Appendix S5. Summary of expert rationales.

***Overview***
Experts provided a range of rationales for quantifying nitrogen (N) export from urban stormwater BMPs under varying hydrologic conditions. Theses rationales formed the basis of the experts' estimates of N loads and associated uncertainty in response to the questions posed in the SEJ protocol document (Appendix S3). We detail the expert rationales here by summarizing the general approaches taken and by reviewing the different emphases placed by experts on factors such as physiographic province, rain event characteristics, and individual BMP design (Table 1). As part of the elicitation, experts were provided with a resource package that included regional N data for the Chesapeake Bay area and a collection of relevant N loading and stormwater studies. Experts cited a number of additional data sources that were used in their calculations or to justify their assumptions.

***General approach***
Total loads of N at watershed outlets were estimated using a range of different approaches. All experts considered watershed size (total), sub-watershed size (individual drainage area intercepted by a BMP), land use type (impervious cover), precipitation amount, and discharge amount. Some experts subdivided the watershed by land use type, differentiating different types of urban development (e.g., parking lots, roads, roofs). Most experts subdivided watersheds into smaller areas that given BMPs were designed to treat. Additional calculations (identified as "deductions", "coefficients", "factors of safety", "discounts", "corrections" or "scaling" factors") were used to account for identifiable sources of uncertainty. Two experts cited the "Simple Method" (MWCOG, 1987) which simplifies estimates of annual N loads based on four parameters: annual rainfall, impervious cover, N concentration, and standard conversion factors. One expert focused on identifying the $5^{th}$ and $95^{th}$ percentiles first, assuming normally distributed N loads for all events. One expert constructed an empirical model to quantify N loads as the sum of N inputs to the watershed, and estimated N removal by the landscape and BMPs. One expert parameterized a mechanistic model of N inputs and outputs in order to estimate N loads at various points in the watershed, creating statistical distributions for individual factors that were thought to influence N processing.

Most experts (8) took the approach of estimating an event mean concentration (EMC) to calculate the total N load exported during a given rain event. EMCs varied mainly by land use/land cover; land use/land cover was categorized as either suburban or forested. One expert further subdivided impervious cover into types: roof tops vs. driveways, and assigned a representative EMC for each. N load data were taken from published studies or government reports (see references listed below). Two experts also drew on data from their own research or experience that included published and non-published data on comparable watersheds, land use types, and BMPs. Most of these same experts (5) calculated rainfall-runoff coefficients to estimate how much stormwater runoff was generated by each precipitation event.

***Piedmont vs. Coastal Plain***
Based on the resolution of the available hydrological data, all experts were more confident in their estimates for the Piedmont scenario than the Coastal Plain scenario as reflected by relatively narrower 90% CIs for the Piedmont. When comparing the two watersheds, one expert

assumed that EMCs were higher for rain events in the Piedmont than in the Coastal Plain based on his assessment of the published literature. One expert deemed that differences in N loads by physiographic province were equivocal and that uncertainty due to other factors was likely to be more important. For the Coastal Plain scenario, all experts expressed reservations about the distance of the precipitation gauge from the BMPs (15 km away from the watershed outlet).

***Timing and magnitude of rain events***
With their assumptions and equations in place, experts carried out calculations for each rain event. Minor adjustments to base N retention efficiencies were made based on an individual expert's estimation of individual rain event characteristics that would affect individual BMP performance, though this practice was not followed by all experts. Experts held varied opinions about the impacts of extreme rain events. Many experts assumed that extreme rain events flushed N from the watershed. For the back-to-back extreme rain events described in the protocol (Appendix S3), most experts (8) deemed the events to be spaced far enough apart in time (1 month) that there would be no carryover effect of the first storm. They surmised that one month was enough time to allow soil storage capacity to reinitialize. These experts generally agreed that the back-to-back events would need to be no more than two weeks apart in order for the first event to influence N loads for the second event. One expert deemed that both extreme back-to-back events would result in increased N export, particularly given the time of year. This expert considered that during spring, summer and fall, fertilization on individual lawns would occur in between storms, providing an additional source of N during the second storm. In contrast to most experts, the expert with the highest calibration score reasoned that the first storm would flush N from the watershed, and in the case of the second storm, N export would be diluted by the volume of water being discharged from the watershed. This expert widened the bounds of uncertainty for this question accordingly.

