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March 22, 1999

Douglas J. Tomchuk  
Emergency and Remedial Response Division  
U.S. Environmental Protection Agency  
290 Broadway, 20<sup>th</sup> Floor  
New York, New York 10007

**RE: EVALUATION OF ANALYTICAL BIAS IN THE USGS WATER COLUMN  
DATABASE**

Dear Mr. Tomchuk:

Enclosed please find the technical memorandum entitled: *Phase 2 Evaluation of Analytical Bias in the USGS Water Column Database*. The purpose of this memorandum is to discuss the analytical bias inherent in the capillary column Aroclor PCB analytical technique employed by the USGS beginning in the late 1980's. USGS PCB samples were quantified using composite response factors derived from manufactured Aroclor standards, most commonly Aroclors 1242 and 1254. This method introduces a significant analytical bias into samples that typically contain a relatively high percentage of mono- and di-chlorinated biphenyls (i.e. samples collected downstream of Fort Edward), as these congeners represent a small weight percent of the Aroclor standards used to quantify them. The memorandum discusses the method developed to quantify the magnitude of this bias based on a subset of USGS chromatograms. The following is a list of the major findings resulting from this study:

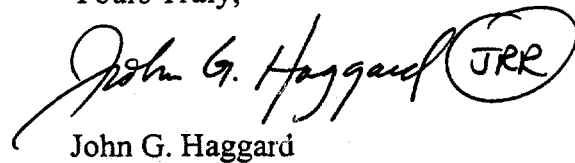
- USGS capillary column water column data are biased low, primarily for sampling stations downstream of Fort Edward,
- the USGS reported Aroclor 1242 concentrations essentially represent the sum of tri- and higher homologs, and
- in the absence of Aroclor 1242 data, Aroclor 1248 can be used as a reasonable approximation of the tri- and higher homolog sum.

Mr. Douglas Tomchuk  
March 22, 1999  
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Please feel free to contact me regarding any questions you may have about the content of this document.

Please place a copy of this letter and memorandum into the Administrative Record being developed for the Upper Hudson River Superfund PCB site.

Yours Truly,

  
John G. Haggard

encl:

cc: William McCabe, U.S. EPA  
Douglas Fisher, U.S. EPA  
Jon Butcher, TetraTech  
William Ports, NYDEC  
Victor Bierman, Limno-Tech  
Jay Field, NOAA  
Charlie Menzie, Menzie Cura  
John Connolly - QEA  
Jim Rhea - QEA



## TECHNICAL MEMORANDUM

**TO:** John Haggard  
**FROM:** James Rhea / Michael Werth  
**RE:** Phase 2 Evaluation of Analytical Bias  
in the USGS Water Column Database

**DATE:** March 22, 1999  
**FILE:** GENhud 111  
**CC:** Mel Schweiger - GE CEP  
John Connolly - QEA

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The purpose of this memorandum is to document QEA's Phase 2 evaluation of analytical biases existing within the Hudson River water column PCB data set generated by the U.S. Geological Survey (USGS). This Phase 2 analysis was performed to supplement the preliminary analysis of potential analytical biases within the USGS data set documented in HydroQual, 1998<sup>1</sup>. For completeness, this memorandum presents background and methodology information stated in HydroQual, 1998, as well as a summary of the Phase 1 preliminary analysis, and the procedures for and conclusions drawn from the Phase 2 analysis.

### I. INTRODUCTION

#### Background

The USGS water column PCB monitoring program was established to provide baseline PCB transport information prior to the implementation of a New York State sponsored dredging project (Schroeder and Barnes, 1983)<sup>2</sup>. Sampling was conducted primarily at Fort Edward, Schuylerville,

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<sup>1</sup> HydroQual, 1998. Memorandum from J. Rhea of HydroQual, Inc. to M. Schweiger and J. Haggard of GE Corporate Environmental Programs, Albany, NY dated 29 January, 1998.

<sup>2</sup> Schroeder, R.A. and C.R. Barnes, 1983. Polychlorinated Biphenyl Concentrations in Hudson River Water and Treated Drinking Water at Waterford, New York. U.S. Geological Survey. Water Resources Investigation Report 83-4188. Albany, New York.

Stillwater, and Waterford, New York. Although the USGS sampling program schedule varied over the years, most sampling was focused around elevated flow events.

Whole water samples were collected and submitted to the USGS National Water Quality Laboratories in Doraville, GA (1975-December 1986) and Denver, CO (December 1986-present) for total suspended solids and PCB analysis. PCB analysis generally followed established protocols, including extraction with a pesticide-grade solvent, clean up to remove potential interference agents, PCB separation on either a packed column (1977-December 1986) or capillary column<sup>3</sup> (December 1986-present), and PCB detection with an electron capture detector<sup>4</sup>. Aroclor PCBs were quantified in the water column samples in the following manner:

- multiple chromatographic peaks were selected from the samples corresponding to peaks from what the analytical chemist identified as the most closely matched Aroclor standard(s),
- the areas of the selected peaks were summed, and
- sample Aroclor concentrations were computed as the product of the sample peak area sum and a composite response factor calculated as the mass of injected standard divided by the sum of the standard peak areas (see section 2).

Potential for significant analytical bias exists in the USGS water column data set. Due to environmental weathering processes, the congener distribution of PCBs within water column samples collected downstream of sediment PCB deposits deviates from that of the source Aroclors. Therefore, the use of composite response factors derived from Aroclor standards may not accurately assess the total PCBs within an environmental sample. Samples collected downstream of Fort Edward contain high percentages of mono- and dichlorobiphenyls, which make up a relatively small weight percent of the Aroclor standards used to quantify them (OBG, 1997<sup>5</sup>). Therefore, there is likely a low bias in the USGS data set. Developing an understanding of this bias is important for the Hudson River Reassessment.

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<sup>3</sup> The USGS used either a 30 meter Supelco, Inc. SPB-5 or J&W, Inc. DB-5 capillary column from 1987-1991.

<sup>4</sup> Personal communication between Robert Wagner of Northeast Analytical, Inc. and Ralph White and Duane Wydoski of the USGS in Denver, CO.

<sup>5</sup> O'Brien & Gere Engineers, Inc. 1997. *Fort Edward Dam PCB Remnant Deposit Containment, 1996 Post-Construction Monitoring Program*. O'Brien & Gere Engineers, Inc., May 1997.

## Objectives

The objectives of the USGS water column data study were to:

- develop an understanding of the nature and magnitude of the analytical bias in the USGS data set,
- develop an understanding of the spatial variability of the bias, and
- assess the effect of the bias on the historical data set.

## Approach

### Phase 1 Analysis

A preliminary analysis of seven water column samples collected in 1987 was performed to assess the potential bias in the USGS data set. The following is a summary of the Phase 1 analysis detailed in HydroQual, 1998:

- copies of gas chromatographs were obtained from the USGS for samples collected during the late 80's;
- a more refined PCB quantitation technique was developed at the chromatographic peak level, based on peak specific response factors derived from directly measured peak heights;
- comparison of results obtained from both quantitation techniques indicated that USGS water column samples were biased low (6 to 44%); and
- Homolog distributions for recomputed 1987 USGS data generally agreed with homolog distributions observed in 1991 pre- Allen Mill event data<sup>6</sup>.

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<sup>6</sup> O'Brien & Gere Engineers, Inc. 1994. *Bakers Falls Operable Unit 3, Remedial Investigation Report*. Syracuse, N.Y. O'Brien & Gere Engineers, Inc. Prepared for the General Electric Company Corporate Environmental Programs, Albany, N.Y. January 1994.

## Phase 2 Analysis

As a result of the preliminary analysis of the seven water column samples, a total of 60 samples were selected for Phase 2 analysis. Phase 2 analysis involved selection of additional samples and refinement of the Phase 1 procedure as follows:

- samples selected for Phase 2 reanalysis were chosen based on ease of interpretation of the chromatographs (this limited the data set to samples collected in 1987);
- PCB quantitation was refined to include peaks greater than DB-1 peak 50 (Phase 1 analysis focused on quantitation of peaks 2-50 only, as these peaks generally accounted for a majority of the PCBs within a sample); and
- the assignment of DB-1 peak 2 (2-Mono CB) was refined based on comparison of USGS DB-5 chromatograph retention times with retention times from current DB-1 column chromatographs<sup>7</sup>.

## **II. PCB QUANTITATION METHODOLOGY**

### USGS Methodology

The USGS quantified Aroclor PCB concentrations from composite response factors derived from select capillary column chromatograph peaks. Within each gas chromatographic set, response factors were developed on an Aroclor basis ( $RF_i$ ) using select peak areas ( $A_{ij}$ ) and Aroclor standard mass ( $M_i$ ) according to the following equation:

$$RF_i = \frac{M_i}{\sum_{j=1}^n A_{ij}}$$

Aroclor concentrations of water column samples [ $Aroclor_s$ ] were then determined from the sample chromatograph by summing the areas of the same select peaks ( $A_{s,j}$ ) used to generate the Aroclor response factors, multiplying by the Aroclor response factor, and dividing by the volume of the sample injected ( $V_s$ ) as follows:

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<sup>7</sup> Analysis performed by Robert Wagner of Northeast Analytical, Inc. comparing ratios of peak retention times.

$$[Aroclor_s] = \frac{RF_i \left( \sum_{j=1}^n A_{sj} \right)}{V_s}$$

### Reanalysis Methodology

Reanalysis of the USGS chromatographs involved development of peak specific response factors derived from Aroclor 1232, 1242, and 1254 standards on a peak height basis, measurement of individual peak heights from 60 water column sample chromatographs, and recalculation of peak, homolog, and total PCB concentrations in the samples. Peaks were identified based upon DB-1 column elution patterns<sup>8</sup> published in Frame et al., 1996<sup>9</sup>. Figure 1 is an example chromatograph for a sample collected at Fort Edward illustrating peak assignments based on the published standards. The specific water column samples selected for reanalysis are summarized in Table 1.

