Executive Summary Report

Phase IV Trackdown of Polychlorinated Biphenyls at the Linden Roselle Sewerage Authority

Prepared for:

New Jersey Harbor Dischargers Group

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Middlesex County Utilities Authority
Bergen County Utilities Authority
Joint Meeting of Essex and Union Counties
Rahway Valley Sewerage Authority
North Hudson Sewerage Authority
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July 28, 2006

Acknowledgments

Phase IV of the PCB Trackdown Study was funded by the New Jersey Harbor Dischargers Group (NJHDG). The NJHDG gratefully acknowledges the leadership and support of the NJHDG PCB Trackdown Committee, Judy Spadone [Chairperson, Linden Roselle Sewerage Authority (LRSA)] and Bridget McKenna [Passaic Valley Sewerage Commissioners (PVSC)]. Mr. Gary Fare, LRSA Executive Director, and LRSA staff also provided essential guidance, resources and support. A number of NJHDG members, including LRSA, PVSC, Rahway Valley Sewerage Authority, Joint Meeting of the Essex & Union Counties and the Middlesex County Utilities Authority, were directly involved in the sampling effort for the study. The NJHDG is especially grateful to Lenny Pires, Bob Kenny, Ed Kochick, Vinny Corsentino, Brian Reddy, Bridget McKenna, Paty Lopes and Bob Safchinsky and for their expertise and inventiveness in sample collection.

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Executive Summary

This Executive Summary reviews the findings of Phase IV of the polychlorinated biphenyl (PCB) pilot trackdown study conducted by the New Jersey Harbor Dischargers Group (NJHDG) at the Linden Roselle Sewerage Authority (LRSA). Phase IV was conducted in a dry run assessment and three tiers, the results of which are appended in separate reports to this summary (see compact disk).

Key Findings

Key findings of Phase IV are:

1. PCBs were progressively tracked to an industrialized area about ¼ mi square in LRSA's western sewershed. This area contributes about half of the total PCB influent loading to LRSA's wastewater treatment plant (1 g/day of the 1.9 g/day main trunk line loading). In comparison, the total PCB loading at the Borough of Roselle's Flume, which receives flow from a residential/commercial area and contributes about one-third of the WWTP influent flow, was only 0.2 to 0.3 g/day. Sediment PCB concentrations in the sewer are also comparatively higher in the area of concern and may act as a "sink" that contributes PCBs to the water flow.

2. Although most of the known discharges to the area of concern were monitored, the PCB source(s) has not yet been identified and confirmed. PCBs in the monitored discharges or found on property adjacent to the main western sewer are either in low concentration or exhibit a "fingerprint" (relative abundance of PCB homologs) that does not match the PCBs found in the western sewer. A "fingerprint" of the PCBs in a sewer tributary to the main western sewer was similar to the PCBs observed in much higher concentrations in the main western sewer line. This sewer may have been a source of the PCBs in the main western sewer. The area is complex with other potential unmonitored sources, including PCB contaminated property, a major railroad corridor and an electric utility substation. At least one discharge to the area, an 18" sanitary sewer, has not yet been monitored.

3. The lack of an active PCB source(s), identified thus far, raises the question of how PCBs may be entering the sewer. Information on the location and pathway of release is needed to confirm the PCB source(s) and, thereby, complete the trackdown. This effort may be the most challenging step in the trackdown.

4. The pilot study revealed the importance of repetitive sampling to overcome the problem of variable PCB results at some sewer locations. Conditions that appear to influence sample variability include (1) the presence of sediment, which sequesters PCBs and may affect whole water results, depending on the amount collected with water samples, and (2) variable concentrations of total suspended solids (TSS), which

can also sequester PCBs and appear to be influenced by the frequency and/or magnitude of rainfall. At least two rounds of PCB sampling are recommended at sewer monitoring locations.

5. Whole water is the preferred sample type for tracking PCBs in sewers. Steps should be taken to either avoid locations where interfering sediment is present or sample in a way that excludes sediment. Sediment sampling may be useful if the origin of the sediment is considered. Samples may not characterize local conditions as sediment may be transported over relatively long distances in the sewer. Therefore, sediment collection should be limited to relatively small, well-defined service areas.

6. Flow monitoring provided essential data for identifying the area of concern. Although PCB concentrations between manholes along the western sewer can be relatively similar, PCB loads are different. Discharges from industries cause the flow to about double in volume in the main western sewer and, as the total PCB concentrations are similar, the PCB loadings are effectively doubled in the area of concern.

7. High resolution gas chromatography (HRGC) with low resolution mass spectrometry (LRMS) is the preferred analysis method because it provides sufficient resolution for the total PCB concentrations typically observed in LRSA's sewers, is about half the cost of HRGC with high resolution mass spectrometry (HRMS) and, unlike GC methods, provides confirmation of detected congeners. Total PCB concentrations measured in Phase IV by HRGC/LRMS were generally much lower than those measured by GC in Phase III, presumably because congeners detected by GC were not confirmed and, unlike HRGC/LRMS, estimated values were included in the total PCB values. Nonetheless, the relative distribution of total PCBs in LRSA's sewers was comparable between phases.

8. Immunoassay may be used as a rapid method of screening total PCBs in sediment as results compare well with gas chromatography (GC)/mass spectrometry (MS). Immunoassay's low cost allows investigators the opportunity to screen many samples at a time. Samples with relatively high PCB levels should be confirmed using GC/MS.

9. Existing literature and data from the New Jersey Atmospheric Deposition Network (NJADN) suggest a net accumulation of atmospheric PCBs on land or surface water. The Delaware River Basin Commission (DRBC) found that atmospheric deposition of PCBs in urban areas may be significant. They included an urban runoff concentration of 62 ng/L total PCBs in the water quality model used for calculating the Delaware Estuary total maximum daily load (TMDL). The NJHDG hypothesized that such PCBs may enter sanitary sewers from (1) surface water that is collected as potable water and subsequently used and discharged to the sewer, (2) storm water runoff that washes PCBs off impervious surfaces and, by cross connection or

infiltration and inflow (I & I), into sewers and (3) groundwater that infiltrates sewers. An analysis of a potable water composite collected from NJHDG members found 0.49 ng/L total PCBs, which indicates that potable water is not a significant source of PCBs. A groundwater sample collected in LRSA's area of concern had relatively high PCB concentrations (10.8 ng/L total PCBs); however, the relative contribution to the western sewer is considered insignificant. The PCB contribution from storm water may be significant as described below.

10. The NJHDG is evaluating the use of manhole cover inserts as a method for monitoring PCBs in storm water that enters sanitary sewer manholes. The manhole insert may also serve as a control measure if manhole infiltration is found to be an important pathway for PCBs. An insert was installed in a manhole opening in the study area of concern. Total PCB concentrations in the storm water and associated sediment (420 ng/L and 140 ng/g, respectively) were higher than levels observed at the study sewer reference location (17 - 30 ng/L and 71 ng/g, respectively, at the Borough of Roselle's Flume). Flow data were not gathered; therefore, the PCB loading to the manhole insert or other manholes in the area of concern is not known. Given the potential for storm water to enter sanitary sewers through infiltration or cross connection, the contribution of PCBs from storm water warrants further investigation. Storm water samples were to be collected in a presumed uncontaminated area in the Borough of Roselle. However, weather conditions have not been favorable and sample collection has been deferred to Phase V.

11. A whole water sample was collected from a newly sewered, residential area near Linden, NJ, that is reportedly not affected by I & I. The total PCB concentration of 10.8 ng/L in the sample indicates that substantial PCB levels may be contributed from purely domestic wastewater. This PCB concentration may represent a large portion of the total PCB levels observed at LRSA's study reference location (i.e., 17 - 30 ng/L at Roselle Flume), which receives residential/commercial flow.

12. Although the pilot study has been research oriented, the costs to date exceed $300,000. Even discounting the costs of methods evaluation in the pilot study, it is anticipated that PCB trackdown for a public owned treatment works (POTW) could cost at least $100,000.

13. Successful trackdown requires an experienced, multi-disciplinary team of chemists, water quality scientists, wastewater engineers and POTW and sewer collection system administrators.

Due to the complexity of LRSA's area of concern and the challenge of identifying the PCB source(s) and its pathway to the sewer, the NJHDG will carefully consider the next steps in the trackdown. The plan for Phase V will include tasks for completing the trackdown and identifying options for subsequent PCB reduction.

Background

In 1994, the U.S. Environmental Protection Agency (EPA) requested the NJHDG, a consortium of ten sewerage authorities, to collect PCB data at its wastewater treatment plants (WWTPs). PCBs were found in WWTP influent and effluent samples[1] and EPA concluded that the PCB contribution from the NJHDG members was "environmentally significant"[2]. EPA requested the NJHDG to implement a trackdown and cleanup program for significant dischargers of PCBs[3], which was consistent with the Comprehensive Conservation and Management Plan for the NY-NJ Harbor Estuary Program (HEP).[4] Subsequent monitoring, under the HEP's Contamination Assessment and Reduction Project (CARP), established that total PCB concentrations of 10 – 12 ng/L are common in WWTP effluents and only a few effluents have concentrations higher than the apparent background.[5]

The NJHDG advised EPA of the experimental nature of a PCB trackdown and cleanup program and agreed to first conduct a pilot study to evaluate methods for tracking PCBs in a representative municipal sewer system. The LRSA was selected as the site for the study because of its relative small service area, industrialized section and separate sanitary and storm sewer systems. These characteristics were considered to be favorable for implementing the initial PCB trackdown. At the time, such trackdowns had only been accomplished in surface waters[6] and, in one case, a municipal sewer system.[7] Therefore, the objectives of the pilot study were two-fold: (1) to evaluate and select the most appropriate sampling and analytical techniques for tracking down PCB contamination and (2) determine if it is possible to identify and reduce significant PCB sources.[8]

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[1] Battelle. 1995. Laboratory Analytical Services on Wastewater Samples: Dry Weather Events I and II, Wet Weather Events I and II. Prepared for the New Jersey Harbor Dischargers Group (C.N. 94-1-NJHDG)

[2] U.S. Environmental Protection Agency. 1995. New York/New Jersey Harbor PCBs Loading: A Review of the PCB Report Submitted by the New Jersey Harbor Dischargers Group, Prepared by I. Chen, July, 1995.

[3] U.S. Environmental Protection Agency. 1995. Letter to Sheldon Lipke, Chairperson, NJHDG, from Richard Caspe, Director, Water Management Division.

[4] New York/New Jersey Harbor Estuary Program. 1996. Comprehensive Conservation and Management Plan. March 1996.

[5] NJHDG. 2005. Collection and Analysis of New Jersey POTW Effluents for Trace Contaminants Entering the NY-NJ Harbor. Presented at the Society of Environmental Toxicology and Chemistry Conference, Baltimore, Maryland

[6] Litten, S., B. Mead and J. Hassett. 1993. Application of Passive Samplers (PISCES) to Locating a Source of PCBs on the Black River, New York. *Environ. Tox. & Chem.* 12:639-647.

[7] Loganathan, B.G., K.N. Irvine, K. Kannan, V. Pragatheeswarn and K.S. Sajwan. 1997. Distribution of Selected PCB Congeners in the Babcock Street Sewer District: A Multimedia Approach to Identify PCB Sources in Combined Sewer Overflows (CSOs) Discharging to the Buffalo River, New York. *Arch. Environ. Contam. Toxicol.* 33, 130-140.

[8] NJHDG. 2001. *Quality Assurance Project Plan – Phase III Trackdown of Polychlorinated Biphenyls (PCBs) in a Municipal Sewer System: Pilot Study at the Linden Roselle Sewerage Authority.* Prepared by Aquatic Sciences Consulting.

Upon completion of the quality assurance project plan and sampling of the WWTP influent in Phases I and II, the NJHDG began tracking PCBs in LRSA's main sewer lines[9] and influent waste streams in Phase III (see Figure ES-1). Two sampling methods were evaluated: whole water composite sampling with automatic samplers and Passive In Situ Continuous Extraction Samplers (PISCES), which, when submerged, absorb PCBs from the water into a hexane reservoir.[10] Whole water sampling was preferred because of its relative ease, reliability and affordability. PISCES results were semi-quantitative and collection of PCBs in the sample medium was considered to be less reproducible than whole water collection. The samples were analyzed by gas chromatography (GC) with electron capture detector (ECD),[11] which was less costly than GC/mass spectrometry (MS) and provided sufficient resolution to detect the ng/L PCB levels typically found at LRSA. Whole water monitoring showed elevated PCB levels in the industrialized western portion of the sewer system and, potentially, the northeastern sewershed. Total PCB concentrations were about three to five-fold higher in the main western sewer, sampled at Manholes 7B and 8, compared to Roselle Flume, which serves a primarily residential/commercial area (Figure ES-1). This pattern was clearly indicated in dry weather, but not wet weather. The similarity in total PCB levels and homologs[12] throughout the sewer system in wet weather suggested a widespread source of PCBs.

