Spokane River PCB Fingerprinting Assessment for the Kaiser Trentwood Site – Revised Draft

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PRESENTED TO

US Environmental Protection Agency, Region 10

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1.0 OBJECTIVES

For EPA Region 10, Tetra Tech assessed available PCB water quality and flow data to evaluate the potential movement of PCBs from a known contaminated site to the Spokane River. Major tasks are listed below:

1. Calculate Mass Balance of PCBs: Performed a congener-specific mass balance on PCBs measured in water collected upstream and downstream of the Kaiser-Trentwood upgradient wells, for low-flow conditions. Two reaches were specified for the mass balance calculation: between the Barker Bridge (RM 90.4) and Mirabeau (RM 86.6) monitoring stations, and between the Mirabeau and Plantes Ferry (RM 84.8) monitoring stations.
2. Analyze water quality and biofilm data: Analyzed differences in congener patterns in biofilm data collected by the Washington Department of Ecology in 2018 near the Kaiser-Trentwood Site as well as upstream and downstream from that site, primarily the Barker Bridge, Mirabeau , and Plantes Ferry stations.
3. Compare biofilm and water column data to groundwater well data: Compared the water column and biofilm data to congener data for PCBs in groundwater wells upgradient and cross-gradient from the Kaiser-Trentwood site to ascertain whether the ambient water and biofilm data indicate a release of PCBs to surface water from groundwater upgradient and cross-gradient from the Kaiser-Trentwood Site.

This memo provides an inventory of the datasets reviewed by Tetra Tech for this effort and presents the loading analysis and mass balance load distributions between the key locations.

2.0 DATA SOURCES

Monitoring locations are shown in Figure 1. Tetra Tech received PCB data for 33 of these wells.

2.1 • BIOFILM DATA

Tetra Tech downloaded the Spokane River Regional Toxics Task Force (SRRTTF) Database, which was created for the purpose of compiling Spokane River PCB data for use and accessibility of Task Force members and other interested users. In the SRRTTF database, there are three biofilm samples for the study area. The mentioned data were collected on 8/27/2018. Table 1 shows the available biofilm data in the database for the study area, which overlap (at the same location but not on the same date) with water column data described in subsection 4.0.

Table 1. Available biofilm data – study area (SRRTTF, Wong and Era-Miller 2019 in draft)

No.	Sample ID	Sample Date	Location Name	Location	Available Water Column Data at this Location	Location ID	Washington Ecology Station ID
1	1809040-03	8/27/2018	Barker Bridge	639	•	SR-BR-G	BB
2	1809040-04	8/27/2018	Mirabeau	638	•	SR-MP	MBU
3	1809040-05	8/27/2018	Plantes Ferry	636	•	SR-PFP-G	PF

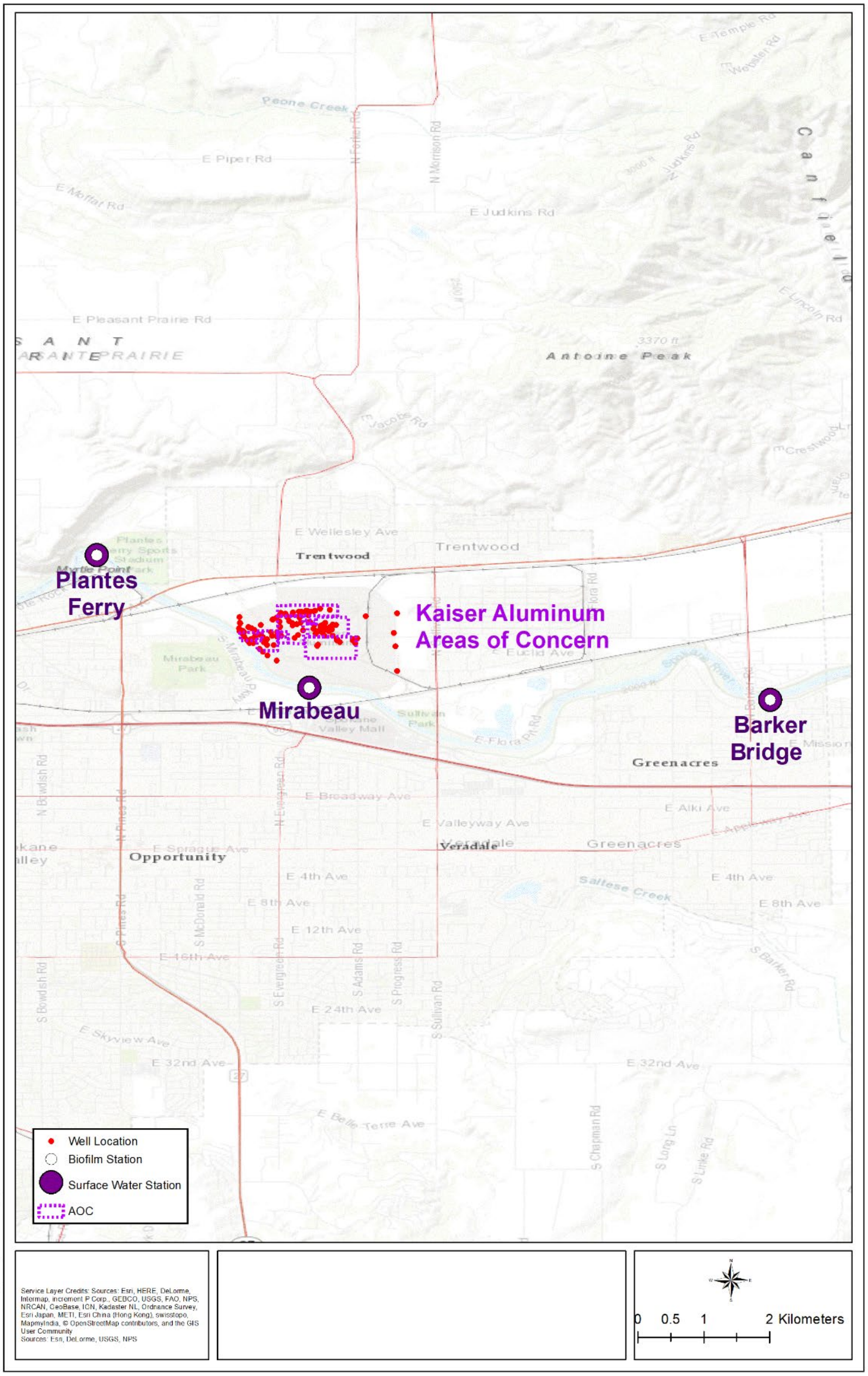

Figure 1. Surface Water, Groundwater and Biofilm Station Locations in the vicinity of the Kaiser-Trentwood Facility

2.2 • WATER COLUMN DATA

The SRRTTF database includes three surface water (SW) stations for the study area, which provide data collected between 8/12/2014 and 8/8/2018. Table 2 shows the available water column data in the database for the study area.

Table 2. Available SW data in the database (study area)

No.	Location ID	Data Type	Location Name	Location	# of samples	Date Range	Washington Ecology Station ID	Rutgers University (Dr. Rodenburg)
1	SR-BR-G	SW	Barker Bridge	639	24	8/12/14 – 8/8/18	SR9	SR-9
2	SR-MP	SW	Mirabeau	638	14	8/8/15 – 8/8/18	SR8a	
3	SR-PFP-G	SW	Plantes Ferry	636	26	8/12/14 – 8/8/18	SR7	SR-7

Dr. Lisa Rodenburg of Rutgers University performed Positive Matrix Factorization (PMF) on Spokane River data (Rodenburg 2016). The study was based on limited fish data, water column data, and WWTP data. She made use of some data from the SRRTTF database and analyzed river flow and instream sampling data from 16 stations. Two of these instream sampling stations are located within the study area of this project and identified in Table 2.

2.3 • GROUNDWATER DATA

The SRRTTF database does not contain groundwater data for the study area. Tetra Tech received Kaiser Wells data from Dave Dilks (LimnoTech 2018) and Jeremy Schmidt (Washington State Department of Ecology). In their 2018 report, LimnoTech analyzed homolog patterns for groundwater well data to estimate PCB loads distributions to the Spokane River. The Limnotech study screened wells to identify areas contributing to elevated river concentrations.

LimnoTech compared PCB homolog patterns from relevant Spokane-area groundwater wells, to homolog patterns for suspected instream groundwater loads identified in a previously developed homolog-specific PCB mass balance for the Spokane River. Table 3 identifies groundwater data collected within the study area of the current project (Kaiser wells).

Table 3. Groundwater data used in LimnoTech report (2018) & Provided by the Department of Ecology

No.	Source	Date	Information
1	EIM		EPA 1668 data GW Wells data - Kaiser Trentwood Facility
2	Kaiser	Mostly April and October: 2010-2017 & 2017-2019 data from Ecology (Jeremy Schmidt)	Data included upgradient groundwater (6 wells: RM-MW-5S (impacted by Kaiser), MW-4, MW-11, MW-10, MW-5, and the North Supply Well) and downgradient wells impacted by multiple sources at Kaiser (2 wells: MW-27 and MW-28) and some wells in Kaiser Site. PCB data are available from 33 wells in total. Sampling time: April and October 2010 – 2019 Kaiser remedial investigation 2008-2009 Few sporadic samples from additional wells or months other than April or October.

3.0 • SPOKANE RIVER PCB HOMOLOG PATTERNS

From the available data, Tetra Tech analyzed similarities and differences in the homolog patterns of data collected at the three locations.

3.1 • GROUNDWATER DATA

Groundwater data collected from the Kaiser-Trentwood study area were investigated to verify the facility as the source of change in Spokane River homolog distributions between Mirabeau and Plantes Ferry. Data from wells located on the eastern edge of the site are intended to represent the background groundwater PCB concentrations from sources other than the Kaiser-Trentwood facility.

Thirty-three monitoring wells on or around the Kaiser-Trentwood site provide PCB homolog data to support this investigation. Figure 2 shows the locations of monitoring wells in the study area, highlighting wells with available data. Average PCB concentrations at each well location are shown in Figure 3. The largest concentrations of PCBs occur in the “Remelt” area of concern, coinciding with the location of the DC-1 and DC-4 furnaces.

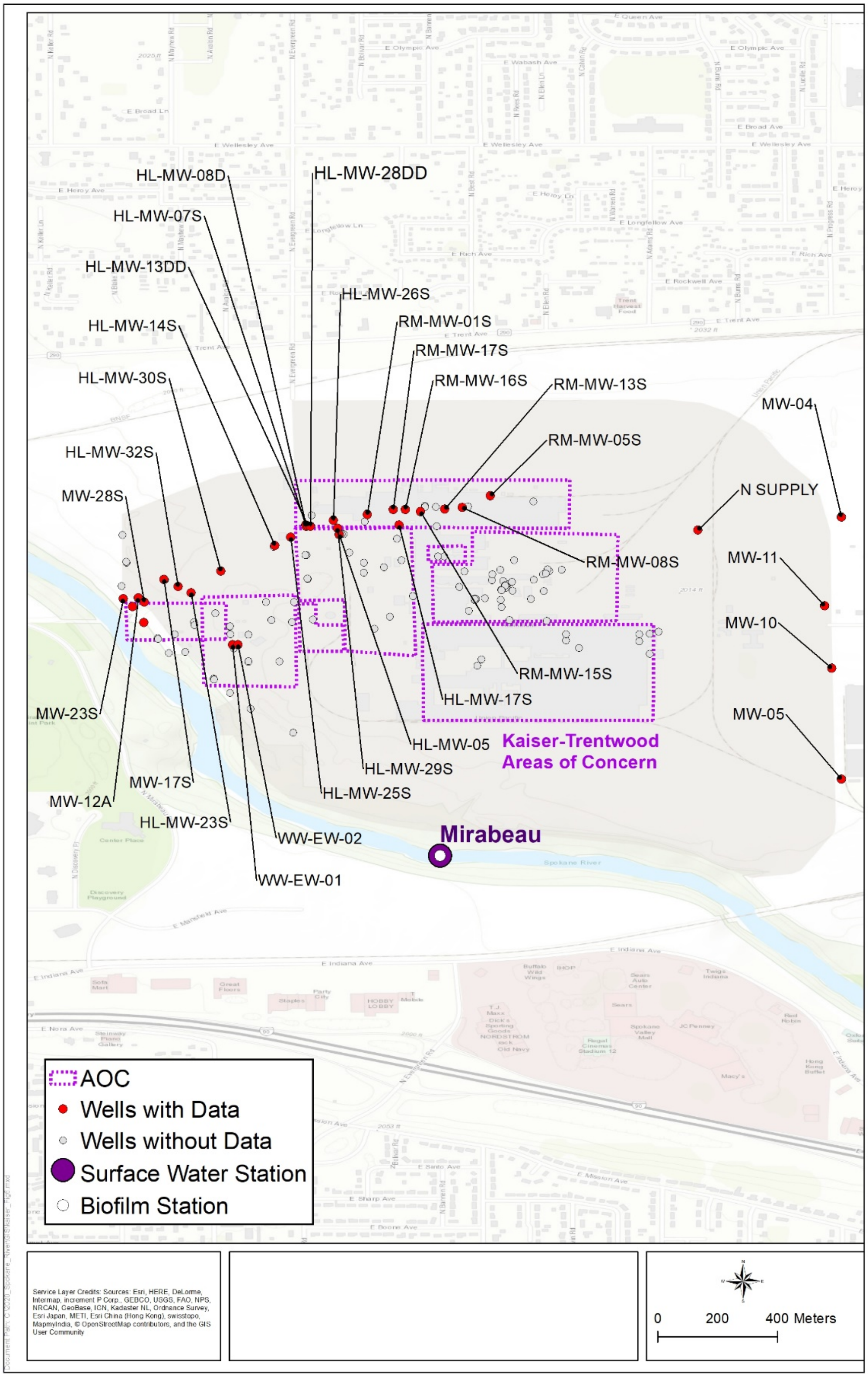

Figure 2. Monitoring Well Locations.