Quantitation of PCBs in the water column samples was accomplished by using peak specific response factors computed from Aroclor 1232, 1242, and 1254 standards. The Phase 1 analysis focused on quantitation of DB-1 peaks 2-50 only, utilizing one Aroclor 1232 standard to quantify DB-1 peaks 2 and 5, and average peak specific response factors derived from several Aroclor 1242 standards to quantify DB-1 peaks 8-50 (HydroQual, 1998). The Phase 2 analysis was expanded to include peaks eluting beyond DB-1 peak 50. Since these peaks represent a relatively small weight percent of an Aroclor 1242 standard, average peak specific response factors for peaks eluting beyond peak 50 were computed based on multiple Aroclor 1254 standards. The use of average peak specific response factors was justified by the small variability among response factors computed from standards selected from different analytical groups.

Peak specific response factors are typically computed based upon known peak mass and measured peak areas. However, since the USGS chromatograph data sheets did not report peak areas for peaks eluting prior to peak 8, an alternative response factor was derived based upon directly measured peak heights. Peak specific response factors for a given Aroclor standard ( $RF_{ij}$ ) were computed according to the following equation:

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<sup>8</sup> The SPB-5 column produces a PCB elution pattern similar to that of the DB-1 column.

<sup>9</sup> Frame, G.M. et al., 1996. Comprehensive, Quantitative, Congener-Specific Analyses of Eight Aroclors and Complete PCB Congener Assignments on DB-1 Capillary GC Columns. *Chemosphere* 33:603-623.

$$RF_{ij} = \frac{M_i \frac{Wt\%_{ij}}{100}}{H_{ij}}$$

where  $Wt\%_{ij}$  is the weight percent of peak  $j$  within Aroclor  $i$  (as reported in Frame et al., 1996), and  $H_{ij}$  is the direct measured peak height for peak  $j$  within Aroclor  $i$ .

The accuracy of using direct measurements of peak heights to estimate Aroclor totals within a sample rather than peak areas was evaluated as in the Phase 1 analysis. The validity of using peak heights was tested by numerically duplicating the USGS quantitation methodology based on directly measured peak heights rather than peak areas, and comparing the results with the reported values (Figure 2). The close agreement between the two methods supports the use of measured peak heights for quantitation of PCBs within the water column samples.

Average peak specific response factors calculated from Aroclor 1232 (peaks 2 & 5 only), Aroclor 1242 (peaks 8-50), and Aroclor 1254 (peaks 50-102) standards were used to compute individual peak concentrations within water column samples. The concentration of each peak in a given sample ( $C_{j,s}$ ) was determined according to the following equation:

$$C_{j,s} = \frac{H_{j,s} RF_{ij}}{V_s}$$

where  $V_s$  is the reported total volume of the sample extracted and  $H_{j,s}$  is the measured height of each peak within the sample. Concentrations for all identifiable peaks up to and including DB-1 peak 102 were computed. A summary of identifiable peaks is presented in Table 2. These peaks account for approximately 93% of the total PCB mass in an Aroclor 1242 standard.

Total PCB concentrations and homolog distributions of the samples were computed using the individual peak concentrations. For peaks in which multiple homologs coelute, the homolog distributions were calculated from coelution information published for Aroclors (Frame et al., 1996).

### III. APPROXIMATION OF BIAS IN USGS DATA

#### Quantification of Bias

To assess the magnitude of the bias within the USGS database, recomputed peak total PCBs were compared with USGS-reported Aroclor PCB values. To facilitate this comparison, it was first necessary to determine the combination of USGS-reported Aroclor concentrations that most accurately represented the total PCBs of a sample. Figures 3 and 4 illustrate the relationship between the recomputed peak total PCBs with both the reported Aroclor 1242 concentration (Figure 3) and the reported sum of Aroclors 1242 and 1254 (Figure 4), on both a total PCB and tri and higher PCB basis. Removal of mono- and di- peaks from the recomputed peak total PCBs suggests that the sum of Aroclors 1242 and 1254 over-quantified PCBs in the samples (Figure 4). However, the reported Aroclor 1242 concentration appears to be a good approximation of tri- and higher PCBs in the samples (Figure 3).

The over-quantification of the USGS-reported total PCBs (sum of Aroclors 1242 and 1254) appears to be the result of an over-quantification of the USGS-reported Aroclor 1254. This over-quantification appears to be an artifact of the composite response factor method employed by the USGS. The peaks most commonly used by the USGS to quantify Aroclor 1254 included DB-1 peaks 51, 53, 54, 56, 57, 58, and 61 (Table 2). These peaks represent a small proportion of Aroclor 1254 PCBs (approximately 30%), and are also present in Aroclor 1242. Using a composite response factor derived from these peaks, as the USGS did, assumes that the entire distribution of Aroclor 1254 peaks is present in a given sample. This is not the case as can be seen in Figure 5. Only a few unique Aroclor 1254 peaks are present in the representative water column sample collected at Fort Edward<sup>10</sup>. Therefore, the USGS over-quantified Aroclor 1254 and consequently the total PCBs (Aroclors 1242 and 1254) within the samples.

To further demonstrate this point, a numerical exercise was performed to evaluate the Aroclor 1254 over-quantification implicit in the composite response factor method employed by the USGS. Using Aroclor 1242 at a peak total concentration of 100 ppm, the corresponding Aroclor 1242 and 1254 concentrations were computed using composite response factors based on the peaks most frequently used for Aroclor standardization by the USGS. In addition to the 100 ppm of Aroclor 1242 calculated by this method, an additional 15-30 ppm of Aroclor 1254 was also quantified. In other words, depending on the peaks used for Aroclor 1254 quantification (which varied among USGS analytical groups), between 15 and 30% over-quantification of total PCBs would result for

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<sup>10</sup> A Fort Edward sample was used so that the signature of peaks greater than DB-1 peaks 2 and 5 can be compared with the Aroclor standards. Stations downstream have similar compositions except for a higher weight percent of peaks 2 and 5.

water column samples exhibiting a PCB composition similar to that of Aroclor 1242. Based on the Aroclor 1254 over-quantification, recomputed peak totals were compared with USGS-reported Aroclor 1242 for evaluation of analytical biases in the USGS data set.

Quantitative comparison of the recomputed peak total PCBs with USGS-reported Aroclor 1242 concentration suggests that the USGS-reported Aroclor 1242 concentration approximately represents the tri- and higher homolog sum of PCBs. In 58 out of 60 samples, the recomputed peak total PCBs exceeded the reported USGS Aroclor 1242 concentrations by between 4 and 70% (Table 3). Adjusting the calculated peak totals by subtracting the contribution of mono- and di- peaks (primarily peaks 2, 5, 8, and 25% of peak 14) enhanced the agreement with the USGS-reported Aroclor 1242 concentration (Figure 3). Hence, the USGS-reported Aroclor 1242 concentration can be interpreted as approximately representing tri- and higher PCBs.

### **Spatial Variability of Bias**

The magnitude of the analytical bias differed between the Fort Edward station and the downstream stations (e.g. Thompson Island, Schuylerville, Stillwater, and Waterford). Figure 6 is a comparison of the recomputed peak total PCBs with the USGS-reported Aroclor 1242 concentration, grouped according to the spatial proximity of the water column sampling stations. Linear regression of the data collected at the Fort Edward station indicated approximately a one to one relationship, suggesting a lack of the bias generally observed in the remaining 51 water column samples collected at the downstream stations. Linear regression applied to the downstream stations resulted in regression lines with slopes greater than one ( $\sim 1.4$ ), indicating that the recomputed peak total PCBs were generally greater than the USGS-reported Aroclor 1242 concentrations for the samples. These results are expected since samples collected at Fort Edward generally exhibit a peak signature similar to Aroclor 1242 (OBG, 1997), while downstream samples exhibit a dechlorinated signature (higher levels of DB-1 peaks 2 and 5) consistent with our current understanding of the system (QEA, 1998)<sup>11</sup>. Therefore, quantification against an Aroclor 1242 standard is a reasonable approximation of total PCBs in the samples collected at Fort Edward but results in an underestimation of total PCBs in downstream stations.

### **Temporal Comparison of Homolog Distributions**

The average homolog distributions calculated from the 60 water column samples collected in 1987 generally agree with homolog distributions computed from 1991 data collected prior to the Allen Mill loading event, as well as with data currently being collected in 1998 (Figure 7). As a

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<sup>11</sup> Quantitative Environmental Analysis, LLC., 1998. *Thompson Island Pool Sediment PCB Sources*, prepared for General Electric Company, Corporate Environmental Programs, March, 1998.

result of the reassignment of peak 2 during the Phase 2 analysis<sup>12</sup>, the homolog composition observed at the Fort Edward station is relatively consistent across all three time periods. Homolog distributions calculated for samples collected at the downstream stations in 1987 are generally consistent with samples collected in 1998. However, the homolog distribution computed for downstream samples collected in 1991 are more indicative of a non-dechlorinated Aroclor 1242 signature, perhaps due to some pre- Allen Mill loading from the GE plant site. Nonetheless, the similarities between the homolog compositions supports the methodology used to calculate homolog distributions using the recomputed peak PCB concentrations.

#### IV. COMPARISON BETWEEN USGS-REPORTED AND EPA DATABASE

The results of the PCB analyses for 1987 samples collected by the USGS are currently incorporated into the USEPA Hudson River PCBs Reassessment RI/FS database. Prior to its incorporation into the USEPA database, these data changed hands several times. Therefore, application of the results described above to these data depend upon how the data may have changed (e.g. treatment of non-detects, transcription errors) over time. The USGS-reported Aroclor PCB values noted on the chromatogram data sheets, and also used in determination of the analytical bias described herein, were compared to the values reported in the EPA database, version 4.1. Of the 60 samples selected for Phase 2 reanalysis, approximately 50% of the Aroclor 1242 values reported in the EPA database differ from the corresponding Aroclor 1242 value listed on the sample chromatogram data sheets. There are several possible explanations for the observed differences between the two data records, including:

- an equal split between Aroclors 1242 and 1254 in the EPA database was determined for approximately 50% of the unmatched samples (qualified by an "N2" qualifier<sup>13</sup>) meaning the data were created based upon a known total PCB concentration and "identified Aroclors" in the sample,
- apparent rounding errors and detection limit issues, and
- unknown reasons, possibly due to transcription errors.