Phase IV Summary

Phase IV focused on the western sewershed (Figure ES-2), where it was anticipated that the PCB source(s) may be more easily located because of its well-defined, relatively isolated area.[13] The PCB contribution from the northeast area was also assessed by monitoring reference locations. Flow monitoring was conducted to calculate PCB loadings. As the source(s) of PCBs was isolated to a smaller area, public records were reviewed to identify nearby PCB contaminated properties and industrial users were queried about PCB activities and contamination at their facilities.

Alternative, innovative trackdown tools continued to be evaluated in support of the original study objective. In addition to the preferred method of whole water sampling, sewer sediment and settleable solids from whole water were collected. High resolution gas chromatography with <u>low</u> resolution mass spectrometry (HRGC/LRMS) was used for

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[9] The sewer system is owned and maintained by the cities of Linden and Roselle.
[10] NJHDG. 2002. *Final Report Trackdown of Polychlorinated Biphenyls (PCBs) in a Municipal Sewer System: Phase III of the Pilot Study at the Linden Roselle Sewerage Authority*. Prepared by Aquatic Sciences Consulting for the New Jersey Harbor Dischargers Group.
[11] US EPA. 1994. *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, SW 846, Method 3540B* (third edition).
[12] PCB homologs are the sums of the congeners at each level of chlorination (i.e., mono, di, tri, tetra, penta, hexa, hepta, nona, octa, deca).
[13] NJHDG. 2004a. *Quality Assurance Project Plan for Phase IV of the Trackdown of Polychlorinated Biphenyls (PCBs) in a Municipal Sewer System: Pilot Study at the Linden Roselle Sewerage Authority*. Prepared by Aquatic Sciences Consulting for the New Jersey Harbor Dischargers Group.

PCB analysis[14] because it provided better resolution and confirmation of detected congeners at slightly more cost than GC-ECD. PCB analysis of the sewer sediment and settleable solids was also performed with an immunoassay procedure, which was envisioned as a low-cost, rapid alternative to HRGC/LRMS.

The widespread occurrence of PCBs in wet weather (Phase III) prompted the NJHDG to evaluate the potential contribution of PCBs from atmospheric deposition and storm runoff. Information on the contribution on atmospheric PCB deposition was gathered from literature and the NJADN. Samples from potential sources were also collected and analyzed for PCBs. The findings were used to evaluate the potential for accumulation of atmospheric PCBs on land and water and their transport to sanitary sewers.

Substantial PCB concentrations from LRSA's residential/commercial area, sampled at Roselle Flume, led the NJHDG to investigate the background PCBs in domestic wastewater. The city of Linden and Borough of Roselle did not have newly sewered residential areas that would exclude extraneous flows such as storm water or I & I. Therefore an alternative sampling location was identified in a nearby, new residential area (Township A).

Dry Run

An initial "dry run" assessment of the proposed alternative procedures, which had not been used for trackdown, was performed before the Phase IV trackdown. Results of a limited sampling and analysis effort indicated that sediment monitoring was more practical and offered less risk of sample contamination than settleable solids collection and analysis[15]. HRGC/LRMS results showed that the ranking of sites according to total PCB levels was similar whether sediment or settleable solids was the sample type. However, substantial sample volumes of whole water (up to 30 gal) were needed to obtain sufficient quantities of settleable solids and the recovered solids required drying and homogenizing to ensure representative results. In contrast, a single grab of dried sieved sediment was sufficient.

Total PCB concentrations, as measured by immunoassay, were generally within the same order of magnitude as those determined by HRGC/LRMS. However, the immunoassay results showed higher PCB levels in the settleable solids samples than in the sediment samples, which was the opposite pattern with the HRGC/LRMS results. It was thought that this difference may be caused by an interference in the immunoassay.[16, 17]

[14] HRGC/LRMS method for PCB congeners was modified from EPA Method 1668A.
[15] NJHDG. 2004b. *Report on the Dry Run Assessment for Phase IV of the Trackdown of Polychlorinated Biphenyls (PCBs) at the Linden Roselle Sewerage Authority.* Prepared by Aquatic Sciences Consulting for the New Jersey Harbor Dischargers Group.
[16] Strategic Diagnostics, Inc. 1998. RaPID PCB Assay Procedures.
[17] US EPA. 1994. Development and Evaluation of Quantitative Enzyme-Linked Immunosorbent Assay (ELISA) for Polychlorinated Biphenyls. Office of Research and Development, Environmental Monitoring Systems Laboratory, Las Vegas, NV.

Recommendations for applying immunoassay in Tier 1 included analyzing a series of sample dilutions in an attempt to dilute out the interference(s).

The dry run results were used to improve the alternative trackdown tools. Improvements made in preparation for Tier 1 included (1) freeze drying solids samples to minimize PCB losses compared to heated drying and obtain dry solids for accurate comparison of results between sampling locations, (2) repetitive sampling to account for variable results and (3) streamlined procedures for possible future collection of settleable solids.

Tier 1

Sampling locations included Manholes 7B and 8 in the industrialized portion of western sewershed, Roselle Flume and LRSA's main trunk line at Manhole T/T3 (Figure ES-2). Additional locations in the western sewershed included Manholes W-NE and W-NW, which are located upstream of the industrialized area and receive flow from residential/ commercial areas, and the Relief Line, which receives high flows diverted from the main western line.

Total PCB concentrations measured in Phase IV by HRGC/LRMS were generally much lower than those measured by GC in Phase III, presumably because the congeners detected by GC were not confirmed and, unlike HRGC/LRMS, estimated values were included in the total PCB concentrations. Nonetheless, the relative distribution of PCBs in LRSA's sewers was comparable between phases.

The pattern of elevated PCB levels in the western sewershed that was observed in Phase III was still evident.[18] Total PCB levels in whole water at Manholes 7B and 8 in the western sewershed were four to seven-fold higher than the reference location at Roselle Flume (Figure ES-3). As shown in Figure ES-4, the PCB loading of 1.7 g/day from Manhole 8 accounted for the majority of the loading to the LRSA WWTP (i.e., 1.8 g/day at Manhole T3 plus <0.1 g/day in the Relief Line). The Phase IV loadings, which were based on more accurate flow data than for Phase III, indicated that the northeastern sewershed is not a major contributor of PCBs.

Total PCB concentrations in whole water averaged ten-fold higher in Manhole W-NE than Manhole W-NW (Figure ES-3). When flow rates were considered, Manhole W-NE appeared to contribute PCBs in excess of the loading observed downstream at Manhole 7B (Figure ES-4). However, PCBs in the underlying sediment at Manhole W-NE (1,040 ng/g average for two sampling rounds) may have influenced the water PCB levels. It was necessary to place the water sampler's intake line on the bottom of the sewer pipe to ensure that a full composite sample would be collected. Not surprisingly, some sediment was observed in the composite sample container at Manhole W-NE. A comparison of the

[18] NJHDG. 2005. *Tier 1 Report/Tier 2 Plan for the Phase IV Trackdown of Polychlorinated Biphenyls (PCBs) at the Linden Roselle Sewerage Authority*. Prepared by Aquatic Sciences Consulting for the New Jersey Harbor Dischargers Group.

PCB homologs indicated that the water and sediment PCBs at Manhole W-NE did not match the water homolog pattern at Manhole 7B. Therefore, the area sampled by Manhole W-NE did not appear to be the primary source of PCBs at Manhole 7B.

Although PCB concentrations at Manholes 7B and 8 were relatively similar (i.e., 122 and 157 ng/L, respectively), PCB loads were different (Figure ES-4). Discharges from industries downstream of Manhole 7B more than doubled the flow in the western sewer line at Manhole 8. When this flow difference is considered, Manhole 7B accounted for less than half of the loading at Manhole 8 (average of 0.6 g/day vs. 1.7 g/day, respectively, for both rounds). These results indicate a PCB source(s) in the service area between Manholes 7B and 8.

In general, the distribution of sediment PCB concentrations among the manholes matched the whole water PCB pattern. Significant concentrations of PCBs were found in sediment from manholes near Manholes 7B and 8 (6 to 7 ppm).[19] These results support the whole water results in indicating a PCB source along the western sewer between Manholes 7B and 8.

Sediment PCB concentrations in the Relief Line (15 ppm total PCBs) were much higher than for all other locations [i.e., more than twice the Manhole 8(2) level]. Relatively little sediment was found at the Relief Line water sampling point and sediment PCBs apparently did not influence water concentrations of PCBs. It was not clear if the source of sediment PCBs in the Relief Line is local or may be some distance upstream, within the Manhole 7B service area, as sediment can be carried throughout the sewer system. Also, a railroad parallels the Relief Line. PCBs were once used in electrical transformers and other equipment by railroad companies.

HRGC/LRMS results compared well with the split sample immunoassay results [correlation coefficient (R^2) of 0.95]. However, inconsistencies between whole water and sediment results, as noted for the Relief Line, suggest that trackdown by immunoassay of sediment alone could be misleading. Sediment was envisioned as a suitable sample for immunoassay because PCB concentrations are above immunoassay's relatively high minimum detection level (whole water concentrations are too low). In an effort to continue using immunoassay as a tracking tool and obtain more consistent data, settleable solids were re-evaluated as an alternative sample to sediment in Tier 2.

Tier 2

<u>Trackdown</u>

Sampling locations were added to help delineate the PCB source(s) in the western area of concern. Water, settleable solids and sediment samples were collected at the locations

[19] Sediment was collected at the next manholes downstream of Manholes 7B and 8 (i.e., Manholes 7B(2) and 8(2).

shown in Figure ES-5. These locations included the service area of Manhole W-NE, where samples were collected to better define the PCB source(s) in the upper western sewershed.

Results were variable between sampling rounds.[20] Total PCB concentrations in whole water increased in the direction of flow from Manhole 7B to Manhole SM and were essentially equal at Manhole SCP and the western sewershed boundary at Manhole 8 (Figures ES-6 and ES-7). However, the magnitude of the increase at Manhole SM varied between sampling rounds. Also, PCB concentrations in the upper portion of western sewershed were variable. PCB concentrations in whole water from Manholes SM, ELM and ROS were about three-fold higher or more in Round 2 than in Round 1. The difference may be related to the increase in TSS concentrations in Round 2 compared to Round 1 and/or variability in sampling the underlying sediment, which contained PCBs.

When flow data are considered, results for both sampling rounds showed a pattern of higher PCB loadings at Manholes SM, SCP and 8 (0.9 to 3.2 g/day) compared to Manhole 7B (0.3 to 0.5 g/day) as shown in Figures ES-8 and ES-9. The difference in PCB loadings (two to six-fold) was larger than the difference in PCB concentrations (slightly greater than one to four-fold) because of the substantial flow added by the industries just downstream of Manhole 7B. The results were consistent with PCB loading results for Tier 1. The higher PCB loadings at Manholes SM and ELM were an artifact of the variable PCB concentrations, perhaps influenced by PCBs in underlying sediment.

The trackdown objective stated in the quality assurance project plan (QAPP) is “to identify sources in LRSA’s western sewershed that contribute total PCB concentrations that are more than three to six-fold higher than the levels observed at the western sewershed terminus” (NJHDG 2004a). This objective was interpreted to apply to PCB loadings as well as concentrations. Given the flow contribution between Manholes 7B and 8, it would be expected that PCB concentrations may not differ by three to six-fold. However, when flow is taken into account, the objective was met with respect to PCB loadings. Therefore, the loading results indicated a “significant” PCB source between Manholes 7B and SM.

