

New York/New Jersey Harbor Estuary Program

**SEDIMENT AREA LOADING COMPONENT ANALYSIS AND
SPREADSHEET TOOL DEVELOPMENT II
HACKENSACK RIVER AND LOWER/RARITAN BAYS
INTERPRETATIVE TECHNICAL MEMORANDUM**

**TECHNICAL SUPPORT FOR
NY/NJ HARBOR ESTUARY PROGRAM
USEPA REGION 2
TOXICS TMDL MODEL DEVELOPMENT**

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Under subcontract agreement with the Hudson River Foundation**

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1.0 INTRODUCTION

The previously developed CARP models were applied to evaluate two areas of the New York New Jersey Harbor sediment bed as unit response loading source components. These areas are the Hackensack River and the Lower/Raritan Bays. Two PCB homologs, tetra-CB and hexa-CB were evaluated per EPA's specification. In total, four thirty-two year simulations of the CARP model were performed and the results of the model simulations were stored within previously developed HEP and CARP spreadsheet tools so that EPA and the States could perform "what if?" calculations.

The sediment bed areas, as shown in Figure 1, were identified by EPA for this work assignment and a previously completed work assignment as:

This assignment:

- Hackensack River
- Lower/Raritan Bays

Previous assignment:

- Upper Bay (bounded by the Kill van Kull and Newark Bay confluence and the George Washington, Verrazano Narrows, and Brooklyn Bridges)
- Hudson River (bounded by the George Washington Bridge, Spuyten Duyvil, and Troy Dam)
- Arthur Kill

The original CARP effort had included the Passaic River and Newark Bay sediment areas shown on Figure 1. Sediment areas not specifically delineated and represented as "other" include:

- Harlem River
- East River
- Long Island Sound
- Jamaica Bay
- Bight
- Raritan River

In the loading source component analysis, each of the sediment bed areas was activated in the model on a stand-alone basis to isolate the impacts of that sediment bed area on contaminant concentrations in water, sediment, and biota throughout the system over thirty-two years of simulation. The spreadsheet tools store the results at the end of the thirty-two years of simulation. The long simulation time allows for a response of the system to a long-term exposure to the contamination in the sediment bed areas now.

The role of each of the sediment bed areas is expected to be more apparent for hexa-CB, a higher chlorinated homolog, than for tetra-CB. This is consistent with the fact that higher chlorinated compounds are more strongly associated with particles and therefore have greater residence time in the system due to estuarine trapping, decreased volatilization and smaller effects of other diffusive exchange processes. On the other hand, the current loadings of tetra-CB are generally greater than those of hexa-CB, producing potentially greater concentrations in the bed, water column, and biota. For this reason, the role of tetra-CB from sediment bed areas may be greater than hexa-CB.

2.0 RESULTS OF THE ANALYSIS

The results of the analysis are fully presented in the spreadsheet tools delivered to EPA. Results are both tabulated and graphically displayed within the spreadsheet tools. A narrative discussion is provided here for each of the two newly evaluated sediment areas, Hackensack River and Lower/Raritan Bays, as well as that portion of the sediment bed defined as “All Other Areas.” “All Other Areas” refers to those portions of the sediment bed in Harlem River, East River, Long Island Sound, Jamaica Bay, Bight, and Raritan River.