However, the relative percent differences between the USGS reported Aroclor 1242 PCB concentrations and those appearing within the EPA database are small (generally less than 20-30%).

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<sup>12</sup> During the Phase 1 analysis, an elevated weight percent of monochlorinated biphenyl was observed for recomputed USGS samples collected at the Fort Edward station.

<sup>13</sup> Butcher, J.B. 1997. USGS PCB Data. Memorandum to the Hudson River Team. April 14, 1997.

Moreover, the average absolute difference for each monitoring station is generally less than 10 ng/l, indicating that the reporting errors should not significantly impact loading calculations.

In an attempt to improve loading estimates based on the USGS data, a subset of the Phase 2 samples was selected to determine a data-based assessment of the Aroclor split for data qualified as "N2" (assumed equal split of total PCBs between identified Aroclors for a given sample) in the EPA database (Butcher, 1997). Statistics computed for Aroclor 1242 and 1254 values originally reported by the USGS for the data set described herein suggest that a more representative Aroclor split is approximately 75% Aroclor 1242 and 25% Aroclor 1254.

## **V. APPLICATION TO THE REMAINING USGS DATA SET (1988 - 1996)**

The preceding Phase 2 analysis of the USGS capillary column chromatograms focused on 60 water column samples collected in 1987. In support of current modeling efforts, the results of this analysis need to be applied to the remainder of the USGS water column data set from 1988 to 1996. Between 1988 and 1991, the USGS listed Aroclor 1248 as an identified Aroclor in addition to or in place of Aroclor 1242 (Table 4). Since the PCB congener distributions for Aroclors 1242 and 1248 overlap significantly, the quantification of both Aroclors 1242 and 1248 via the USGS method would significantly over-estimate the total PCBs within a sample. Therefore, if both Aroclors 1242 and 1248 are reported, only Aroclor 1242 should be considered.

An exercise similar to that employed to demonstrate the Aroclor 1254 over-quantification (Section III) was used to determine if Aroclor 1248 is a reasonable approximation of tri and higher PCBs in the absence of Aroclor 1242 data. Using the peaks most commonly selected by the USGS for standardization, Aroclor 1242 and 1248 PCB concentrations were determined for all of the Phase 2 samples based on the total weight percent of these standardization peaks within their respective standards. For example, the peaks most commonly used in quantifying Aroclor 1242 by the USGS were DB-1 peaks 14, 15, 17, 23, 24, 25, 26, 31, 32, 34, 37, 38, and 39. These peaks account for approximately 60% of the total PCB mass in an Aroclor 1242 standard (Frame et al., 1996). An Aroclor 1242 PCB concentration was calculated for each sample by summing the recomputed Phase 2 peak concentrations for the above mentioned peaks, and dividing that by 60%. The same calculation was repeated for Aroclor 1248 using the peaks most commonly used by the USGS in quantifying Aroclor 1248. On average, the Aroclor 1248 concentration was approximately 15% higher than Aroclor 1242. Based on this analysis, it is reasonable to consider Aroclor 1248 as an approximation of tri- and higher PCBs in the absence of Aroclor 1242 data.

## VI. SUMMARY AND CONCLUSIONS

Based on the preceding Phase 2 analysis of inherent biases in the USGS data set, and the application of the findings of this analysis to the current USEPA database, the following observations are offered:

- the USGS data are biased low between 4 and 70%, primarily for stations downstream of Fort Edward,
- average homolog compositions observed in the recomputed USGS data generally agree with our understanding of the system,
- based on an evaluation of the quantification technique employed by the USGS, the USGS-reported Aroclor 1242 concentrations essentially represent the sum of tri- and higher homologs,
- the variability between samples listed in the EPA database version 4.1 and PCB values originally reported by the USGS introduces an indeterminate error into the database which, based upon the review of the 1987 USGS records, should not significantly impact average PCB loading calculations, and
- in the absence of Aroclor 1242 data, Aroclor 1248 can be used as a reasonable approximation of the tri- and higher homolog sum.

## VII. RECOMMENDATIONS

QEA offers the following recommendations for future application of the USGS data collected after 12/01/86<sup>14</sup>:

- directly use Aroclor 1242 reported in the EPA database version 4.1 as a tri- and higher PCB estimate,
- in the absence of Aroclor 1242 data, use Aroclor 1248 reported in the EPA database version 4.1 as a tri- and higher PCB estimate,

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<sup>14</sup> Review of documentation revealed that samples collected during December, 1986 were not analyzed until 1987, when capillary column analysis was implemented. Samples collected prior to this date were analyzed using packed column chromatography and should be handled according to the method described by John Butcher in a memo to LTI and TAMS dated December 11, 1996

- if both Aroclors 1242 and 1248 were identified, use Aroclor 1242 as a tri- and higher PCB estimate, and
- for data qualified as "N2", indicating an equal fraction Aroclor split between all identified Aroclors, correct the data to reflect the statistically-derived Aroclor split of 75% Aroclor 1242; 25% Aroclor 1254.

## General Electric Company - Hudson River Project

**Table 1. List of USGS Supplied Hudson River PCB Gas Chromatographs  
Selected for Reanalysis**

| SAMPLING<br>STATION | SET<br>NUMBER | USGS<br>ID NUMBER | DATE<br>COLLECTED | Reported<br>Aroclor 1242 [ug/L] | Reported<br>Aroclor 1254 [ug/L] |
|---------------------|---------------|-------------------|-------------------|---------------------------------|---------------------------------|
| Fort Edward         | 4.02          | 73570022dup       | 12/17/87          | 0.016                           | 0.005                           |
| Fort Edward         | 4.02          | 73570022          | 12/17/87          | 0.013                           | 0.009                           |
| Fort Edward         | 252.06        | 72510020          | 04/03/87          | 0.010                           | 0.006                           |
| Fort Edward         | 252.06        | 72510021          | 04/03/87          | 0.016                           | 0.007                           |
| Fort Edward         | 252.06        | 72510026          | 03/10/87          | 0.009                           | 0.001                           |
| Fort Edward         | 251.07        | 72510028A         | 04/01/87          | 0.039                           | 0.013                           |
| Fort Edward         | 251.07        | 72510028B         | 04/01/87          | 0.037                           | 0.011                           |
| Fort Miller         | 4.02          | 73570019          | 12/18/87          | 0.016                           | 0.005                           |
| Rogers I.           | 268.03        | 72670016B         | 09/17/87          | 0.031                           | 0.008                           |
| Rogers I.           | 268.03        | 72670016A         | 09/17/87          | 0.067                           | 0.021                           |
| Schuylerville       | 4.02          | 73570018          | 12/18/87          | 0.019                           | 0.005                           |
| Schuylerville       | 251.07        | 72480060          | 04/15/87          | 0.016                           | 0.008                           |
| Schuylerville       | 252.06        | 872510019         | 04/22/87          | 0.020                           | 0.009                           |
| Schuylerville       | 251.05        | 72480053          | 04/02/87          | 0.038                           | 0.012                           |
| Schuylerville       | 251.07        | 72510030A         | 03/10/87          | 0.013                           | 0.005                           |
| Schuylerville       | 268.03        | 73370012          | 11/24/87          | 0.023                           | ---                             |
| Stillwater          | 4.02          | 73570021          | 12/18/87          | 0.018                           | 0.003                           |
| Stillwater          | 252.06        | 72510023          | 04/15/87          | 0.015                           | 0.005                           |
| Stillwater          | 268.03        | 873370008         | 11/23/87          | 0.009                           | 0.007                           |
| Thompson I.         | 268.03        | 72670018B         | 09/17/87          | 0.020                           | 0.006                           |
| Thompson I.         | 268.03        | 72670018A         | 09/17/87          | 0.050                           | 0.010                           |
| Waterford           | 247.08        | 72470057          | 04/03/87          | 0.069                           | 0.014                           |
| Waterford           | 247.08        | 72470123A         | 04/08/87          | 0.032                           | 0.010                           |
| Waterford           | 247.08        | 72470123B         | 04/08/87          | 0.021                           | 0.005                           |
| Waterford           | 247.08        | 72470122B         | 04/11/87          | 0.020                           | ---                             |
| Waterford           | 247.08        | 72470125B         | 04/12/87          | 0.017                           | 0.006                           |
| Waterford           | 247.08        | 72470126A         | 04/09/87          | 0.015                           | 0.009                           |
| Waterford           | 247.08        | 72470124A         | 04/07/87          | 0.021                           | ---                             |
| Waterford           | 247.08        | 72470125A         | 04/12/87          | 0.017                           | 0.003                           |
| Waterford           | 247.08        | 72470124B         | 04/07/87          | 0.015                           | ---                             |
| Waterford           | 247.08        | 72470122A         | 04/11/87          | 0.016                           | ---                             |
| Waterford           | 247.08        | 72470032          | 04/07/87          | 0.029                           | 0.009                           |
| Waterford           | 247.08        | 72460040          | 04/15/87          | 0.020                           | 0.006                           |
| Waterford           | 247.08        | 72460041          | 04/15/87          | 0.016                           | 0.005                           |
| Waterford           | 247.08        | 72460043          | 04/07/87          | 0.030                           | 0.010                           |
| Waterford           | 247.08        | 72460044          | 04/11/87          | 0.017                           | 0.004                           |
| Waterford           | 247.08        | 72460045          | 04/15/87          | 0.015                           | 0.013                           |
| Waterford           | 247.08        | 72460046          | 04/07/87          | 0.030                           | 0.010                           |
| Waterford           | 247.08        | 72470034          | 12/30/86          | 0.015                           | 0.008                           |
| Waterford           | 247.08        | 72470035A         | 12/05/86          | 0.024                           | 0.007                           |
| Waterford           | 247.08        | 72470035B         | 12/05/86          | 0.024                           | 0.006                           |
| Waterford           | 4.02          | 73570020          | 12/18/87          | 0.019                           | 0.006                           |
| Waterford           | 251.07        | 72480056          | 04/12/87          | 0.016                           | 0.016                           |
| Waterford           | 251.07        | 72480057A         | 04/22/87          | 0.024                           | 0.009                           |
| Waterford           | 251.07        | 72480057B         | 04/22/87          | 0.021                           | 0.009                           |
| Waterford           | 251.05        | 72480050A         | 04/09/87          | 0.014                           | 0.006                           |
| Waterford           | 251.05        | 72480050B         | 04/09/87          | 0.010                           | 0.003                           |
| Waterford           | 251.05        | 72480051A         | 04/10/87          | 0.018                           | 0.010                           |
| Waterford           | 251.05        | 72480051B         | 04/10/87          | 0.015                           | 0.010                           |
| Waterford           | 251.05        | 72480052A         | 05/22/87          | 0.033                           | 0.008                           |
| Waterford           | 251.05        | 72480052B         | 05/22/87          | 0.028                           | 0.009                           |
| Waterford           | 251.05        | 72480047A         | 04/07/87          | 0.038                           | 0.011                           |
| Waterford           | 251.05        | 72480048A         | 04/09/87          | 0.021                           | 0.006                           |
| Waterford           | 251.05        | 72480048B         | 04/09/87          | 0.039                           | 0.007                           |
| Waterford           | 251.05        | 72480049A         | 04/09/87          | 0.024                           | 0.006                           |
| Waterford           | 251.05        | 72480049B         | 04/09/87          | 0.018                           | 0.008                           |
| Waterford           | 268.03        | 72670017A         | 09/17/87          | 0.041                           | 0.009                           |
| Waterford           | 268.03        | 72670017B         | 09/17/87          | 0.034                           | 0.010                           |
| Waterford           | 251.07        | 72480055B         | 04/22/87          | 0.032                           | 0.020                           |
| Waterford           | 268.03        | 872670015A        | 09/17/87          | 0.053                           | 0.013                           |