The average distribution of PCB homologs and characteristic congeners in whole water samples from upstream manholes (ELM, 516 and ROS) indicated a predominance of Aroclor 1254. Downstream, the pattern shifted to a greater abundance of penta, tetra and hexa-chlorobiphenyls at Manhole 7B (Figure ES-10). As the flow continued to Manhole SM, lower chlorinated biphenyls (tetra, penta and tri-chlorobiphenyls) and characteristic congeners indicated the prevalence of Aroclors 1016/1242 and 1254. These results

[20] NJHDG. 2006a. *Tier 2 Report/Tier 3 Plan for the Phase IV Trackdown of Polychlorinated Biphenyls (PCBs) at the Linden Roselle Sewerage Authority*. Prepared by Aquatic Sciences Consulting for the New Jersey Harbor Dischargers Group

provided further evidence for a PCB source in the vicinity of Manholes 7B and SM that dominates the downstream PCB homolog pattern.

Immunoassay of the settleable solids samples did not provide comparable results to HRGC/LRMS. Although the pattern of higher total PCB concentrations at Manholes SM, SCP and 8 was evident by both immunoassay and HRGC/LRMS, there were inconsistencies. Also, much higher PCB concentrations were measured by immunoassay compared to HRGC/LRMS, which suggested a positive interference with immunoassay.

Total PCB concentrations in sediment were variable, yet a pattern was evident. Total PCBs were more than one to two orders of magnitude higher at Manhole SM (i.e., 11,750 to >100,000 ng/g by immunoassay) than at other sampling locations (406 – 1,067 ng/g). These results provide further evidence of a PCB source in the vicinity of Manhole SM. Immunoassay results for sewer sediment correlated well with HRGC/LRMS in Tier 1; therefore, the Tier 2 results were expected to be valid. Nonetheless, the remaining portions of the Manhole SM samples were forwarded for confirmation analysis by HRGC/LRMS. The HRGC/LRMS results (i.e., 181 and 16.6 ppm for Rounds 1 and 2, respectively) confirmed the immunoassay results.

Given earlier results, uncertainty remains about the suitability of using immunoassay of sediment for PCB trackdown. Sediment at the sampling locations may not characterize local conditions as it may be transported over relatively long distances in the sewer. Therefore, the source of sediment used for immunoassay or GC/MS should be limited to a relatively small, well-defined service area.

Atmospheric Deposition of PCBs

The fate and transport of atmospheric PCBs is not easily understood and, as stated in the QAPP, NJHDG does not intend to study this question in detail. Existing literature and NJADN data were reviewed to first determine if there could be a net accumulation of atmospheric PCBs on land or surface water. Lisa Totten, PhD, an air quality expert with the NJADN, cited local data that supported a net deposition of PCBs onto land.[21] Although PCBs, particularly lower chlorinated congeners, can volatilize back into the atmosphere, which creates a flux between air, land and water, the NJADN data indicate a net deposition. Scientific literature and information obtained from the DRBC provided further evidence of the atmospheric deposition of PCBs in urban settings like LRSA's service area.[22]

[21] Personal communication, November, 2005

[22] DRBC. 2003. Calibration of the PCB Water Quality Model for the Delaware Estuary for Penta-PCBs and Carbon. Prepared by the Delaware River Basin Commission.

PCBs have been shown to accumulate on soil[23] and building surfaces[24,25] over time. Precipitation can wash deposited chemicals off of these surfaces and runoff can convey them to storm sewers or surface waters.[26] A literature review performed by DRBC, as part of the PCB TMDL model for the Delaware Estuary, indicated that total PCB concentrations in urban runoff may average 62 ng/L. Although LRSA has separate sanitary and storm water sewer systems, storm water may enter sanitary sewers through cross connections or infiltration. Therefore, it is possible that PCB contaminated runoff is conveyed to the WWTP. Based on this reasoning, the NJHDG decided to collect and analyze samples from sources that may convey air-deposited PCBs to sanitary sewers.

Tier 3

Trackdown

As shown in Figure ES-11, Tier 3 the area of concern in Tier 3 was located along the main western sewer line between Manholes 7B and SM. Samples of whole water were collected from twelve locations in this area, including three industrial users, a sewer tributary to the main western sewer and several locations on the western sewer.[27] The tributary sewer is located downstream of Manhole 7B and conveys flow from two industries, which are anonymously named B and C. Industry B is closing, but batch discharged process and storm water during Tier 3. Industry C is a batch discharger that discharged once or twice a day during Tier 3. The tributary sewer was sampled at Manhole FCP, which marks the point where the sewer was recently diverted south of its original junction with the main western sewer.[28] The cutoff section of the original tributary sewer was sampled near its junction with the main western line at Manhole GMQ. A few yards downstream of this junction, Industry A discharges to the western sewer line. Storm water at Industry A is discharged to a containment basin where dry and wet weather flows are segregated for discharge to LRSA's sewer and Kings Creek, respectively. The dry weather flow is combined with the process flow before discharge to the main western sewer. Further downstream, the main western sewer line was

[23] Wong, F., Diamond, M., Truong, J., Robson, M., Harrad, S., Bidleman, T. 2003. Accumulation and Chiral Analysis of Organic Chemicals in Forest Soils Along an Urban-Rural Gradient. Presented at the 2003 Annual Conference of the Society of Environmental Toxicology and Chemistry.
[24] Butt, C., Diamond, M., Bahavar, B., Stern, G. 2003. Seasonal Trends in Surface Organic Films Along an Urban-Rural Transect. Presented at the 2003 Annual Conference of the Society of Environmental Toxicology and Chemistry.
[25] Murphy, T.J., Sweet, C.W., 1994. Contamination of PTFE surfaces by PCBs in the Atmosphere. Atmos. Environ. 28, 361-364.
[26] Labencki, T., Diamond, M., Motelay-Massei, A., Truong, J., Branfireun, B., Dann, T. In Press. Variability in and Mechanisms of PAH Washoff From Urban Impervious Surfaces.
[27] NJHDG. 2006b. *Tier 3 Report for the Phase IV Trackdown of Polychlorinated Biphenyls (PCBs) at the Linden Roselle Sewerage Authority*. Prepared by Aquatic Sciences Consulting for the New Jersey Harbor Dischargers Group.
[28] The tributary sewer was re-routed in April 2005 during construction of the city of Linden's flood control sewer.

sampled at Manholes MK, RLD and SM. A small pipe inside Manhole MK that conveys additional dry weather flow from Industry A was also sampled.

In addition to sewer water, samples were collected from (1) a storm water insert fitted to the opening of Manhole RLD, which is located in the area of concern in an area prone to flooding and (2) domestic wastewater from a newly sewered, residential area (Township A). The NJHDG was interested in evaluating the storm water insert as a method for monitoring PCBs in storm water runoff that may enter sanitary sewer manholes. The insert at Manhole RLD was fabricated from stainless steel in order to meet specifications for collection of samples for trace PCB analysis (Figure ES-12).

Results for both sampling rounds showed similar patterns in PCB concentrations along LRSA's western sewer line (Figures ES-13 and ES-14). Manhole MK had, by far, the highest total PCB concentrations of the sampling locations and the Round 1 result (630 ng/L) was among the highest PCB levels observed in LRSA sewer water samples collected to date[10,18,20]. The next highest total PCB concentrations for Tier 3 were observed downstream at Manholes RLD and SM.

Total PCB levels at Manhole SM (70 – 114 ng/L) were lower than the Tier 2 concentrations (170 - 471 ng/L). Total PCB concentrations at Manhole 7B were similarly lower in Tier 3 (36 - 38 ng/L) than in Tier 2 (79 - 118 ng/L). The Tier 2 PCB levels at Manhole 7B were close to those observed in Tier 1 (73 – 172 ng/L). A review of precipitation records indicated greater rainfall prior to and during Tier 3 compared to Tiers 1 and 2. As would be expected, total suspended solids (TSS) concentrations of sewer samples collected during these periods appeared to be inversely correlated with rainfall (i.e., higher TSS levels in Tiers 1 and 2 compared to Tier 3). Given the affinity of PCBs for solids, the lower PCB concentrations at Manholes 7B and SM in Tier 3 compared to Tiers 1 and/or 2 may be related to the frequency and/or magnitude of rainfall.

As shown in Figures ES-13 and ES-14, Industry A's discharge was one of three inputs that exhibited total PCB concentrations (44 ng/L in Round 2) that were greater than those observed at the study reference location, Roselle Flume (17 - 30 ng/L in Tier 1). PCB concentrations in Industry A's discharge appear to be influenced by PCBs in the industry's dry weather flow (97 ng/L in Round 2), which combines with Industry A's process flow before discharge. Total PCB concentrations in the Round 1 dry weather sample (19 ng/L) were five-fold lower than in Round 2 and the Industry A discharge had correspondingly lower total PCB levels in Round 1 (5 ng/L).

Manhole GMQ was another location that had total PCB concentrations (150 ng/L in Round 1) above the reference level at Roselle Flume (Figure ES-15). The results for Rounds 1 and 2 were variable (i.e., 8 ng/L total PCBs for Round 2). The water samples did not include actual discharge from Industries B and C as the tributary sewer was diverted upstream at Manhole FCP in April 2005 (more than eight months before Tier 3 sampling). The water samples may have contained I & I and/or residual discharge from Industries B and C. PCB concentrations in Industry B's and C's current discharge and Industry B's storm water basin were $\leq$4 ng/L; therefore, it is unlikely that relatively recent industrial discharges contributed to the PCB levels observed downstream at Manhole GMQ. The Round 1 result indicates the presence of PCBs from past activities.

Relatively low PCB concentrations at Manhole FCP (7.9 ng/L), which marks the beginning of the tributary sewer diversion, suggest that residual PCBs are not present upstream of the diversion (Figure ES-15). However, only a single data point was obtained and, given the variability observed at Manhole GMQ, the absence of PCBs can not be confirmed.

The third input with PCB levels higher than the Roselle Flume reference level was the storm water collected in the Manhole RLD insert (Figure ES-16). Both water and sediment concentrations of total PCBs in the storm water (i.e., 420 ng/L and 140 ng/g) were higher than water and sediment PCB levels observed at the Roselle Flume reference location (17 - 30 ng/L and 71 ng/g, respectively, in dry weather; NJHDG 2005). It is not known if these results may be representative of storm water elsewhere in the LRSA's service area; however, the total PCB concentrations at Manhole RLD are significant. Given the potential for storm water to enter sanitary sewers through infiltration or cross connection, the contribution of PCBs from storm water warrants further investigation.

The storm water insert results were compared to data for the main western sewer line. The total PCB level in the water portion of the storm water insert sample was in the range of total PCB levels observed in the main western sewer. The total PCB concentration in the sediment portion of the sample was lower than the levels found in the western sewer at the nearby Manhole SM (16,600 – 181,000 ng/g in Tier 2; NJHDG 2006). Although the storm water may be a source of PCBs found in the western sewer, it is not possible to estimate the magnitude of the PCB contribution (i.e., loading) without knowing the volume of water and sediment that infiltrates Manhole RLD or other manholes in the area of concern. This information should be gathered as part of a further investigation of storm water sources of PCBs. In an effort to minimize the PCB discharge, LRSA is replacing the oversized cover at Manhole RLD.

Total PCB loadings[29] are shown in Figure ES-17. The sum of the total PCB loadings from Manholes 7B and GMQ and Industry A's discharge (0.3 - 0.4g/day) accounts for less than 15% of the total PCB loading at the next downstream location, Manhole MK (3.3 – 4.5 g/day). Further downstream at Manholes RLD and SM, total PCB loadings decreased more than five-fold to 0.5 – 0.8 g/day. The cause of this decrease is unknown; however, as indicated by earlier results, the underlying sediment in sewers may have affected the water PCB levels. Nonetheless, the results indicate that the primary source(s) of PCBs is upstream of Manhole SM between Manholes MK and 7B. The

[29] PCB loading estimates were calculated based on flow data obtained in Tier 2 for Manholes 7B and SM and industry flow rates monitored or estimated during Tier 3 sampling.

results also suggest that neither Industry A nor the tributary sewer sampled at Manhole GMQ is a significant, current source of the PCBs observed in the main western sewer.

Manhole MK exhibited PCB concentrations and loadings that were about six to seven-fold higher than those observed at the downstream boundary of the area of concern (Manhole SM). Therefore, by definition, the PCB source(s) is located at or upstream of Manhole MK and downstream of Manhole 7B.