2.1.1 Hexa-CB Sediment Responses Due to Lower/Raritan Bays Area Sediments

For hexa-CB, concentrations in the sediments of the Lower/Raritan Bays sediment area now will spread somewhat into surficial sediment concentrations in other sediment areas in the future based on the CARP model calculations stored in the spreadsheet tools. The model results suggest that the now in-place sediment contamination from the Lower/Raritan Bays sediment area has its greatest external impact on future concentrations of hexa-CB in Jamaica Bay and in the Arthur Kill. 12% and 11%, respectively, of future hexa-CB concentrations in Jamaica Bay and Arthur Kills sediments will be from the Lower/Raritan Bays sediment area. The next most impacted external area is the Raritan River. Surficial sediments in the Lower Bay are expected to be replaced by sediments migrating in from external sediment areas (42%) and by deposition of on-going current sources (12%), with 47% of expected future hexa-CB concentrations in the Lower Bay sediment area due to sediments currently in-place in the Lower/Raritan Bays. Surficial sediments in Raritan Bay are expected to be replaced by sediments migrating in from external sediment areas (39%) and by deposition of on-going current sources (22%), with 40% of expected future hexa-CB concentrations in the Raritan Bay sediment area due to sediments currently in-place in the Lower/Raritan Bays. The management implications are that while a remedy for Lower/Raritan Bays sediments will have at most a 40-47% impact on hexa-CB concentrations in the Lower/Raritan Bays and other Harbor sediments, remediation of sediments in other Harbor areas will also have similar (i.e., about 40% of expected future concentrations) impacts on the Lower/Raritan Bays sediment area. TMDLs (i.e., reduction of deposition of current loads) would be expected to contribute at most a 22% reduction to future hexa-CB concentrations in the Lower/Raritan Bays sediments.

2.1.2 Hexa-CB Water Column Responses Due to Lower/Raritan Bays Area Sediments

Hexa-CB results in the water column are similar to those described for the sediment bed in terms of spatial patterns of response. Hexa-CB from the Lower/Raritan Bays sediment area today is projected to contribute enough to water column concentrations of hexa-CB in the future to be entirely responsible for violations of the human health water quality standards applicable to the summation of ten PCB homologs. Expected future concentrations of hexa-CB in the water column due to sediment concentrations from the Lower/Raritan Bays sediment area today range from effectively 0 ng/L in the Upper Hudson to 0.1274 ng/L in Raritan Bay. The water quality standards for all PCBs, not just hexa-CB, are 0.001 ng/L in New York and 0.064 ng/L in New Jersey.

2.1.3 Tetra-CB Sediment Responses Due to Lower/Raritan Bays Area Sediments

For tetra-CB, concentrations in the sediments of the Lower/Raritan Bays sediment area now will spread somewhat into surficial sediment concentrations in other sediment areas in the future based on the CARP model calculations stored in the spreadsheet tools. The model results suggest that the now in-place sediment contamination from the Lower/Raritan Bays sediment area has its greatest external impact on future concentrations of tetra-CB in Jamaica Bay and in the Arthur Kill. 20% and 9%, respectively, of future tetra-CB concentrations in the Jamaica Bay and Arthur Kill sediments will be from the Lower/Raritan Bays sediment area. The next most impacted external area is the Raritan River. Surficial sediments in the Lower Bay are expected to be replaced by sediments migrating in from external sediment areas (45%) and by deposition of on-going current sources (18%), with 37% of expected future tetra-CB concentrations in the Lower Bay sediment area due to sediments currently in-place in the Lower/Raritan Bays. Surficial sediments in Raritan Bay are expected to be replaced by sediments migrating in from external sediment areas (42%) and by deposition of on-going current sources (28%), with 30% of expected future tetra-CB concentrations in the Raritan Bay sediment area due to sediments currently in-place in the Lower/Raritan Bays. The management implications are that while a remedy for Lower/Raritan Bays sediments will have at most a 30-37% impact on tetra-CB concentrations in the Lower/Raritan Bays and other Harbor sediments, remediation of sediments in other Harbor areas will also have similar (i.e., about 44% of expected future concentrations) impacts on the Lower/Raritan Bays sediment area. TMDLs (i.e., reduction of deposition of current loads) would be expected to contribute at most a 28% reduction to future tetra-CB concentrations in the Lower/Raritan Bays sediments.