**Note**

Reported Aroclor PCB Concentrations from Chromatograph Data Sheets

## General Electric Company - Hudson River Project

**TABLE 2. Summary Of Identifiable Peaks From USGS Chromatogram Samples**

| DB-1 Peak Number | BZ# Number | Structure  |
|------------------|------------|------------|
| 2                | 1          | 2          |
| 5                | 4          | 2 2'       |
| 5                | 10         | 2 6        |
| 8                | 5          | 2 3        |
| 8                | 8          | 2 4'       |
| 10               | 19         | 2 2'6      |
| 14               | 15         | 4 4'       |
| 14               | 18         | 2 2'5      |
| 15               | 17         | 2 2'4      |
| 16               | 24         | 2 3 6      |
| 16               | 27         | 2 3'6      |
| 17               | 16         | 2 2'3      |
| 17               | 32         | 2 4'6      |
| 21               | 26         | 2 3'5      |
| 22               | 25         | 2 3'4      |
| 23               | 31         | 2 4'5      |
| 24               | 28         | 2 4 4'     |
| 24               | 50         | 2 2'4 6    |
| 25               | 21         | 2 3 4      |
| 25               | 33         | 2 3'4'     |
| 25               | 53         | 2 2'5 6'   |
| 26               | 22         | 2 3 4'     |
| 26               | 51         | 2 2'4 6'   |
| 27               | 45         | 2 2'3 6    |
| 29               | 46         | 2 2'3 6'   |
| 31               | 52         | 2 2'5 5'   |
| 31               | 73         | 2 3'5'6    |
| 32               | 49         | 2 2'4 5'   |
| 33               | 47         | 2 2'4 4'   |
| 34               | 48         | 2 2'4 5    |
| 34               | 75         | 2 4 4'6    |
| 37               | 44         | 2 2'3 5'   |
| 37               | 104        | 2 2'4 6 6' |
| 38               | 37         | 3 4 4'     |
| 38               | 42         | 2 2'3 4'   |
| 38               | 59         | 2 3 3'6    |
| 39               | 64         | 2 3 4'6    |
| 39               | 71         | 2 3'4'6    |
| 42               | 40         | 2 2'3 3'   |
| 43               | 57         | 2 3 3'5    |
| 46               | 74         | 2 4 4'5    |
| 46               | 94         | 2 2'3 5 6' |
| 47               | 61         | 2 3 4 5    |
| 47               | 70         | 2 3'4'5    |
| 47               | 76         | 2 3'4'5'   |

| DB-1 Peak Number | BZ# Number | Structure      |
|------------------|------------|----------------|
| 48               | 66         | 2 3'4 4'       |
| 48               | 93         | 2 2'3 5 6      |
| 48               | 95         | 2 2'3 5'6      |
| 49               | 55         | 2 3 3'4        |
| 49               | 91         | 2 2'3 4'6      |
| 49               | 98         | 2 2'3 4'6'     |
| 50               | 56         | 2 3 3'4'       |
| 50               | 60         | 2 3 4 4'       |
| 51               | 84         | 2 2'3 3'6      |
| 51               | 92         | 2 2'3 5 5'     |
| 51               | 155        | 2 2'4 4'6 6'   |
| 53               | 90         | 2 2'3 4'5      |
| 53               | 101        | 2 2'4 5 5'     |
| 54               | 99         | 2 2'4 4'5      |
| 56               | 83         | 2 2'3 3'5      |
| 56               | 109        | 2 3 3'4 6      |
| 57               | 86         | 2 2'3 4 5      |
| 57               | 97         | 2 2'3 4'5'     |
| 57               | 152        | 2 2'3 5 6 6'   |
| 58               | 87         | 2 2'3 4 5'     |
| 58               | 111        | 2 3 3'5 5'     |
| 58               | 115        | 2 3 4 4'6      |
| 59               | 85         | 2 2'3 4 4'     |
| 59               | 116        | 2 3 4 5 6      |
| 60               | 136        | 2 2'3 3'6 6'   |
| 61               | 77         | 3 3'4 4'       |
| 61               | 110        | 2 3 3'4'6      |
| 67               | 107        | 2 3 3'4'5      |
| 67               | 108        | 2 3 3'4 5'     |
| 67               | 147        | 2 2'3 4'5 6    |
| 69               | 106        | 2 3 3'4 5      |
| 69               | 118        | 2 3'4 4'5      |
| 69               | 149        | 2 2'3 4'5'6    |
| 73               | 146        | 2 2'3 4'5 5'   |
| 73               | 161        | 2 3 3'4 5'6    |
| 74               | 105        | 2 3 3'4 4'     |
| 74               | 132        | 2 2'3 3'4 6'   |
| 77               | 141        | 2 2'3 4 5 5'   |
| 80               | 137        | 2 2'3 4 4'5    |
| 82               | 138        | 2 2'3 4 4'5'   |
| 82               | 163        | 2 3 3'4'5 6    |
| 89               | 128        | 2 2'3 3'4 4'   |
| 95               | 156        | 2 3 3'4 4'5    |
| 95               | 171        | 2 2'3 3'4 4'6  |
| 102              | 180        | 2 2'3 4 4'5 5' |

**Note:**

Congener Identification Based On *Frame*, 1996

## General Electric Company - Hudson River Project

**Table 3. Summary Of The USGS Reported Aroclor 1242 PCB Concentrations And The Recalculated Peak Total PCB Concentrations For Samples Selected For Phase 2 Analysis**

