Exhibit C

Comments on "Economic Analysis for the Proposed Revised Definition of 'Waters of the United States'" (EPA-Army 2018)

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Introduction

The U.S. Environmental Protection Agency and U.S. Department of the Army (EPA-Army 2015) estimated the total quantified benefits of the Clean Water Rule (CWR) to range from a low of $339 million to a high of $350 million (2014 dollars). The largest component of these benefits was due to wetland mitigation, which was estimated at $306 million (using the "original number of ORM2 other waters records" scenario). EPA-Army (2015) concluded that the benefits of the CWR exceed the costs.

In the repeal rule, EPA-Army (2017) stated that the "largest and most uncertain estimates from the[ir] 2015 CWR ... [economic analysis] are associated with the benefits of the CWA 404 program." The agencies argue that the wetland mitigation benefits are uncertain for several reasons. In response to this uncertainty the agencies choose to dismiss the monetized benefits presented in their 2015 analysis, instead presenting them as qualitative benefits in EPA-Army (2017). They justify this decision by stating that they "believe the cumulative uncertainty in this context is too large to include quantitative estimates in the main analysis for this proposed rule". In the "low end" scenario (Tables 1, p. 9) the $314 million (2016 dollars) in wetland mitigation benefits from EPA-Army (2015) are replaced by "$B". This, in effect, places a value of zero on wetland benefits as can be seen in the bottom line total in Table 1 (p. 9).[1]

The agencies have taken three different approaches to evaluate wetland mitigation benefits. In EPA-Army (2015), the agencies used only the point estimate of $306 million without sensitivity analysis around this estimate, ignoring the uncertainty. In EPA-Army (2017), the agencies again choose to avoid sensitivity analysis but this time they moved to an extreme position and avoided quantitative measurement of the benefits. In EPA-Army (2018), the agencies take a different approach than in the two previous economic analyses. That analysis adopted the most conservative, worst case scenario aggregate benefit assumption from EPA-Army (2015). The aggregate wetland benefit point estimate is $59.4. This aggregate benefit estimate is biased downward, significantly underestimating wetland benefits.

The aggregate wetland benefit is the product of willingness to pay per wetland acre and the

[1] EPA-Army refers to the CWA 404 wetland benefits as "foregone benefits" in the 2017 and 2018 economic analyses. Benefits set forth in the CWR (EPA 2015) are referred to as costs in EPA-Army (2017, 2018) and costs set forth in CWR (EPA 2015) are referred to as benefits in EPA-Army (2017, 2018). Throughout these comments I will refer to the CWA 404 wetland benefits without the "foregone" modifier to avoid confusion.

number of households who enjoy this benefit. There is one clear reason for the downward bias in the aggregate wetland benefit estimate as EPA-Army moves from the (2015) study to the (2018) study. This is the overly conservative definition of the "geographic extent of the market" (i.e., the number of households who enjoy the wetland benefit per acre). In this context, "conservative" means that the analysis errs on the side of underestimating wetland benefits. Specifically, the agencies limit benefit estimates by state boundaries—ignoring wetland benefits to households in neighboring states, the region, or nation. The economic literature demonstrates that wetland benefits are not limited by political boundaries.

It is less clear why the willingness to pay per wetland acre is lower relative to the 2015 CWR analysis, which is a significant flaw in the 2018 analysis. Several assumptions made by EPA-Army (2018) may be conservative, driving aggregate benefits down still further. Considering the uncertainty in both the estimates of the willingness to pay per acre and the number of households the appropriate approach requires a relaxation of the conservative assumptions and development of a range of benefit estimates and the completion of formal sensitivity analysis.

<u>EPA-Army (2018) relies on an inappropriately defined geographic extent of the market</u>

Smith (1993) was the first to emphasize that the "geographic extent of the market", in other words the aggregation rule, can be a more important consideration than research that fine tunes willingness to pay estimates. The aggregation rule for any given analysis is simply the method used to determine which households benefit from wetland protection and therefore should be considered in the willingness-to-pay analysis. The aggregation rule in EPA-Army (2015) was to adopt a "blended approach" between state and regional level aggregation. This blended approach is still a superior point estimate for the CWA 404 wetland benefits, as explained below. EPA-Army (2018) inappropriately restricts attention to the state-level aggregation. Standard benefit-cost analysis under uncertainty would consider the range of benefit estimates between the state level and the regional level approaches to be an appropriate approach. I will turn to the appropriate treatment of uncertainty in the last section of these comments.