2.1.4 Tetra-CB Water Column Responses Due to Lower/Raritan Bays Area Sediments

Tetra-CB results in the water column are similar to those described for the sediment bed in terms of spatial patterns of response. Tetra-CB from the Lower/Raritan Bays sediment area today is projected to contribute enough to water column concentrations of tetra-CB in the future to be entirely responsible for violations of the human health water quality standards applicable to the summation of ten PCB homologs. Expected future concentrations of tetra-CB in the water column due to sediment concentrations from the Lower/Raritan Bays sediment area today will range from effectively 0 ng/L in the Upper Hudson to 0.2101 ng/L in Raritan Bay. The water quality standards for all PCBs, not just tetra-CB, are 0.001 ng/L in New York and 0.064 ng/L in New Jersey.

2.1.5 Hexa-CB Sediment Responses Due to Hackensack River Area Sediments

For hexa-CB, concentrations in the sediments of the Hackensack River sediment area now will contribute minimally (less than 29%) to surficial sediment concentrations in the future based on the CARP model calculations stored in the spreadsheet tools. The model results suggest that the now in-place sediment contamination from the Hackensack River sediment area has its greatest external impact on future concentrations of hexa-CB in Newark Bay. Hexa-CB in the Hackensack River sediment area today is expected to account for about 7.3% of future hexa-CB concentrations in Newark Bay. Another place that sediments from the Hackensack River area will contribute hexa-CB to in the future is the Arthur Kill. Future sediment concentrations in the Hackensack River itself will be controlled by: sediment contamination in the Hackensack River today (29%), transport from

other sediment areas (16%), and external loadings to the system (55%). Management of Hackensack River sediment hexa-CB contamination doesn't appear to be a strong strategy for cleanup of other Harbor areas.

2.1.6 Hexa-CB Water Column Responses Due to Hackensack River Area Sediments

Hexa-CB results in the water column are similar to those described for the sediment bed in terms of spatial patterns of response. Hexa-CB from the Hackensack River sediment area today is projected to contribute enough to water column concentrations of hexa-CB in the future to be entirely responsible for violations of the human health water quality standards applicable to the summation of ten PCB homologs. Expected future concentrations of hexa-CB in the water column due to sediment concentrations from the Hackensack River sediment area today range from 0, in the Upper Hudson River, to 0.5075 ng/L, in the Hackensack River itself. The water quality standards for all PCBs, not just hexa-CB, are 0.001 ng/L in New York and 0.064 ng/L in New Jersey.

2.1.7 Tetra-CB Sediment Responses Due to Hackensack River Area Sediments

For tetra-CB, concentrations in the sediments of the Hackensack River sediment area now will contribute minimally (less than 34%) to surficial sediment concentrations in the future based on the CARP model calculations stored in the spreadsheet tools. The model results suggest that the now in-place sediment contamination from the Hackensack River sediment area has its greatest external impact on future concentrations of tetra-CB in Newark Bay. Tetra-CB in the Hackensack River sediment area today is expected to account for about 6.6% of future tetra-CB concentrations in Newark Bay. Another place that sediments from the Hackensack River area will contribute tetra-CB to in the future is the Arthur Kill. Future sediment concentrations in the Hackensack River itself will be controlled by: sediment contamination in the Hackensack River today (34%), transport from other sediment areas (22%), and external loadings to the system (44%). Management of Hackensack River sediment tetra-CB contamination doesn't appear to be a strong strategy for cleanup of other Harbor areas.

2.1.8 Tetra-CB Water Column Responses Due to Hackensack River Area Sediments

Tetra-CB results in the water column are similar to those described for the sediment bed in terms of spatial patterns of response. Tetra-CB from the Hackensack River sediment area today is projected to contribute enough to water column concentrations of tetra-CB in the future to be entirely responsible for violations of the human health water quality standards applicable to the summation of ten PCB homologs. Expected future concentrations of tetra-CB in the water column due to sediment concentrations from the Hackensack River sediment area today range from 0, in the Upper Hudson River, to 1.0319 ng/L, in the Hackensack River itself. The water quality standards for all PCBs, not just tetra-CB, are 0.001 ng/L in New York and 0.064 ng/L in New Jersey.