| STATION       | SAMPLE ID   | DATE     | FORT EDWARD FLOW | REPORTED 1242 | RECOMPUTED TOTAL | PERCENT LOW BIAS |
|---------------|-------------|----------|------------------|---------------|------------------|------------------|
| Fort Edward   | 73570022dup | 12/17/87 | 6450             | 0.016         | 0.019            | 17%              |
| Fort Edward   | 73570022    | 12/17/87 | 6450             | 0.013         | 0.018            | 27%              |
| Fort Edward   | 72510020    | 04/03/87 | 18500            | 0.010         | 0.011            | 11%              |
| Fort Edward   | 72510021    | 04/03/87 | 18500            | 0.016         | 0.017            | 8%               |
| Fort Edward   | 72510026    | 03/10/87 | 4150             | 0.009         | 0.010            | 5%               |
| Fort Edward   | 72510028A   | 04/01/87 | 28300            | 0.039         | 0.048            | 18%              |
| Fort Edward   | 72510028B   | 04/01/87 | 28300            | 0.037         | 0.047            | 22%              |
| Fort Miller   | 73570019    | 12/18/87 | 6430             | 0.016         | 0.031            | 48%              |
| Rogers I.     | 72670016B   | 09/17/87 | 4490             | 0.031         | 0.032            | 4%               |
| Rogers I.     | 72670016A   | 09/17/87 | 4490             | 0.067         | 0.062            | -9%              |
| Schuylerville | 73570018    | 12/18/87 | 6430             | 0.019         | 0.037            | 48%              |
| Schuylerville | 72480060    | 04/15/87 | 11200            | 0.016         | 0.028            | 43%              |
| Schuylerville | 872510019   | 04/22/87 | 6840             | 0.020         | 0.027            | 25%              |
| Schuylerville | 72480053    | 04/02/87 | 24000            | 0.038         | 0.063            | 40%              |
| Schuylerville | 72510030A   | 03/10/87 | 4150             | 0.013         | 0.023            | 44%              |
| Schuylerville | 73370012    | 11/24/87 | 5800             | 0.023         | 0.040            | 42%              |
| Stillwater    | 73570021    | 12/18/87 | 6430             | 0.018         | 0.041            | 56%              |
| Stillwater    | 72510023    | 04/15/87 | 11200            | 0.015         | 0.020            | 25%              |
| Stillwater    | 873370008   | 11/23/87 | 6010             | 0.009         | 0.009            | 2%               |
| Thompson I.   | 72670018B   | 09/17/87 | 4490             | 0.020         | 0.034            | 40%              |
| Thompson I.   | 72670018A   | 09/17/87 | 4490             | 0.050         | 0.071            | 30%              |
| Waterford     | 72470057    | 04/03/87 | 18500            | 0.069         | 0.087            | 21%              |
| Waterford     | 72470123A   | 04/08/87 | 19000            | 0.032         | 0.033            | 4%               |
| Waterford     | 72470123B   | 04/08/87 | 19000            | 0.021         | 0.027            | 23%              |
| Waterford     | 72470122B   | 04/11/87 | 12800            | 0.020         | 0.017            | -17%             |
| Waterford     | 72470125B   | 04/12/87 | 13800            | 0.017         | 0.031            | 46%              |
| Waterford     | 72470126A   | 04/09/87 | 15600            | 0.015         | 0.021            | 29%              |
| Waterford     | 72470124A   | 04/07/87 | 21200            | 0.021         | 0.033            | 36%              |
| Waterford     | 72470125A   | 04/12/87 | 13800            | 0.017         | 0.028            | 40%              |
| Waterford     | 72470124B   | 04/07/87 | 21200            | 0.015         | 0.032            | 54%              |
| Waterford     | 72470122A   | 04/11/87 | 12800            | 0.016         | 0.026            | 39%              |
| Waterford     | 72470032    | 04/07/87 | 21200            | 0.029         | 0.046            | 37%              |
| Waterford     | 72460040    | 04/15/87 | 11200            | 0.020         | 0.026            | 23%              |
| Waterford     | 72460041    | 04/15/87 | 11200            | 0.016         | 0.022            | 26%              |
| Waterford     | 72460043    | 04/07/87 | 21200            | 0.030         | 0.046            | 35%              |
| Waterford     | 72460044    | 04/11/87 | 12800            | 0.017         | 0.028            | 39%              |
| Waterford     | 72460045    | 04/15/87 | 11200            | 0.015         | 0.024            | 38%              |
| Waterford     | 72460046    | 04/07/87 | 21200            | 0.030         | 0.047            | 36%              |
| Waterford     | 72470034    | 12/30/86 | 6110             | 0.015         | 0.016            | 5%               |
| Waterford     | 72470035A   | 12/05/86 | 9120             | 0.024         | 0.042            | 42%              |
| Waterford     | 72470035B   | 12/05/86 | 9120             | 0.024         | 0.043            | 45%              |
| Waterford     | 73570020    | 12/18/87 | 6430             | 0.019         | 0.043            | 56%              |
| Waterford     | 72480056    | 04/12/87 | 13800            | 0.016         | 0.027            | 40%              |
| Waterford     | 72480057A   | 04/22/87 | 6840             | 0.024         | 0.048            | 50%              |
| Waterford     | 72480057B   | 04/22/87 | 6840             | 0.021         | 0.043            | 51%              |
| Waterford     | 72480050A   | 04/09/87 | 15600            | 0.014         | 0.019            | 26%              |
| Waterford     | 72480050B   | 04/09/87 | 15600            | 0.010         | 0.012            | 14%              |
| Waterford     | 72480051A   | 04/10/87 | 12800            | 0.018         | 0.027            | 32%              |
| Waterford     | 72480051B   | 04/10/87 | 12800            | 0.015         | 0.027            | 45%              |
| Waterford     | 72480052A   | 05/22/87 | 2180             | 0.033         | 0.110            | 70%              |
| Waterford     | 72480052B   | 05/22/87 | 2180             | 0.028         | 0.082            | 66%              |
| Waterford     | 72480047A   | 04/07/87 | 21200            | 0.038         | 0.058            | 35%              |
| Waterford     | 72480048A   | 04/09/87 | 15600            | 0.021         | 0.034            | 38%              |
| Waterford     | 72480048B   | 04/09/87 | 15600            | 0.039         | 0.059            | 34%              |
| Waterford     | 72480049A   | 04/09/87 | 15600            | 0.024         | 0.036            | 33%              |
| Waterford     | 72480049B   | 04/09/87 | 15600            | 0.018         | 0.028            | 35%              |
| Waterford     | 72670017A   | 09/17/87 | 4490             | 0.041         | 0.055            | 25%              |
| Waterford     | 72670017B   | 09/17/87 | 4490             | 0.034         | 0.044            | 23%              |
| Waterford     | 72480055B   | 04/22/87 | 6840             | 0.032         | 0.078            | 59%              |
| Waterford     | 872670015A  | 09/17/87 | 4490             | 0.053         | 0.073            | 28%              |

**Notes:**

USGS Flow as Reported in EPA Database, version 4.1

Reported Aroclor 1242 Concentrations from Original USGS Data Sheets

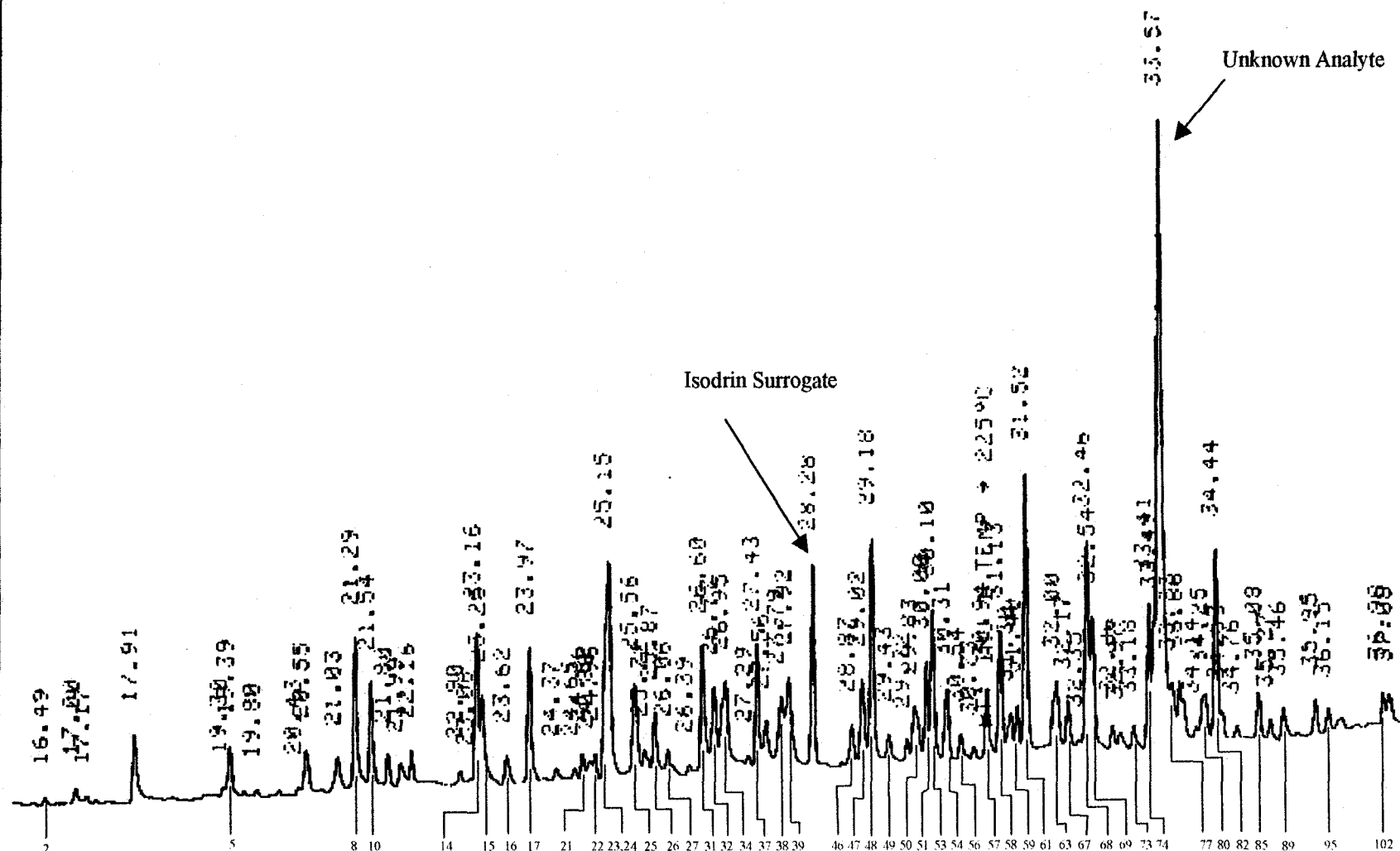
## General Electric Company - Hudson River Project