EPA-Army (2018) (pp. 62-65) argues that since the primary valuation studies take a state-level approach then it is inappropriate to expand the value estimates beyond state borders. For example, consider a mean willingness to pay per acre estimate for state j, WTP_j. In this case, when aggregating willingness to pay estimates the "geographic extent of the market" is limited to the political jurisdiction by assumption. If B is the aggregate wetland benefit, then $B_j = \sum_{i=1}^{n_j} WTP_{ij} \times A_j$, where n_j is the household population of state j and A_j is the wetland acreage of state j. This aggregation rule, by assumption, constrains the aggregate wetland benefit estimate. This constraint on wetland benefits results in a downward bias because willingness to pay for wetlands spills across state lines. In their 2018 economics analysis, EPA-Army has reversed their decision from 2015 and no longer consider the value of benefits to residents of households outside the borders of the state where a wetland is located.

The critical flaw in that analysis is that willingness to pay for natural resources is not constrained by political jurisdictions. There is evidence that wetland benefits spill across state lines. This evidence is embodied in the "distance-decay" contingent valuation literature. Conceptually, the distance-decay relationship is $WTP = \alpha + \beta D$, where D is distance and α, β are parameters to be estimated. The "distance-decay" relationship is found when the parameter on distance is estimated to be negative. Willingness to pay declines as the individual or household lives further from the natural resource site. The economic jurisdiction, in contrast to the political jurisdiction, is determined from this data-driven model and not by assumption. The estimated distance over which willingness to pay should be aggregated is found by solving for the distance that drives willingness to pay to zero, $\widehat{D} = -\alpha/\beta$. With this definition of the geographic extent of the market aggregate, wetland benefits in state j are $B_j = \sum_{i=1}^{n_{\widehat{D}k}} WTP_i \times A_j$, where $n_{\widehat{D}k}$ is the population with positive willingness to pay for wetlands in state j. This aggregation rule considers all households who would benefit.

There is economic theory to support the empirical distance-decay relationship for use values and passive use values.[2] In terms of use values, Whitehead (1994, 1995a) uses the fact that the implicit price of recreational use of the resource is a function of distance (and resource quality). In the Whitehead (1994) paper, I work out the theoretical relationship between willingness to pay for a quality improvement and the implicit price of recreation. The theory shows that there should be a negative relation between willingness to pay and the implicit price of recreation, and the parameter on price provides a measure of the additional recreation trips that would be taken with the improvement in resource quality. Whitehead (1995b) shows how this relationship can be used to differentiate between use and passive use values. Huang, Haab, and Whitehead (1997) show that this relationship in the contingent valuation data is consistent with the recreation data.

Considering passive use values, Whitehead and Blomquist (1991a) develop a model that suggests a pathway from observable behavior to the formation of passive use value. The logic begins with the well-known negative relationship between site-specific outdoor recreation and distance to the site. Recreation and other past observable behaviors is a necessary condition for information about the natural resource. Then logically, information about the natural resource is a necessary condition for valid passive use values. Whitehead and Blomquist (1991a) find empirical evidence for this theory with the Whitehead and Blomquist (1991b) wetland benefit data used in EPA-Army (2018).

The distance-decay relationships described above, $WTP = \alpha + \beta D$, is a reduced-form model of these more theoretical relationships between distance and willingness to pay. The reduced form distance-decay model is better adapted to determination of the geographic extent of the market. Consideration of the distance-decay model leads to a significantly more accurate method of estimating aggregate wetland benefits relative to the political jurisdiction constrained approach

[2] The total economic value of a natural resource is the sum of use value and passive use value. Use value results from the on-site experience of a natural resource. Passive use value results from the enjoyment obtained from a natural resource while off-site. See Smith (1987).

adopted by EPA-Army (2018).

There is much evidence in the empirical contingent valuation literature that the aggregate benefits of natural resources will be biased downwards if willingness to pay is aggregated over political jurisdictions, as in EPA-Army (2018). Sutherland and Walsh (1985) and Silberman, Gerlowski and Williams (1992) were the first to demonstrate the empirical distance-decay effect. Loomis (1996) was the first to show how this relationship could affect aggregation of benefits for policy analysis. Loomis (1996) conducts Washington state-wide and national contingent valuation surveys for the value of removing two dams on the Elwha River. The empirical model suggests that willingness to pay falls by $0.01 for each mile the survey respondent is removed from the river. The mean willingness to pay is $78 in Washington State. Using the distance-decay empirical model the willingness to pay is $58 two thousand miles away. Loomis (1996) estimates that 97% of the total benefits are out-of-state.

Of the wetland valuation studies used in EPA-Army (2018), the Loomis et al. (1991) data exhibits a distance-decay effect as demonstrated by Pate and Loomis (1997). The authors present a willingness to pay function for their wetland improvement scenario of $WTP = 372 - 33 \times \ln(D)$. With this functional form, willingness to pay falls by $150 for the first 100 miles away from the wetland area but the remaining distance-decay is relatively flat, falling by $100 from 100 to 2000 miles away. Loomis (2000) shows that limiting aggregation to the state population would underestimate benefits by 82%.

