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March 20, 2000

Dr. Ellen Bentzen
Research Scientist
Trent University, Environmental Studies
Environmental Modeling Center
Peterborough, Ontario CANADA K9J 7B8

RE: Hudson River PCBs Superfund Site: Baseline Modeling Report Peer Review

Dear Dr. Bentzen:

In anticipation of the upcoming peer review of EPA's Baseline Modeling Report, I enclose for your consideration a short report concerning Charge Question 11. The report was prepared by Dr. John Connolly of the firm Quantitative Environmental Analysis (QEA) on GE's behalf, and addresses the apparent inconsistency between the conclusions in EPA's Baseline Modeling Report and Low Resolution Coring Report.

I am sending you this Report because I believe it will assist you in your deliberations on Charge Question 11. These inconsistencies are important and potentially lead to different remedial approaches. As a result, the apparent discrepancy should be resolved, but I also appreciate that it is up to you whether to consider the information in this Report.

If you have any questions, please do not hesitate to contact me or John Connolly at (201) 930-9890.

Yours truly,

John G. Haggard

JGH/bg

Enclosure

Critical Issues Imbedded in Fate and Transport Model Peer Review Charge Question 11

To evaluate remedial options to reduce PCB levels in fish of the Upper Hudson River one must understand the degree to which humans and key animal species might be exposed to the PCBs in the water and sediments. This, in turn, raises the question of the long-term fate of the sediment PCB inventory. Do burial processes sequester and isolate PCBs from humans and animals or do other physical and biological processes make the bulk of the PCB inventory potentially available for exposure to humans and animals?

All of the charge questions you have been directed to answer are important to the evaluation of USEPA's models. However, one question is of paramount importance to the issue of remedy selection because it is directed to the long-term fate of the PCB inventory in the sediment. Question 11 raises the possibility that a conflict exists between the results of the fate and transport model and the results of separate data analyses presented in the Low Resolution Coring Report (LRCR: USEPA, 1998). A key conclusion of the model is that burial is sequestering PCBs in the sediment (as stated in charge question 11 and by Vic Bierman of LimnoTech in his presentation to you). In contrast, a key conclusion of the LRCR is that PCBs in the most highly contaminated areas are not being buried, but are being redistributed by unidentified means within the system (as stated in charge question 11 and in the LRCR). Although these conclusions are plainly inconsistent, EPA has suggested that the different conclusions result from the differing spatial scales of the two analyses. This implies that the redistribution suggested by the LRCR analysis (presumably caused by net erosion) is occurring at a smaller spatial scale than is discernable by the model.

Question 11 raises two fundamental issues:

- First, although it is possible that areas deemed depositional by the model contain regions of net erosion, is the scale of the model so crude that it fails to identify erosional areas which contribute important quantities of PCBs to the water column and biota?

- Second, which analysis is better suited to support remedial decisions – the model's mass balance approach which incorporates all relevant data into a mechanistically-based framework or the LRCR's geochemical approach which examines one type of data without mechanistic or mass balance constraints?

The answers to these questions are fundamentally important in the remedial analysis. If, as the LRCR's analysis would suggest, a major fraction of the PCBs entering the water column comes from cohesive sediment areas whose PCB inventory is being made available through mechanisms such as net erosion, then the PCBs in those areas could be a target for a form of remediation different from that selected for depositional areas. Conversely, if, as the model concludes, the bulk of the PCB inventory is sequestered and the dominant sources are upstream inputs and surface sediments in general, then targeting the buried PCB mass for remediation is likely to be ineffective.

We believe the answers to these two questions are straightforward. Although EPA's model has its limitations and could be improved, the model's inherent conceptual view is correct. The model accounts for the important sources and sinks of PCBs within the Thompson Island Pool, as evidenced by its ability to replicate the PCB concentration trends in the sediment and water column. It does so by burying PCBs in the sediment, principally in the cohesive sediments; the highest concentrations of PCBs typically occur below the bioturbated surface layer in the cohesive sediments. All of the cohesive sediment areas are subject to deposition and there is no indication from EPA's modeling analyses that a significant fraction of the PCB inventory has been mobilized and redistributed from any of these areas.

The only condition under which the conclusions of the modeling and the geochemical analysis might not be contradictory is one in which the locations targeted in the geochemical analysis deviate from the average condition represented by the model in a manner that would yield net erosion. Such deviation would be possible if the locations targeted in the geochemical analysis experienced velocities (and shear stresses) that: 1) were higher than the average for the model area; and 2) were of sufficient magnitude to cause an erosion flux that exceeded the depositional flux.