PCB homolog distributions were compared between sampling locations to further evaluate the PCB source(s) between Manholes 7B and MK. As shown in Figure ES-18, PCBs with a higher level of chlorination (i.e., tetra, penta and hexa chlorinated biphenyls) were present in the Round 2 sample of Industry A's dry weather flow than in the Round 1 sample (tri, tetra and penta chlorinated biphenyls). As expected, this pattern was reflected to some extent in the Industry A discharge samples for Rounds 1 and 2 (Figure ES-19). The homolog distributions indicate that Industry A's dry weather flow is not the primary contributor of PCBs to the western sewer line as lower chlorinated biphenyls, which are indicative of Aroclors 1016, 1242 and 1254, are predominant at Manholes MK, RLD and SM (see Figure ES-20). Storm water entering Manhole RLD also does not appear to be a primary contributor of PCBs in the western sewer. Higher chlorinated biphenyls (hexa, penta, hepta) were present in the storm water insert sample than in the western sewer (Figure ES-21). As shown in Figure ES-22, the homolog distribution for the Round 1 Manhole GMQ sample is generally similar to the homolog distribution observed at Manholes MK, RLD and SM. These results indicate that the sewer accessed by Manhole GMQ may be a source of the PCBs observed downstream at Manholes MK, RLD, SM, as well as Manholes SCP and 8 in Tier 2.

Although flow is no longer discharged through Manhole GMQ, it is conceivable the tributary sewer may have contributed more substantial PCB loadings in the past. High levels of PCBs observed in the sediment at Manhole SM (total PCBs up to 181,000 ng/g in Tier 2) may indicate residual contamination from past activities. Industry B reported PCB contamination at two locations at its facility; however, the PCB type (Aroclor 1254) does not match the predominant Aroclors 1016/1242 in the western sewer line at Manholes MK, RLD and SM. A review of sewer maps also indicated no current pathway for PCBs to enter LRSA's sewer. Therefore, the source of PCBs at Manhole GMQ is unknown.

Unidentified PCB source(s) may be located along the western sewer line between Manholes 7B and MK. For example, it was learned that an 18-inch sanitary sewer, which originates from the southwest end of West Elizabeth Ave, ties into the western sewer below Manhole 7B (see Figure ES-11). Also, a review of public records identified four PCB contaminated properties in LRSA's western sewershed. All of the properties are located above the upstream boundary of the area of concern (Manhole 7B). However, contamination from one property reportedly migrated offsite to an area adjacent to the railroad, which is downstream of Manhole 7B (see Figure ES-11). The predominant PCB type in the contaminated area is Aroclor 1242, which matches the type observed in the western sanitary sewer. However, the pathway for the PCB contamination to the sewer has not yet been defined; therefore, this site is not a confirmed source.

Results for the Township A sample indicate that substantial PCB levels may be contributed from domestic wastewater. Total PCB concentrations in the sample were 10.8 ng/L. This PCB concentration may represent a large portion of the total PCB levels observed at LRSA's study reference location (i.e., 17 - 30 ng/L at Roselle Flume), which receives residential/commercial flow. Other PCB data on urban residential wastewater are limited. No PCBs were detected in pump station samples collected in Delaware County[30]; however, the pump stations receive commercial/industrial flows, which may dilute PCBs from residential areas.

<u>Atmospheric Deposition of PCBs</u>

Sources that may convey air-deposited PCBs to LRSA's sewers include (1) surface water that is collected as potable water and subsequently used and discharged to the sewer, (2) storm water runoff that washes PCBs off impervious surfaces and, by cross connection or I & I, into sewers and (3) groundwater that infiltrates sewers. Existing PCB data for potable water and groundwater were reviewed to determine if the results were suitable for evaluating the potential contribution of PCBs. The local water supply company, New Jersey American Water (NJAW, formerly Elizabethtown Water Company), provided data that showed no detectible PCBs; however, the reporting limits were relatively high (0.08 – 0.1 ppb by Aroclor). A more sensitive analysis was needed; therefore, the NJHDG prepared a composite of potable water samples from ten of its WWTPs and submitted the sample for analysis by EPA Method 1668A,[31] which involves HRGC/high resolution mass spectrometry (HRMS). The total PCB concentration in the sample was 0.49 ng/L, which is nearly two orders of magnitude lower than the total PCB concentrations observed at the sewer reference location, Roselle Flume (17 - 30 ng/L in Tier 1). Although the potable water result is a single data point, the result indicates that potable water is not a significant source of PCBs.

As noted, the manhole insert results indicate a potential for significant contribution of PCBs from storm water. Additional sampling is recommended to determine if the results are representative of storm water elsewhere in the LRSA service area. More data are forthcoming on storm water. Storm water samples were to be collected in a presumed uncontaminated area in the Borough of Roselle. However, weather conditions have not been favorable and sample collection has been deferred to Phase V.

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[30] DELCORA. 2005. Report on the Phase I Trackdown of Polychlorinated Biphenyls (PCBs) at Delaware County Regional Water Quality Control Authority's Western Regional Treatment Plant. Prepared by Aquatic Sciences Consulting for DELCORA.
[31] US EPA. 1999. Method 1668, Revision A: Chlorinated Biphenyl Congeners in Water, Soil, Sediment, and Tissue by HRGC/HRMS. Office of Water. EPA No. EPA-821-R-00-002

PCB data for groundwater near the western sewer line were obtained. In 2003, a groundwater sample was collected and analyzed as part of an application for discharge from construction of the city of Linden's flood control sewer, which is located in the vicinity of the area of concern (Figure ES-11). The sample contained 10.8 ng/L total PCBs. Although the PCB concentrations were relatively high, the results indicate that groundwater collected near the flood control sewer is not a significant contributor of PCBs to the area of concern.

Phase V Plan

The QAPP states that a PCB reduction plan will be developed based on the Phase IV findings. However, the PCB source(s) have not yet been identified. The NJHDG will review the Phase IV results and submit a plan for completing the trackdown.

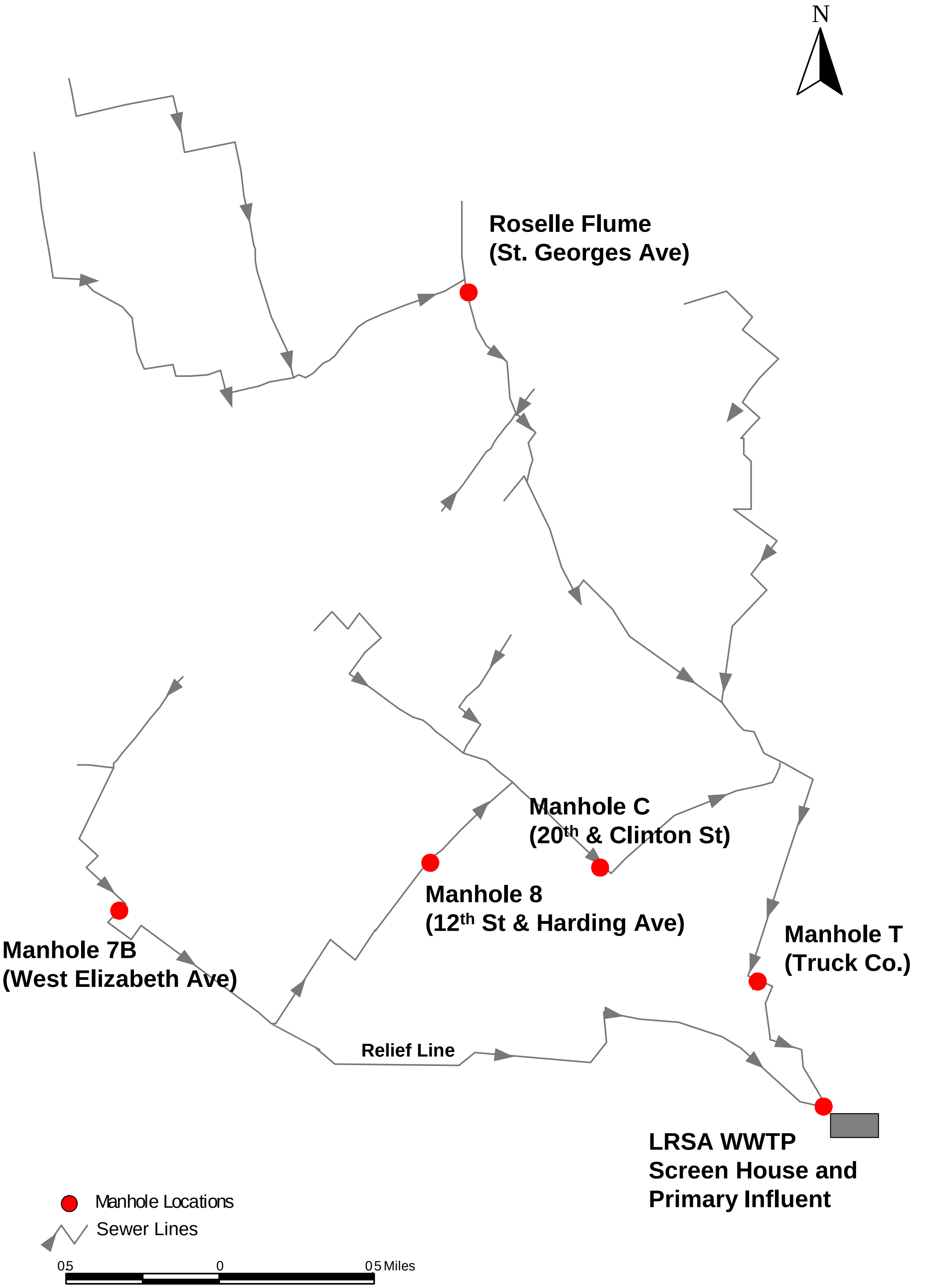


Figure ES-1. LRSA's Main Sanitary Sewer Lines and Sampling Locations for Phase III