This brief review of the literature suggests that the state level aggregation rule used by EPA-Army (2018) leads to an underestimate of the aggregate benefits.[3] The state level aggregation rule is, at best, a lower bound on the aggregate benefits. Presentation of the lower bound as the preferred aggregate benefit point estimate is inappropriate and cannot serve as the basis for a proper benefit-cost analysis.

<u>Willingness to pay per acre estimates</u>

Benefit transfer is defined as the use of a benefit estimate developed from a study site at a policy site for which no benefit estimate is available. A study site is the location where benefits have been estimated. A policy site is the location where a benefit estimate is needed for a benefit-cost analysis. No primary benefit study has been conducted at the policy site

There are two types of benefit transfers, both of which are used in EPA-Army (2018), though without adequate information provided to fully understand the willingness to pay per acre estimate used in the benefit-cost analysis. A unit value transfer involves the use of a willingness to pay estimate with little ability to adjust it for local conditions.[4] In contrast, a benefit function

[3] See Johnston et al. (2017) for reference to other more recent studies that investigate the distance-decay link.

[4] Note that it is possible to adjust for differences in income from the study site to the policy site with assumptions about the income elasticity of willingness to pay.

transfer is possible when the benefit estimate at the study site is a function of site and study characteristics. When the benefit estimate is transferred to the policy site, differences in the site and study characteristics can be accounted for. EPA-Army (2018) employs unit value transfer and a meta-analysis benefit function transfer.

Unit value transfer

EPA-Army (2018) describes a unit value transfer analysis but is overly cautious when interpreting the benefit transfer literature. EPA-Army (2018) asserts that a unit value transfer analysis cannot be conducted if there are significant differences in the study site and policy site. That has been shown to be incorrect. Whitehead, Morgan and Huth (2015), in the context of benefit transfer with the contingent valuation method, point out that this restrictive condition is rarely met in real world policy analysis and assess the level of error that might be experienced if benefit transfer is conducted in a less than ideal situation.

In an empirical application, Whitehead, Morgan and Huth (2015) find that unit value and benefit function value estimates across states are not statistically different, indicating the potential for valid benefit transfer. The average benefit transfer error across each of the comparison methods is 25% which is lower than most of the transfer error estimates from the contingent valuation benefit transfer studies in the literature. Kaul et al. (2013) find that the mean transfer error is 36% with a range of 20% to 125%.

The unit value transfer exercise completed by EPA-Army (2018) assigns $0 value to states that are more dissimilar than states with existing wetland benefit estimates (Table III-4). This approach is not appropriate unless the agencies believe that the value of wetlands is equal to $0 in those states. An appropriate approach would be to transfer wetland benefits to states without estimates using the best available estimate. In other words, EPA-Army (2018) should fill in the blanks in the "Unit Value Transfer Foregone Benefits" column in Table III-9 with the necessary caveats. Estimates of transfer errors from the literature could be applied in a sensitivity analysis.

Meta-analysis function transfer

Meta-analysis function transfer may be preferred to unit value transfer. Differences in study sites and study characteristics can be incorporated in a valuation model and used to develop estimates for different sites and situations. EPA-Army (2018) relies on a literature review and a meta-analysis regression model (Moeltner et al., 2018) to conduct their national level aggregate benefit analysis. The literature review describes a different set of primary benefit studies relative to that used by EPA-Army (2015).[5] The effect of the use of a different set of primary benefit studies on the willingness to pay per acre estimate is not made clear in EPA-Army (2018).

Moeltner et al. (2018) describe in detail how the meta-analysis function can be used to assign per

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[5] The studies are described in a December 10, 2018 memo from Besedin and Moeltner to the EPA.

acre wetland values in a case study. In contrast, EPA-Army (2018) provides relatively little detail about the decisions made when predicting willingness to pay per acre values (pp. 73-74). The aggregate benefit estimate in EPA-Army (2018) is $59.4 million with a 95% confidence interval of $238 thousand and $122 million. The point estimate is a 38% reduction from the comparable $96.5 million unit value transfer estimate described in Table 1 below. There is no explanation given for why the meta-analysis function transfer estimate is so much lower than the estimate adjusted from EPA-Army (2015), other than the potential effect of a different set of primary studies (but, as stated above, this is not made clear).