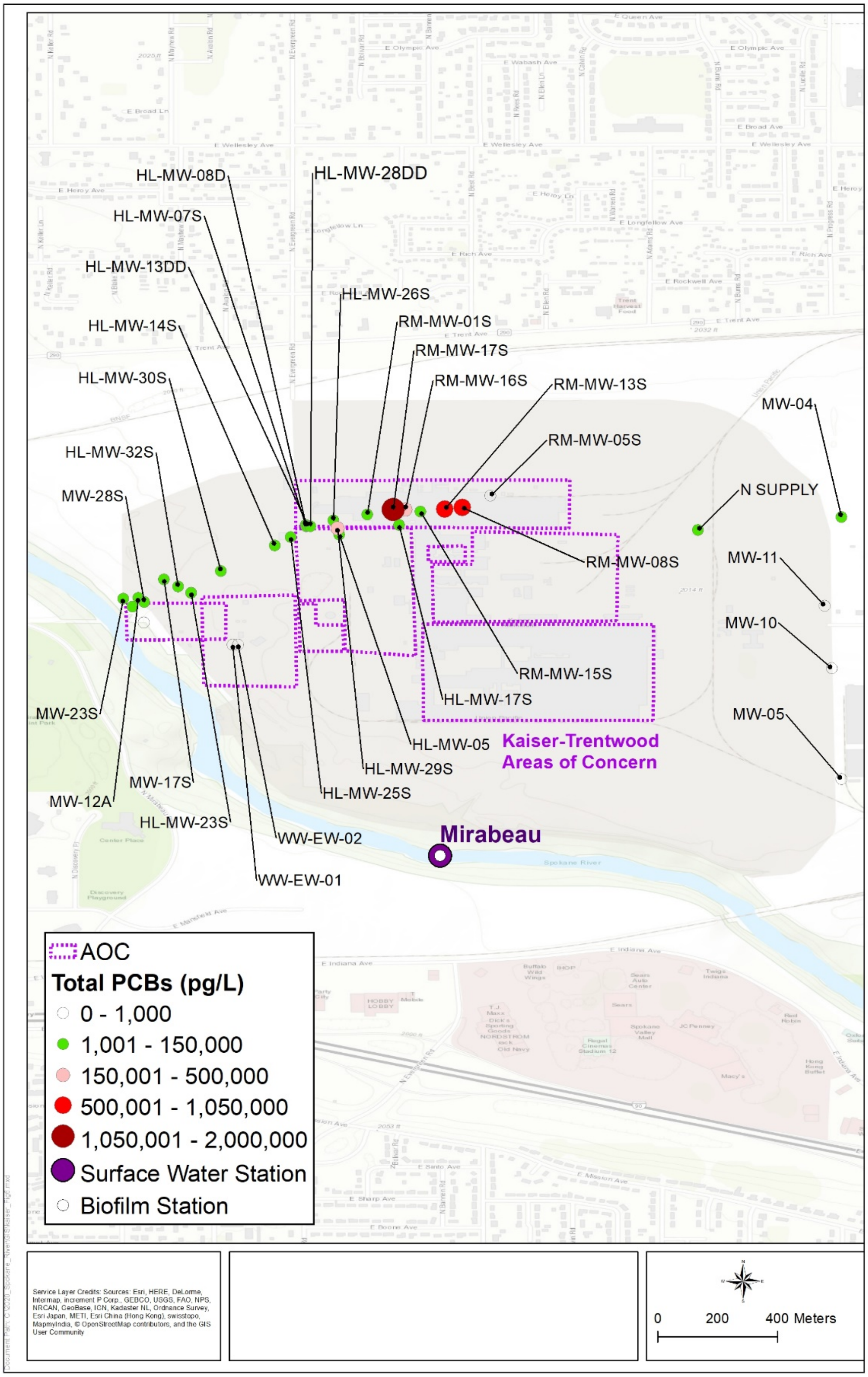

Figure 3. Average Total PCB Concentrations by Well Location

Average homolog distributions were developed for wells with data, and the results are shown in Figure 4. Of the 33 wells, 23 of these wells have a homolog signature where the primary components are Trichloro and tetrachloro biphenyls, exceeding 90% of the total composition. Figure 5 shows that these high concentrations centered around the remelt area are comprised of over 90% trichloro and tetrachloro biphenyls. These markers suggest the groundwater plume is a source of the increase in PCB concentrations between Mirabeau and Plantes Ferry. However, the plume is not the only source of PCBs in the Spokane River.

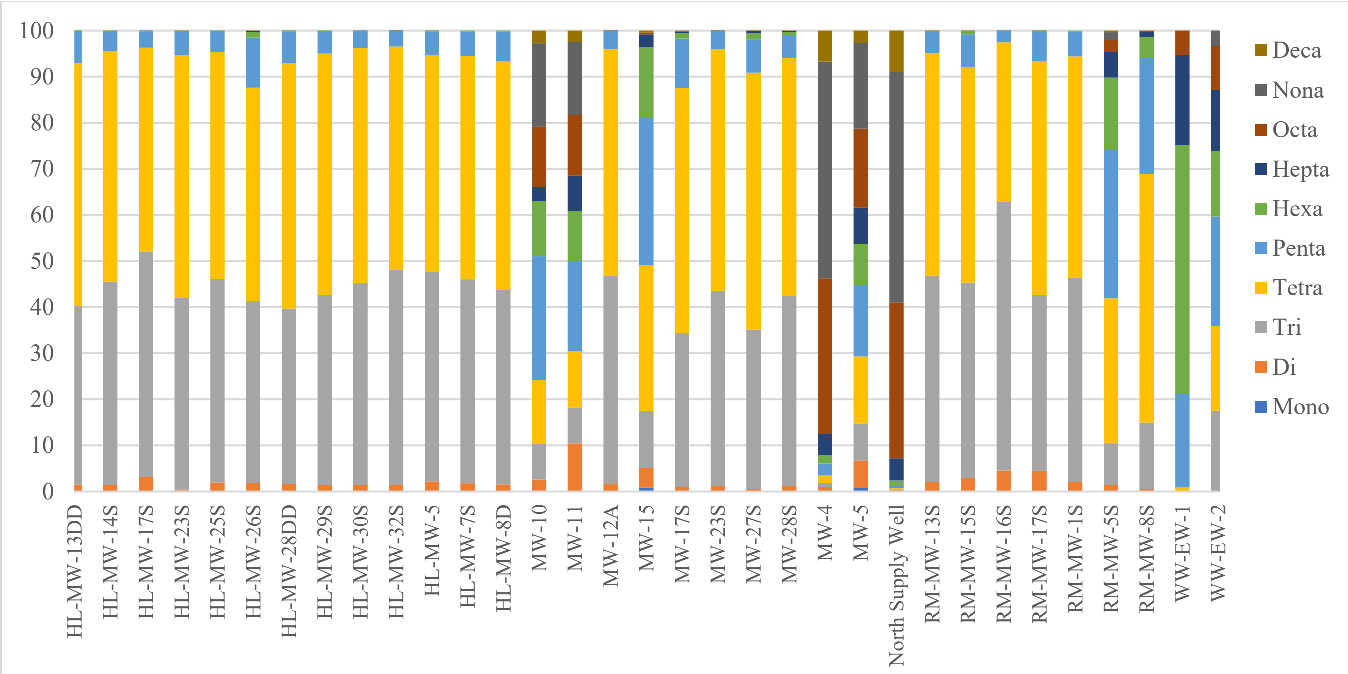

Figure 4. PCB Homolog Distributions for 33 Monitoring Wells in the Study Area.

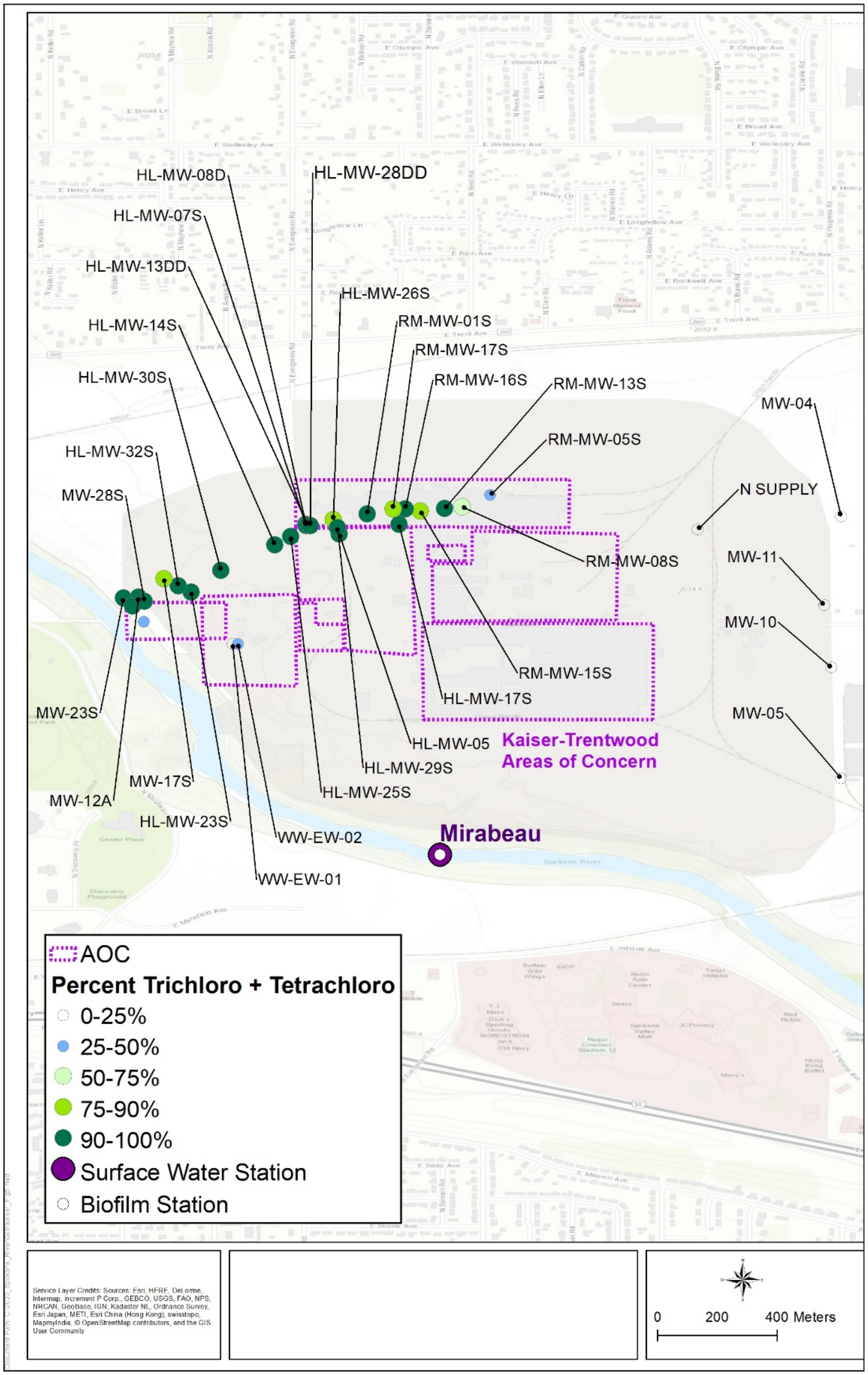

Figure 5. Trichloro and Tetrachloro Biphenyl Percentages by Well Location

Tetra Tech recognized four patterns for the 33 wells (Figure 6). Figure 7 is a larger scale view of the wells depicted with pie charts illustrating the shared patterns.

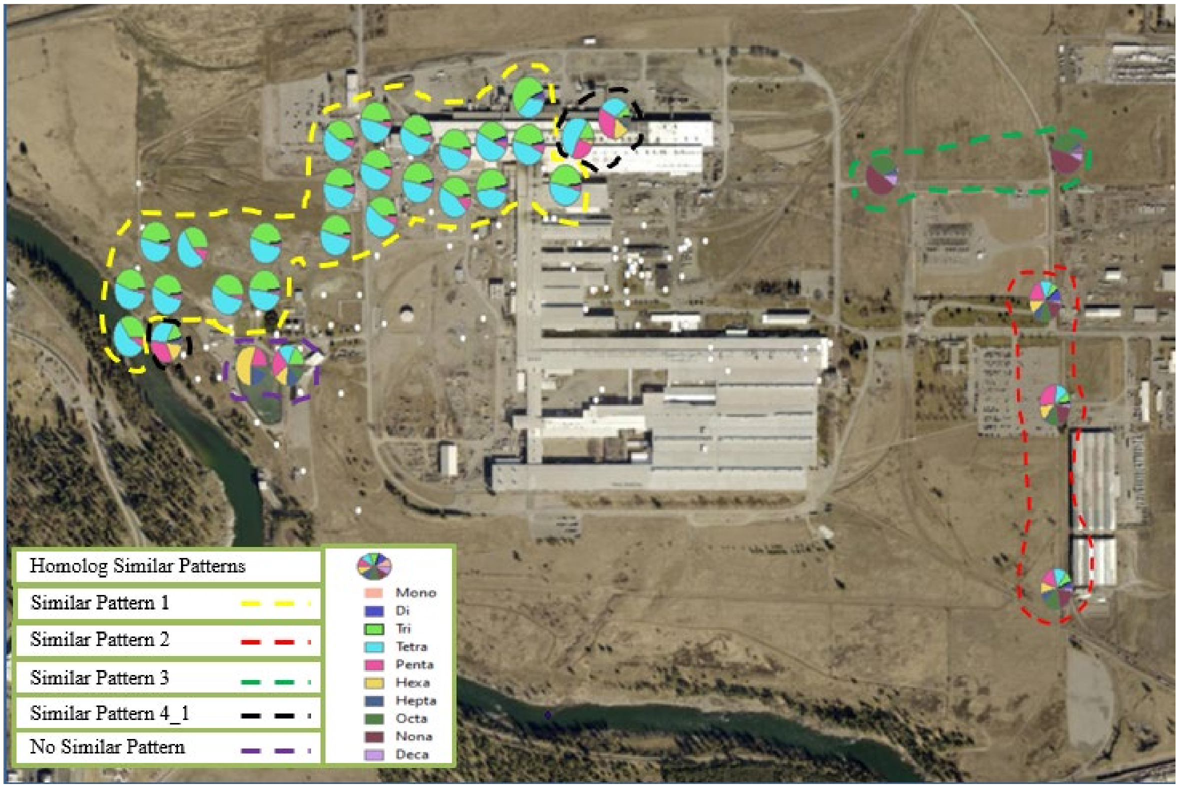

Figure 6. Similar Homolog Patterns for the wells in the study area.