EPA has made no attempt to determine whether such deviation exists. Such a determination can be made using the EPA hydrodynamic and sediment erosion model, which has spatial resolution comparable to, or finer than, that of the geochemical analysis (see Figures 3-2 and 3-3 of the RBMR; USEPA, 2000). The General Electric hydrodynamic and sediment transport model, whose results were used by EPA in calibrating its model, also has sufficient resolution to examine conditions on the scale of the geochemical analysis. As shown for each of the 1994 sampling clusters on which the geochemical analysis relies (see attached figures), the GE model indicates that the targeted locations are **not** erosional and tend to have greater deposition rates than the averages for the larger areas represented by the HUDTOX model.

As both EPA's and GE's models conclude and as all of the field data show, the bulk of the buried PCB mass in the most highly contaminated areas has not migrated to the sediment surface where it could be released and redistributed:

- Water column mass balance analyses around the Thompson Island Pool show no evidence of PCB flux from sediments beyond that indicated by the models (GE, 1998; page 31)
- Sediment sampling throughout the Thompson Island Pool shows no evidence of a spatial shift in the distribution of PCB mass within the pool. Instead, the data indicate a continuous decline over time in both areas of high and low contamination that is replicated by the GE and EPA models (Figures 4-44 and 4-45 of the GE model report - GE, 1999; Figure 7-15 of the RBMR- USEPA, 2000).
- 1998 sediment data contradict the conclusion that the areas targeted in the geochemical analysis are subject to a significant and ongoing process of mass loss (GE, 1998; pages 32-34)
- No surface sediments have the high ^{137}Cs concentrations characteristic of material deposited in the 1960s and 1970s and shown to be associated with the bulk of the PCB mass in the most highly contaminated areas (GE, 1998; page 48)
- Almost all finely sectioned sediment cores show that maximum concentrations and bulk of the PCB mass remain buried below the surface sediments (GE, 1998; p.40)

- The PCB composition in the water column shows no evidence of a major contribution from the dechlorinated PCBs characteristic of the bulk of the PCB mass in the most highly contaminated areas (GE, 1998; pages 46-48)
- The PCB composition in fish indicates that they have not been exposed to the dechlorinated PCBs characteristic of the bulk of the PCB mass in the most highly contaminated areas (GE, 1998; page 47)

An obvious question is why did the LRCR conclude that PCBs in the most highly contaminated areas are not being buried if the modeling and the data cited above are at variance with such a conclusion? The answer lies in the flawed methodology of the LRCR analysis (GE, 1998). The analysis relies on comparisons between sediment PCB data collected in 1984 and 1994. Unfortunately, the comparisons are not valid because the 1984 samples chosen for the comparison were not randomly picked from all the data lying within designated areas, but were chosen because they had among the highest PCB levels in the data set. Further, the ability to see statistically meaningful differences between the 1984 and 1994 samplings was severely impaired because of the extreme variability among samples and the relatively small sample size. Finally, the statistical analysis of the data did not account for all of the sources of variance and may have underestimated the uncertainty of the estimated mass change[1]. The reported uncertainty is already so large (4 to 59 percent) that the analysis has little power to determine what has occurred to the PCB inventory between 1984 and 1994.

In sum, question 11 invites acceptance of the untenable attempt to reconcile two irreconcilable conclusions. Either the conclusion reached applying the mechanistically-based, mass-balance approach used by the models is correct (that is, that the vast bulk of the PCBs in the cohesive sediments are being buried) or the LRCR's non-mechanistic and limited geochemical analysis is correct (that is, that a substantial fraction of the PCBs in the cohesive sediments are not being buried). This is a central issue that should be resolved in order to aid the decision-making process at this site.

[1] USEPA could have obtained an appropriate confidence interval for the year-to-year change by conducting an analysis of variance using a two-way classification by cluster and by year.

Given the weakness inherent in the statistical data comparison approach and the methodology errors, the LRCR conclusions are too unreliable to be used to understand PCB fate within the sediments of the TIP. The best overall tool to use is the mechanistically-based models that reconcile all the data available for each media.

REFERENCES

[GE] General Electric Company. 1998. *Comments of the General Electric Company on Phase 2 Report - Review Copy, Further Site Characterization and Analysis, Volume 2C-A - Low Resolution Sediment Coring Report, Addendum to the Data Evaluation and Interpretation Report,* Hudson River PCBs Reassessment RI/FS developed for the USEPA Region 2 by TAMS Consultants *et al.* July 1998.

