical scenario. This is most pronounced in Scenario 4, when city A and city B are contributing loading close to their allowable pollutant loads. This effect is masked somewhat in Scenario 2, when upstream city B is contributing load well in excess of its allowable pollutant load. Methods 2 and 3 provide similar results when treatment is not present (Scenarios 1 and 2), but deviate when treatment is present (Scenarios 3 and 4).

Method 4 – Allowable Pollutant Load differs from all other methods in that it gives upstream cities credit for the load expected under natural conditions. Should the LMRWMO wish to maintain this credit, Method 4 is recommended in all situations. If credit for allowable pollutant load is not deemed necessary, Methods 2 and 3 are recommended. When treatment is not present, Method 2 – Impervious Area is recommended. When treatment is present, Method 3 – Relative Pollutant Load is recommended.

Selecting a Cost Allocation Method

The applicability of each cost allocation method described herein varies according to the specifics of the proposed project. In general, use of the simplest method deemed appropriate and acceptable to the LMRWMO Board shall be used. Because of the additional effort associated with the Cost for Equivalent Treatment option, use of that allocation approach should be limited to instances when the affected member cities cannot agree to another cost allocation method.

The following should normally be used for method selection, but is not mandatory:

- If the tributary drainage areas from each member city are similar, consider Method 1 (Total Area Method).
- If the project cost is relatively low, consider Method 1 (Total Area Method) or Method 2 (Effective Impervious Area Method).
- If treatment BMPs are present in upstream tributary areas, consider Method 2 (Effective Impervious Area Method), Method 3 (Relative Pollutant Load) or Method 4 (Allowable Pollutant Load).
- If a quantitative calculation of pollutant load is required, consider Method 3 (Relative Pollutant Load) or Method 4 (Allowable Pollutant Load).
- When a reduction in an upstream city's financial obligation for stormwater discharged to a downstream community is appropriate due to implementation of BMPs in the upstream tributary area, consider Method 4 (Allowable Pollutant Load).
- If affected member cities are dissatisfied with all other methods, consider using the Cost for Equivalent Treatment allocation method.

When the information and resources allow, calculation and comparison of all four methods are recommended as part of determining the most appropriate cost allocation. The LMRWMO Board may determine that the most appropriate cost allocation is based directly on one of the four methods identified herein, or it may be an average or combination of several different methods. Understanding the range of possible cost allocation scenarios will result in greater confidence in the ultimate cost allocation selected.

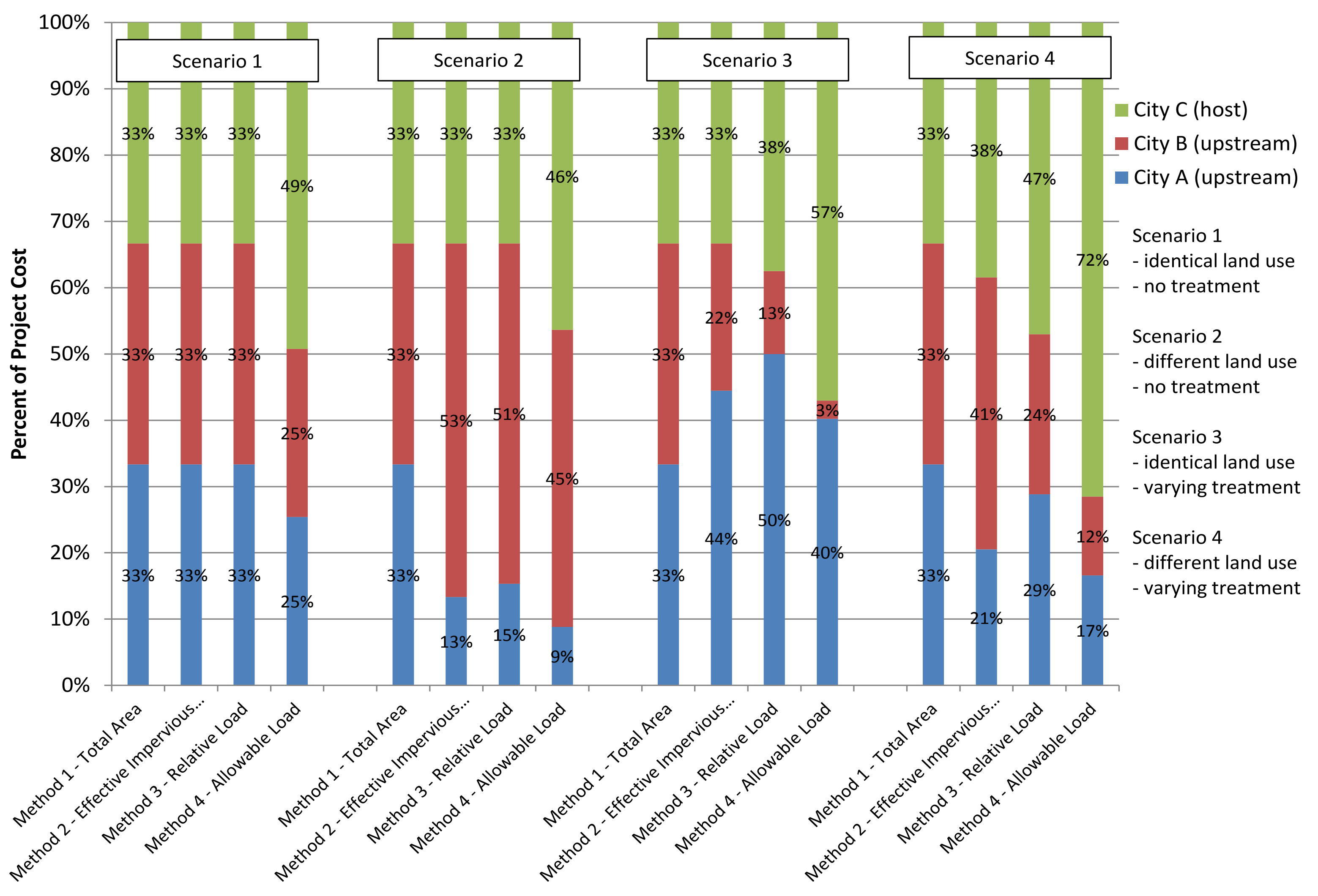

Figure 6. Summary of cost allocation results for all scenarios

Table 3. Summary of contributing area inputs for Scenarios 1 through 4

Watershed Characteristic	Scenario 1			Scenario 2			Scenario 3			Scenario 4		
	City A	City B	City C	City A	City B	City C	City A	City B	City C	City A	City B	City C
Total Area (acres)	10	10	10	10	10	10	10	10	10	10	10	10
Land Use	Inst	Inst	Inst	Res	Com	Inst	Inst	Inst	Inst	Res	Com	Inst
Impervious Fraction	0.5	0.5	0.5	0.2	0.8	0.5	0.5	0.5	0.5	0.2	0.8	0.5
Is there treatment?	No	No	No	No	No	No	No	Yes	Yes	No	Yes	Yes
Untreated Area (acres)	10	10	10	10	10	10	10	0	5	10	0	5
Area treated by BMP 1 (single pond)	--	--	--	--	--	--	--	5	5	--	5	5
BMP 1 Removal Efficiency	--	--	--	--	--	--	--	0.5	0.5	--	0.5	0.5
Area treated by BMP 2 (infiltration)	--	--	--	--	--	--	--	5	--	--	5	--
BMP 2 Removal Efficiency	--	--	--	--	--	--	--	1.0	--	--	1.0	--