2.2 RESPONSES TO “ALL OTHER” AREA SEDIMENTS

While the CARP model results stored in the spreadsheet tools identify the expected future concentrations of tetra-CB and hexa-CB in water, sediment, and biota throughout the Harbor due to current sediments specifically from each of the Passaic River, Newark Bay, the Arthur Kill, the Upper Bay Area, the Hudson River Area, the Lower/Raritan Bays area, and the Hackensack River, the now available CARP model results consider tetra-CB and hexa-CB from the sediments of the Raritan River, the East River, Jamaica Bay, the Bight, and the Sound as a single source, “All Other Sediments.” Where “All Other Sediments” contribute significantly to expected future ambient concentrations of tetra-CB and hexa-CB, the EPA specifically requested that HydroQual offer an opinion as to the dominant portion of “All Other Sediments” responsible.

Based on CARP model results, “All Other Sediments” are expected to be an important (i.e., >10%) future source in a number of regions as tabulated in Table 1. In each case the likely contributors are also noted.

Table 1. Identification of locations where “All Other Sediments” are expected to contribute to tetra-CB and hexa-CB future contamination and likely drivers.

Reach Impacted by “All Other Sediments”	Probable Identification of “All Other Sediments”
Lower Hudson River (below mp 13.9)	East & Harlem Rivers sediments
Upper Bay	East River sediments
Lower Bay	East River sediments Jamaica Bay sediments
Kill van Kull	East River sediments
Newark Bay	East River sediments
Arthur Kill	East River sediments Raritan River sediments
Raritan Bay	Raritan River sediments Jamaica Bay sediments
Harlem & Lower East Rivers	East & Harlem Rivers sediments Long Island Sound sediments
Upper East River/Western Long Island Sound	Long Island Sound sediments East River sediments
Eastern long Island Sound	Eastern Long Island Sound sediments
Bight/Ocean	Bight sediments East & Harlem Rivers sediments Raritan River sediments Jamaica Bay sediments