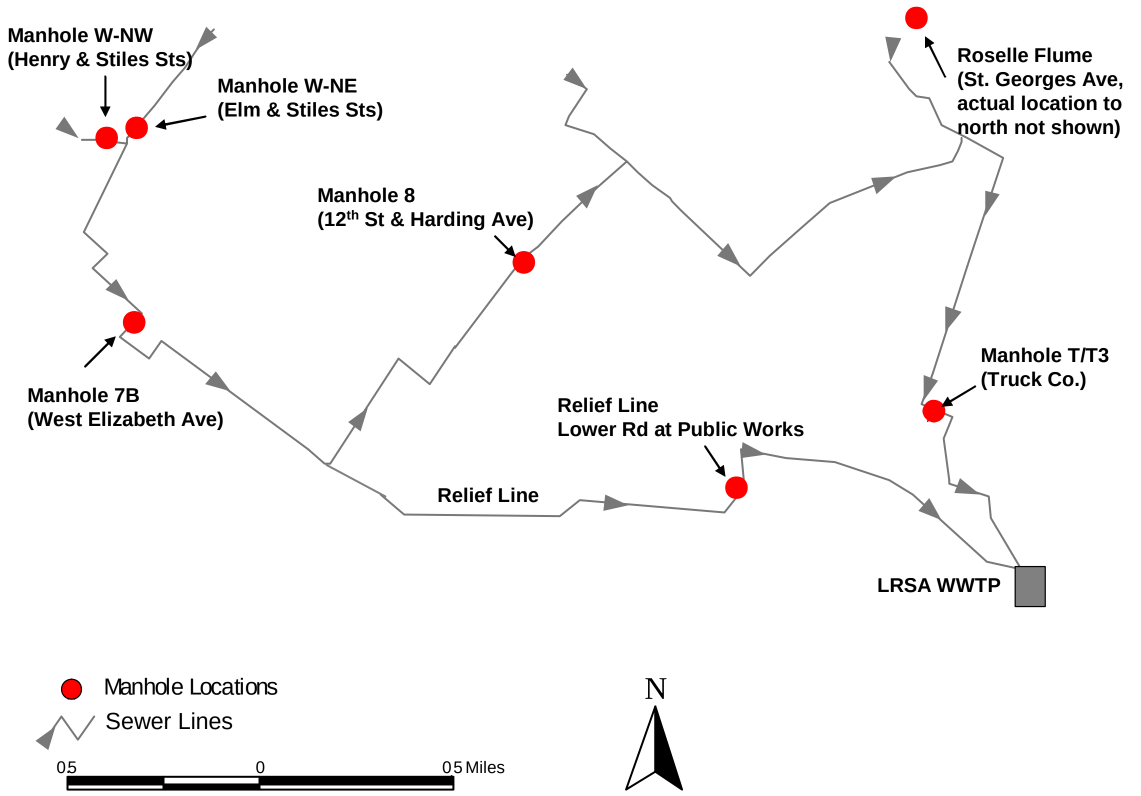
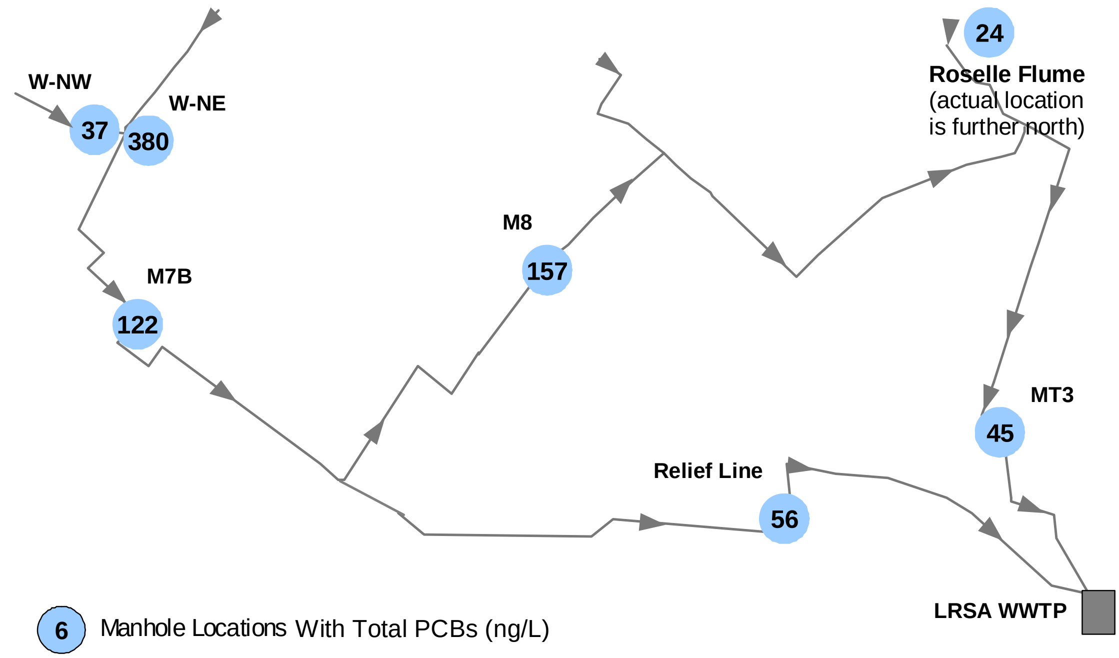
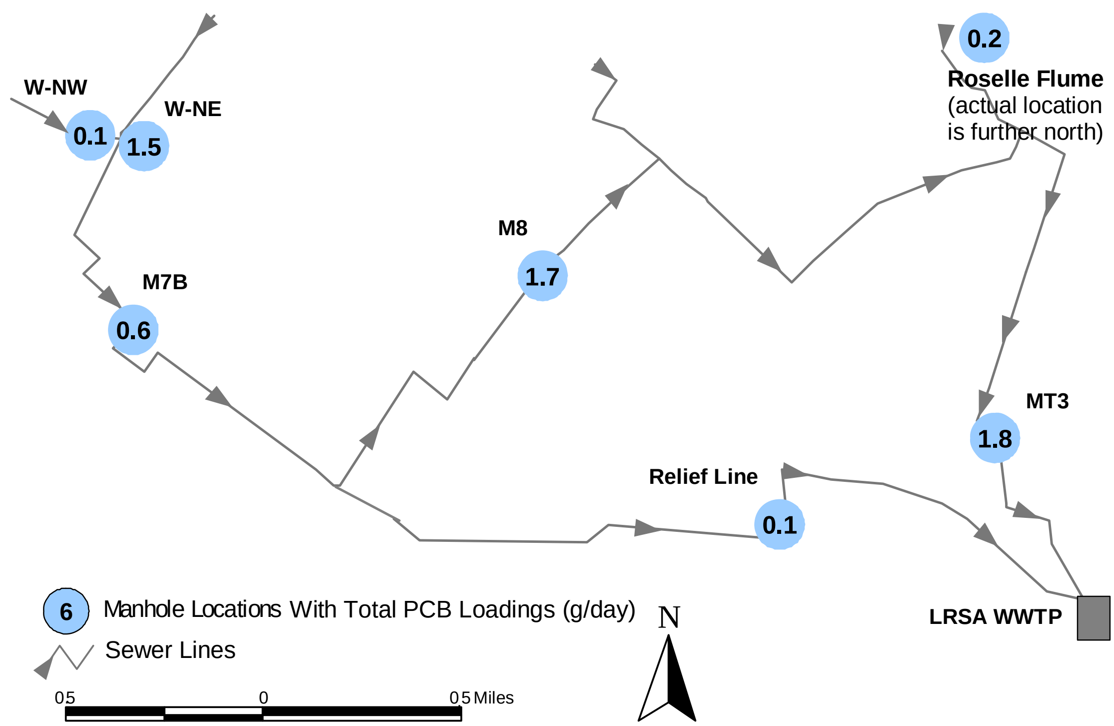


Figure ES-2. LRSA's Western Sewer System, Main Trunk Line and Sampling Locations for Phase IV, Tier 1





Figures ES-3 and ES-4. Averaged Total PCB Concentrations, ng/L, (Top) and Averaged Total PCB Loadings, g/day, (Bottom) in Whole Water Collected From Manholes in Tier 1

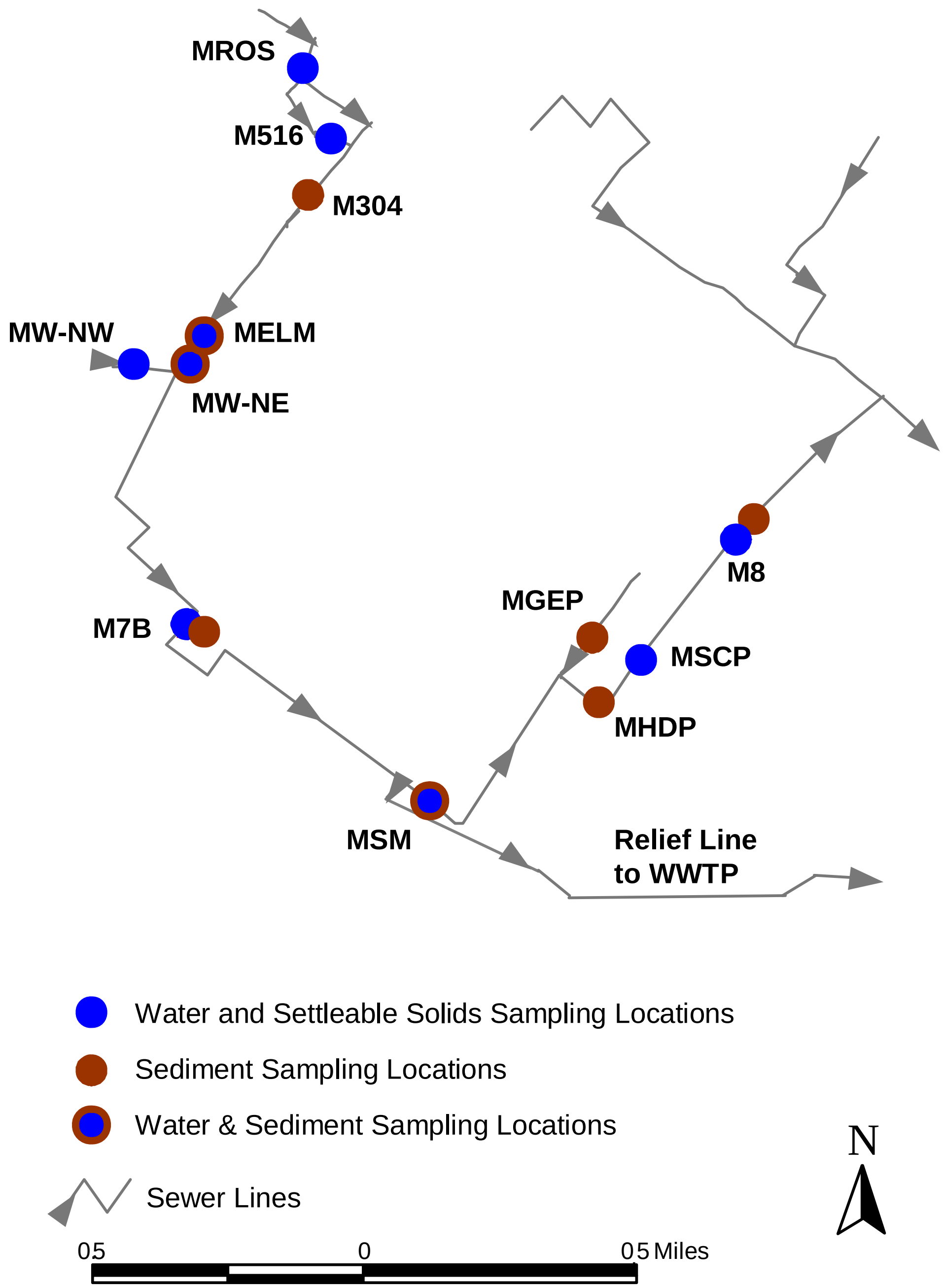
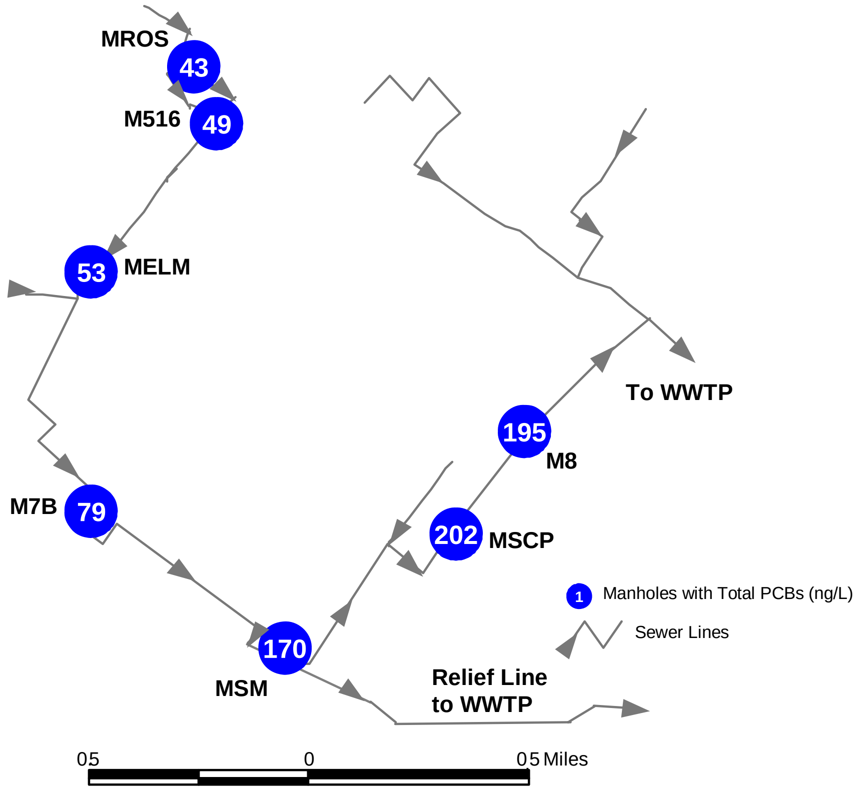
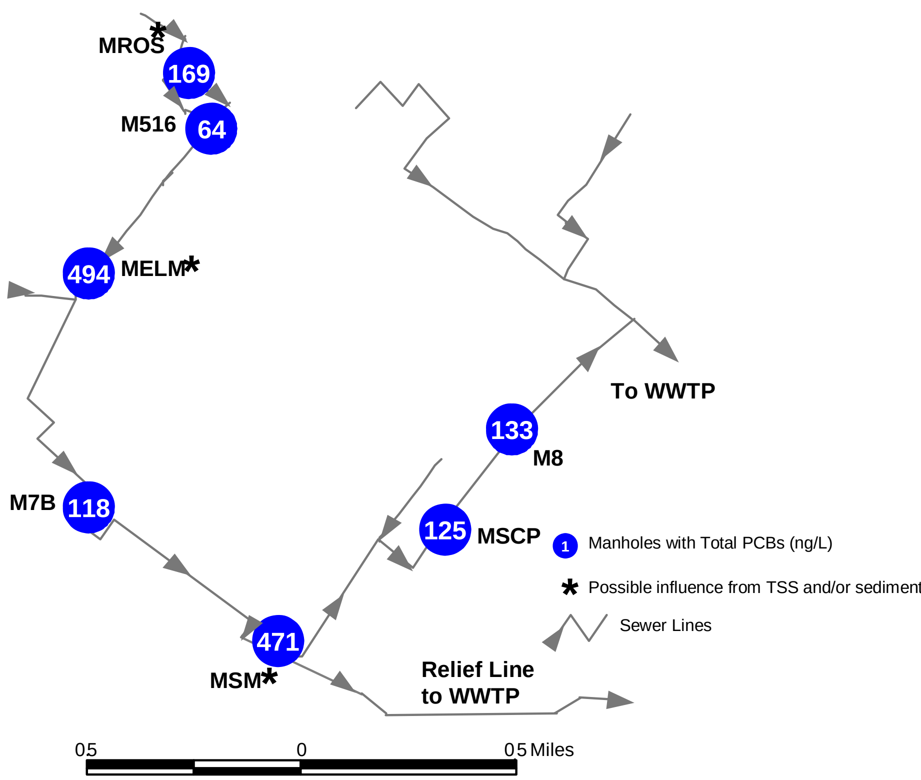
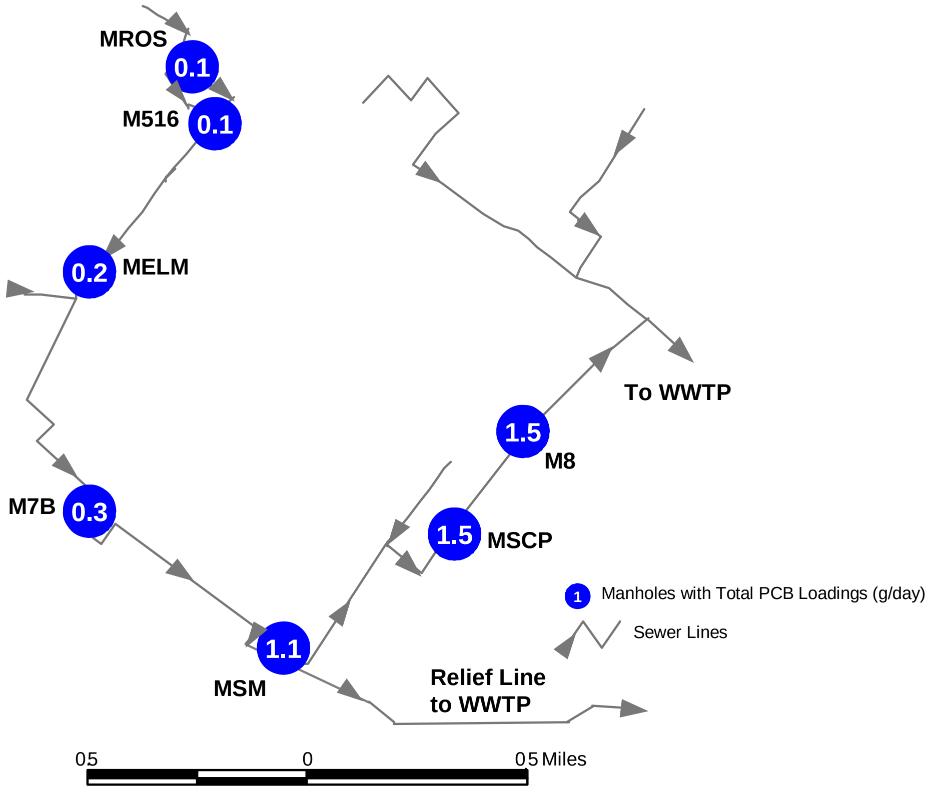