EPA-Army (2018) uses the same meta-analysis model as in Moeltner et al. (2018) but does not provide enough detail to assess the differences in the predicted willingness to pay per acre estimates. This raises six questions, the answers to which are needed to understand the willingness to pay per acre estimates that lead to the $59.4 million wetland benefit estimate in EPA-Army (2018):

[1] Moeltner et al. (2018) describe how to estimate the mean benefit estimate from the meta-analysis regression when the natural log of willingness to pay is the dependent variable. In general, the median willingness to pay is the exponential of the natural log: $\widetilde{WTP} = exp(lnWTP)$. The mean willingness to pay is $\overline{WTP} = exp(lnWTP + 0.5\sigma^2)$, where σ^2 is the variance of $lnWTP$. Moeltner et al. (2018) describe how to predict the mean with "error effects" and empirically shows that the median willingness to pay estimate is significantly lower than the mean willingness to pay. While Table III-9 describes "mean WTP" in the headings it is not clear if the inclusion of the second term in the parenthetical of the mean *WTP* equation has been included in the calculation. The question for the agencies is: Is the mean WTP or median WTP estimate used in the meta-analysis function transfer analysis? If the median is used then the aggregate wetland benefit estimate is biased downward since the mean willingness to pay is more appropriate for benefit-cost analysis. This is because the median is the willingness to pay where one-half of respondents are willing to pay less and the other half are willing to pay more. Conceptually, it is the amount that would generate a 50% vote in favor of a policy referendum. If the willingness to pay distribution is skewed right, the mean will be greater than the median. If the median is aggregated over the population it will be lower than the mean aggregated over the population. The mean willingness to pay aggregated over the population is the total benefit, which is the appropriate measure of willingness to pay required for benefit-cost analysis.

[2] Moeltner et al. (2018) set the lump sum variable equal to zero in order to simulate annual benefits. This variable differentiates the studies that use a one-time (i.e., lump sum) payment versus an annual payment in the contingent valuation scenarios. The mean parameter on the lump sum variable is positive, as predicted by theory (i.e., respondents will pay more if they are asked to pay a certain amount of money one time relative to being asked to pay the same amount annually). How do the Agencies handle the lump sum variable? My suggestion would be to set lump sum equal to zero as in Moeltner et al. (2018) to simulate annual payments.

[3] Moeltner et al. (2018) give equal weight to the voluntary and coercive (e.g., an income tax)

payment vehicles. This decision downwardly biases the willingness to pay per acre estimates, which would result in an underestimate of aggregate benefits if this assumption is adopted by EPA-Army (2018). Carson and Groves (2006) show that a coercive payment vehicle is one which contributes to the consequentiality of the contingent valuation scenarios. Consequential surveys more accurately measure true benefits because respondents have an incentive to answer a contingent valuation question truthfully if their responses might affect policy. There is a small empirical literature assessing how consequentiality affects benefit estimates (Vossler and Watson 2013, Groothuis et al. 2017). The early evidence suggests respondents who feel the survey is inconsequential report downwardly biased (and invalid) willingness to pay estimates. For the purposes of mimicking a consequential survey and producing a more valid wetland benefit estimate the voluntary variable should be set equal to zero. It is not clear how the Agencies handled this variable in the EPA-Army (2018) analysis.

[4] Moeltner et al. (2018) report separates estimates for all four combinations of local and forested wetlands (i.e., local/forested, local/non-forested, non-local/forested and non-local/non-forested. The EPA-Army (2018) reports one willingness to pay per acre estimate without discussion. How do the agencies handle the local and forested variables? Note that the mean parameter on the local variable is positive, providing some evidence of the distance-decay relationship described above. One way to simulate the distance-decay effect is to set the local variable equal to one for the state-level willingness to pay estimates and zero for the regional willingness to pay estimates.

[5] The meta-analysis function includes variables for three wetland functions equal to one if the function is captured in the primary study and zero otherwise: cultural ("nonextractive recreation"), provisioning ("fishing, hunting") and regulating ("water filtration, flood control"). The Moeltner et al. (2018) model includes estimated parameters which allow a description of the monetary contribution of these functions relative to the willingness to pay baseline. The provisioning function has a relatively large negative parameter, the regulating function has a relatively large positive parameter and the cultural function has a relatively small negative parameter. When conducting the benefit transfer, setting the provisioning and cultural function variables to one would lower willingness to pay. Setting the regulating function variable to one would have a positive effect on willingness to pay.

Moeltner et al. (2018) estimate willingness to pay per acre that only include cultural values by setting the cultural variable equal to one. Do the agencies follow Moeltner et al. (2018) and set the cultural variable equal to one? How are the provisioning and regulating variables handled? These decisions should be explained in order to better communicate the types of willingness to pay values being transferred. Since the Moeltner et al. (2018) approach is only an example, it should not be followed for the current analysis. The input variables should be tailored to fit the characteristics of the wetlands at the state level as closely as possible. For example, if a percentage of a state's wetlands support the wetland function then that percentage could be used as the input variable (e.g., 0.45 instead of zero or 1). In the absence of this sort of information, using the means of these variables would be preferred with sensitivity analysis to determine the impact of these decisions.

