Principal study questions:

P1. When will PCB levels in fish meet human health and ecological risk criteria under continued NO ACTION?

P2. Can remedies other than NO ACTION significantly shorten the time required to achieve acceptable risk levels?

P3. Could a flood scour sediments, exposing and redistributing buried contamination?

It is noted that question 2 is not under the domain of the BMR results.

HUDTOX:

Note: answers are offered for certain questions only for this section as my expertise lies with the bioaccumulation models. The approach taken with the HUDTOX model questions has emphasis towards its use ultimately for future decisions and application to contaminant concentrations in biota (question P1). Overall, HUDTOX is an impressive model given the difficulty of mapping and parameterizing all the processes an advective system. Nonetheless, there are still specific issues to be addressed before its use in any decision process for the Hudson River.

A1. *The HUDTOX model links components describing the mass balance of water, sediment, and PCBs in the Upper Hudson. Are the process representations of these three components compatible with one another, and appropriate and sufficient to help address the principal study questions?*

The mass balance model for PCBs in the Hudson must take into account the balance for water, including flow from the main river and tributaries, plus mixing; the balance for solids, which includes the important component of tributary loading (to a greater extent than water loading), and interaction between deposition to sediments and resupension from sediments; and the PCB mass balance which is influenced by the water and solids mass balances, and which includes chemical partitioning between dissolved and particulate phases where organic carbon plays a key role. Given the available data which was not all originally designed for the purpose of constructing the HUDTOX (or bioaccumulation) models, the processes defined for HUDTOX for these three components are compatible with one another and are appropriate for addressing the principal study questions. The fundamentals of these processes are approaching sufficiency. Two weak links (but not exclusive), include the lack of a broader range of temporal sediment data (see question 8 below) and treatment of the PCB partitioning (question 10). Also, further resolution to the issues raised in Question 11 must be considered.

the model has completely captured the mechanisms governing PCB distributions among the media. The intensive effort expended for the water and solids mass balances are more robustly based, even considering where data are lacking. It is more difficult for the PCB mass balance because of the assumptions governing the distribution of PCBs between dissolved and associated states (to dissolved organic carbon, DOC, and particulate organic carbon) are not as well characterized nor supported by empirical data (e.g. the partitioning to DOC; see below).

A5. *HUDTOX employs an empirical sediment-water transfer coefficient to account for PCBs loads that are otherwise not addressed by any of the mechanisms in the model. Is the approach taken reasonable for model calibrations? Comment on how this affects the uncertainty of forecast simulations, given that almost half of the PCB load to the water column may be attributable to this empirical coefficient.*

A6. *Are there factors not explicitly accounted for (e.g. bank erosion, scour by ice or other debris, temperature gradients between the water column and sediments, etc) that have the potential to change conclusions drawn from the models*?

In general, the most likely factors appear to be accounted for. There is obviously no forecasting future events outside the realm of the past observations, but one factor which could influence the various processes (including bioaccumulation pathways) would be possibly significant change in the nutrient water quality by either increased inputs (increased development in the watershed) or improved water quality (better sewage treatment, agricultural practices, etc). This could change solids loadings (inputs and sedimentation), temperature, and PCB partitioning (plus food web structure obviously the latter point for the bioaccumulation models) which may be outside the current boundaries examined in the model. Changes in *in situ* production may change sedimentation rates (as well feeding relationships and all the related effects). The sensitivity analysis indicates that substantial changes in solids loading have an impact on the model outcome. The model forecast is for a sufficiently long period that such changes are not impossible.

A7. *Using the model in a forecast mode requires a number of assumptions regarding future flows, sediment loads, and upstream boundary concentrations of PCBs. Are the assumptions for the forecast reasonable? Is the construct of the hydrograph for forecast predictions reasonable? Should such a hydrograph include larger events?*

The assumptions for the forecast are reasonable and well developed. I do not believe that the hydrograph should include larger events- the model is based upon averages which is a reasonable

in the water column. This is both an interesting and important question to address fully, because of the implications of deriving the bioavailable PCB concentration taken up by biota. The Hudson River has both high DOC concentrations (range 3 to 6 mg/L) and variable solids (2 to 100 mg/L). Partition coefficients were derived to characterize the distribution of PCBs among three phases in the water column: dissolved (= bioavailable), particulate-bound and DOC-bound. The partition coefficient for DOC, K_B, is set to equal 1.0 * K_{DOC}. (Equation 5-11). This is based upon the statement that "dissolved organic materials are typically assumed to be composed entirely of organic carbon, f_{OC} = 1". This is a surprising statement, as organic matter by its nature has to have the other essential macro & micro- elements (P, N, O, S, etc).

Hence, K_B is related to K_{DOC} (probably incorrectly). K_{DOC} is reported as commonly estimated as "K_{POC} * a binding efficiency factor based on analysis of field data measurements of each chemical phase". What is the binding efficiency factor? Presumeably this is further developed in the DEIR, but insufficient information is given in the RBMR for adequate evaluation of this development (the BMR description is lacking in detail; for example, not all the terms are adequately defined. Note for example, that L in these equations must refer to volume but L is also used several pages before for length; notation should be consistent and defined throughout! What is L_W , for example; the next page uses L_{WATER}). The statement is made that there is considerable uncertainty in the determination of these 3-phase partition coefficients, but this is not clearly elaborated. The BMR states the result that the lightest PCB congeners are highly associated with DOC in the water (up to 50% of their total) but congeners comprising tri+ are only about 10% associated with DOC. Thus, the most soluble PCB congeners are largely bound to DOC? This contradicts the situation in the sediments where all congeners are approximately equal in their association with organic carbon.

Another observation which does not seem to be explained is the tremendous difference in estimated log K_{POC} and log K_{DOC} between GE and Phase 2 data, both which are given in Table 6-28. These are order of magnitude differences? Thus, theoretically this well may be an important approach because DOC is important in this river, and it may be that the average values derived for the partition coefficients are reasonable (except for equating all organic matter as carbon), but there is no way of adequately assessing this based upon the information provided in the BMR.

Overall, this is an important issue, but to what extent? The sensitivity analysis demonstrated that K_{POC} is an important parameter. Where no sensitivity analyses done for K_{DOC}? This must be clarified and/or further resolved. The comment above in the question that the reviewers for the DEIR considered there to be insufficient data to resolve this question is vague: the BMR suggests that there were data but specifics are not sufficiently identified.

comprehensive, I recommend that several independent reviewers be retained to review not just the BMR, but hand in hand with the DEIR, LRC, all previous review comments, and the GE reports. This would effectively constitute an audit. Sufficient time has to be allocated to these auditors, with opportunity to meet and question the people who have put such tremendous effort into analysing the data and developing these models. The auditor/reviewers would be in a strong position, however, to objectively assess the entire process. This peer review process will have been a useful contribution but probably has been hampered by both having insufficient time (note that while we were enlisted in the fall of 1999, documents were delivered only two months prior to the Review meeting, at the end of January 2000) and by not having all the information in hand (e.g. the DEIR and LRC). To address the scope of some of the questions requires information not provided in the BMR.