2.3 BIOTA RESPONSES DUE TO ALL AREA SEDIMENTS

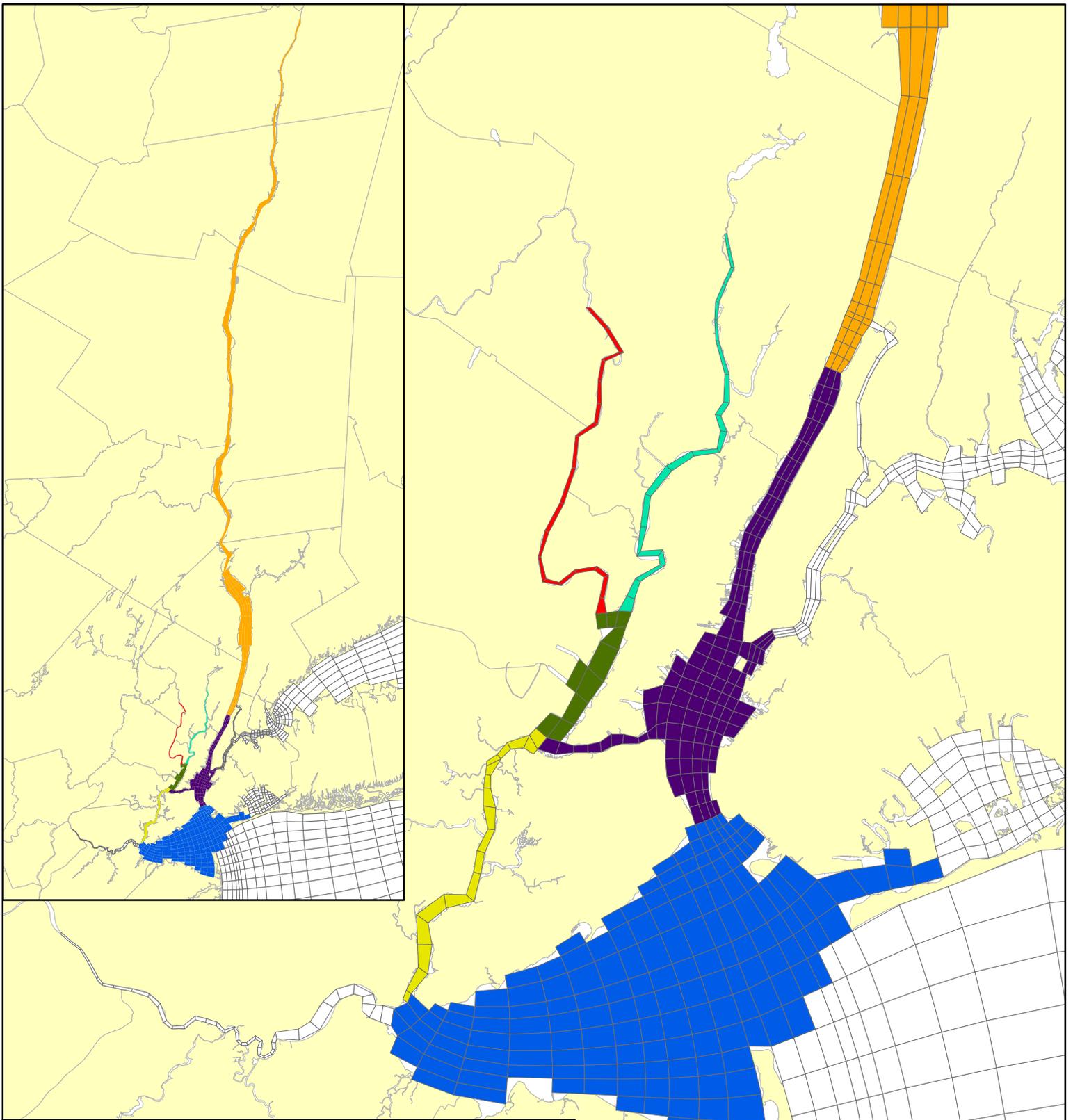
The spreadsheet tools include results for a number for different benthic and pelagic organisms. Since these results were calculated by applying bioaccumulation factors (BAFs) to water column results and biota-sediment accumulation factors (BSAFs) to sediment results, further discussion of the biota responses beyond the discussions for sediment and water column responses are not warranted. By virtue of the BAFs and BSAFs, biota responses will track sediment and water column responses.

3.0 FURTHER INFORMATION NEEDS TO CHARACTERIZE SEDIMENT AREA INFLUENCES MORE COMPLETELY

Drawing final management conclusion about exactly where to remedy sediments to achieve the greatest benefits requires a consideration of additional contaminants beyond tetra-CB and hexa-CB. Other contaminants will have different spatial patterns of current and historical source inputs. Candidate contaminants might include other PCB homologs, dioxin/furan congeners, or DDT and its metabolites. Benzo(a)pyrene and chlordane are not suggested for this purpose since previous results suggest their future concentrations are controlled more by on-going sources than by in-place sediments. In addition, the contribution of sediments from the East River, which have relatively high tetra-CB and hexa-CB current concentrations, to future concentrations in other sediment areas is a significant unknown. The role of East River sediments could be addressed by conducting additional unit response loading source component simulations with the CARP model and further expanding the CARP model spreadsheet tools.

4.0 OVERALL CONCLUSIONS

Of the two sediment areas evaluated as sources of tetra-CB and hexa-CB, the Lower/Raritan Bays sediment area produces greater percentages of future PCB concentrations over broader spatial areas than does the Hackensack River sediment area. In general, both of the sediment areas evaluated tend to act locally, with diminished benefits in other areas of the Harbor.



Matrix Sediment Regions