[6] Moeltner et al. (2018) set the study year variable (lnyear) equal to the "log of (2018-1988). This simulates the willingness to pay estimated in a 2018 study. Since the mean parameter on study year is positive, any simulation of a study year earlier than 2018 will result in a lower willingness to pay per acre estimate. How does the EPA-Army (2018) handle the study year variable?

Since the aggregate wetland benefit estimate is significantly lower than previous estimates, the role of each of these features of the meta-analysis model should be clearly explained and documentation provided for public review.

<u>Inadequate Treatment of Uncertainty</u>

Uncertainty is inherent in any economic analysis. Statistical uncertainty is captured in confidence intervals that result from the statistical properties of the central tendency of a benefit estimate (i.e., variance around the mean). Another type of uncertainty results from assumptions made during the analysis. The EPA-Army (2018) addresses the former but not the latter.

Statistical uncertainty

The agencies account for statistical uncertainty by developing confidence intervals for the lower bound state-level willingness to pay estimates (based on the meta-analysis) and these are presented in Table III-9 (pp. 78-79). The aggregate benefit estimate is $59.4 million with a 95% confidence interval of $238 thousand and $122 million.

While the statistical uncertainty is presented, it is not utilized in the analysis. For example, consider a comparison with the CWA 404 category cost estimates. The range of potential annual avoided costs in the CWA 404 category in the baseline scenario is $86 million to $206 million presented in Table 1 of EPA-Army (2017, p. 10). Considering these two numbers as standards (without confidence intervals), the aggregate benefit estimate is not statistically different from the lower cost estimate at the p=.05 level. The aggregate benefit estimate is statistically different from the high cost estimate at the p=.05 level. Since the 95% threshold is an arbitrary standard, especially considering its use in policy analysis, the agencies should develop estimates of the probabilities (p-values) at which the estimated benefits are less than the costs to assess the statistical uncertainty.

Uncertainty and assumptions

The major assumption made by the EPA-Army (2018) is that the state political jurisdiction is the appropriate geographic extent of the market. This assumption results in a conservative aggregation rule, i.e. one that excludes households that would benefit.

Farrow (2013), in his article "How (not to) lie with benefit cost analysis" suggests that "Act(ing) as if a number is certain" is "lie #4." EPA-Army (2018) presents their aggregation rule as the most defensible and does not formally consider others in their analysis. This is inappropriate considering the uncertainty about their state-level aggregation assumption given the evidence from the distance-decay literature. Farrow suggests that reviewers:

> *Ask "Does there seem to be a false level of precision in this analysis?" and "Are we told whether the results change if reasonable changes are made to the analysis?"*

The answers to these questions for EPA-Army (2018) are "yes" and "no," respectively. Considering Farrow (2013), the appropriate method for presenting aggregate benefits is with a sensitivity analysis considering how benefits change if reasonable changes are made. For example, a reasonable change considering the distance-decay literature is to re-consider the regional aggregation rule used in EPA-Army (2015). For simplicity, suppose that the upper bound of the aggregate benefit estimate is the regional aggregate benefit estimate from EPA-Army (2015) (using the "original number of ORM2 other waters records" scenario) since this number can be easily calculated. This upper bound number is not presented in EPA-Army (2015) but the state level aggregation number is reported in EPA-Army (2018) on page 67 (rounded to three significant digits). The state-level benefit estimate and the blended state-regional estimate allows calculation of an upper bound regional benefit estimate. The blended approach is described by the EPA-Army (2015, p. 50) as:

> *Instead, on a region by region basis, EPA has taken a blended approach, using the simple average of the WTP applied at the regional level and the weighted average WTP applied at the state level for the states in that region, and applied this blended WTP to the acreage estimated for that region.*

Assuming that this approach is roughly the midpoint between the state and regional estimates allows an estimate of the regional aggregate benefit estimate to be developed as $Regional\ Benefit = 2 \times Blended\ Benefit - State\ Benefit$. The state, blended, and regional wetland benefit estimates using the 2015 study assumptions of a 50-year time horizon and a different willingness to pay per-acre are presented in Table 1.[6]

[6] The calculations are described in EPA-Army (2018) but not in EPA-Army (2015).