Table 4. USGS Identified Aroclors by Year

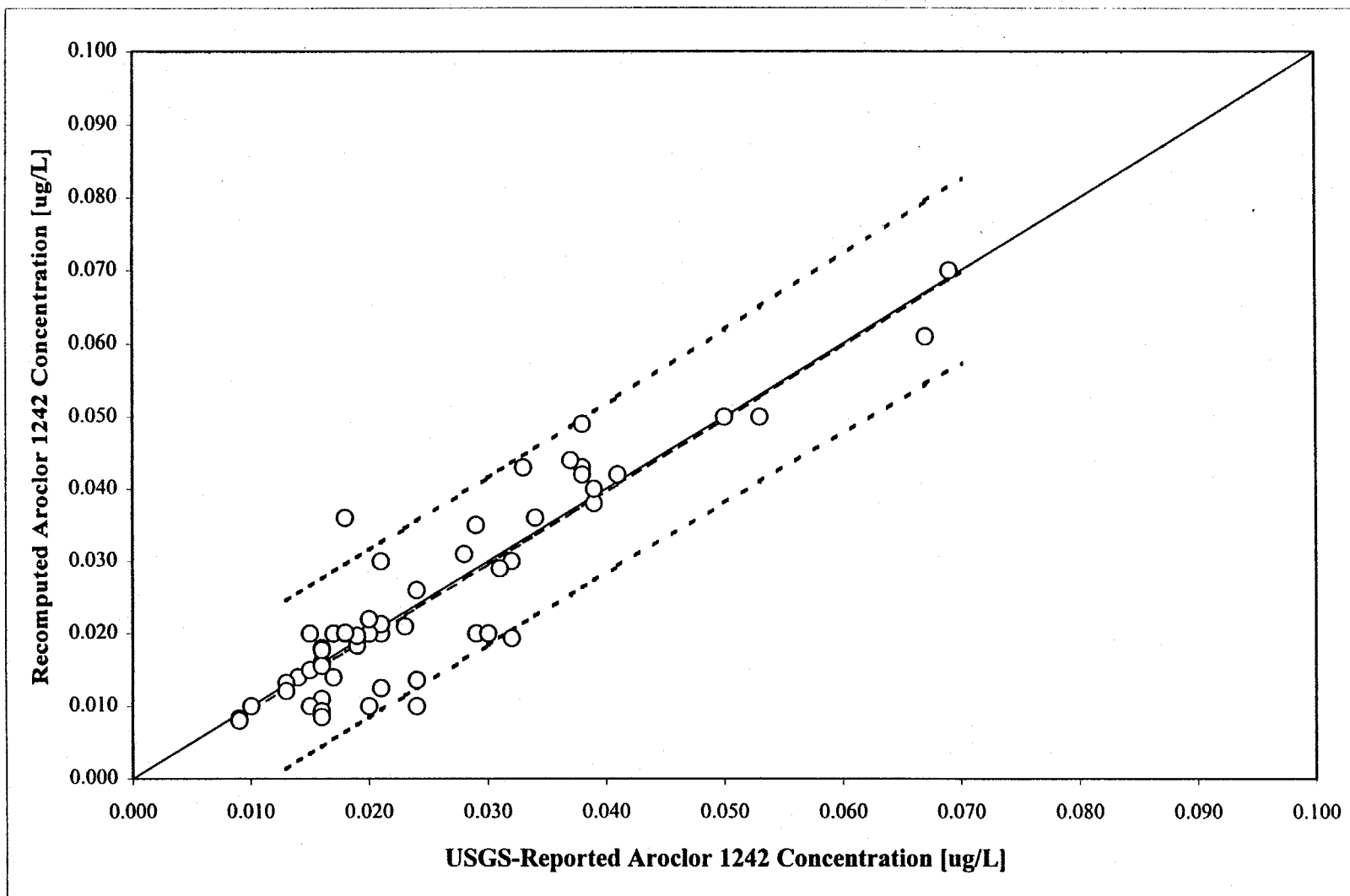
| Year | Aroclor 1242 | Aroclor 1248 | Aroclor 1254 | Notes                |
|------|--------------|--------------|--------------|----------------------|
| 1987 | X            |              | X            |                      |
| 1988 | X            | X            | X            |                      |
| 1989 | X            | X            | X            | 40 samples all 1248  |
| 1990 | X            | X            | X            |                      |
| 1991 | X            | X            | X            |                      |
| 1992 | X            |              | X            |                      |
| 1993 | X            |              | X            |                      |
| 1994 | X            |              | X            |                      |
| 1995 | X            |              | X            | only Aroclors listed |
| 1996 | X            |              | X            | only Aroclors listed |

**Note:**

Numbers Above Individual Peaks Represent Retention Time in Minutes



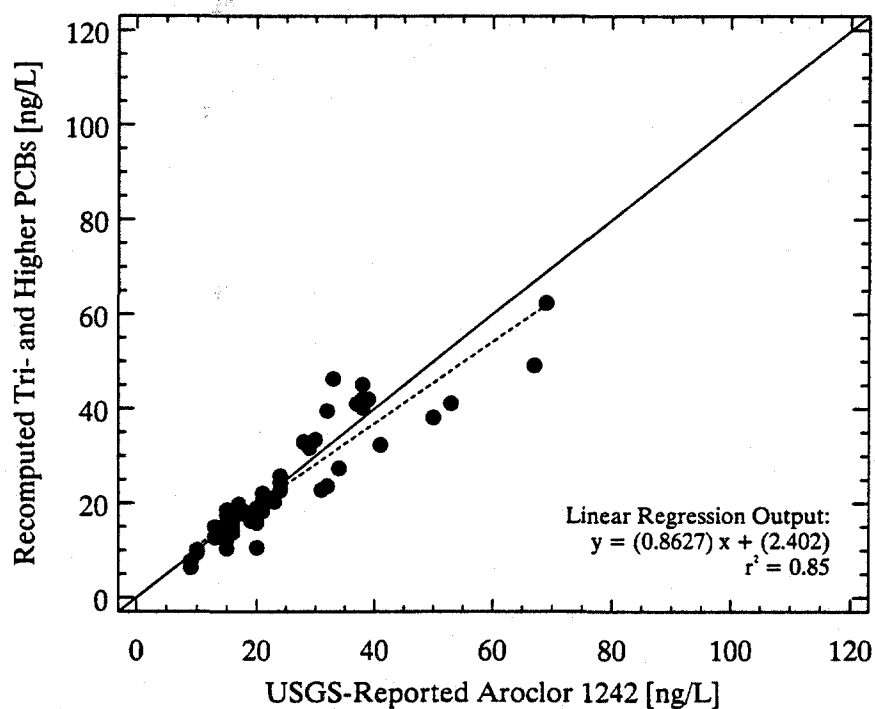
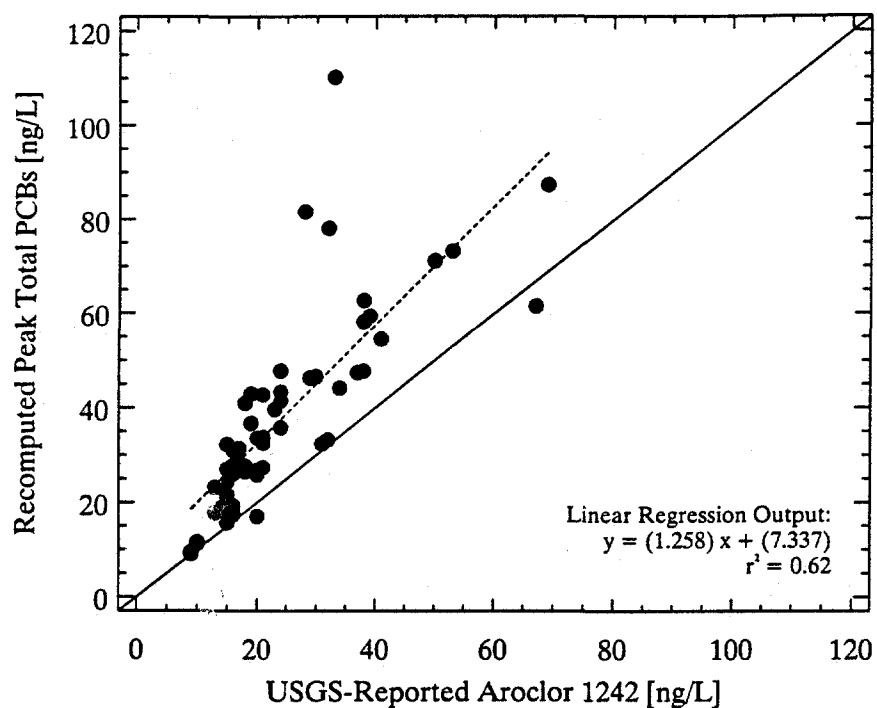
**Figure 1. Sample Chromatogram Collected at Fort Edward, N.Y.  
Illustrating DB-1 Peak Assignments Based On Published Standards**