[QEA] Quantitative Environmental Analysis, LLC. 1999. *PCBs in the Upper Hudson River, Volume 2 - A Model of PCB Fate, Transport, and Bioaccumulation.* Prepared for General Electric Company. May, 1999.

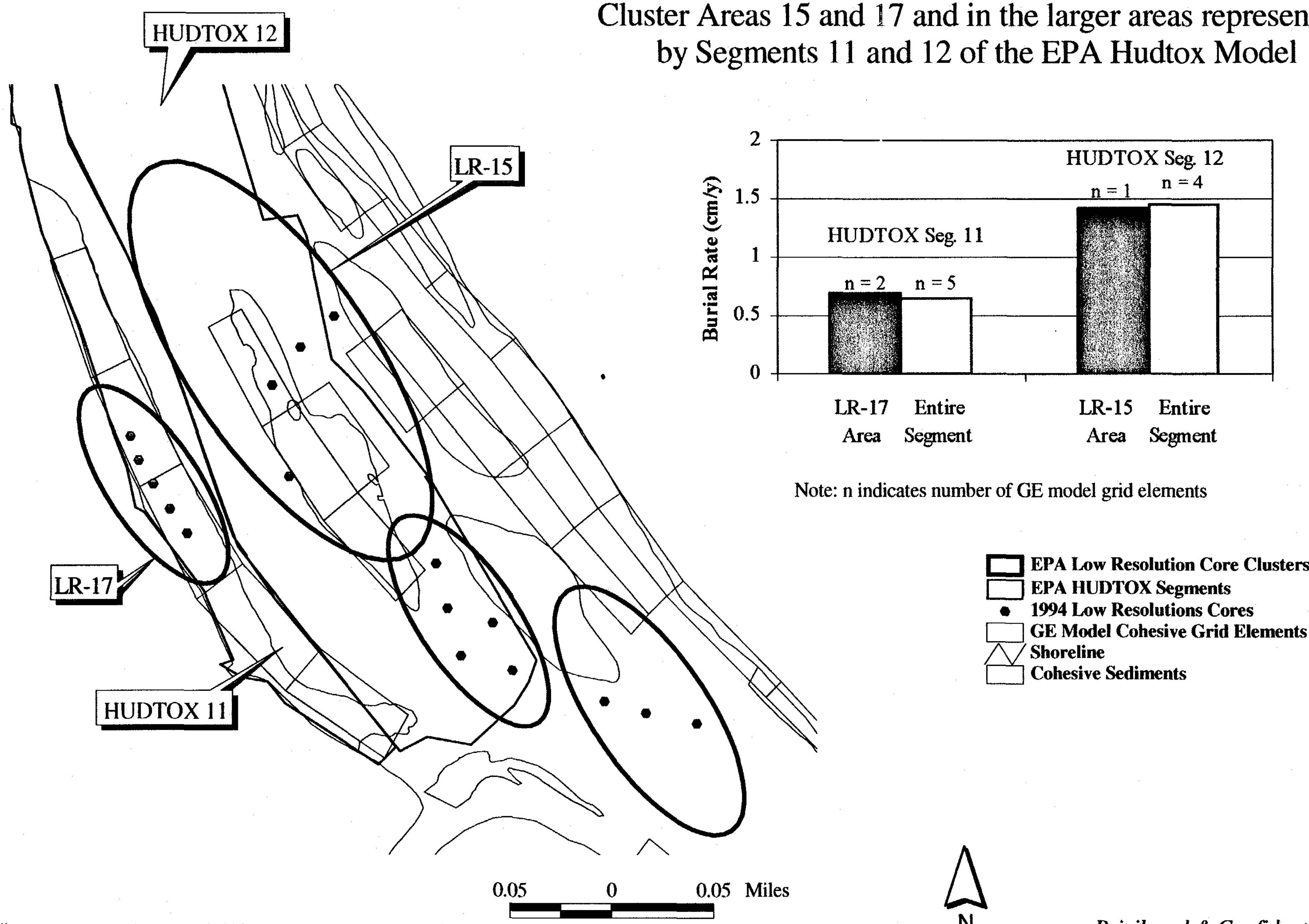
Sokal, R.R. and Rohlf, F.J., 1995. *Biometry: The principles and practice of statistics in biological research.* 3rd Edition, W.H. Freeman and Company, New York. 887 p.