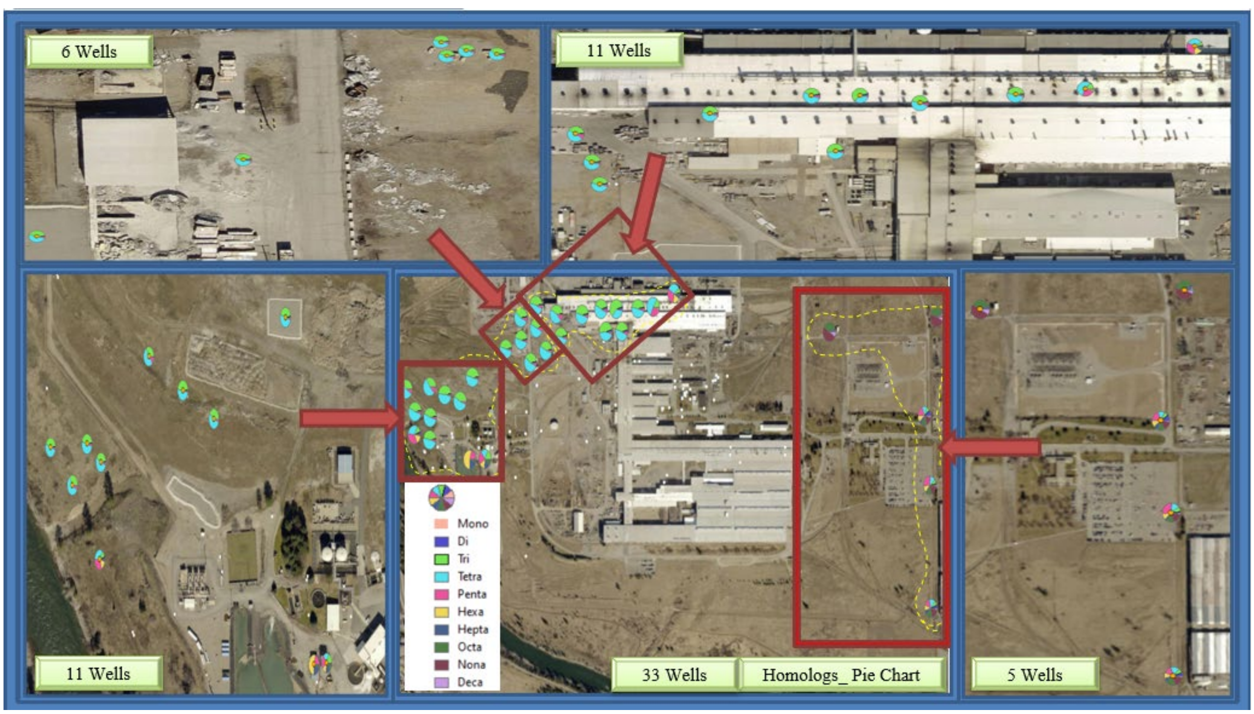

Figure 7. Spatial distributions of 33 wells in the study area.

Figure 8 through Figure 11 show the homolog patterns as a bar chart for each similar homolog pattern.

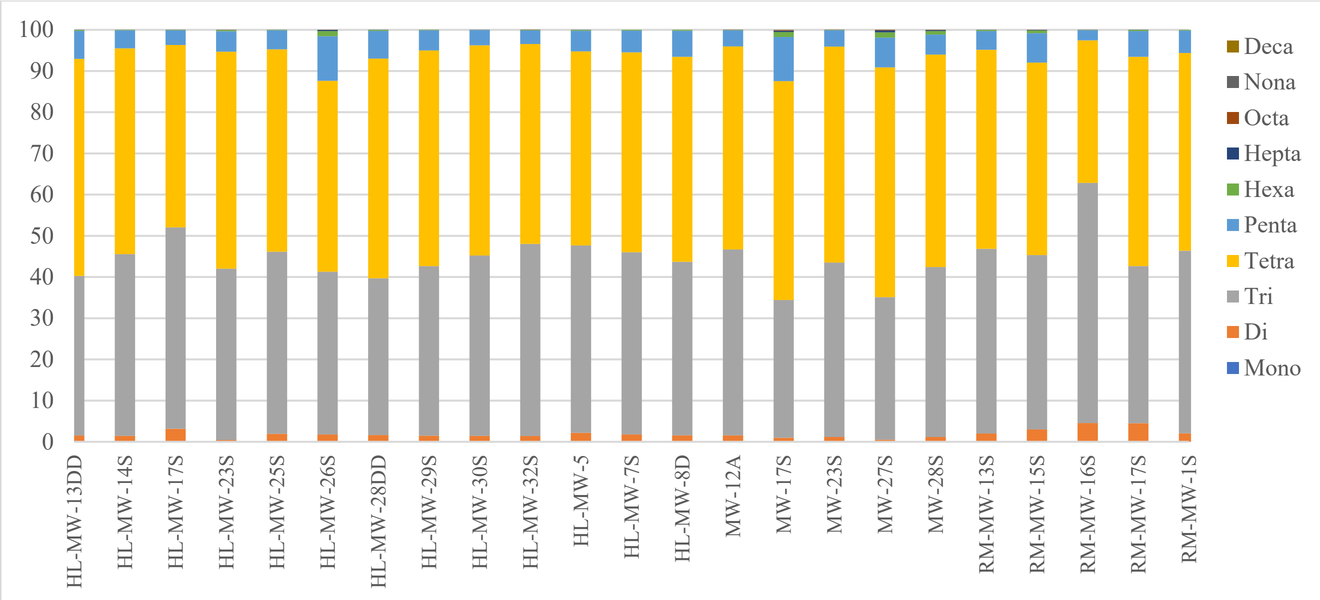

Figure 8. Similar Homolog Pattern 1 for the wells in the study area (23 wells).

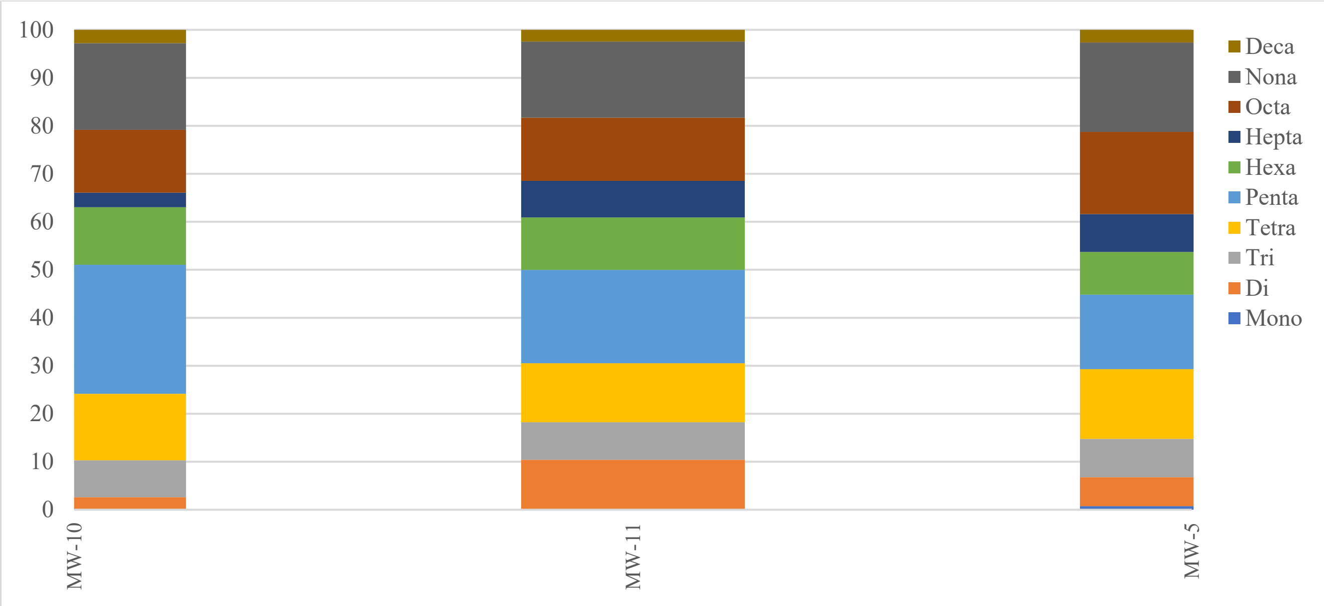

Figure 9. Similar Homolog Pattern 2 for the wells in the study area (3 wells).

Figure 10. Similar Homolog Pattern 3 for the wells in the study area (2 wells).

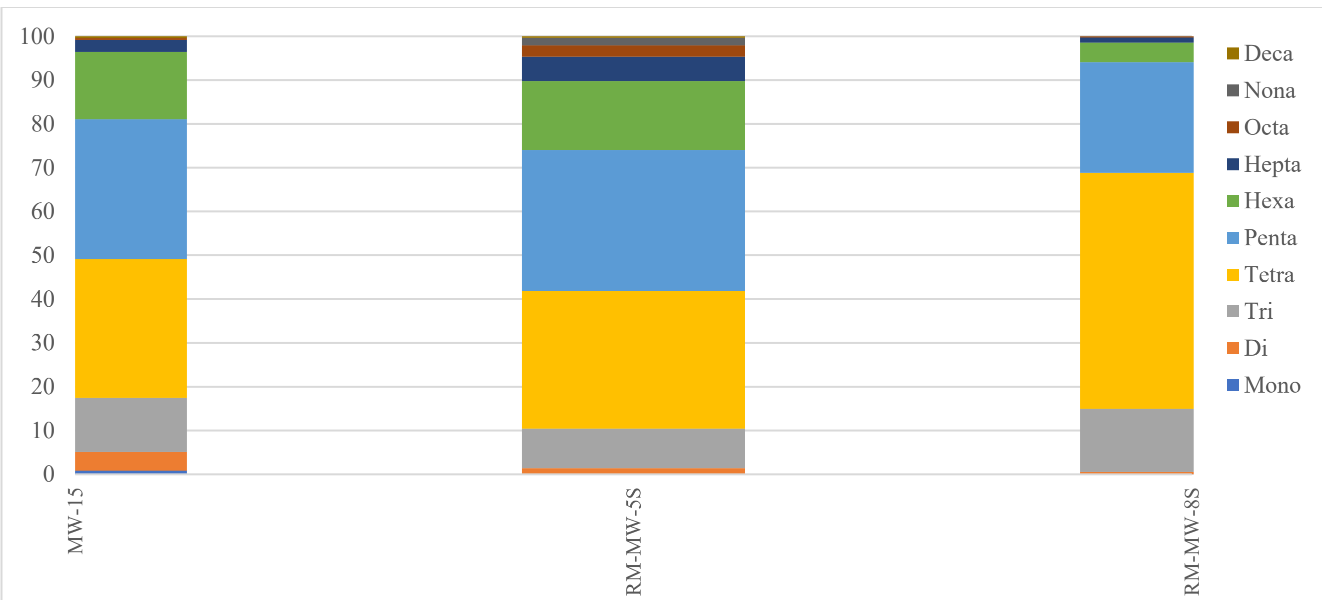

Figure 11. Similar Homolog Pattern 4_1 for the wells in the study area (3 wells).

3.2 • BIOFILM DATA

Biofilm homolog patterns are shown in Figure 12. Biofilm samples were taken along the northern bank of the river in slower-moving, shallow water. As can be seen in this figure, the pattern at the PF station is different than the pattern at BB and MBU stations which are more similar to each other. However, some notable differences can be seen: There are more heavy PCBs, less mid-weight PCBs, and more Lightweight PCBs at the MBU station relative to the BB station.

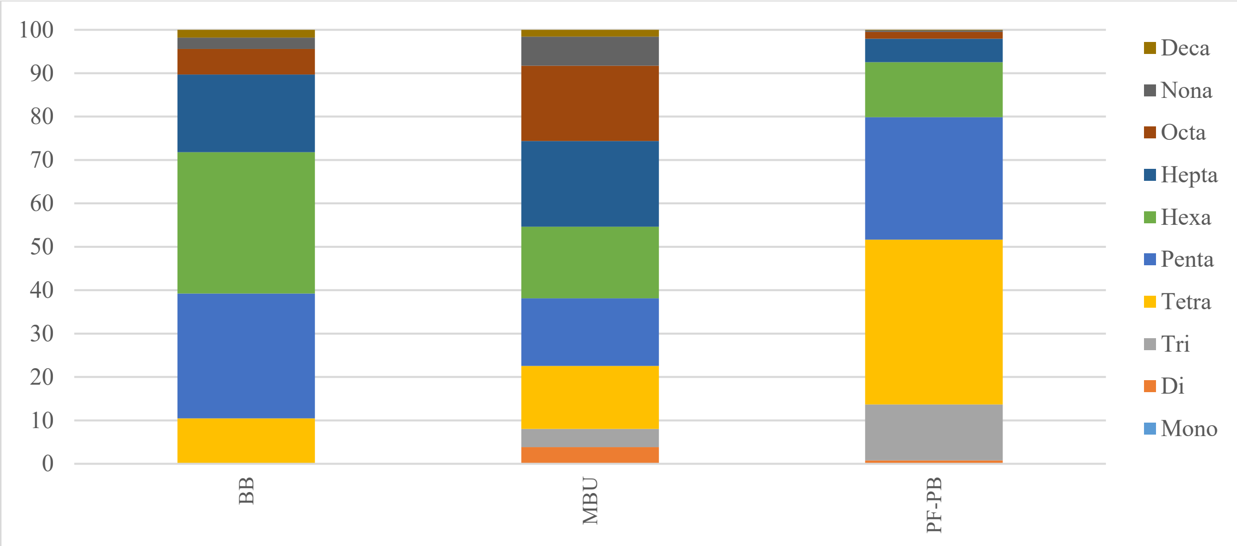

Figure 12. Average Total PCB Homolog Distributions for the Biofilm data (3 stations)

3.3 • SURFACE WATER DATA

Surface water homolog patterns are shown in Figure 13. Surface water samples were taken just below the water surface at the middle of the channel. As can be seen in this figure, the pattern in PF station is different than the pattern in BB and MBU stations which are similar here as well. As with the biofilm data, there are some notable differences: Fewer heavy PCBs and mid-weight PCBs and more Lightweight PCBs at MBU station compared to the BB station.