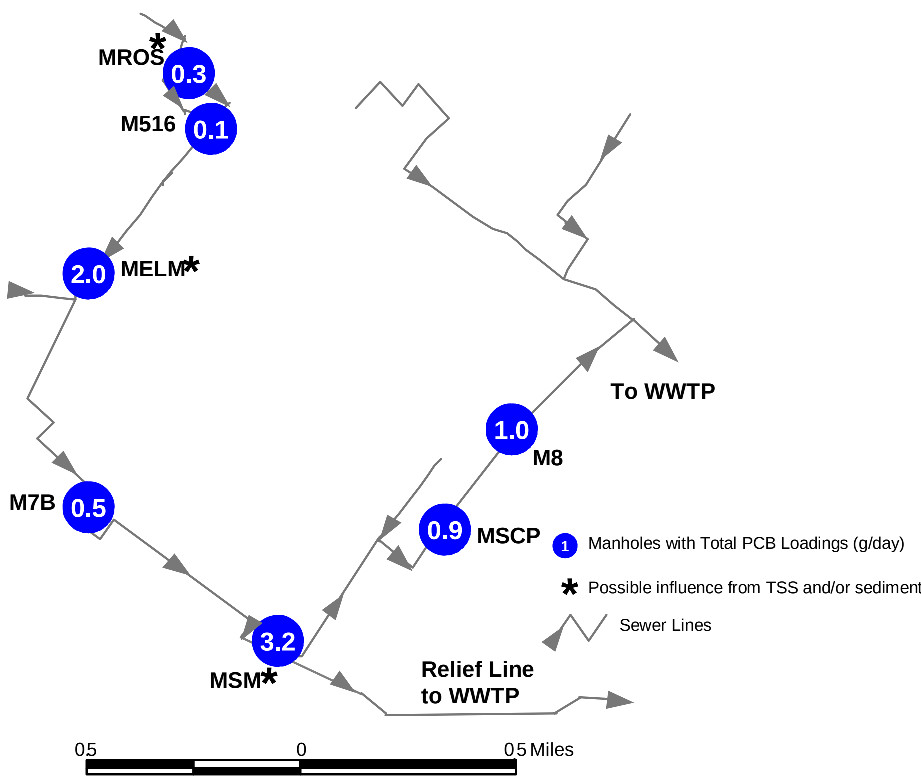
Figure ES-5. LRSA's Western Sewer System and Sampling Locations for Phase IV, Tier 2





Figures ES-6 and ES-7. Total PCBs (ng/L) in Whole Water Samples Collected from LRSA's Western Sewershed in Round 1 (top) and Round 2 (bottom) of Tier 2





Figures ES-8 and ES-9. Total PCB Loadings (g/day) in Whole Water Samples Collected in Round 1 (top) and Round 2 (bottom) of Tier 2 (Phase IV)

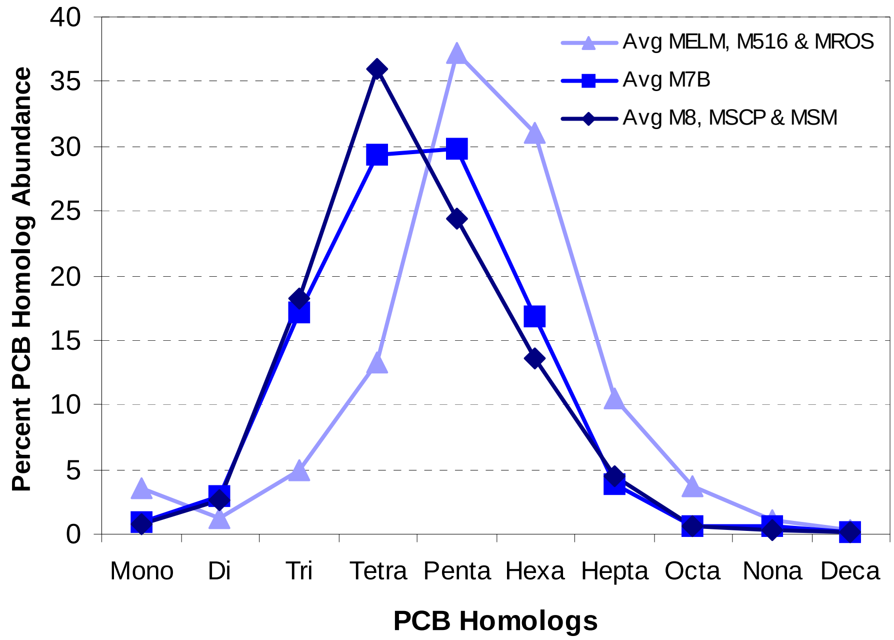


Figure ES-10. Average PCB Homolog Distributions for Whole Water Samples Collected in Two Rounds From Upstream (Manholes ELM, 516 and ROS), Midstream (Manhole 7B) and Downstream Locations (Manholes SM, SCP and 8) in the Western Sewershed

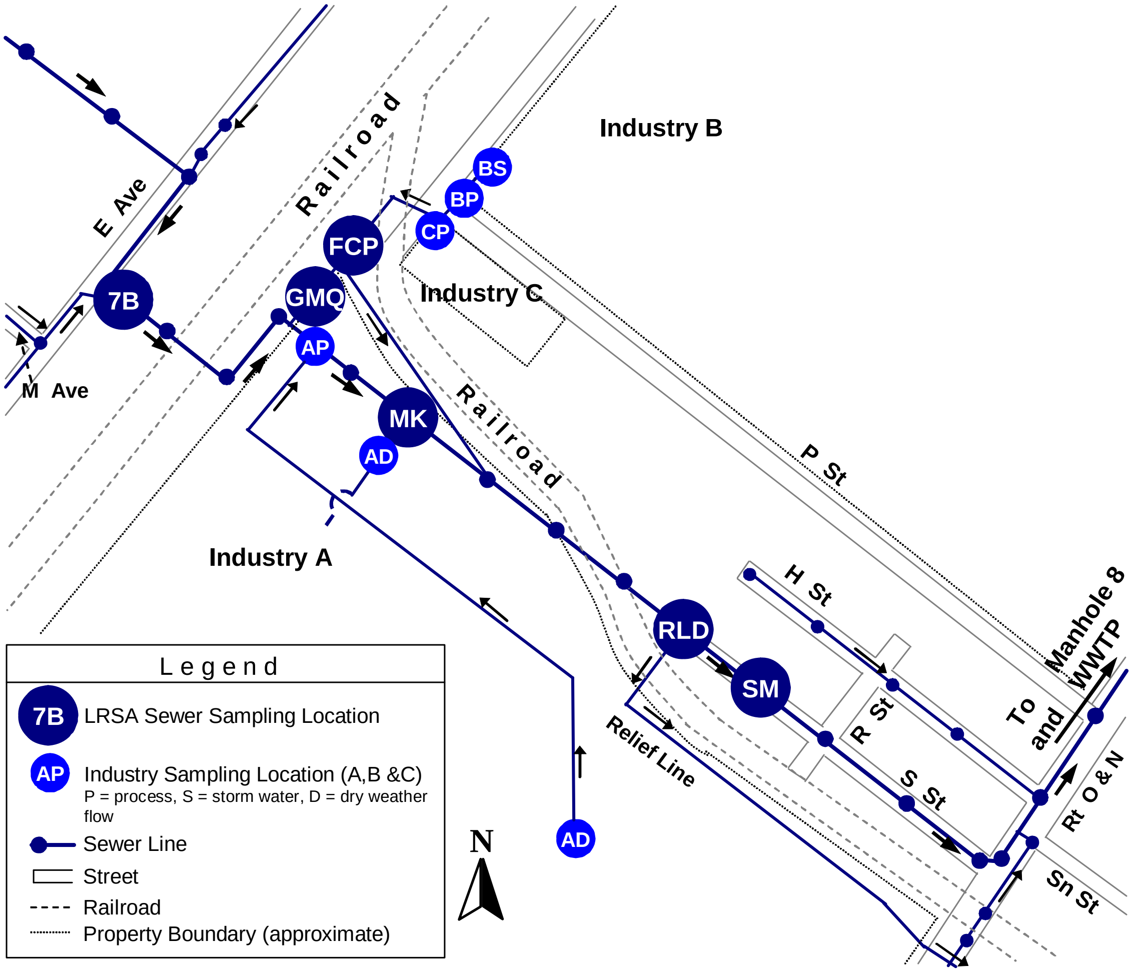


Figure ES-11. Area of Concern and Sampling Locations for Tier 3 (Phase IV)