Table 1. Annual Wetland Benefits			
	Aggregation Rule ($millions)		
Study	State	"Blended"	Regional
2015	107	306	505
2018	96.5	276	456

The regional aggregate wetland benefit estimate of $505 million is not inconsistent with the Loomis (2000) result that over 82% of the wetland benefits are enjoyed by out of state residents in the Loomis et al. (1991) study. In other words, if only a state level estimate were available, assuming that 18% of the total benefits accrued at the state level and the regional benefits are the total, the regional benefits would be: $Regional\ benefit = State\ benefit/(1 - .82)$. Applying this benefit transfer logic to the 2015 state level benefit estimate of $107 million in Table 1, the regional benefit would equal $594 million.

Consider the second row of benefits in Table 1. EPA-Army (2018) employs a more conservative approach to estimating willingness to pay per acre, using (a) a different set of wetland benefit studies and (b) a 20 year time horizon instead of a 50 year time horizon to develop a present value of the stream of annual benefits (which is then annualized). The changes in part (a) may be justified as the excluded studies appear to be less valid than the remaining studies (Moeltner et al. 2018). But the effect on willingness to pay per acre of this change is not made explicit. The change in (b) requires even further justification by the Agencies. A 20 year time horizon will yield lower present values than a 50 year horizon and it is not clear why this change was made. These two changes combined yield a state-level aggregation rule annual wetland benefit estimate of $96.5 million which is slightly more than 90% of the estimate from the 2015 study. Scaling the "blended" and regional estimates down by the same factor yields a benefits range of $96.5 million to $456 million with a midpoint of $276 million.

Sensitivity analysis

EPA-Army (2015) recognizes the overly conservative position taken in the state-level aggregation assumption. Considering the state-level aggregation rule (pp. 49-50):

> *Benefits from wetland losses now being compensated for via compensatory mitigation may also be assumed to accrue at the state level. This approach assumes that only residents within a state's boundaries receive benefits from wetland losses offset within that state. This calculation for benefits may be overly conservative as wetlands can provide services and benefits to downstream waters beyond a state's boundaries, but it serves as a useful point of comparison.*

I agree with the assessment that the state-level aggregation rule is "overly conservative". EPA-Army (2018) also agrees that the state-level approach is "overly conservative" (p. 67) and yet still presents the estimates from the state-level aggregation rule as their preferred point estimate of aggregate wetland benefits: $96.5, as set forth in Table 1. This is not defensible given the tools of sensitivity analysis available for benefit-cost analysis (Boardman et al. 2017, Farrow 2018).

Considering the regional approach, EPA-Army (2015) states (p. 49):

> *However, aggregating benefits using the wetland region requires ascribing benefits over a large geographic area and there are not data available to allow for examination of the effect distance from the resource being valued has on* [household willingness to pay] *for wetlands.*

EPA-Army (2018) states (p. 67):

> *"... the regional approach is inappropriate for a benefit transfer exercise because the extent of the market considered in the majority of the original studies was narrower (e.g., state population).*

The approach taken in EPA-Army (2018) is not a defensible position given the estimates of distance-decay parameters that are available in the economic literature (e.g., Pate and Loomis 1997 for the wetlands data used in Loomis et al. 1991). The logic of using the distance-decay parameter from the literature as a validity check on the regional benefit estimate is similar to the logic of using benefit estimates in a benefit transfer exercise. When the time and money resources are not available to conduct the appropriate distance-decay study then the necessary components of the analysis can be borrowed "off-the-shelf" to assess the potential impact of the assumption of the state-level aggregation rule.

Considering the wide range of aggregate benefit estimates over the state and regional aggregation rules, EPA-Army (2015) states (p. 50):

> *There are no clear boundaries determining to whom benefits should accrue. Though both approaches are described above as appropriate, estimating mitigation benefits using both and presenting the results as a range would introduce more variation to the analysis than is warranted.*

I disagree with this statement. When there is significant uncertainty in an estimate in benefit-cost analysis, in this case the aggregation rule, a range of estimates from the lowest defensible amount to the highest defensible amount is exactly what should be presented. Formal textbook sensitivity analysis is available to better understand the comparison of benefits and costs.[7]

If the distribution of benefits across the range is assumed to be uniform, with each dollar value equally likely, then a best/worst case analysis should be conducted. In a best/worst case analysis two net benefit estimates are calculated. In the worst case scenario (described as such supposing the policy, e.g., the CWR, is pursued) the lowest benefit estimate is compared to the highest cost

[7] See Chapter 11 of Boardman et al. (2017).

estimate. In the best case scenario, the highest benefit estimate is compared to the lowest cost estimate. These two net benefit ($Net\ benefit = benefit - cost$)) estimates give two extreme pictures of the potential outcomes. If the best case scenario generates negative net benefits then the policy should not be pursued. If the worst case scenario generates positive net benefits then the policy should be pursued. If the best and worst case net benefit estimates disagree, in other words if the best case scenario has positive net benefits and the worst case scenario has negative net benefits, then the decision-maker must consider the magnitude of the difference and the degree of societal risk-aversion when making the policy decision.