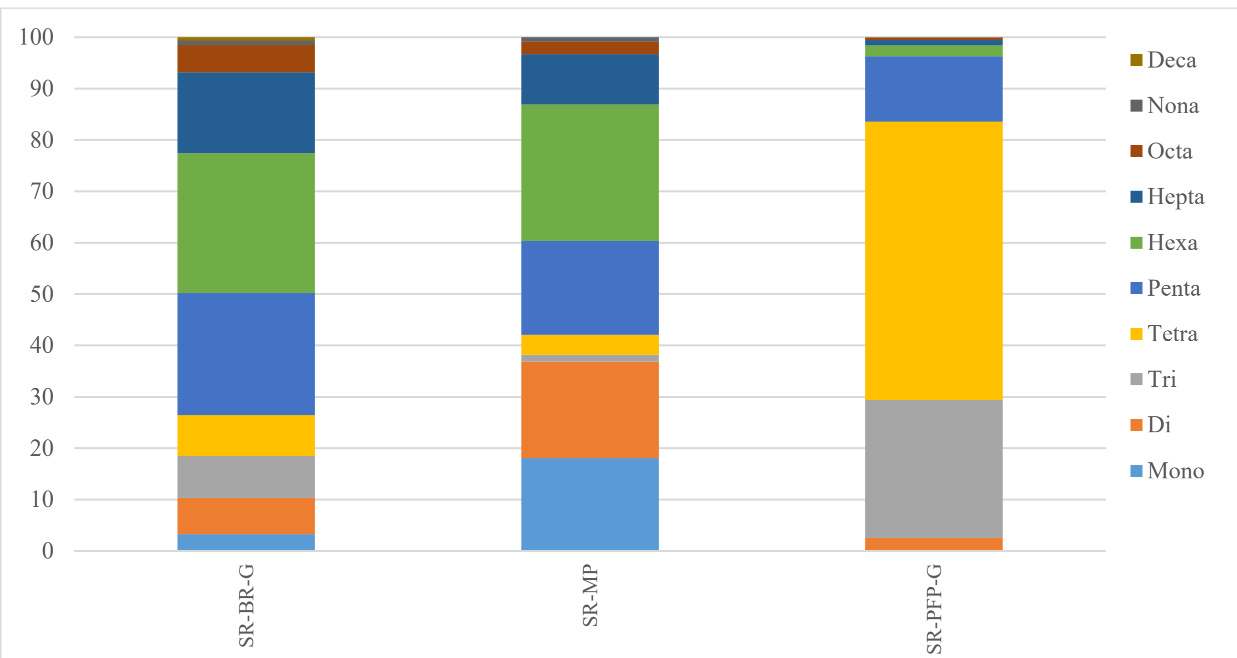

Figure 13. Average Total PCB Homolog Distributions for the Surface Water data (3 stations).

4.0 PCB LOADING ANALYSIS

A loading analysis was performed for the Spokane River and groundwater sources in alignment with the PCB mass balance project objective. The study area-specific data described in Section 2 were paired with the concurrently measured flows at surface water and biofilm monitoring stations. PCB loads were calculated at three surface water monitoring locations. These include, from upstream to downstream; Barker Bridge, Mirabeau, and Plantes Ferry Park. The river concentration and flow data were exclusively collected during low-flow conditions, and the mass balance calculations based on these observations will represent loading estimates specifically for low-flow conditions. A coarse estimate of groundwater discharge from the site during low flow conditions was also conducted to estimate the impact of groundwater seepage to the Spokane River adjacent to the Kaiser-Trentwood facility. PCB concentration results from sampled monitoring wells on the Kaiser-Trentwood site were additionally combined with estimates of groundwater flow to estimate the groundwater component of loading for the reach between Mirabeau and Plantes Ferry.

4.1 • SPOKANE RIVER PCB LOADING ESTIMATION

A Mass balance analysis was conducted for two reaches adjacent to the Kaiser-Trentwood facility: from Barker Bridge to Mirabeau, and from Mirabeau to Plantes Ferry (Figure 14). The Barker Bridge monitoring location, upstream of the Kaiser-Trentwood site, provides background loading of PCBs in the Spokane River at this location. The Mirabeau monitoring site captures the PCB loading just upstream of the main Kaiser-Trentwood facility groundwater plume, and the Plantes Ferry monitoring site will be considered the downstream boundary, or the “sink” location.

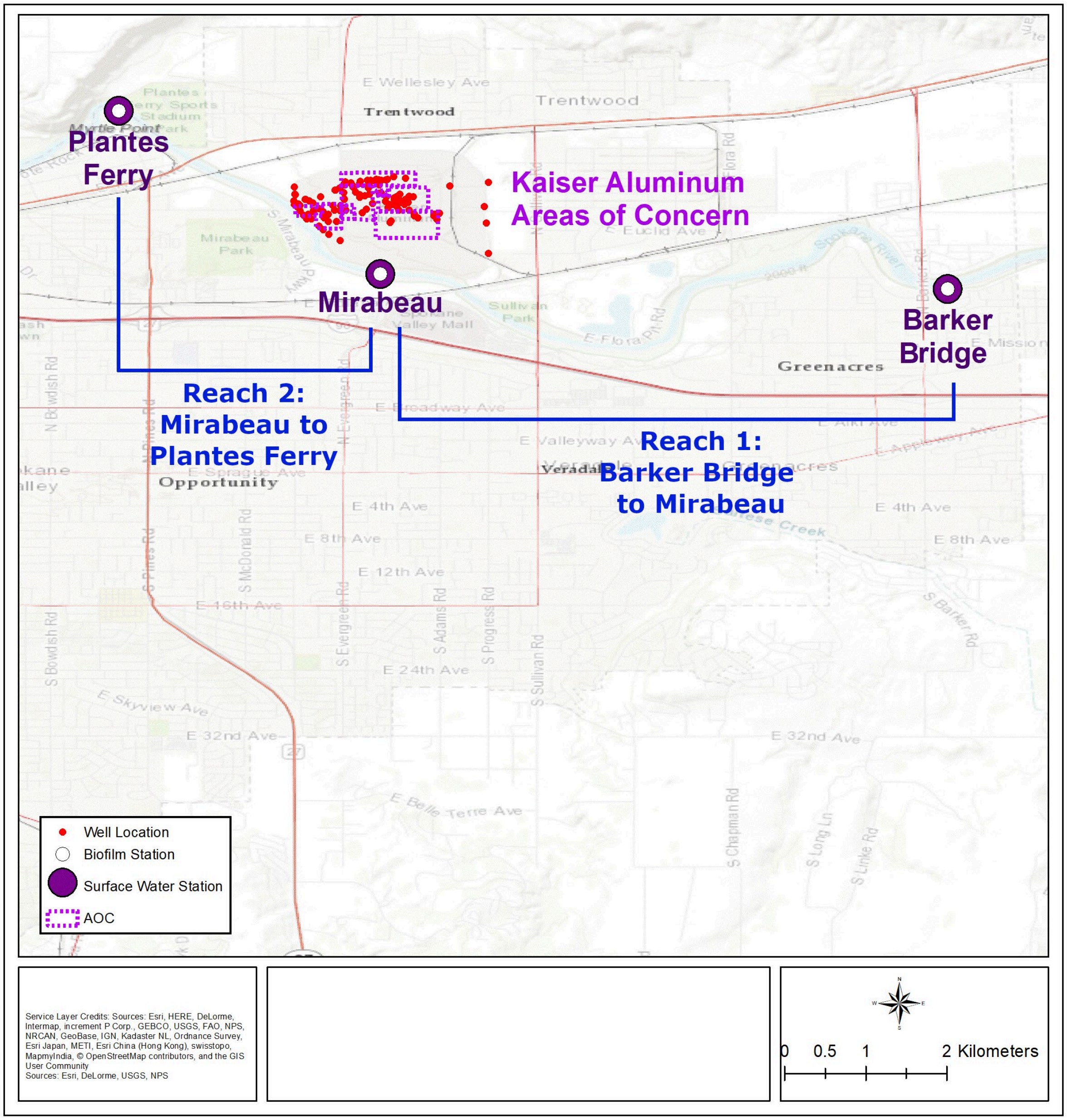

Figure 14. Map of the two reaches over which the mass balances are calculated.

4.1.1 • Spokane River PCB Mass Balance: Loading

The PCB load at Barker Bridge was estimated to provide the Spokane River source component of the mass balance. For each monitoring site, the daily flow measurements recorded during sampling events (Table 4) were applied to the measured PCB concentrations from each sampling event to estimate the Spokane River PCB load distributions by homolog group. The monitoring data were all collected during the month of August, during different years. For each monitoring year (2014, 2015, and 2018), the daily calculated load distributions for each monitoring event were averaged to produce mean loading values for the August monitoring period of that year. These mean loading values by homolog group were then compared between monitoring sites to assess the relative PCB input and output over each reach (Figure 15). The magnitude of flows observed during the 2014 and 2018 monitoring years are similar, while the 2015 monitoring event occurred during a period of lower flow than the others. Across monitoring dates, a clear trend is visible of Spokane River flow rates dramatically increasing from Barker Bride to Plantes Ferry, indicating the tendency for these reaches to be gaining flow from groundwater discharge during these low-flow periods.

Table 4. Flow rates observed at monitoring stations during sampling events, reported as cfs.

Date	Barker Bridge	Mirabeau	Plantes Ferry
8/12/2014			927
8/14/2014	271.1		923
8/16/2014	347.1		919
8/18/2014	483.7		989
8/20/2014	572		1060
8/22/2014			1050
8/24/2014	323		948
8/18/2015	110	500	620
8/19/2015	110	490	630
8/20/2015	120	470	600
8/21/2015	120	460	620
8/22/2015	120	450	610
8/4/2018	244	730	907
8/5/2018	220	697	911
8/6/2018	238	681	924
8/7/2018	235	721	899
8/8/2018	245	701	898

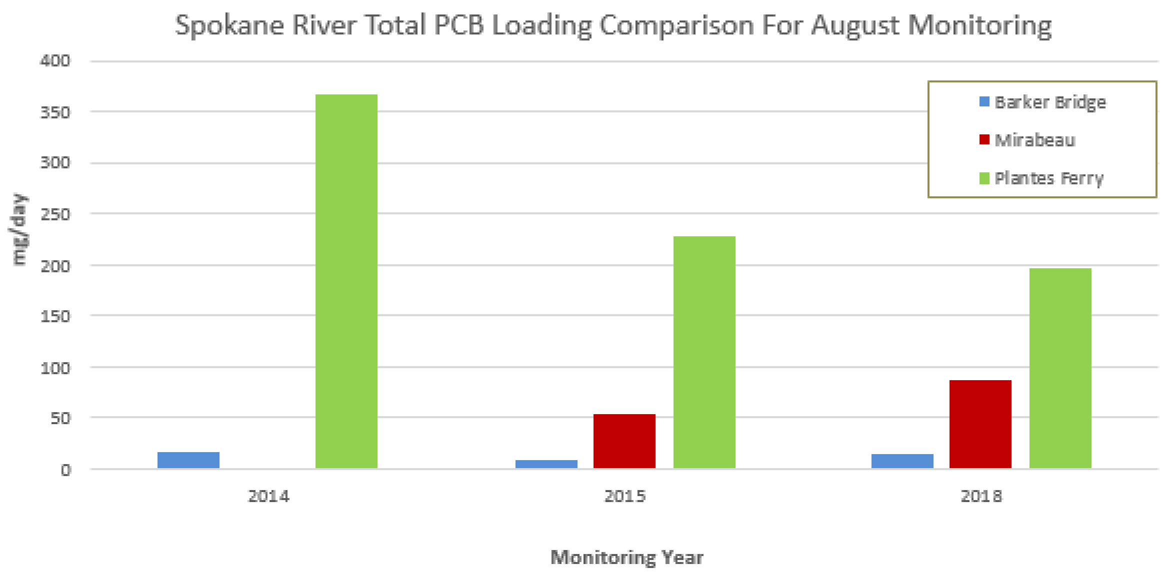

Figure 15. Mean total average PCB loading rates for the August monitoring period of each monitoring year. No PCB monitoring data were reported for the Mirabeau station in 2014.

The PCB load estimated at Mirabeau represents the aggregate load from all PCB sources upstream of Mirabeau for the mass balance, representing the downstream end of the mass balance for the first reach, and the upstream end of the mass balance for the second reach. By estimating the PCB load at a point in space rather than a river segment, the PCB estimate at that location acknowledges all bidirectional groundwater flow and gaining/losing characteristics upstream of Mirabeau. The Spokane River upstream source component does not require quantification of the communication between the Spokane River and groundwater upstream of Mirabeau. However, reintroduction of PCBs downstream of Mirabeau from losing segments upstream of the Mirabeau location may influence other components of the mass balance. From the elevated PCB concentrations observed at Mirabeau relative to Barker Bridge, it is clear that there are additional PCB inputs to this reach, whether from local sources or travelling through groundwater from further upland.

The overall PCB loads at Barker Bridge are the lowest of the three sites, ranging from 8.6 to 16.2 mg/day. The relative composition of these loads varies across the monitoring years, shown in Figure 16.