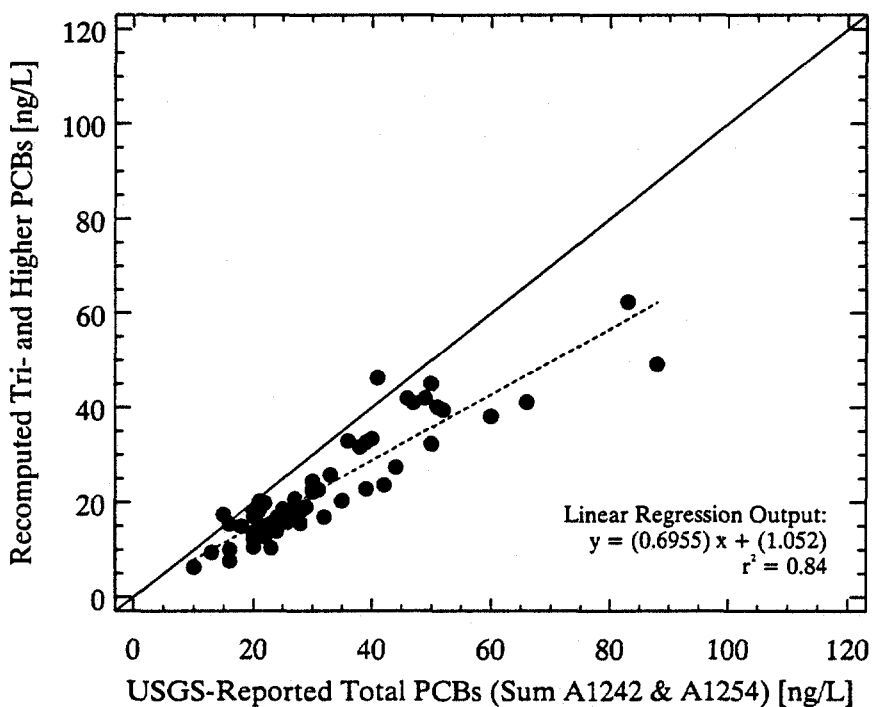
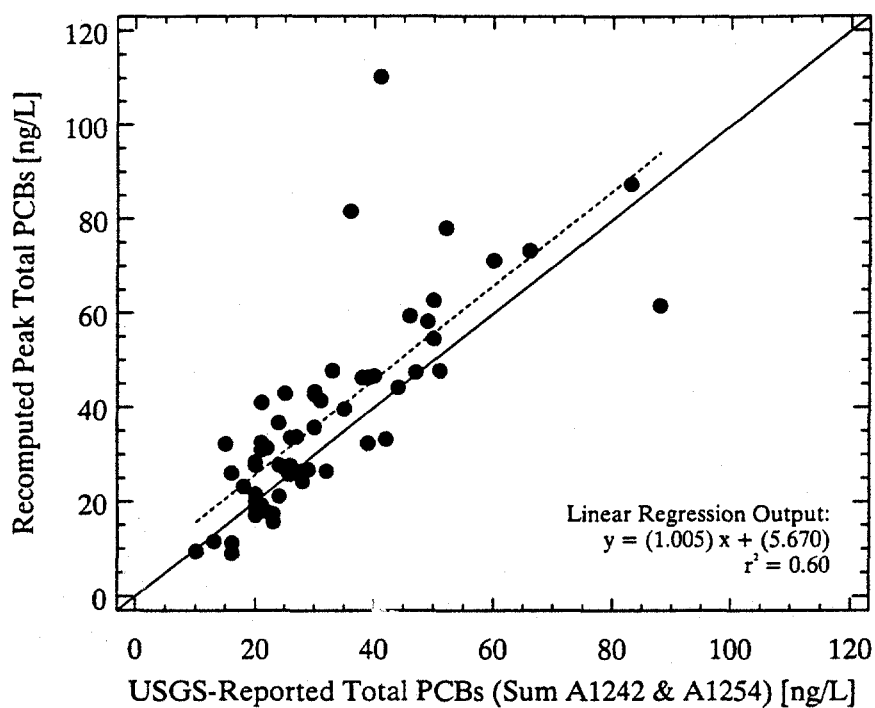
**Figure 2. Comparison of USGS-Reported Aroclor 1242 Concentration Based on Peak Area Composite Response Factors With Recomputed Aroclor 1242 Concentrations Based on Directly Measured Peak Height Composite Response Factors.**

**Note: Dotted Lines Represent Linear Regression +/- Prediction Limits at a 95% Confidence Level**

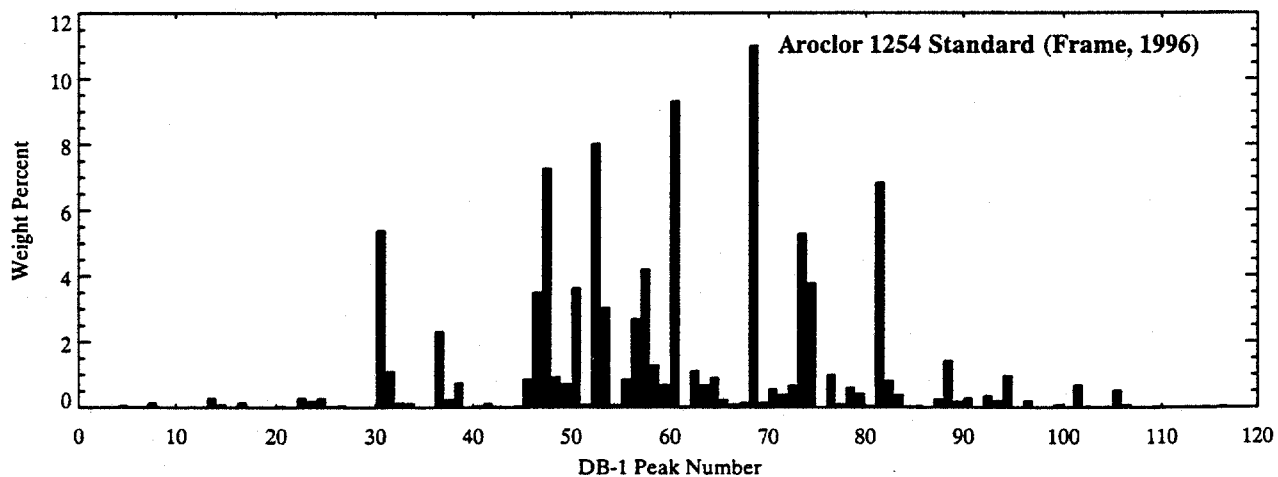
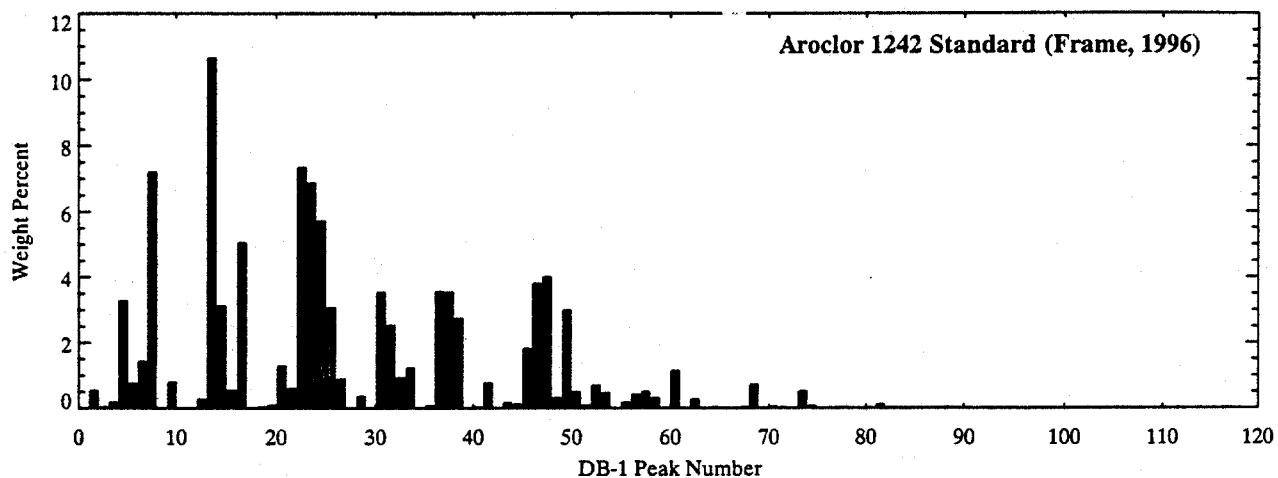
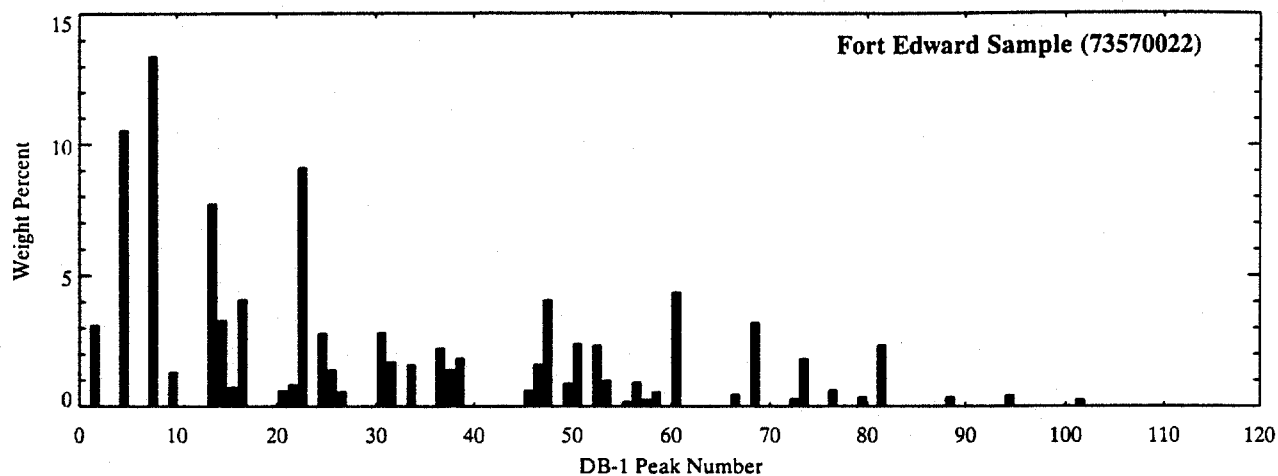
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**Figure 3. Comparison Between the USGS-Reported Aroclor 1242 Concentration and the Recomputed PCB Concentration on Both a Total and Tri- and Higher Basis**