Figure ES-12. Installation of Fabricated Storm Water Insert in Manhole RLD

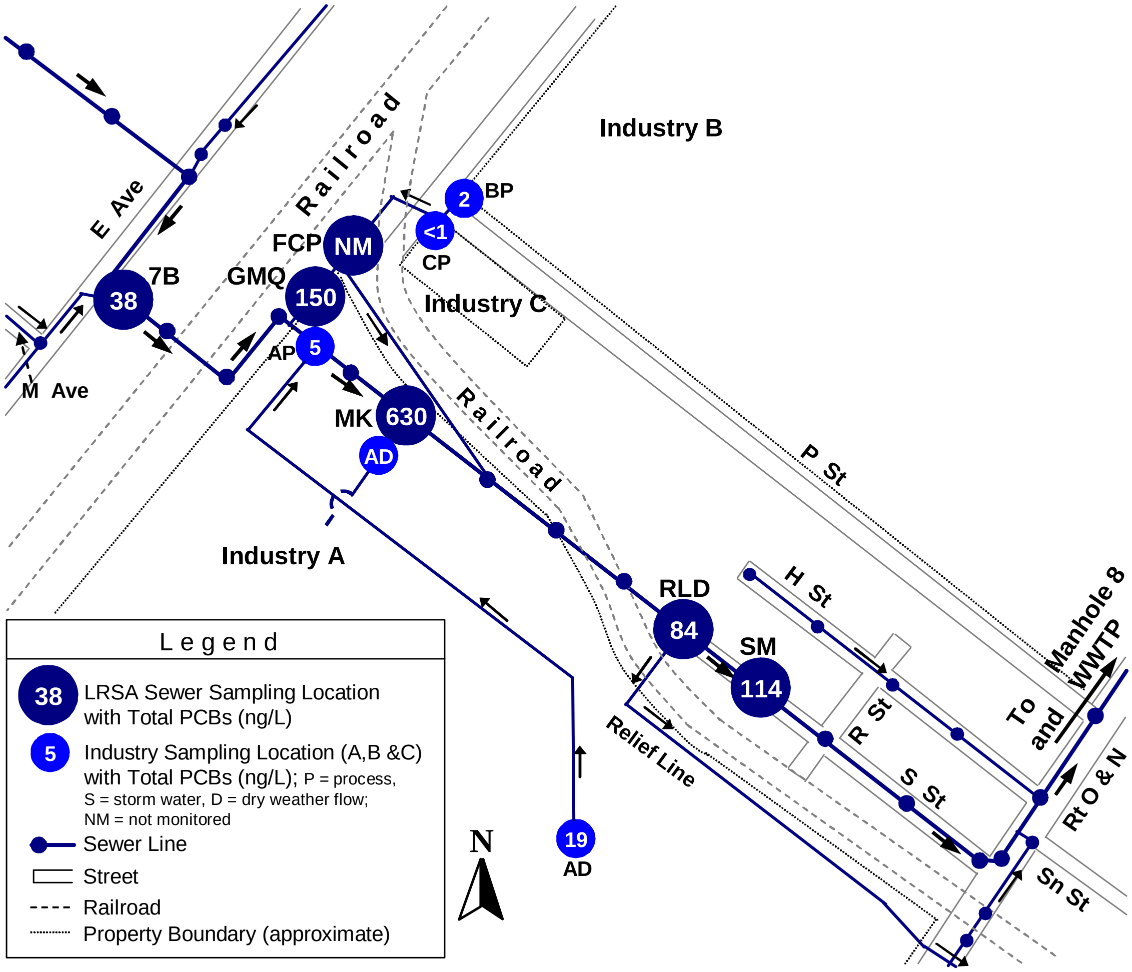


Figure ES-13. Total PCB Concentrations (ng/L) for Round 1 by Tier 3 Sampling Location (Phase IV)

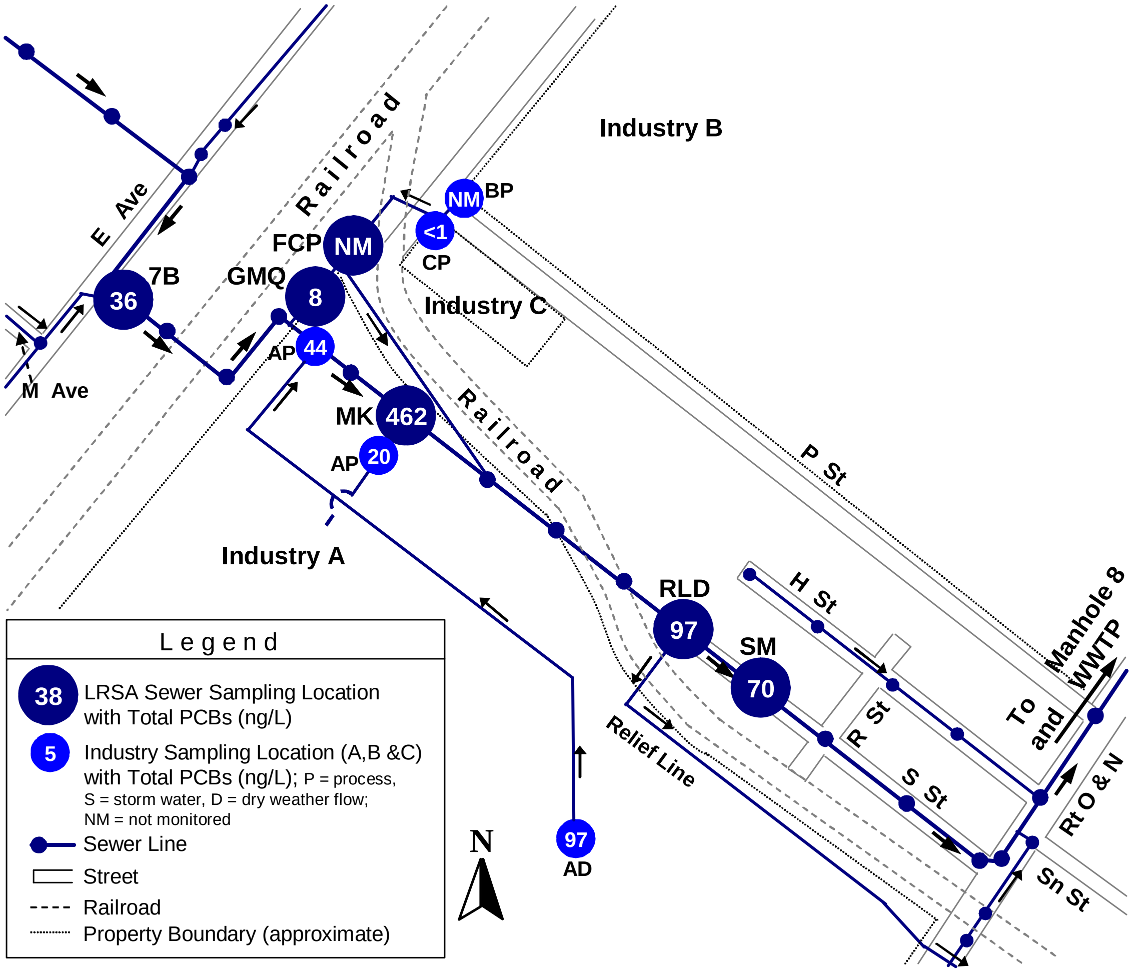


Figure ES-14. Total PCB Concentrations (ng/L) for Round 2 by Tier 3 Sampling Location (Phase IV)

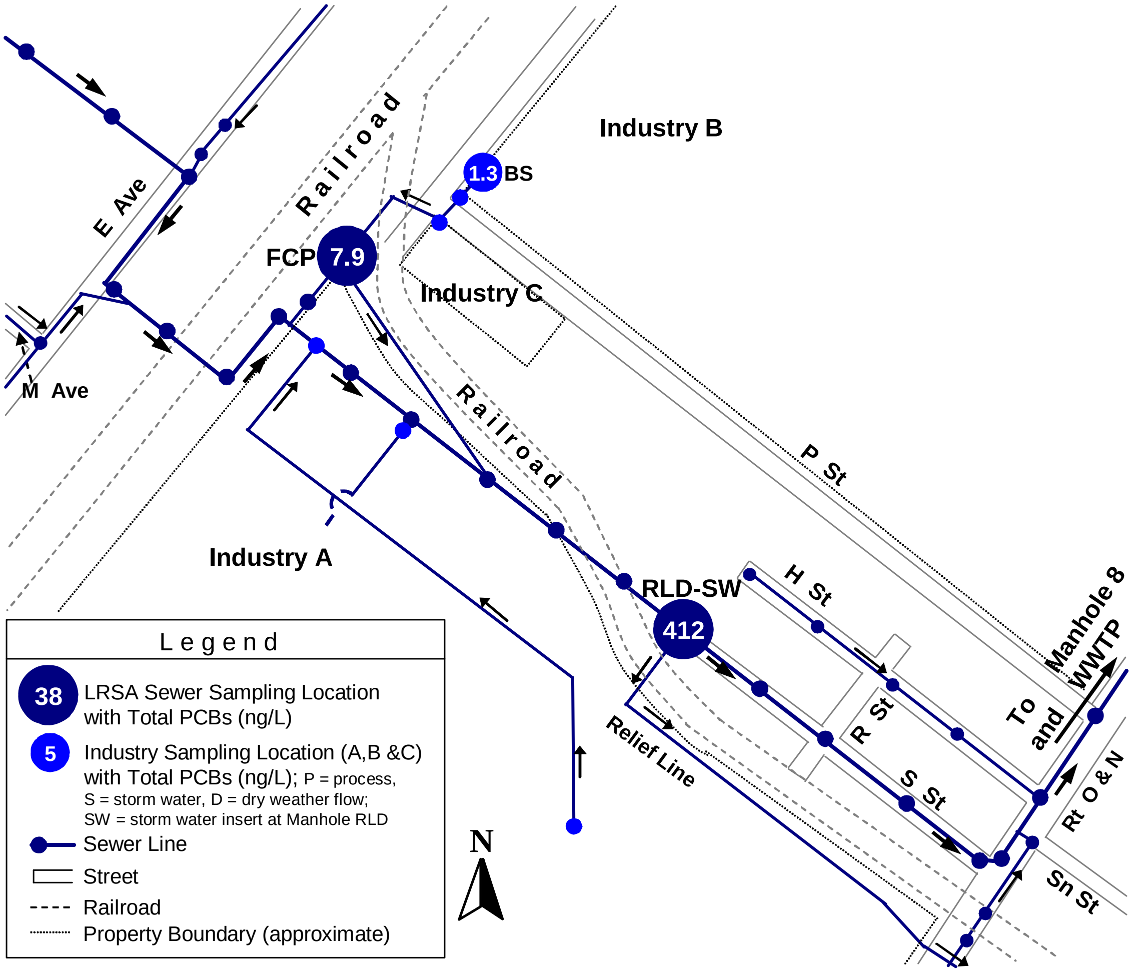


Figure ES-15. Total PCB Concentrations (ng/L) for Tier 3 Locations - Post Round 2