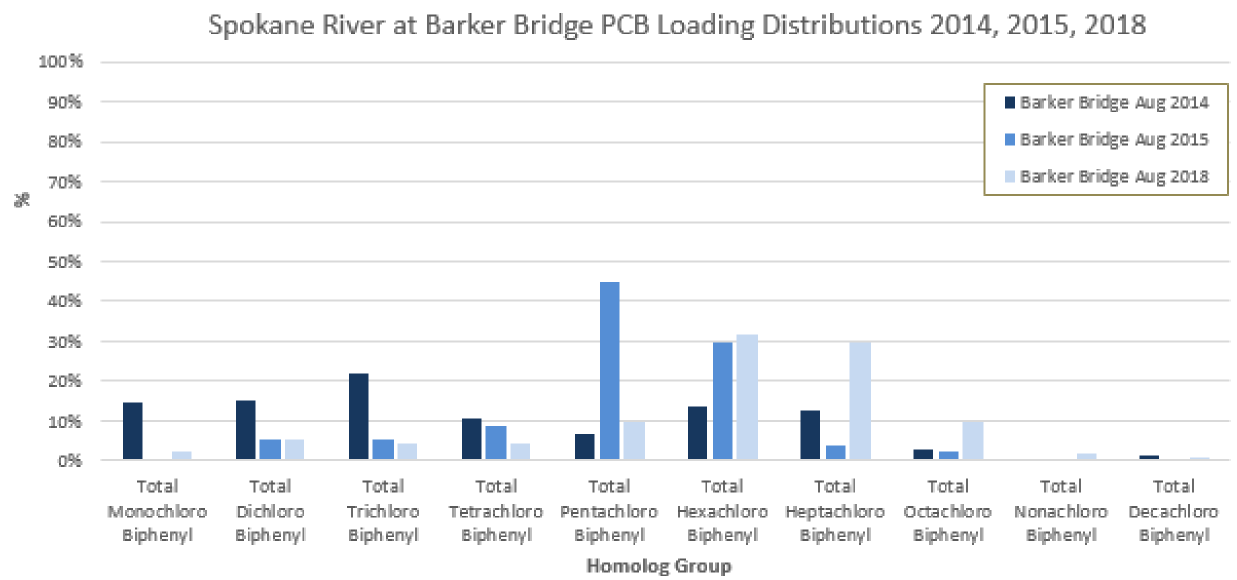

Figure 16. Estimated PCB Load Distributions to the Spokane River at Barker Bridge, 2014-2018.

The load distributions at Mirabeau were notably different between the 2015 and 2018 monitoring events (Figure 17), likely due to differences in the magnitudes of flow observed during these years, and related groundwater-surfacewater interactions. The PCB load distribution at Mirabeau in 2015 is primarily comprised of pentachloro, hexachloro, and heptachloro biphenyl components at 32.9%, 46.1%, and 12.8%, respectively. Together, these three homolog groups represented 91.8% of total PCBs entering the study area from the Spokane River at Mirabeau. In 2018, the monoclhloro and dichloro biphenyl components represented 34.2% and 34.6% of the total PCB load, respectively.

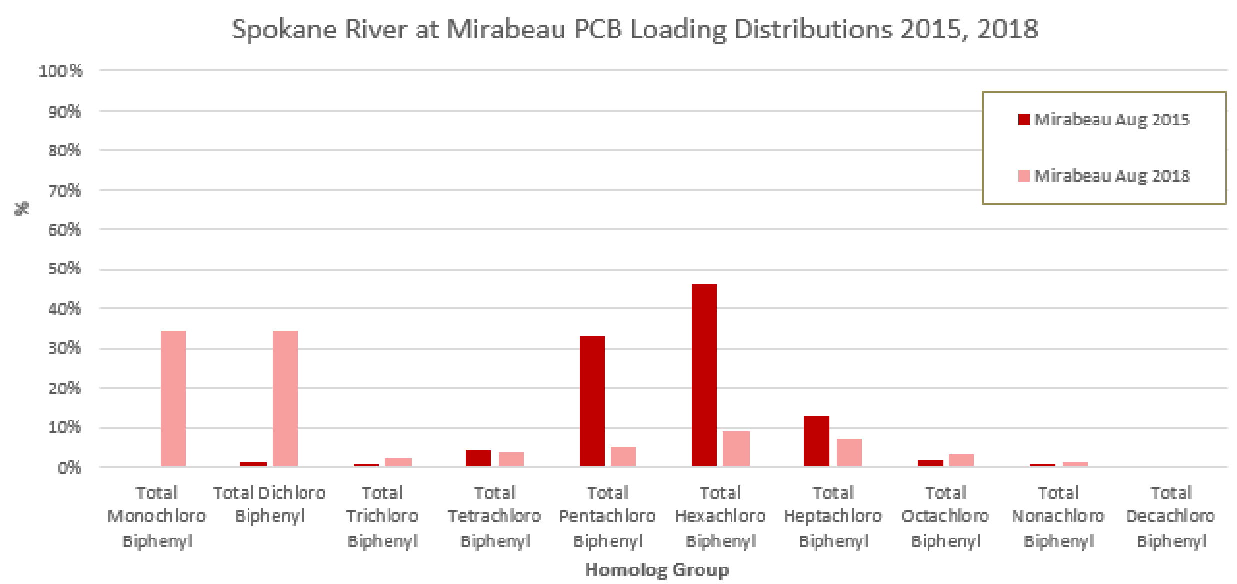

Figure 17. Estimated PCB Load Distributions to the Spokane River at Mirabeau, 2015-2018.

The PCB loads at Plantes Ferry remained consistent between the three monitoring years (Figure 18), with trichloro, tetrachloro, and pentachloro biphenyl components representing 29.2%, 53.9%, and 13.5% of the total PCB load in 2015, respectively, and 96.4% of the total load, combined.

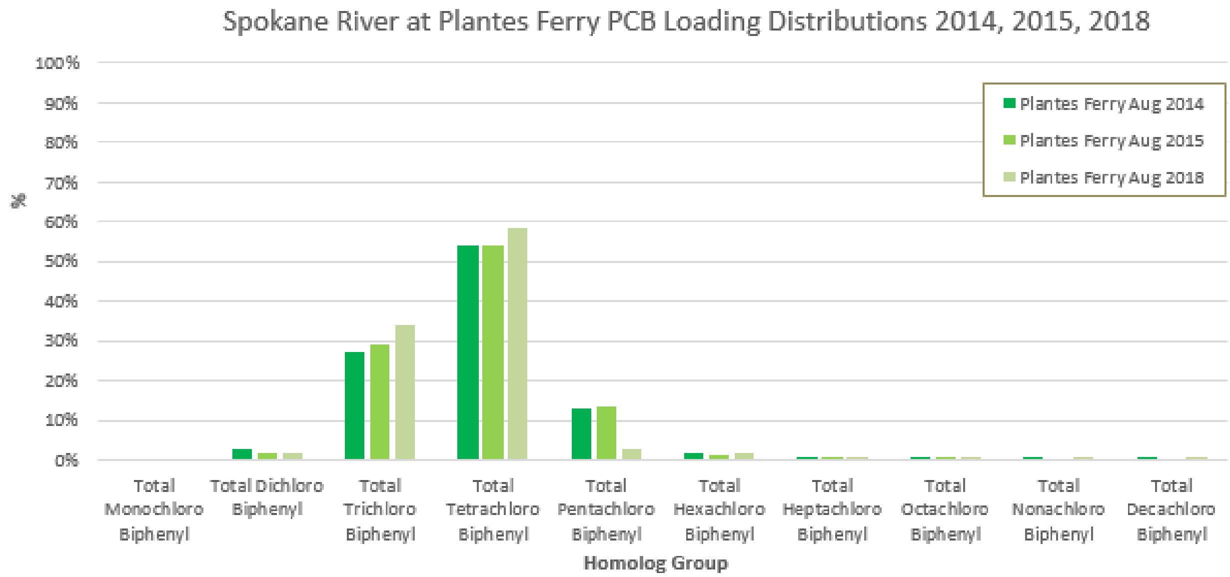

Figure 18. Estimated PCB Load Distributions to the Spokane River at Plantes Ferry, 2014-2018.

4.1.2 • Spokane River PCB Mass Balance: Comparisons

Due to the variation in loading among sampling years, each sampling year was plotted separately to visualize the loading comparisons for that year.

Figure 19 provides the estimated load distributions for the 2014 monitoring period based on the observed flow and PCB data collected at each site, while Figure 20 shows 2015, and Figure 21 shows 2018. No monitoring data were reported for Mirabeau in 2014, so it is not included in the 2014 comparison. The average loading by homolog group across the three monitoring years was then calculated to numerically compare the mean loading at each site.

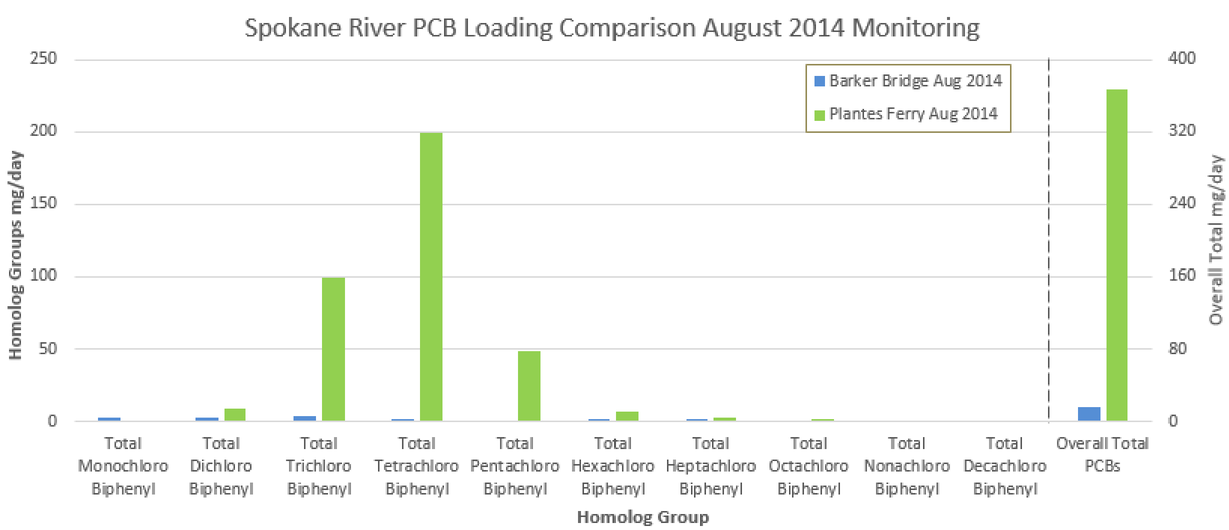

Figure 19. Estimated PCB homolog load distribution comparisons, 2014.

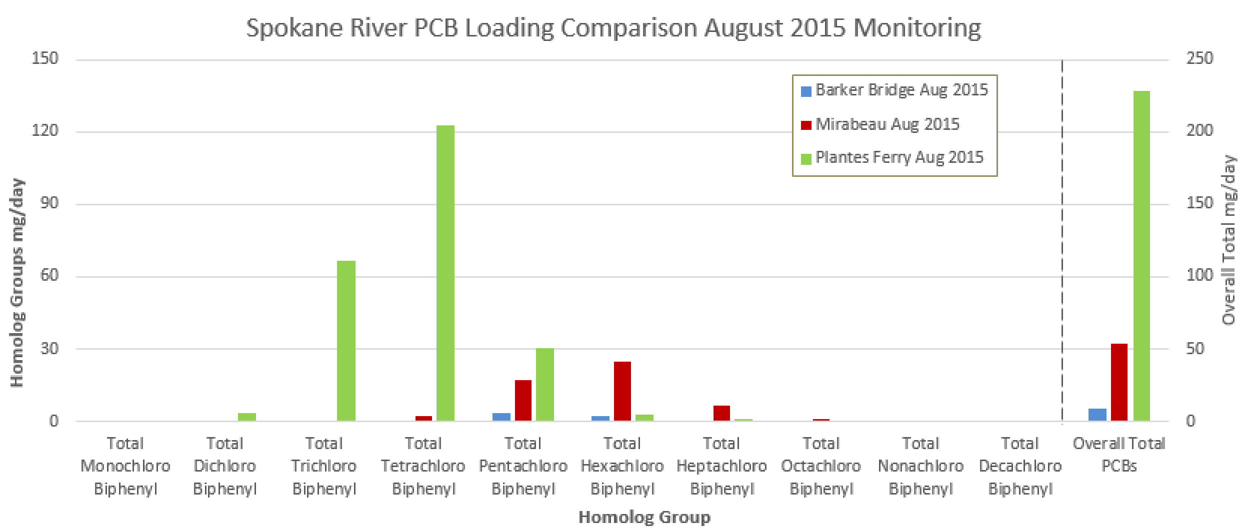

Figure 20. Estimated PCB homolog load distribution comparisons, 2015.

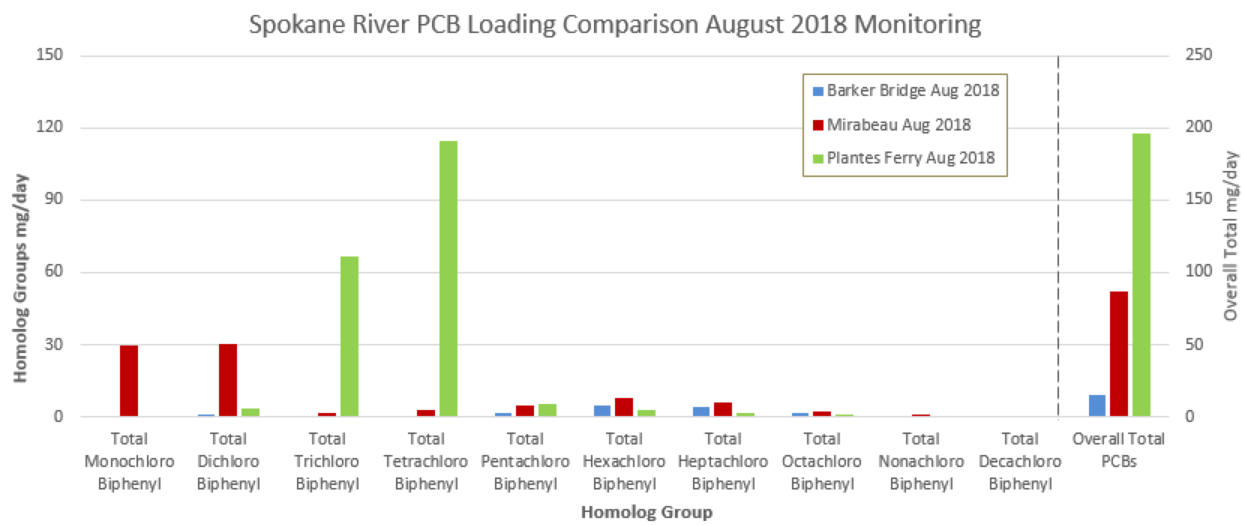

Figure 21. Estimated PCB homolog load distribution comparisons, 2018.