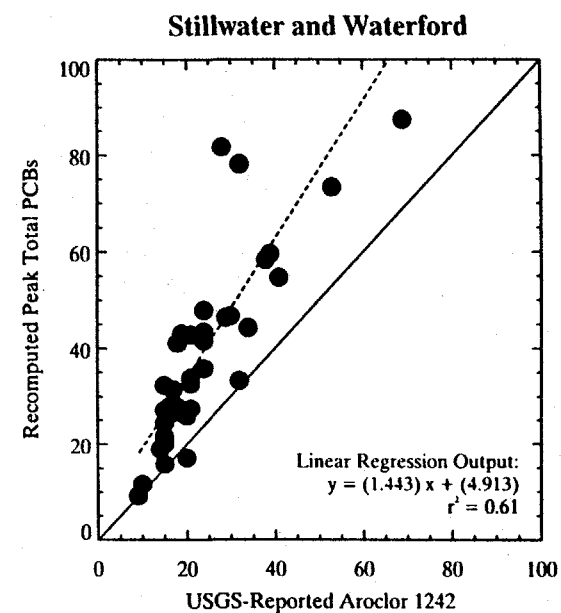
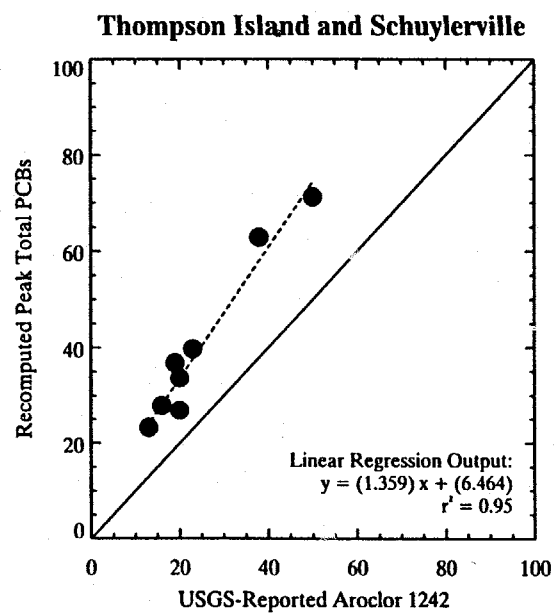
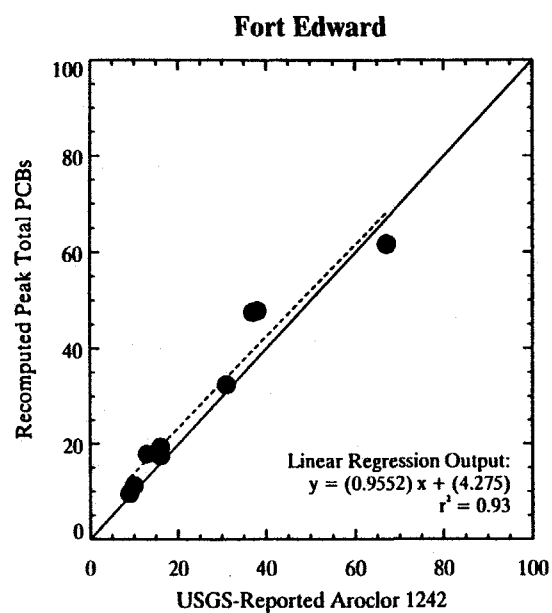


**Figure 4. Comparison Between the USGS-Reported Aroclor Total Concentration and the Recomputed PCB Concentration on Both a Total and Tri- and Higher Basis**



**Figure 5. Composition of a Representative Water Column Sample Compared to Published Aroclor Standards**

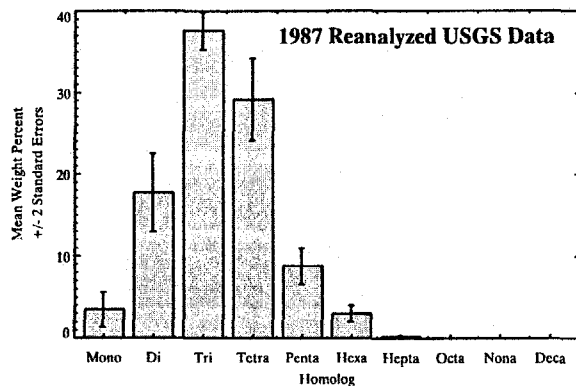
*Note: DB-1 Peaks 23 and 24 Quantified as a Single Peak in Fort Edward Sample*



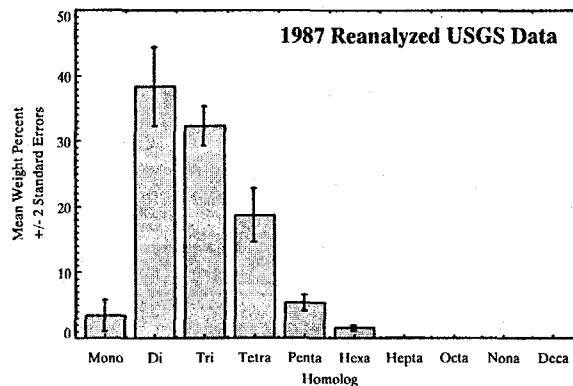
**Figure 6. Comparison Between the USGS-Reported Aroclor 1242 Concentration and the Recomputed Peak Total PCBs Separated According to Sampling Station**

316932

# Fort Edward



# Thompson Island and Schuylerville



# Stillwater and Waterford

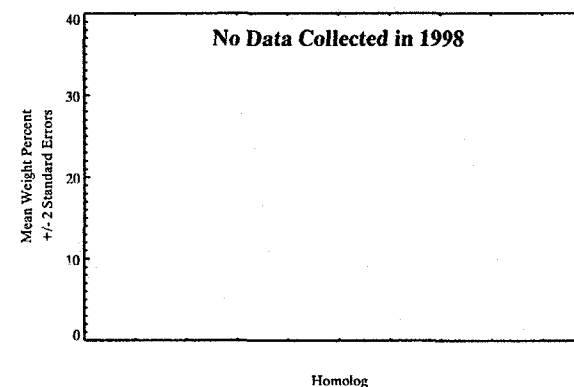
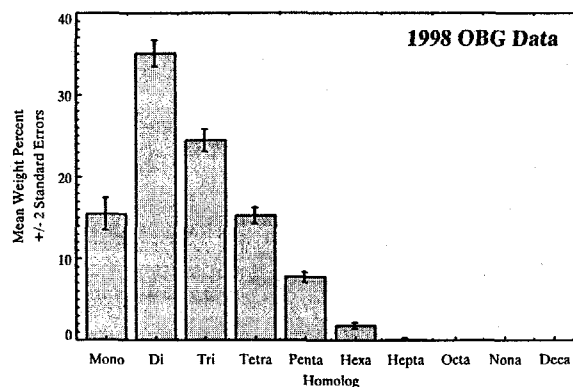
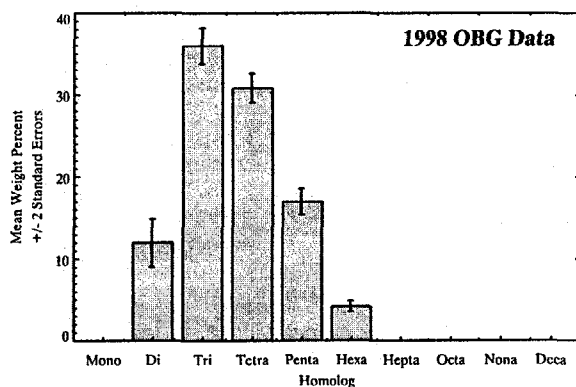
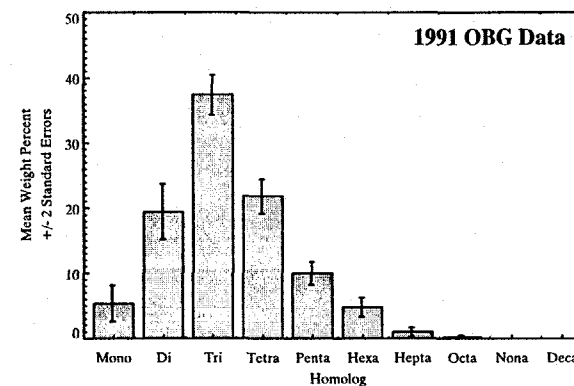
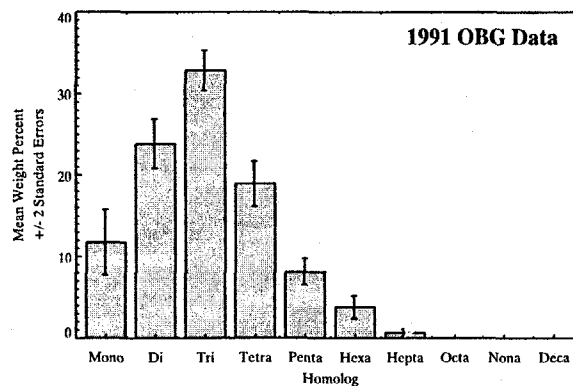
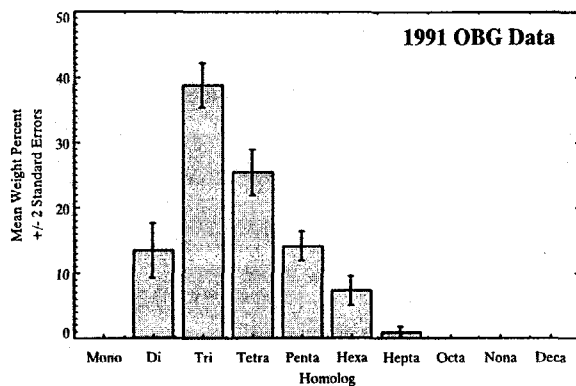
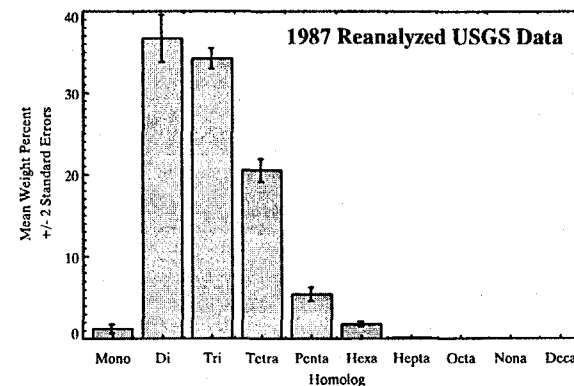


Figure 7. Comparison of Average Calculated Homolog Composition by Station for 1987 USGS Reanalyzed Data, 1991 pre- Allen Mill OBG Data, and 1998 OBG Data

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