It is the role of the analyst to present the range of uncertainties in benefit-cost estimates to the decision maker. In effect, EPA-Army (2018) is solely conducting a worst case scenario analysis by comparing what may be the most conservative willingness to pay per acre estimates aggregated over the smallest number of households (i.e., the state-level aggregation rule) which they acknowledge is too conservative (EPA-Army 2015, pp. 49-50 quoted above). The conduct of a worst case analysis, in isolation, is inappropriate in a benefit-cost analysis under uncertainty.

If each dollar value across the range is not equally likely then best/worst case analysis is less appropriate. This conclusion is implicit in the statements made by EPA-Army (2015, 2018) quoted above. According to the EPA-Army (2015, 2018) it is defensible to assume that the state-level aggregation rule yields downward biased wetland benefits and the regional-level aggregation rule yields upward biased aggregate benefits.

The agencies in EPA-Army (2018) should address the uncertainty embodied in these ranges of estimates using standard, textbook methods. Once a benefit-cost analyst has developed a reasonable and defensible range of estimates, there are a number of methods available to consider how to assess the impact of the range of uncertainty. If the midpoint of the range, or other measure of central tendency (e.g., the "blended" benefit estimate from EPA-Army 2015), is considered most likely then the distribution could be assumed to be normal with standard deviation equal to the range divided by 6 (by the empirical rule) or a triangular distribution could be assumed with the minimum and maximum equal to the upper and lower bounds of benefits. Both of these distributions put little to no weight on the likelihood of the extreme values affecting the analysis. Similar assumptions could be applied to the range of cost estimates. With these statistical distributions Monte Carlo simulation should be employed by EPA-Army to determine the mean net benefit, error bands and the probability that the net benefit over the simulated statistical distributions is positive or negative.

Other issues

There are three other issues that deserve mention. These are the Federalism scenarios, unquantified benefits and the case studies.

Federalism Scenarios

EPA-Army (2018) develops "Federalism" scenarios in which they predict the state response to regulatory rollback. This is an interesting analysis but not appropriate for this benefit-cost analysis. First, there is no empirical evidence provided that this sort of state response will be forthcoming. On the other hand, there is historical evidence that the state response will be weaker than the Federal response for a variety of reasons (e.g., see Stanton and Whitehead, 1994). There is nothing in the EPA Guidelines for Economic Analysis (NCEE 2014) that suggests that this analysis is appropriate.

The Federalism scenario analysis is a highly speculative and not a defensible component of this economic analysis. If there is precedent for this sort of Federalism analysis in Federal benefit-cost analysis then it should be cited. If not, the Federalism scenarios should be discarded.

Unquantified Benefits

The benefits of four policy categories (CWA 301 Compliance, CWA 401 Administration, CWA 402 Pesticide General Permit Implementation and CWA 404 Mitigation – Streams) are unquantified and replaced with the $B placeholder. This, in effect, places a value of zero on these benefits. Instead of this treatment of unquantified benefits, there should be a separate breakeven analysis for this component of the benefit-cost analysis. A breakeven analysis projects the unquantified benefits from zero to the point at which the net benefits are zero. In this simple case, the breakeven benefits are equal to the costs. The Agencies should then present analysis considering the probabilities that these benefits will be greater than or less than the breakeven point. Without this analysis, the naïve policy maker will look to the bottom line estimates of benefits and costs and assume that the unquantified benefits are equal to zero. In the current compilation of benefits and costs, this will bias the decision towards less protection of wetlands.

Case Studies

The case studies rely on the willingness to pay estimates from Blomquist and Whitehead (1998). This study produces a conservative willingness to pay estimate for two reasons. First, it uses a voluntary contribution payment vehicle which is conservative for theoretical reasons (Carson and Groves 2007). Brouwer et al. (1999) estimates that an income tax payment vehicle generates larger willingness to pay estimates in a wetlands meta-analysis. This result could be applied to the benefit estimates in the case studies to improve accuracy.

Second, Blomquist and Whitehead (1998) use the median willingness to pay which, as described above, is lower than the mean willingness to pay estimate and biases downward aggregate benefits. In my own re-analysis of these data, the mean willingness to pay is $15.25 while the median is $4.69. The mean willingness to pay estimate is (at least) 3.25 times larger than the published median willingness to pay estimates.[8] In other words, using the median willingness to pay from Blomquist and Whitehead (1998) instead of the mean willingness to pay biases the aggregate benefits downward by a substantial amount. The mean is the most conceptually appropriate measure of willingness to pay for use in benefit-cost analysis.