The reach between Barker Bridge and Mirabeau shows an overall average increase in PCB load by 57.2 mg/day, with all homolog component loads increasing except for tri and deca chloro biphenyl. Of the total PCB output at Mirabeau, 13.2% of the PCB load is represented by the source loading at Barker Bridge, while 82.2% of the load is input from other sources. Of the total input from Barker Bridge, a net of 4.8% exits along the reach via degradation/sorption/uptake (represented by the small decreases in tri and deca chloro biphenyl), while the remaining 95.2% exits the reach via streamflow at Mirabeau.

Based on the analysis in Section 4 and the Spokane River PCB load calculations above, Kaiser-Trentwood provides a large fraction of the trichloro and tetrachloro biphenyl homolog components observed at Plantes Ferry. The reach between Mirabeau and Plantes Ferry shows an overall average increase in PCB load by 193.4 mg/day, with tri, tetra, penta, and deca chloro biphenyl all increasing. Of the total PCB output at Plantes Ferry, 10.4% of the PCB load is represented by the source loading at Mirabeau, while 89.6 is attributed to the Kaiser-Trentwood facility groundwater plume assuming no additional sources of these homolog groups between Kaiser-Trentwood and Plantes Ferry. Of the total input, a net of 60.9% exits along the reach via degradation/sorption/uptake (represented by the decreases in mono, di, hexa, hepta, octa, nona chloro biphenyl), while the remaining 39.1% exits the reach via streamflow at Plantes Ferry. Figure 22 shows the conceptual model of the study area and mass balance components.

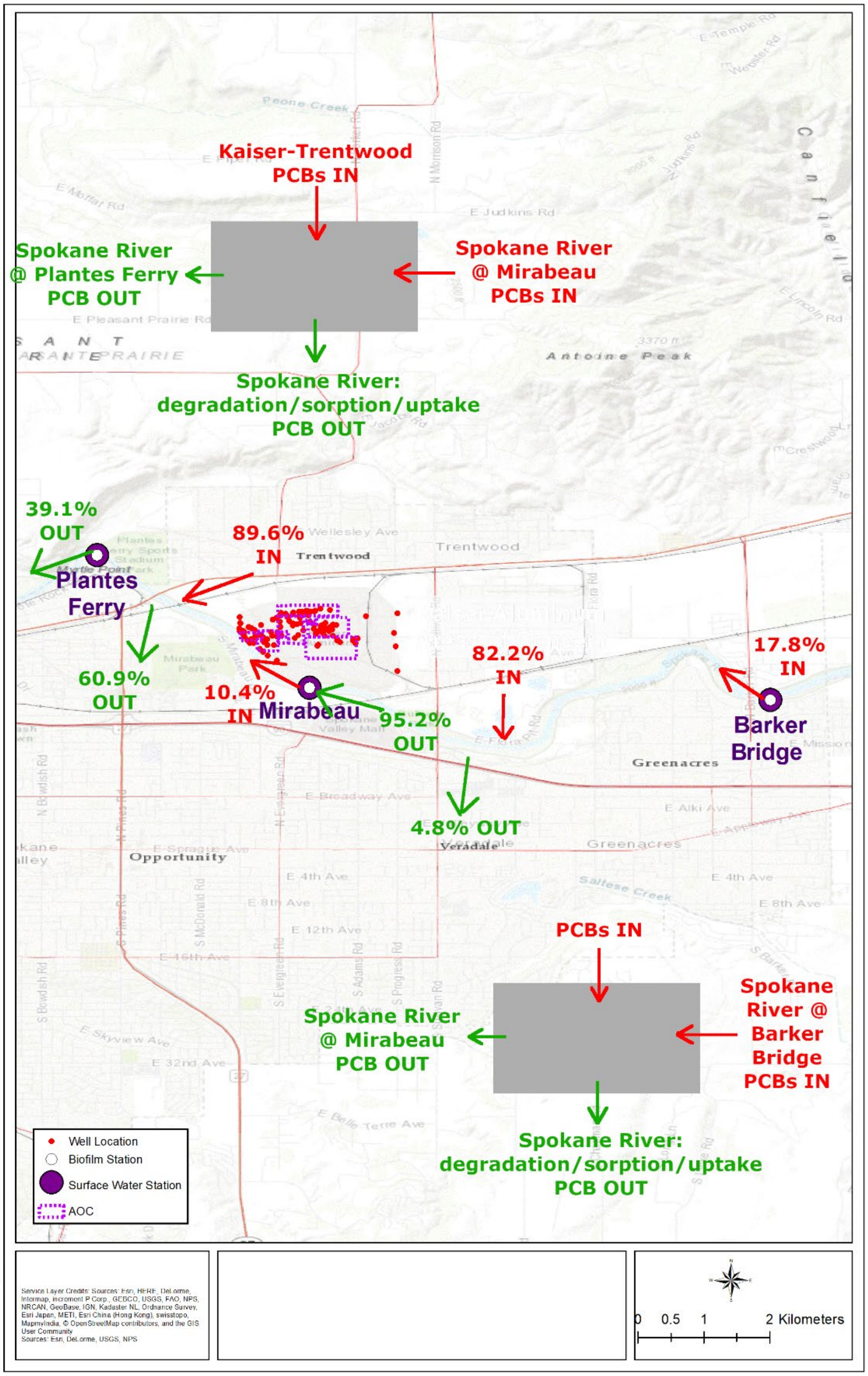

Figure 22. Conceptual Model of the PCB Mass Balance.

4.1.3 • Estimate of Groundwater Contribution

A coarse assessment of groundwater contributions to the reaches adjacent to the Kaiser-Trentwood facility was conducted using publicly available hydrogeologic data. The intent of the groundwater assessment was to provide a range of estimates of daily groundwater flow contributions during the study monitoring periods, and to apply those seepage estimates to the groundwater PCB concentration data to inform the mass balance assessment.

Background information on the groundwater interactions with Spokane River in the study area was found in Paul et. al., 2007, and Caldwell & Bowers, 2003. The surficial Spokane Valley-Rathdrum Prairie Aquifer, through which the Spokane River flows, is described as comprised of highly conductive glacial sediments. These conditions are suitable for estimating groundwater flow with Darcy's Law, Q = -hKA, where Q is the flow rate, h is the head gradient, K is the hydraulic conductivity, and A is the cross-sectional area.

While the regional groundwater flow through the valley follows the general direction of the Spokane River, on a smaller scale, some portions of the river are losing water to the aquifer, while others are gaining. Caldwell & Bowers (2003) describe the portion of Spokane River upstream from this study area as a losing segment, while the river adjacent to the Kaiser-Trentwood site is gaining. Hsieh, et. al. (2007) report the lateral hydraulic conductivity of the aquifer in our study area as 2,500 ft/day. With hydraulic gradients in the range of 0.001 to 0.01 ft/ft, this would equate to lateral groundwater velocities of 2.5 to 25 ft/day. Observations and simulations of groundwater seepage into Spokane River during September 2004 and October 2005 over the reach between Flora Road (between the Barker Bridge and monitoring Mirabeau stations) and Centennial Trail Bridge (just downstream from the Plantes Ferry monitoring station) produced estimations of 400 cfs gains in streamflow from groundwater. While it appears that a greater portion of the groundwater seepage into the river between Mirabeau and Plantes Ferry comes from the north side of the river, additional streamflow gain is contributed by groundwater flow from the southern side.

Groundwater monitoring wells with water elevation data were identified in the study area from the Washington Department of Ecology Environmental Information Management Database. Available groundwater level data from 2012 to 2018 were retrieved. Groundwater observation data are limited along the Spokane River, with clusters of monitoring wells located at various sites of interest, such as the Kaiser-Trentwood site. Due to the limited availability of continuous groundwater elevation data and well density along these reaches of the Spokane River, a groundwater flow estimation was only able to be produced for the segment adjacent to the Kaiser-Trentwood site.

Three wells with consistent quarterly groundwater elevation records from the Kaiser-Trentwood site, KT-MW-04, KT-MW-05, and KT-WW-MW-06, were used to calculate the overall direction of groundwater flow. Monitoring events from fall, winter, spring, and summer all showed little variation in the overall direction of groundwater flow as measured by head in the wells onsite and ranged from 27.1 to 30.6 degrees south of west, with an average of 29.5 degrees. This consistent direction of groundwater flow tracks well with the line of monitoring wells following the plume from the site, described in Section 3.1 (Figure 23).

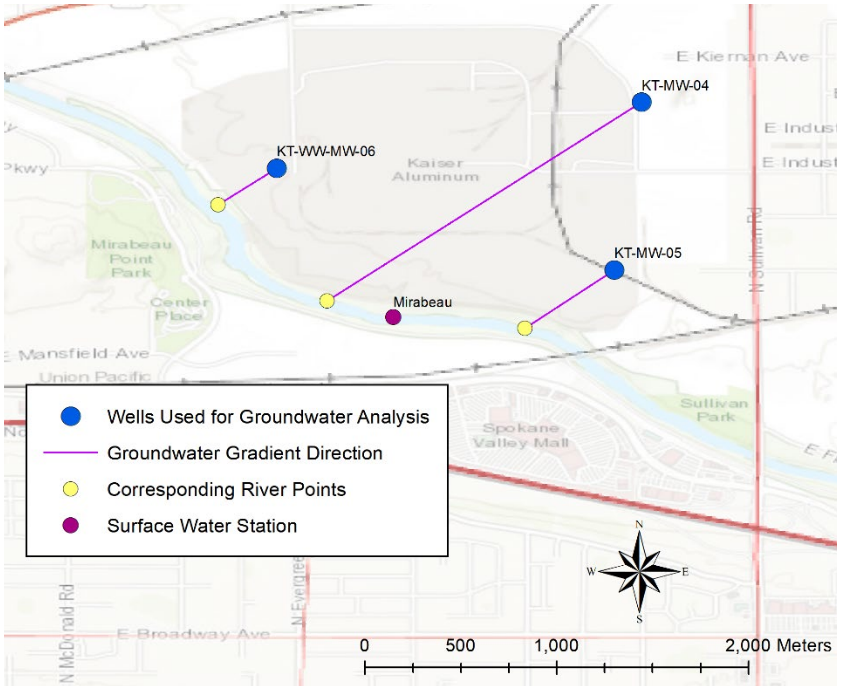

Figure 23. Groundwater monitoring wells used to evaluate groundwater flow direction and magnitude, with corresponding points on Spokane River used to estimate hydraulic gradient.

To develop the hydraulic head gradient for the aquifer between the Kaiser-Trentwood site, the groundwater elevations were compared with estimated water surface elevations on the Spokane River, located at river points aligned with the average groundwater flow direction from each well. Water surface elevations needed to be estimated for the river points, due to the lack of water elevation data in the immediate area. A relationship between the water surface elevation at the Sullivan Bridge crossing, just upstream from the Kaizer-Trentwood site, and water surface elevation measured at USGS Gage 1249000 (Spokane River at Post Falls) was previously established by Hsieh, et. al., 2007. While the range of water surface elevations for which the relationship was established fall outside of the range of water surface elevations that occur during the low flow periods of interest for this study, the trend did demonstrate a nearly linear relationship between water surface elevation at the two sites. Similarly, a nearly linear relationship between water surface elevation at the Post Falls gage, and USGS Gage 12422500 (Spokane River at Spokane), can be observed by reviewing modern records, with the difference in water surface elevation between the two sites staying consistently within a few feet of a constant value of 296 ft. From these existing relationships, it is reasonable to assume an approximately linear relationship between water surface elevations at various points along this reach. Using a 2015 LIDAR DTM from the Washington State Department of Natural Resources, an average difference in elevation between the water surface at the river points noted in Figure 23, and the water surface at USGS Gage 12422500 was determined. The calculated difference for each of the river points was then applied to the observed water surface elevation data at USGS Gage 12422500 for the dates on which groundwater elevations were collected from the Kaiser-Trentwood wells. Hydraulic gradients between the wells and corresponding river points ranged from 0.0023 ft/ft to 0.0078 ft/ft, with gradients during lower flow months (July, October, November) ranging from 0.0023 ft/ft to 0.0052 ft/ft. From satellite imagery, the average width of the Spokane River between Mirabeau and Plantes Ferry during July and August is approximately 130 ft. River depths reported during the August 2015 monitoring events in this area average 3 ft. Due to the shallow depths within this region, the difference between the area of the bed in contact with the aquifer and the area of the water surface will be negligible. Based on reporting of a greater quantity of groundwater entering the river from the northern side of this reach, 75% of the river bed is assumed to be receiving groundwater from that direction in these estimations. The cross-sectional area of the river receiving groundwater from the northeastern direction is approximated as 97.5 sq.ft. per ft of river.

Estimates of groundwater gain for low-flow conditions along the northern side of the Spokane River segment adjacent to the Kaiser-Trentwood site ranged from 0.0065 to 0.0146 cfs per ft of river, with a mean value of .0098 cfs per ft of river. For the reach between Mirabeau and Plantes Ferry, this translates to minimum, mean, and maximum estimates of 70.1, 105.4, and 157.3 cfs of groundwater gain, respectively. From the 2015 and 2018 monitoring events, the difference in flow observations between these two stations ranged from 120 to 243 cfs. Well level data from the reach between Barker Bridge and Mirabeau were insufficient to assess variations in groundwater gain along the entire reach.

Estimates of PCB loading from the Kaiser-Trentwood facility to the Spokane River via groundwater can be conducted for the Mirabeau to Plantes Ferry reach, using estimated seepage rates and concentrations from monitoring wells. Using the direction of groundwater flow, and the homolog group patterns for well data, there is 800 ft of stream receiving groundwater measured by the “No Pattern” wells near the western side of the site, and 1200 ft of stream receiving groundwater measured by the Pattern 1 wells (Figure 24). While there were not enough well level and PCB concentration records available to estimate the PCB loading of the entire reach between Barker Bridge and Mirabeau, concentrations from the Pattern 2 wells on the eastern side of the site could be used to estimate the PCB loading for a portion of the reach. By assuming the same ranges of groundwater discharge to the river over this reach, and extrapolating the concentrations from the Pattern 1 wells, the groundwater PCB load was also estimated over the 5000 ft segment from Sullivan Road to Mirabeau (Figure 24).