[USEPA] U.S. Environmental Protection Agency, 2000. *Phase 2 Report – Review Copy: Further Site Characterization and Analysis – Volume 2D – Revised Baseline Modeling Report.* Hudson River PCBs Reassessment RI/FS, January 2000.

[USEPA] U.S. Environmental Protection Agency. 1999. *Hudson River PCBs Reassessment RI/FS Responsiveness Summary for Volume 2C-A - Low Resolution Sediment Coring Report, Addendum to the Data Evaluation and Interpretation Report,* February 1999.

[USEPA] U.S. Environmental Protection Agency. 1998. *Phase 2 Report - Review Copy, Further Site Characterization and Analysis, Volume 2C-A - Low Resolution Sediment Coring Report, Addendum to the Data Evaluation and Interpretation Report,* Hudson River PCBs Reassessment RI/FS developed for the USEPA Region 2 by TAMS Consultants *et al.* July 1998.

Comparison of GE model computed cohesive sediment burial rates in Low Resolution Coring Analysis Cluster Areas 15 and 17 and in the larger areas represented by Segments 11 and 12 of the EPA Hudtox Model



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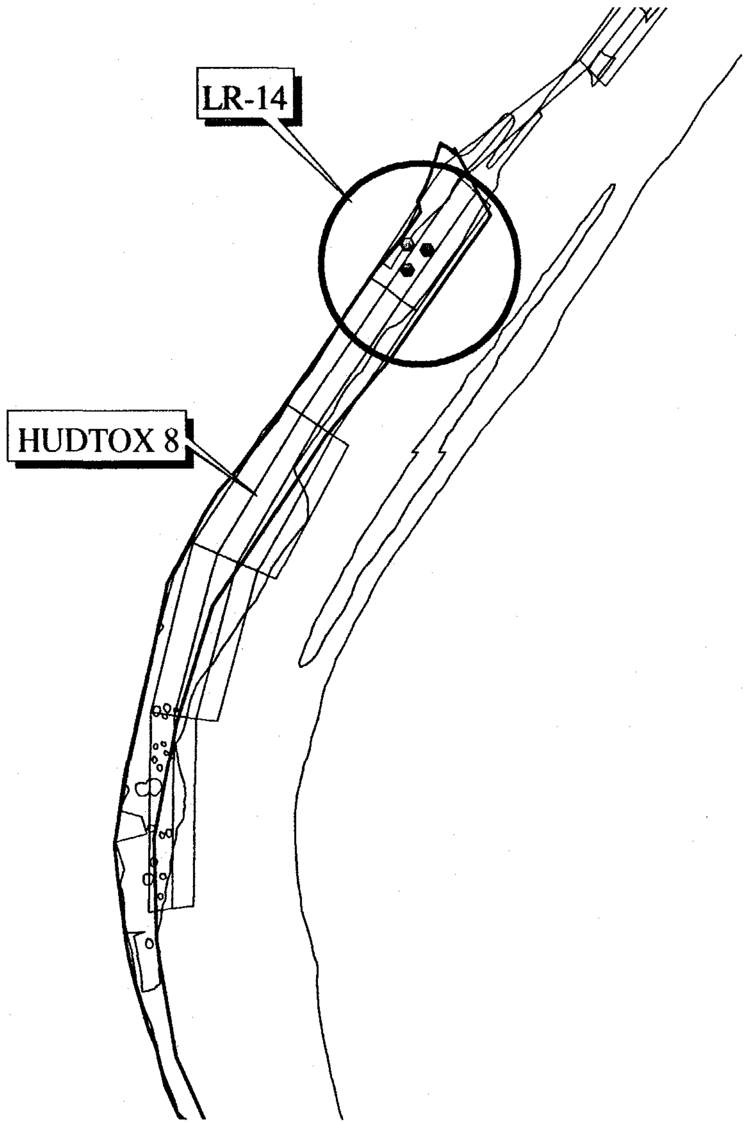
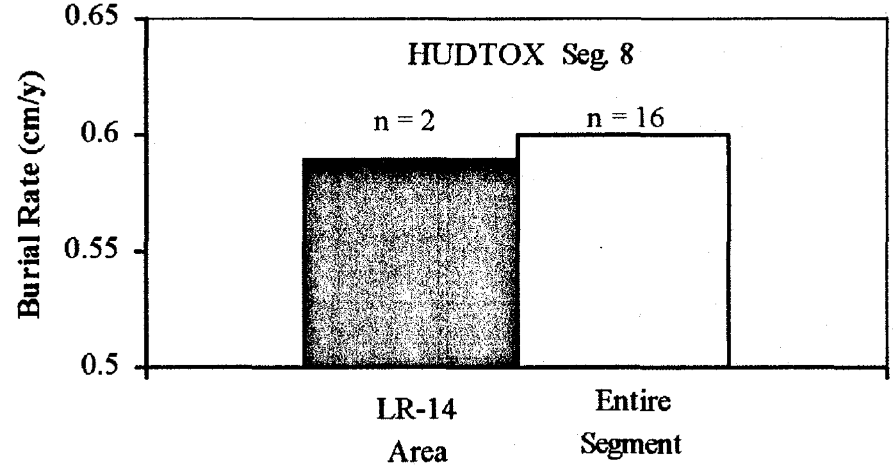
Comparison of GE model computed cohesive sediment burial rates in Low Resolution Coring Analysis Cluster Area 14 and in the larger area represented by Segment 8 of the EPA Hudtox Model