***BMP-level characteristics***
As instructed in the protocol document, all experts assumed that BMPs were in good working order and regularly maintained. For all rain events (including extreme and back-to-back events), all experts assumed that all BMPs did not fail structurally. For individual BMP performance, expert opinions varied widely on the impact of seasonality, sediments, physiographic setting, treatment train, and antecedent conditions (which experts treated as a "soil wetness", "soil storage", or "soil capacity" factor). One expert accounted for seasonality based on their reckoning that plant growth was seasonal and would therefore influence biotic uptake of vegetated BMPs. Two other experts reasoned that season was important but that individual BMP performance was more uncertain, or that seasonal variation was captured in other parameters (e.g., soil wetness). Similar responses were elicited regarding antecedent conditions as a factor in both typical and extreme rain events.

Experts were fairly confident about the effectiveness of detention ponds and wetlands due to the availability of published studies. However estimates of performance for other BMP types were more variable. Of all the BMP categories, experts were most uncertain about ther performance of regenerative stormwater conveyance structures (RSC). Estimates of effectiveness varied between 0 and 74%. The most common approach was to use N retention efficiencies for what experts believed to be similar practices. These included bioretention (1 expert), dry swale (1), and infiltration trench (1). Experts who assigned 0% removal did so based on a lack of published data, or deemed that the area treated was very small and was therefore likely to be insignificant to the total N budget. Experts were mixed on the effects of the BMP retrofits for similar reasons (i.e., lack of data, insignificant amount of area treated by the BMP). Some published studies of BMP performance were repeatedly cited by the experts. Koch et al. 2014 (detention ponds, constructed wetlands and swales), which was provided to all experts prior to the elicitation, was cited by 7 experts. Davis et al. 2012 (bioretention) was cited by 2 experts, Filoso and Palmer 2011 (RSC) was cited by 2 experts, and MWCOG 1987 was cited by 2 experts.

***Other uncertainties***

All experts acknowledged the need for more empirical data on the effectiveness of individual BMPs across a range of hydrological conditions. When asked about what they deemed were other sources of uncertainty, several factors were identified: soil type (3 experts), groundwater inputs (2), fertilization usage (2), impervious cover sub-classifications (2), individual BMP specifications (2), biological in-stream processes (1), sewer locations (1).

Table 1. Summary of approaches used by each expert in the elicitation. Also included are environmental factors considered to be particularly important by each expert in estimating BMP performance.

| | Expert | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| General approach | | | | | | | | | | |
| Mass balance | X | | X | | X | | X | X | | |
| Process-based model | | X | | | | | | | X | |
| SWMM | | | | | | | | X | | |
| Simple Method | | | | X | | X | | | | X |
| Contextual factors | | | | | | | | | | |
| Rain event characteristics | | X | X | | | | X | X | X | |
| Physiographic province | | | | | | | | X | | |
| Subdivided watershed area | | | X | | | | X | X | X | |
| Subdivided land cover | | | X | | | | X | X | X | |
| Individual BMP | | | X | | | | X | | | |
| Antecedent conditions | | | X | | | | | X | | |
| Season | | | X | | | | | | | |
| BMP type | X | X | X | | | | X | X | X | |
| Soil type | | | X | | | | | X | | |
| Back-to-back extreme events | | | | | | | | | | |
| No difference in BMP performance | | X | X | | X | X | | X | X | X |
| Significant difference in BMP performance | X | | | X | | | X | | | |

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