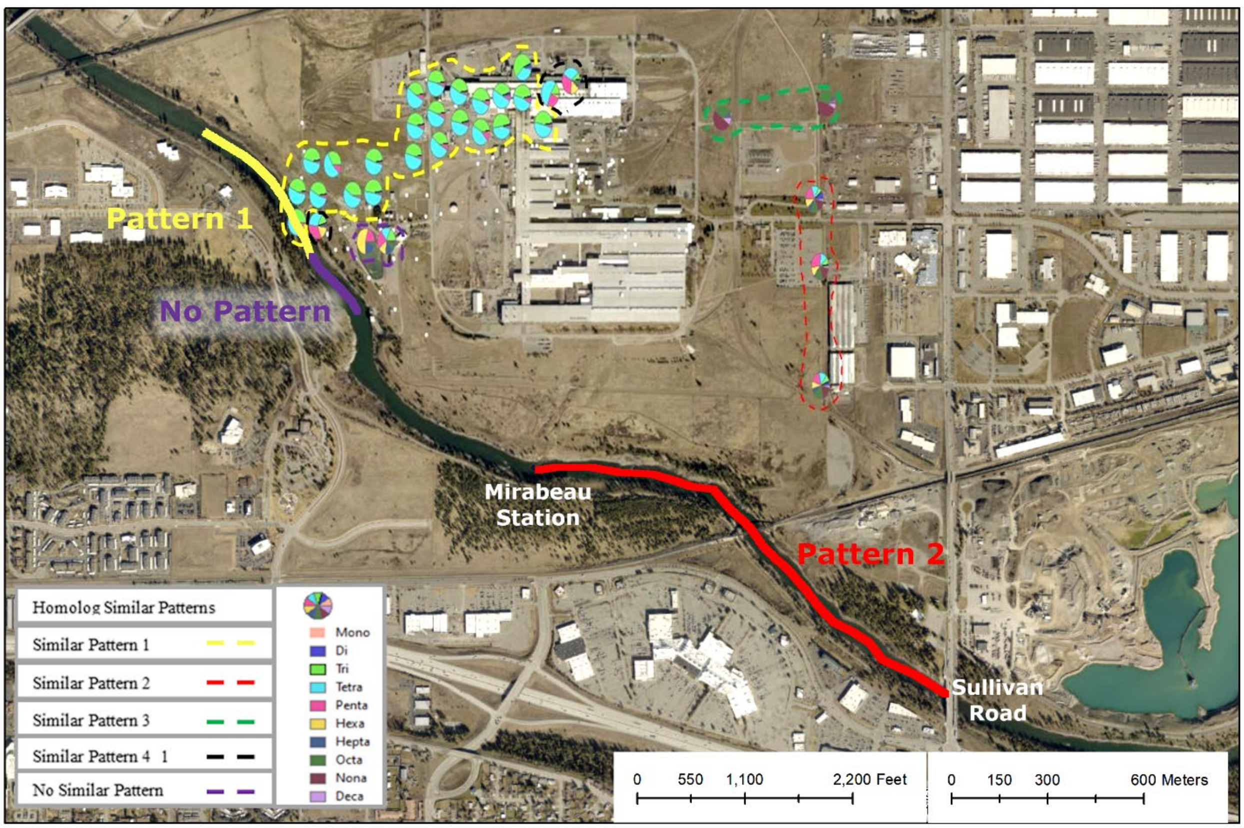

Figure 24. Reach segments used to estimate groundwater PCB loading, with associated well homolog patterns.

For the sake of only including known PCB concentrations near the edge of the river, concentration data from wells further upland were excluded from estimating the concentration in groundwater seeping into the Spokane River. Combining the nearest wells in each group to produce average homolog constituents, and applying the rates of groundwater seepage previously established results in an overall estimate of 353 mg/day of PCB load from the Kaiser-Trentwood groundwater plume to the reach between Mirabeau and Plantes Ferry, with breakdowns by homolog group presented in Figure 25. These estimates show a similar pattern of elevated tri and tetra chloro biphenyl groups to what is observed at the Plantes Ferry monitoring site. While the estimates of PCB load from groundwater seepage exceed the values observed at the Plantes Ferry site, they may provide insight to the magnitude of input, and the corresponding rates of degradation, sorption, or uptake.

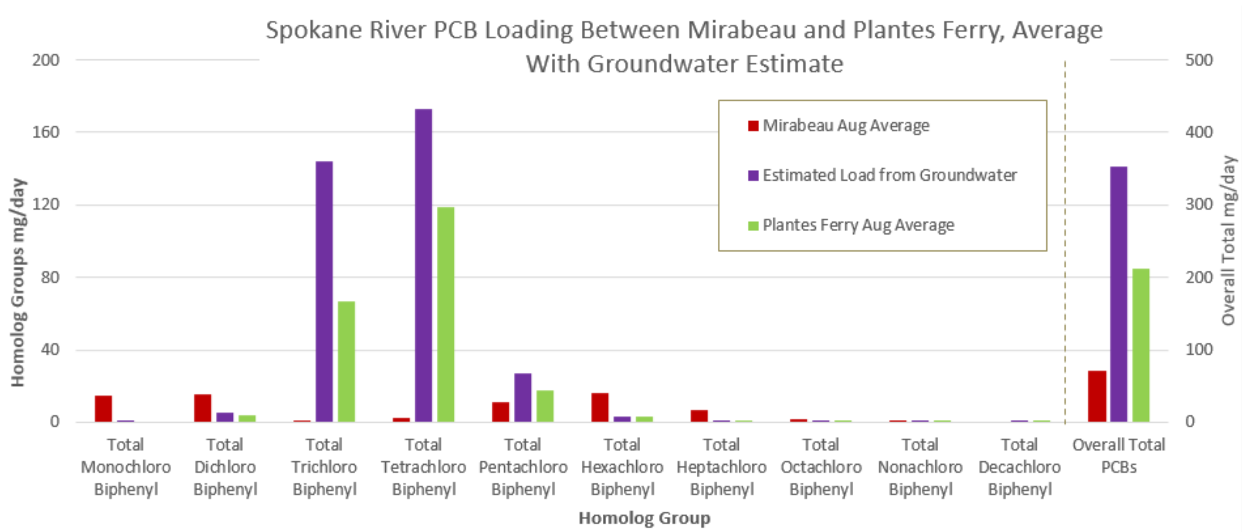

Figure 25. Estimated PCB load by homolog group from groundwater seepage to Spokane River, between Mirabeau and Plantes Ferry.

For the reach between Barker Bridge and Mirabeau, the PCB homolog patterns detected in the wells at the easternmost edge of the Kaiser-Trentwood site do not, alone, account for the homolog pattern detected at the Mirabeau site. Applying the average concentrations from the Pattern 2 wells at the eastern edge of the site, and the average estimated groundwater seepage rate, produced an overall estimate of 12.0 mg/day PCB loading from groundwater seepage between Sullivan Road and Mirabeau (Figure 26).

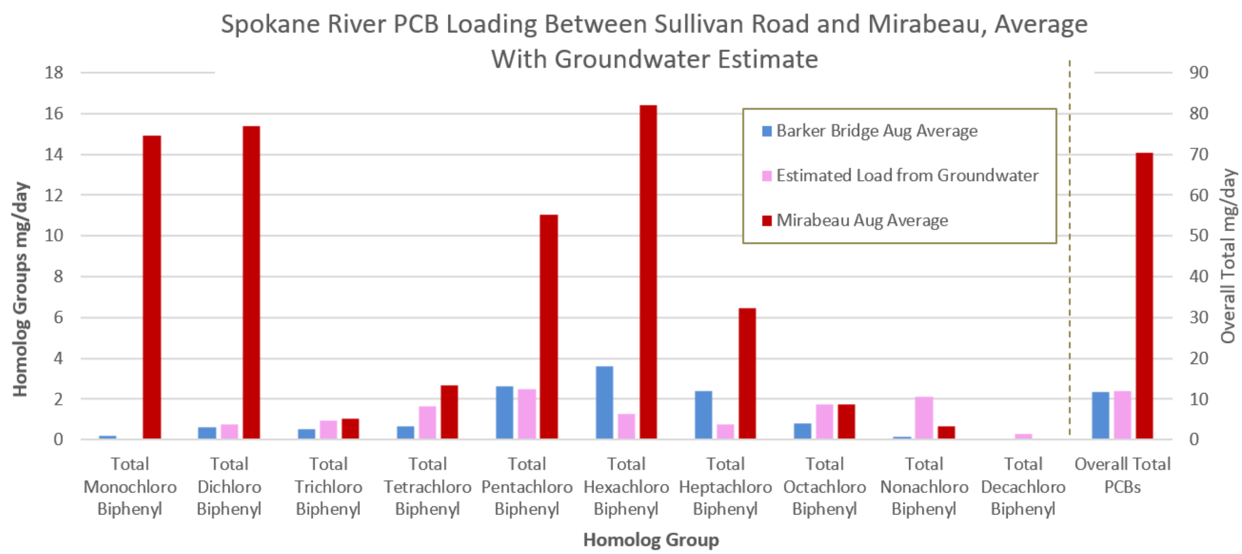

Figure 26. Estimated PCB load by homolog group from groundwater seepage to Spokane River, between Sullivan Road and Mirabeau Station

5.0 • WATER QUALITY AND BIOFILM DATA

Data collected at the Barker Bridge, Mirabeau, and Plantes Ferry monitoring stations were reviewed for patterns in homolog distributions from upstream to downstream stations. Figure 26 shows the surface water and biofilm data for all three stations. As can be seen in this figure, there is similarity between surface water and biofilm homologs in Barker Bridge and Plantes Ferry stations, but they differ from the patterns in the data at Mirabeau station. There is likely another PCB source affecting the MBU biofilm sample. Due to the differences in sample collection between the surface water and biofilm locations, the MBU sample may have been more reflective of groundwater discharge to the river.

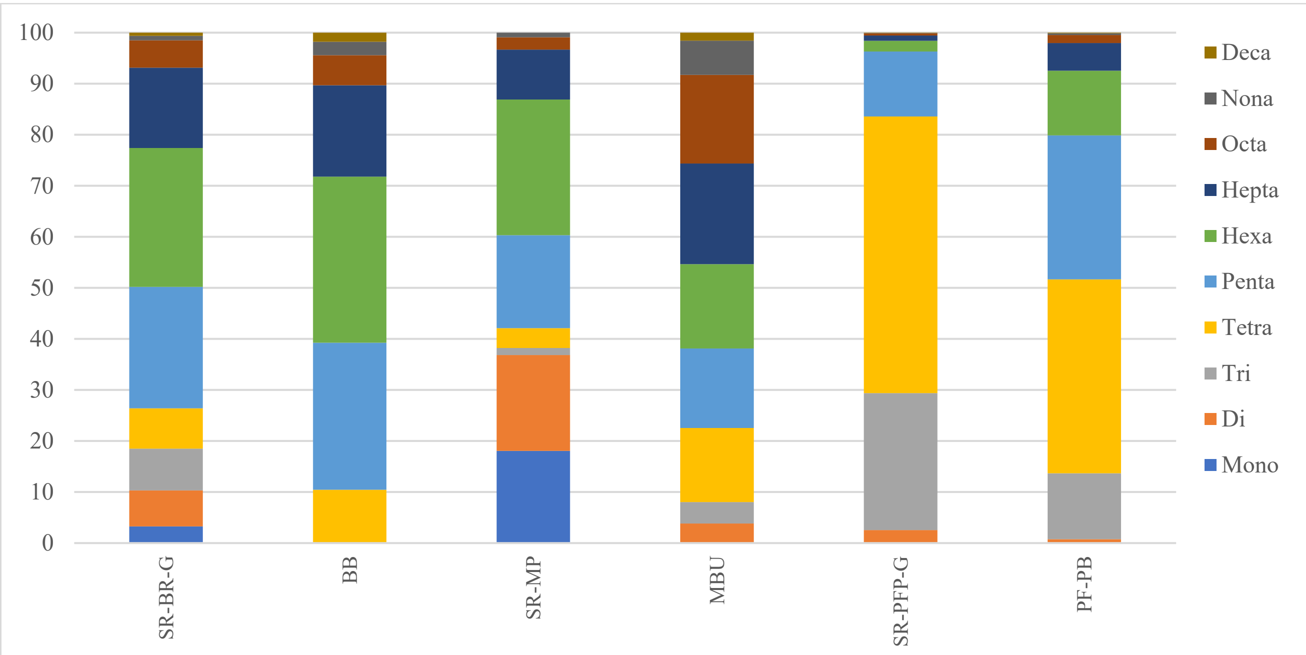

Figure 27. Average Total PCB - Surface water and biofilm Homolog Pattern for all stations in the study area (3 stations).

Figure 27 shows the average homolog concentrations at each of the study area locations between 2014 and 2018. Figure 28 shows the distribution across homologs in a percentage format. The upstream Barker Bridge PCB homolog distributions are primarily comprised of pentachloro, hexachloro, and heptachloro biphenyl homolog groups. When summed, these three components represent 67% of the total PCB mass in samples taken between 2014 and 2018. The summed concentration of these groups is 0.0137 ng/L when averaged across this time period. At Mirabeau, the next monitoring location downstream from Barker Bridge and adjacent to the Kaiser-Trentwood facility, the summed concentration increases to 0.0256 ng/L. Pentachloro, hexachloro, and heptachloro biphenyl homolog groups retain the same pattern as found at Barker Bridge, and are still significant components (55% of the total). The monochloro and dichloro biphenyl components increase at the Mirabeau location, although this is largely due to data collected in 2018. The homolog group distribution changes significantly at the next downstream monitoring location, Plantes Ferry. Pentachloro, hexachloro, and heptachloro biphenyl homolog groups decrease to 16% of the total PCB makeup (concentration of 0.0197 ng/L), while trichloro and tetrachloro biphenyl groups represent 81% of total PCBs, with a concentration of 0.1005 ng/L. Concentrations of trichloro and pentachloro biphenyl groups average 0.0033 ng/L and 0.0025 ng/L at Barker Bridge and Mirabeau, respectively.