Note: n indicates number of GE model grid elements

EPA Low Resolution Core Clusters
EPA HUDTOX Segments
1994 Low Resolutions Cores
GE Model Cohesive Grid Elements
Shoreline
Cohesive Sediments

0.1 0 0.1 0.2 Miles

N

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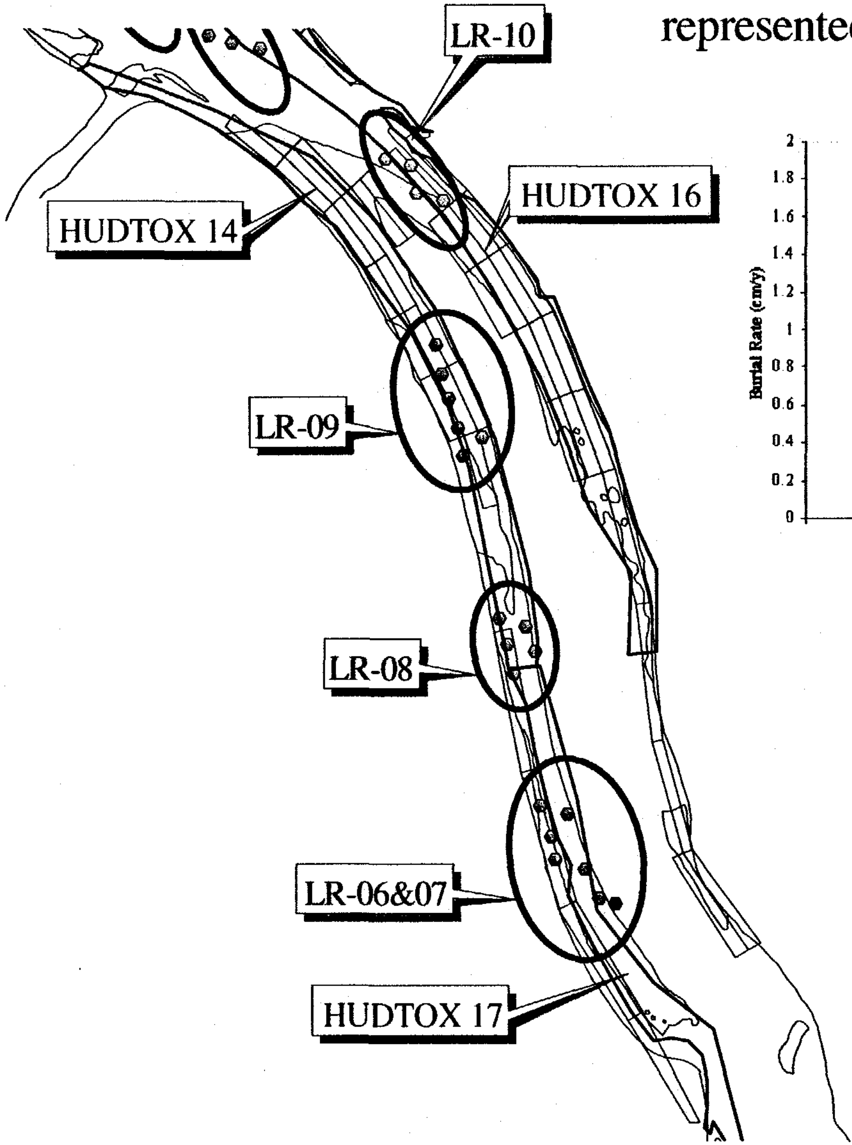
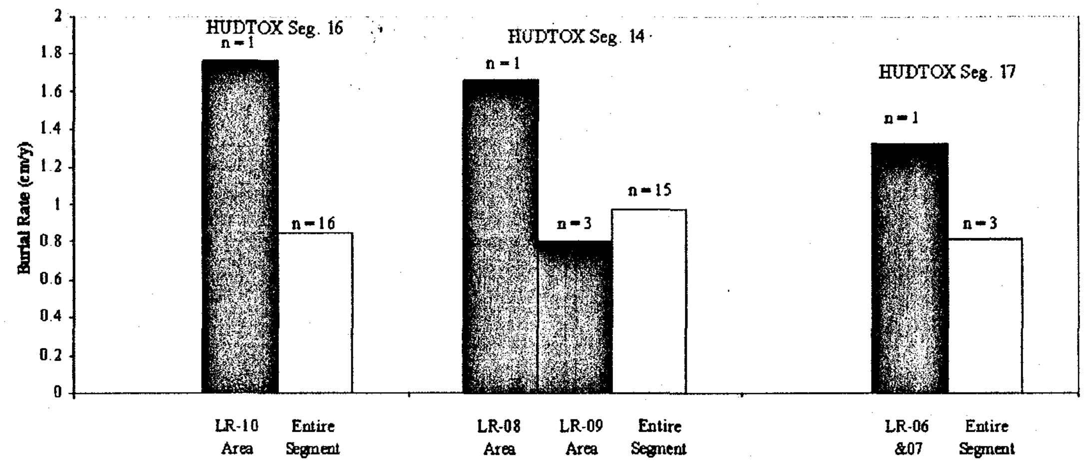
Comparison of GE model computed cohesive sediment burial rates in Low Resolution Coring Analysis Cluster Areas 06&07, 08, 09, and 10 and in the larger cohesive sediment areas represented by Segments 14, 16, and 17 of the EPA Hudtox Model