In order to develop annual estimates of wetland benefits, the agencies use the annual willingness to pay estimates and aggregate these for each of 20 years considering the potential population growth. The present value is then annualized using the formula presented in the EPA guidelines for economic analysis (NCEE 2014). It is not clear why a time horizon of only 20 years is chosen. The EPA-Army (2018) reports that EPA-Army (2015) used a time horizon of 50 years. A 20 year time horizon will generate lower willingness to pay estimates than a 50 year time horizon. This is another potential area that sensitivity analysis is needed as both of these decisions may be defensible.

Increasing future benefits by increasing population is appropriate in the case studies. It would also be appropriate in the Phase I national analysis. This does not appear to have been done. This is another potential area that sensitivity analysis is needed as the constant population assumption is likely too conservative.

Conclusion

The agencies have used a number of inappropriate approaches that tend to understate the potential benefits of wetland protection. The agencies adopt an aggregation rule that understates the number of households over which to sum the household willingness to pay per acre estimate. The aggregation rule presented in EPA-Army (2018) is overly conservative (as acknowledged by the authors of the report). In effect, EPA-Army (2018) is calculating the lowest possible wetland benefits by aggregating willingness to pay per acre over the smallest number of households (i.e., the state-level aggregation rule). There is one clear reason for the downward bias in the aggregate wetland benefit estimate as EPA-Army moves from the (2015) study to the (2018) study. This is the conservative definition of the "geographic extent of the market." A brief review of the distance-decay literature shows that contingent valuation studies that limit benefit transfer to state boundaries significantly underestimates the benefits.

There are potentially other reasons for why the aggregate benefit estimate is too conservative (i.e., low), primarily considering the implementation of the meta-analysis transfer function. There are a number of unexplained elements of the current analysis that could change the

[8] I am using only the more conservative dichotomous, relative to polychotomous, choice data ($n = 222$) in Blomquist and Whitehead (1998). The mean willingness to pay estimate is derived using the nonparametric Turnbull estimator which is a lower bound, conservative estimate of mean willingness to pay. Note that the Blomquist and Whitehead (1998) article was written as a test of the validity of the contingent valuation method and not for use in a benefit-cost analysis. The mean willingness to pay from the re-analysis of these data is more appropriate for benefit-cost analysis.

calculation of the household willingness to pay per acre. Too few details are provided to allow an adequate assessment of the methods used to arrive at the willingness to pay per acre estimate. As presented, the willingness to pay per acre analysis conducted by the EPA-Army (2018) is a black box that may be biasing the aggregate benefit estimate downward.

Whereas the EPA-Army (2017) report threw up its hands and implicitly assigned a zero value to aggregate benefit estimates in the face of uncertainty, the correct approach in benefit-cost analysis is to account for ALL uncertainties in the appropriate manner (Boardman et al. 2017, Farrow 2018). It is the role of the analyst to present the range of uncertainties in benefit and cost estimates to the decision maker. The appropriate incorporation of all uncertainties will likely lead to a very wide range of potential aggregate wetland benefits of the 2015 CWR (and equally wide ranges of reversing that rule). Considering the wide range of possible aggregate benefit estimates and the amount of statistical uncertainty, it may be difficult to develop a benefit-cost analysis that has clear recommendations for the decision maker. But, without a primary benefit estimation study designed for the 2015 CWR, the EPA-Army (2018) report with inclusion of the recommendations in these comments is likely to be the best that the tools of benefit-cost analysis can do. In other words, a good benefit-cost analysis does not necessarily produce a clear answer to a complicated policy question.

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Biography

Dr. John C. Whitehead is a professor in the Department of Economics at Appalachian State University. He received his BA in economics from Centre College and PhD in economics from the University of Kentucky. His teaching includes courses in environmental and natural resource economics, benefit-cost analysis, microeconomics and business statistics. Dr. Whitehead's research includes nonmarket valuation, primarily in the context of recreation, water quality and sports. He has published over 100 peer reviewed articles and book chapters and co-edited two books. He is an associate editor at Marine Resource Economics and successfully completed one-term as an associate editor at the Journal of Environmental Management. He is currently on the editorial council of the Journal of the Association of Environmental and Resource Economists. He is a member of the Socioeconomic Panel (SEP) of the Statistics and Scientific Committee (SSC) of South Atlantic Fishery Management Council. He has served on review panels for the USEPA, NMFS, NSF and Sea Grant. Previously he served on the Board of Directors of the Association of Environmental and Resources Economists and as president of the Socioeconomics Section of the American Fisheries Society. He is a member of the American Economic Association, Association of Environmental and Resource Economists, North American Association of Fisheries Economists, North American Association of Sports Economists and the Southern Economic Association. He was presented with the 2007 Research Award from the Walker College of Business and the 2008 Distinguished Economist Award by the Kentucky Economic Association.