Figure ES-16. Collection of Storm Water Runoff in the Manhole RLD Insert

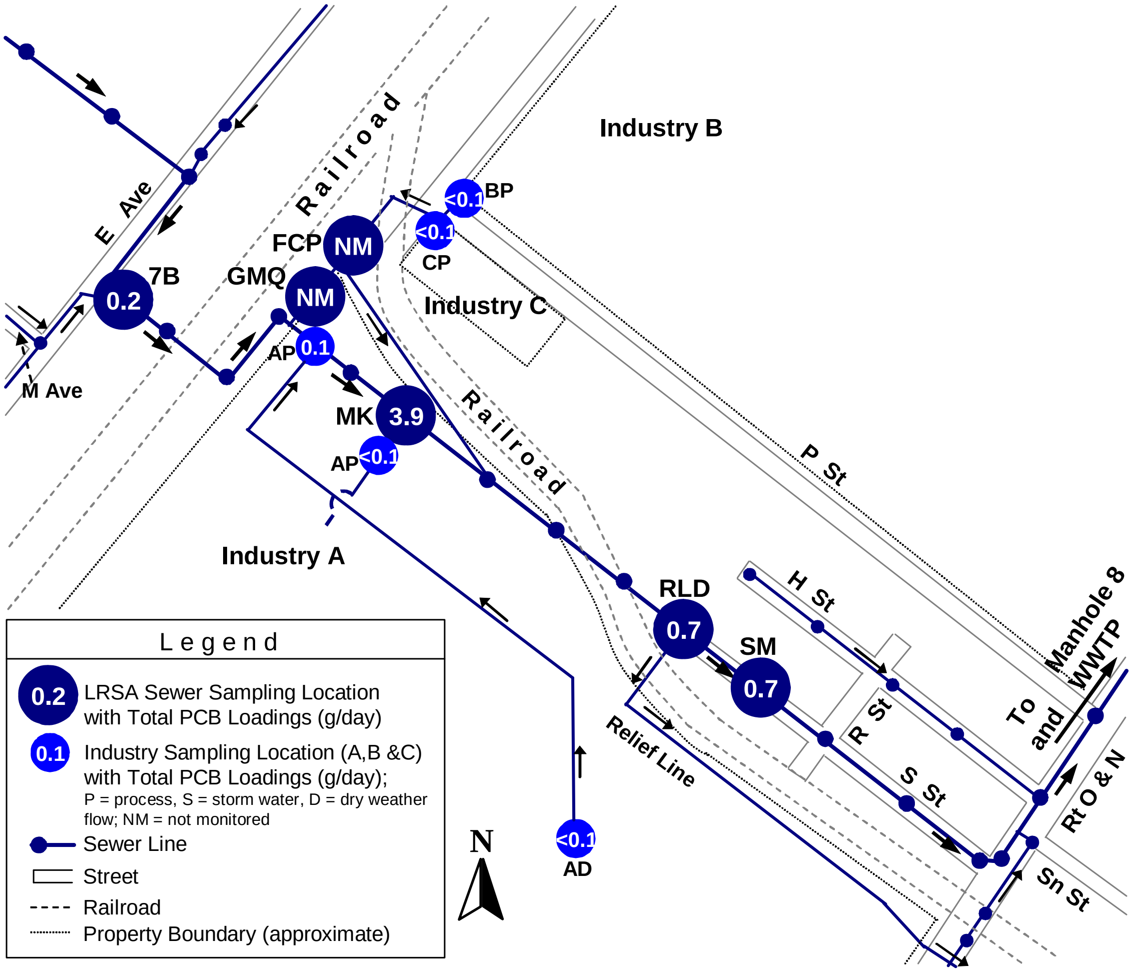
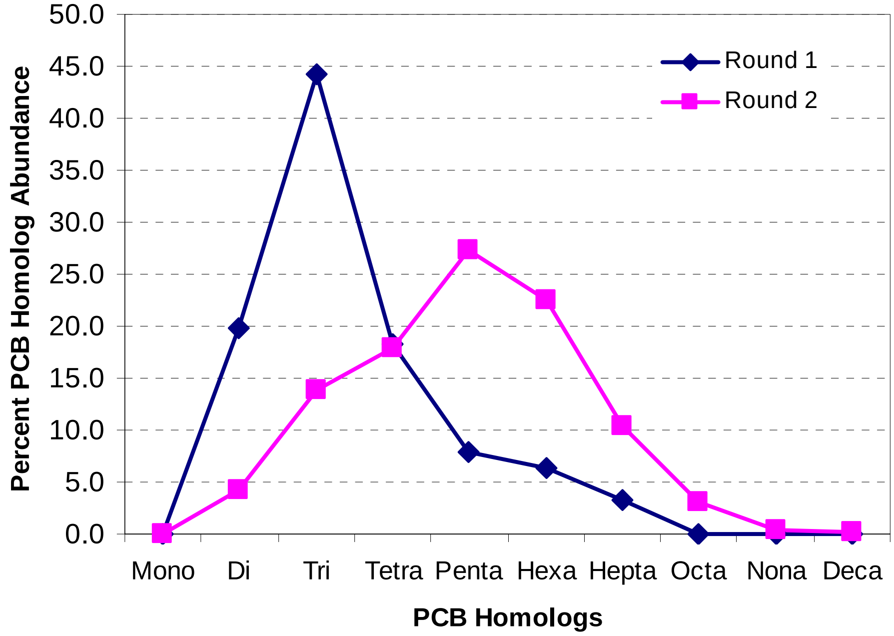
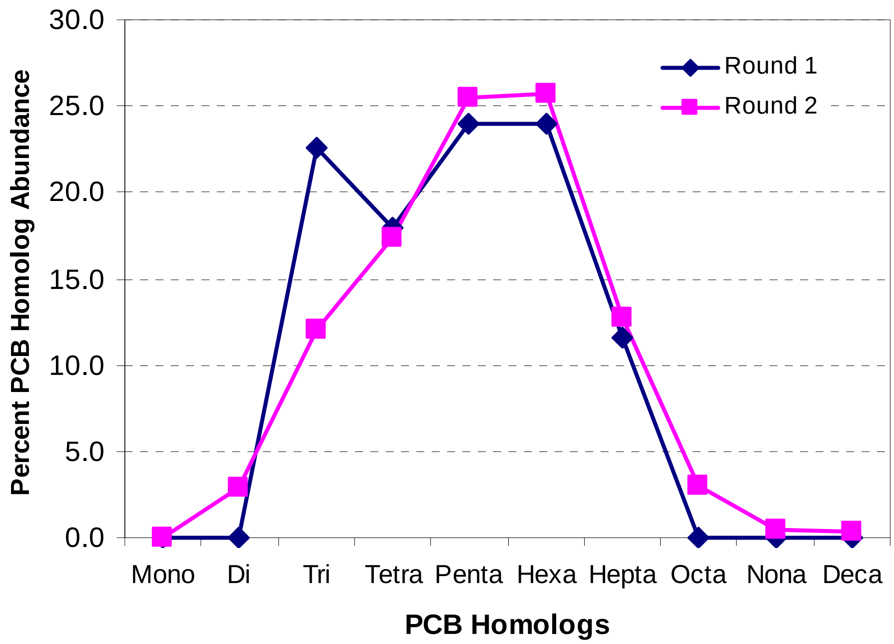
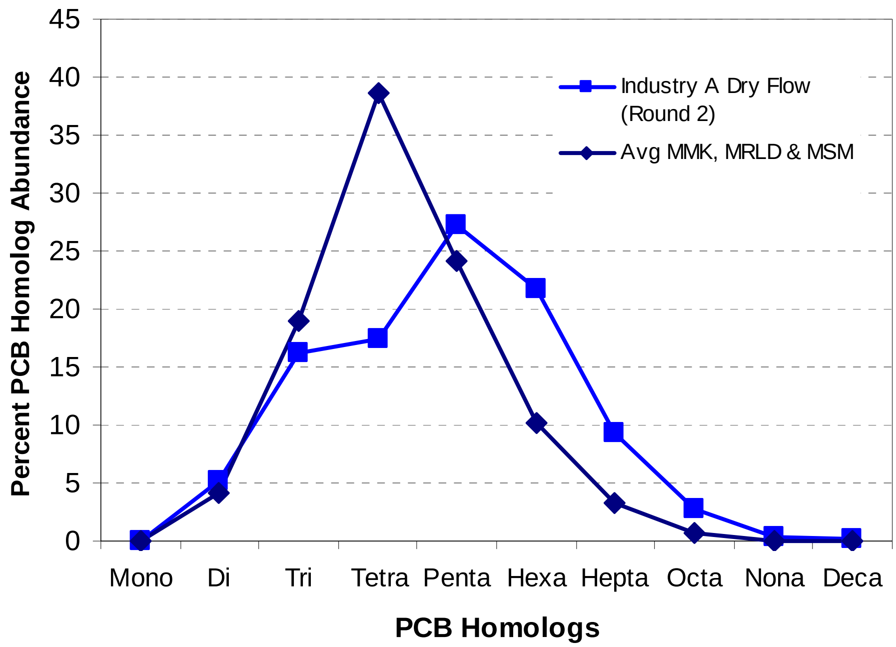


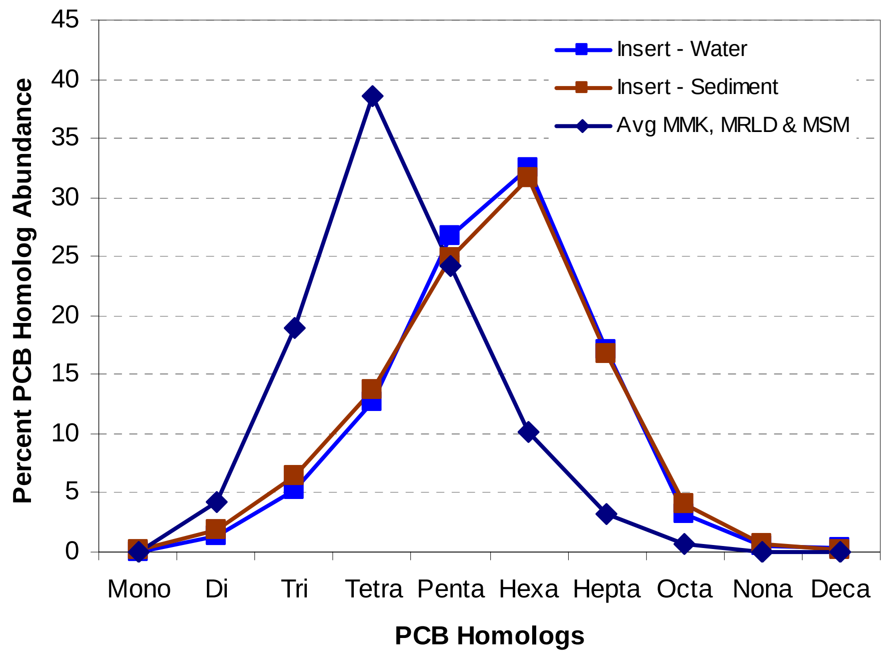
Figure ES-17. Average Total PCB Loadings (g/day) by Tier 3 Sampling Location (Phase IV – Rounds 1 and 2)



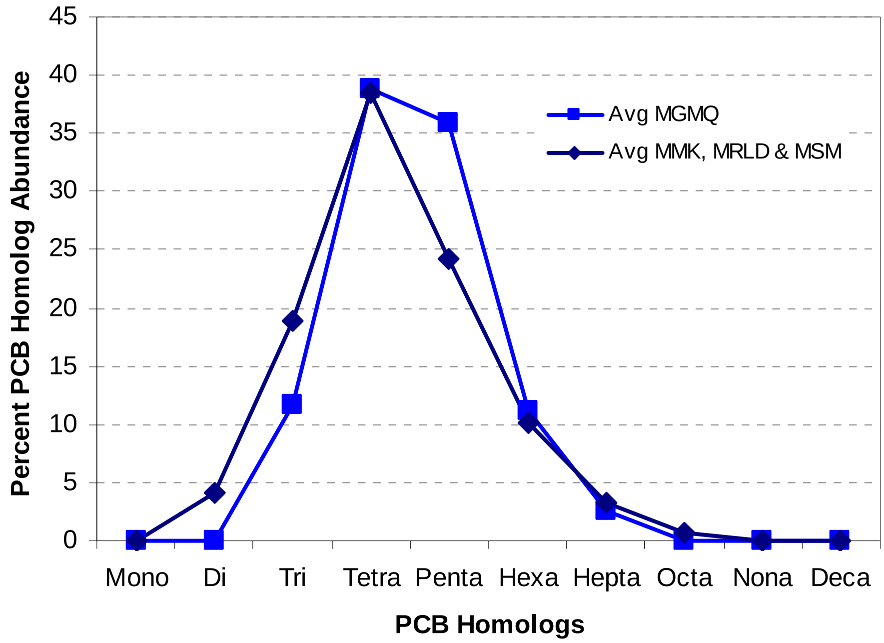


Figures ES-18 and ES-19. PCB Homolog Distributions for Industry A's Dry Weather Flow (top) and Industry A's Final Discharge (bottom) for Tier 3 (Phase IV)





Figures ES-20 and ES-21. Comparison of Average PCB Homolog Distributions for Manholes MK, RLD and SM Versus Industry A's Dry Weather Flow (top) and Manholes MK, RLD and SM Versus Manhole RLD Storm Water Insert for Tier 3 (Phase IV)



Figures ES-22. Comparison of Average PCB Homolog Distributions for Manholes MK, RLD and SM Versus Manhole GMQ for Tier 3 (Phase IV)