Note: n indicates number of GE model grid elements

- EPA Low Resolution Core Clusters
- EPA HUDTOX Segments
- 1994 Low Resolutions Cores
- GE Model Cohesive Grid Elements
- Shoreline
- Cohesive Sediments

0.1 0 0.1 0.2 Miles

N

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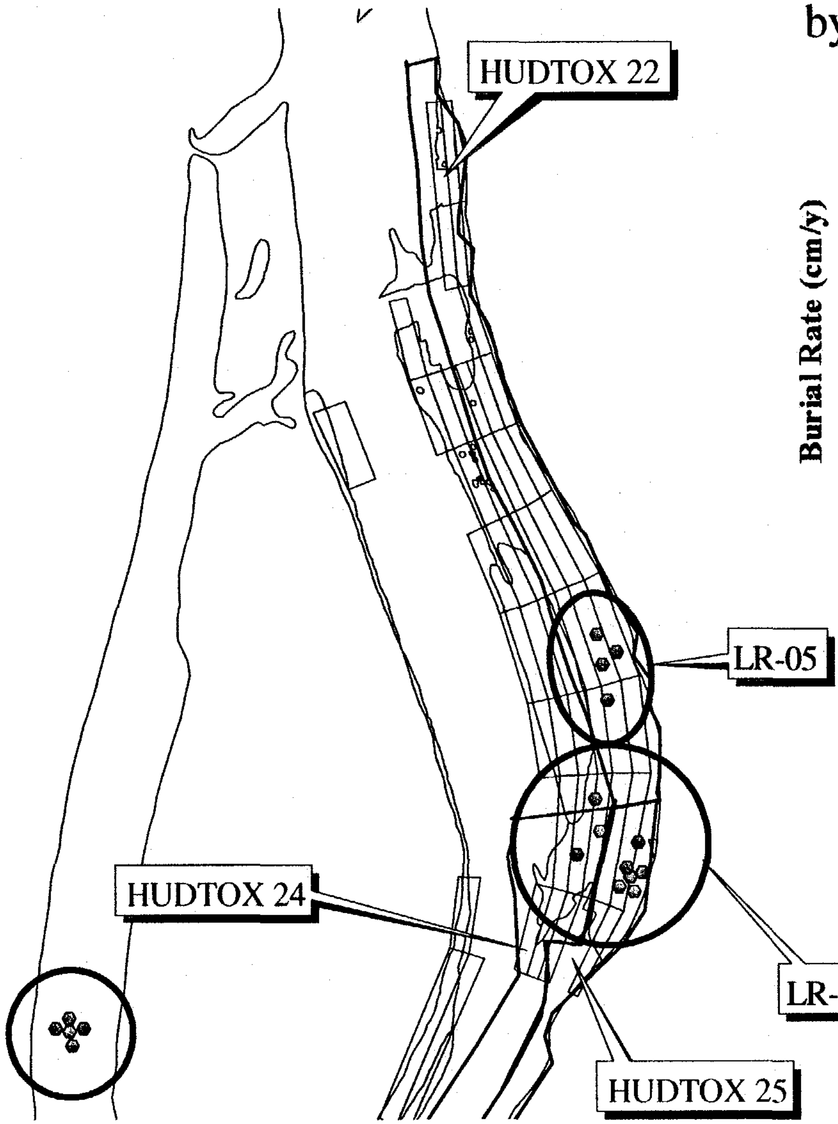
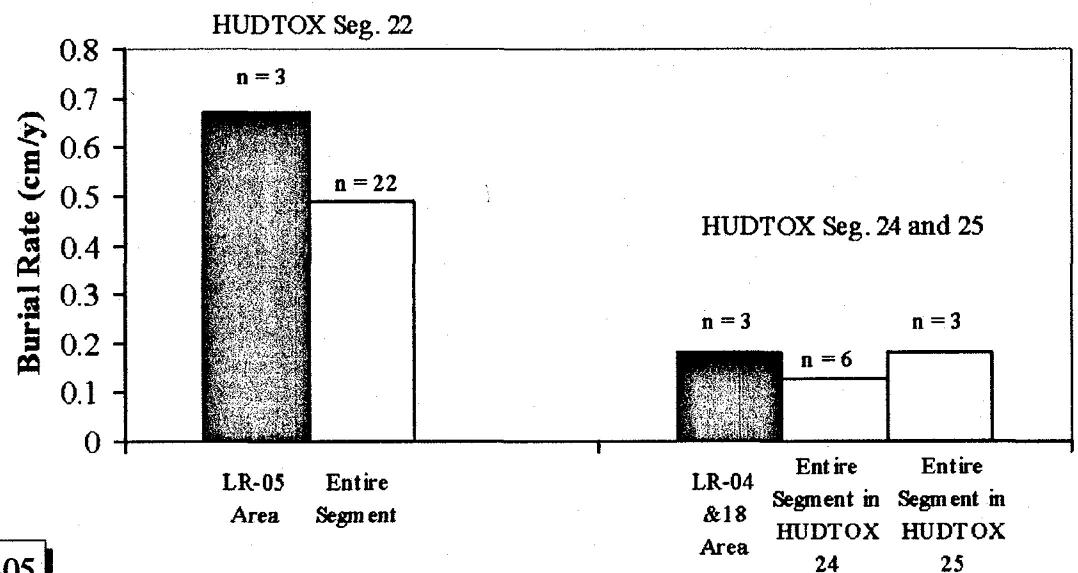
Comparison of GE model computed cohesive sediment burial rates in Low Resolution Coring Analysis Cluster Areas 04&18 and 05 and in the larger areas represented by Segments 22, 24, and 25 of the EPA Hudtox Model





Note: n indicates number of GE model grid elements

EPA Low Resolution Core Clusters
EPA HUDTOX Segments
1994 Low Resolutions Cores
GE Model Cohesive Grid Elements
Shoreline
Cohesive Sediments

0.07 0 0.07 0.14 0.21 Miles

N

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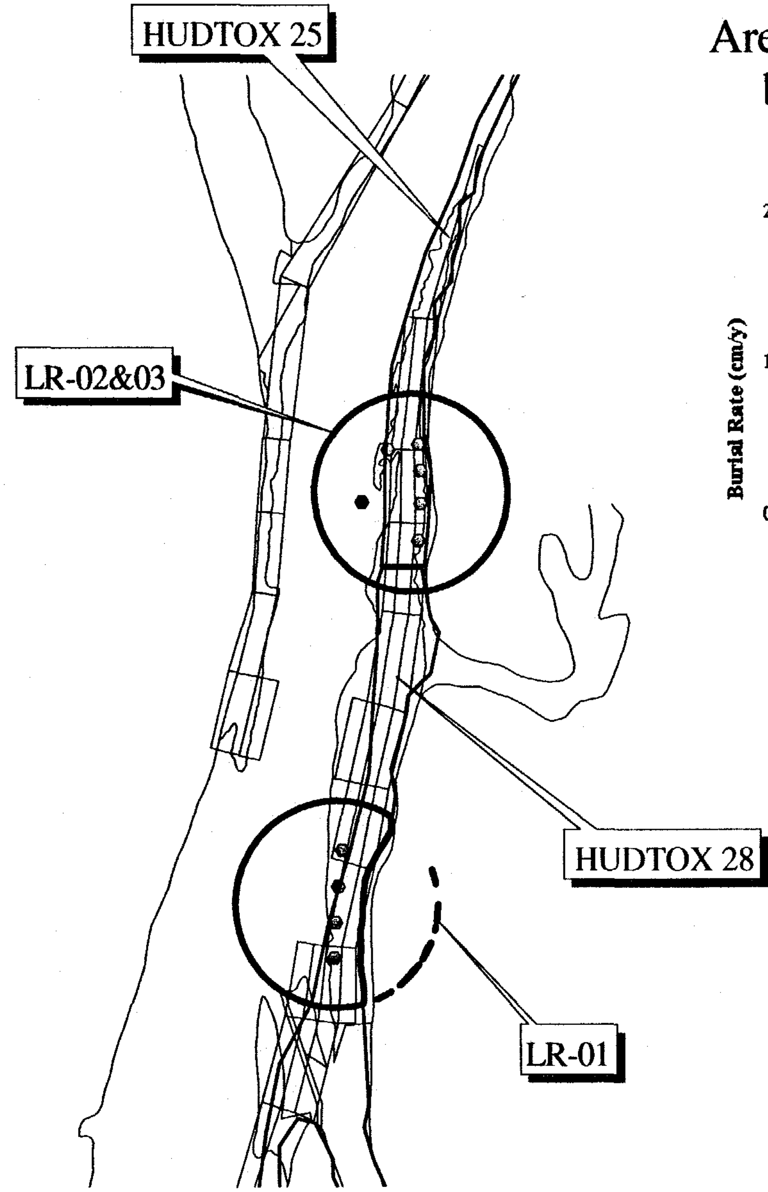
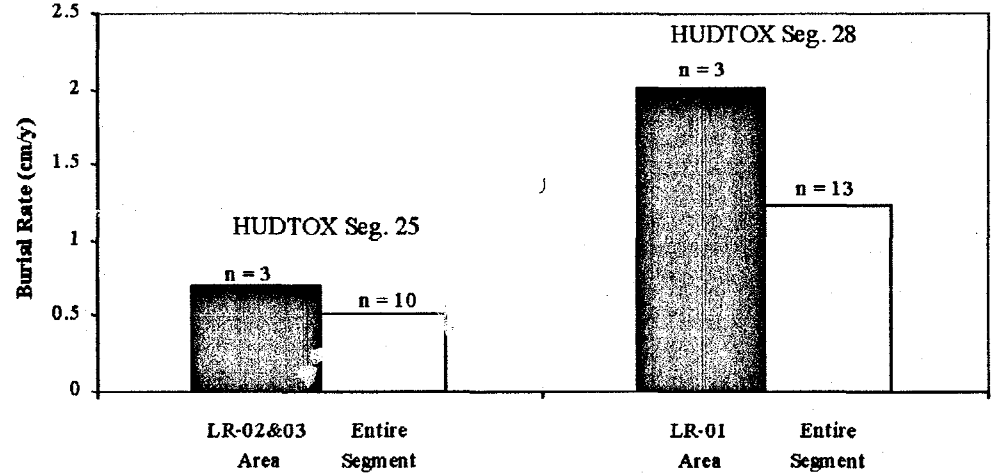
Comparison of GE model computed cohesive sediment burial rates in Low Resolution Coring Analysis Cluster Areas 01 and 02&03 and in the larger areas represented by Segments 25 and 28 of the EPA Hudtox Model





Note: n indicates number of GE model grid elements

EPA Low Resolution Core Clusters
EPA HUDTOX Segments
1994 Low Resolutions Cores
GE Model Cohesive Grid Elements
Shoreline
Cohesive Sediments

0.05 0 0.05 0.1 0.15 Miles

N

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