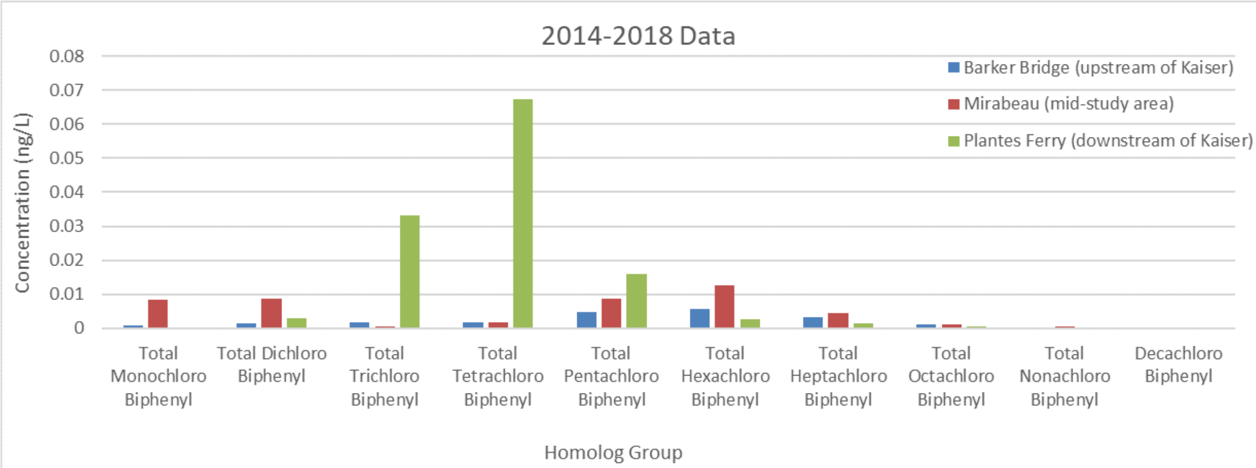

Figure 28. Average PCB Homolog Concentrations, 2014-2018.

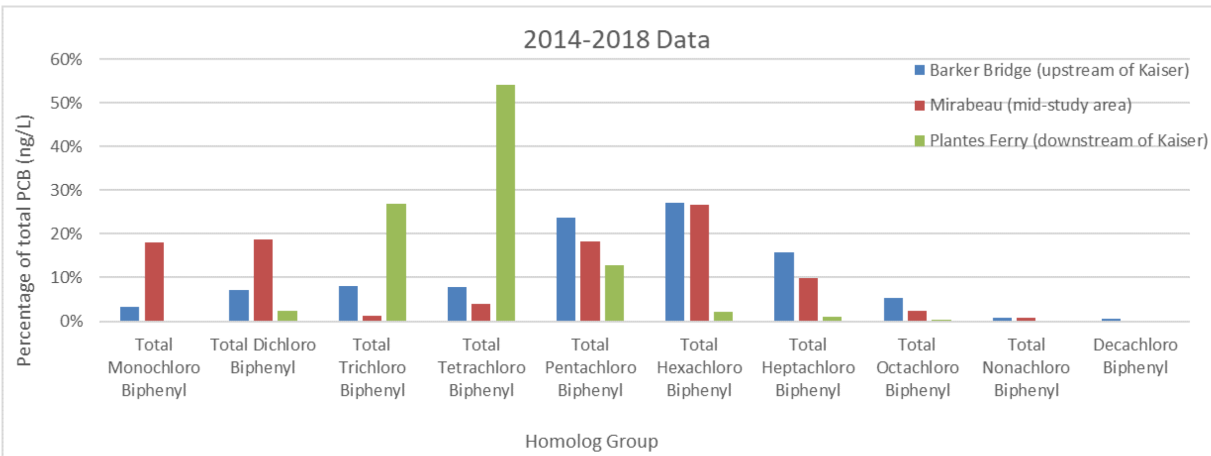

Figure 29. Average Homolog Percentages of Total PCBs, 2014-2018.

Data collected in 2015 suggest similar patterns collected during relatively low flow conditions that isolate groundwater influence. Figure 29 and Figure 30 show the homolog concentrations and group percentages, respectively. Similar to the larger dataset, pentachloro, hexachloro, and heptachloro biphenyl homolog groups represent the majority of the makeup at the upstream Barker Bridge (79%) and Mirabeau (92%) locations, at 0.0231 ng/L and 0.0404 ng/L, respectively. The homolog group distribution changes significantly at the next downstream Plantes Ferry monitoring location. The representation by these groups decrease to 15% at the downstream location at Plantes Ferry at a concentration of 0.0227 ng/L. It is important to note that this concentration is nearly identical to the concentration of these groups at the upstream Barker Bridge location, and lower than the Mirabeau location. This similarity was also observed in the larger 2014-2018 dataset. Trichloro and tetrachloro biphenyl groups represent 83% of total PCBs at Plantes Ferry, with a concentration of 0.1255 ng/L. Concentrations of trichloro and tetrachloro biphenyl groups average 0.0041 ng/L and 0.0022 ng/L at Barker Bridge and Mirabeau, respectively.

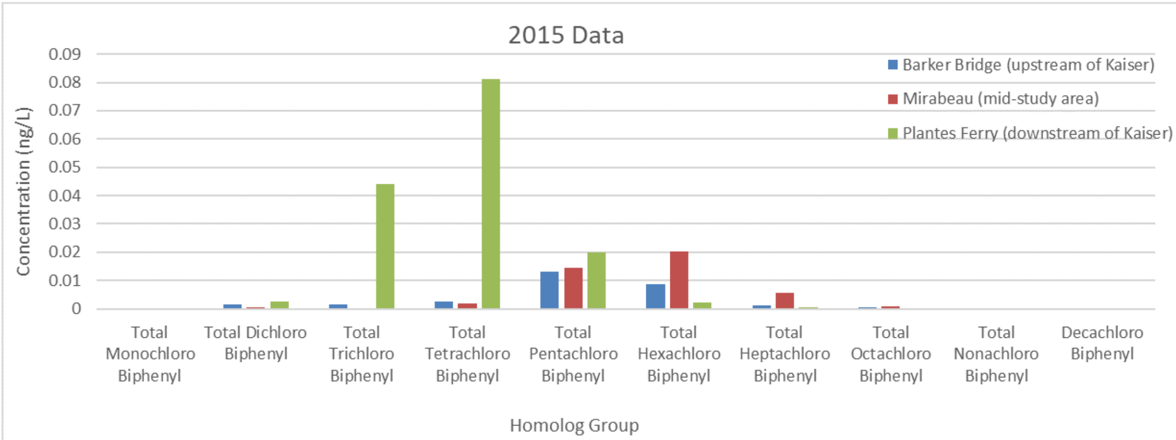

Figure 30. Average PCB Homolog Concentrations, 2015.

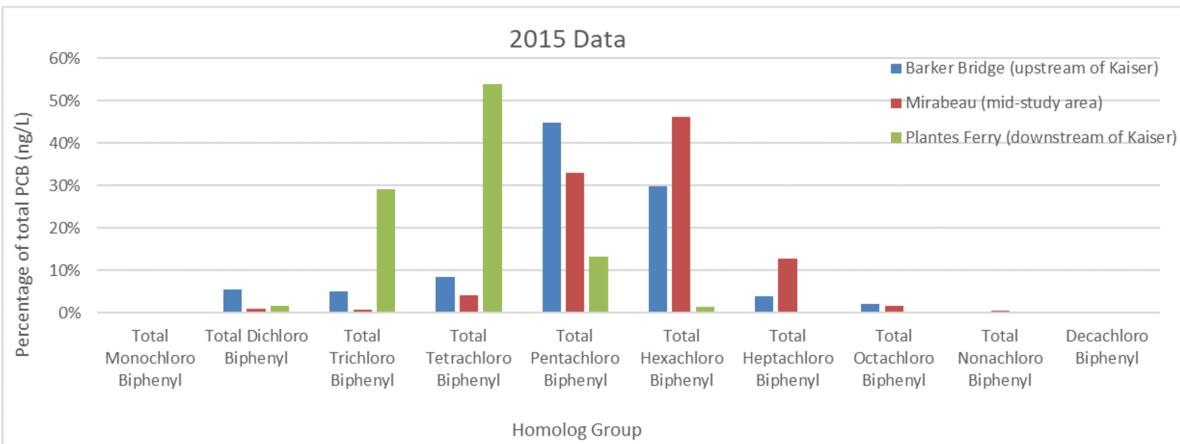

Figure 31. Average Homolog Percentages of Total PCBs, 2015.

In summary, the Barker Bridge and Mirabeau locations have similar homolog distribution patterns and suggest both locations are spatially upstream of influence from the Kaiser-Trentwood facility PCB plume. Although other sources of PCB contamination are contributing to these locations, the homolog signature at the Plantes Ferry location downstream of the Kaiser-Trentwood facility changes drastically and can be verified by groundwater well data presented later in this document. A significant source of trichloro and tetrachloro biphenyl homologs exists between the Mirabeau and Plantes Ferry monitoring locations, which points to the Kaiser-Trentwood facility as the source. As the Mirabeau location is the most downstream location without influence from the Kaiser-Trentwood site, this location will be used to estimate the Spokane River source component of the mass balance.

6.0 • BIOFILM AND WATER COLUMN DATA VS GROUNDWATER DATA

Surface water data at Plantes Ferry is similar to pattern 1 of groundwater data (Figure 31). Also, the average PCB homolog pattern of the biofilm at Mirabeau is similar to the average PCB homolog pattern of the similar pattern 2 of groundwater (Figure 32). Figure 33 shows that the average total PCB homolog pattern at the Barker Bridge station is similar to the average total PCB homolog pattern at Mirabeau station (Mirabeau has more light and mid-weight PCBs and less heavy PCBs than the Barker Bridge). Figure 34 shows that the average total PCB homolog pattern of biofilm at Mirabeau station is under the influence of a combination of biofilm at Barker Bridge station and pattern 2 of groundwater. The amount of heavy PCBs at MBU is higher than the amount of heavy PCBs at BB, and it can be inferred that MBU, as the biofilm sample was collected on the right bank of the Spokane River, is receiving heavy PCBs from an additional source. Due to the similarity of the MBU biofilm homolog pattern with pattern 2 of groundwater, this source is possibly releasing to the right bank of the river. However, one biofilm sample is not enough for a conclusion, and more data (samples) are needed to confirm.

Figure 35 shows that the average total PCB homolog pattern of biofilm at Plantes Ferry station is under the influence of a combination of biofilm at Mirabeau station and similar pattern 1 of groundwater. The amount of heavy and mid-weight PCBs at PF is higher than the amount of heavy and mid-weight PCBs at MBU. Figure 36 shows that the maximum difference between homologs in MBU and similar pattern 2 of groundwater belongs to hepta and nona with approximately 13.5 and 11 percent, respectively (MBU has higher hepta and lower nona).

Other processes like dechlorination, sedimentation, absorption by fish tissues, etc., should be considered in a more comprehensive analysis.

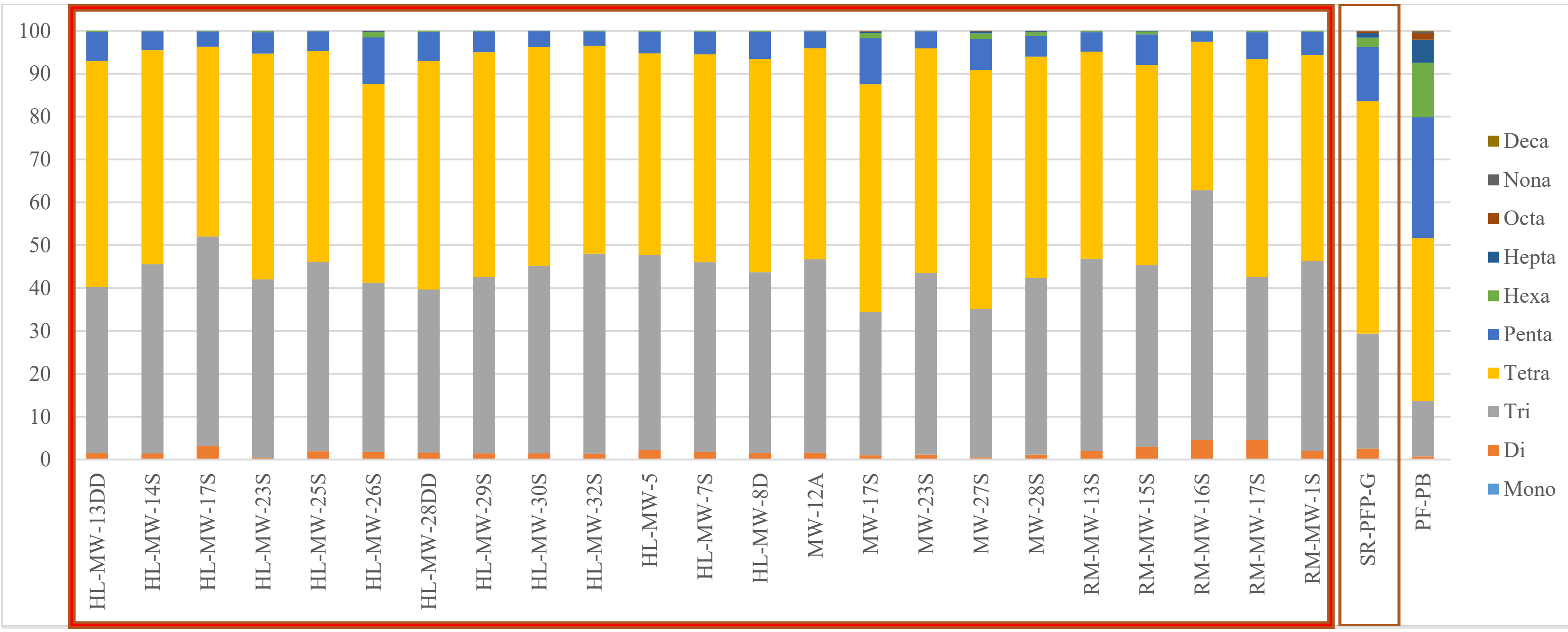

Figure 32. Average Total PCB - Surface water Plantes Ferry and similar Homolog Pattern 1 of groundwater.

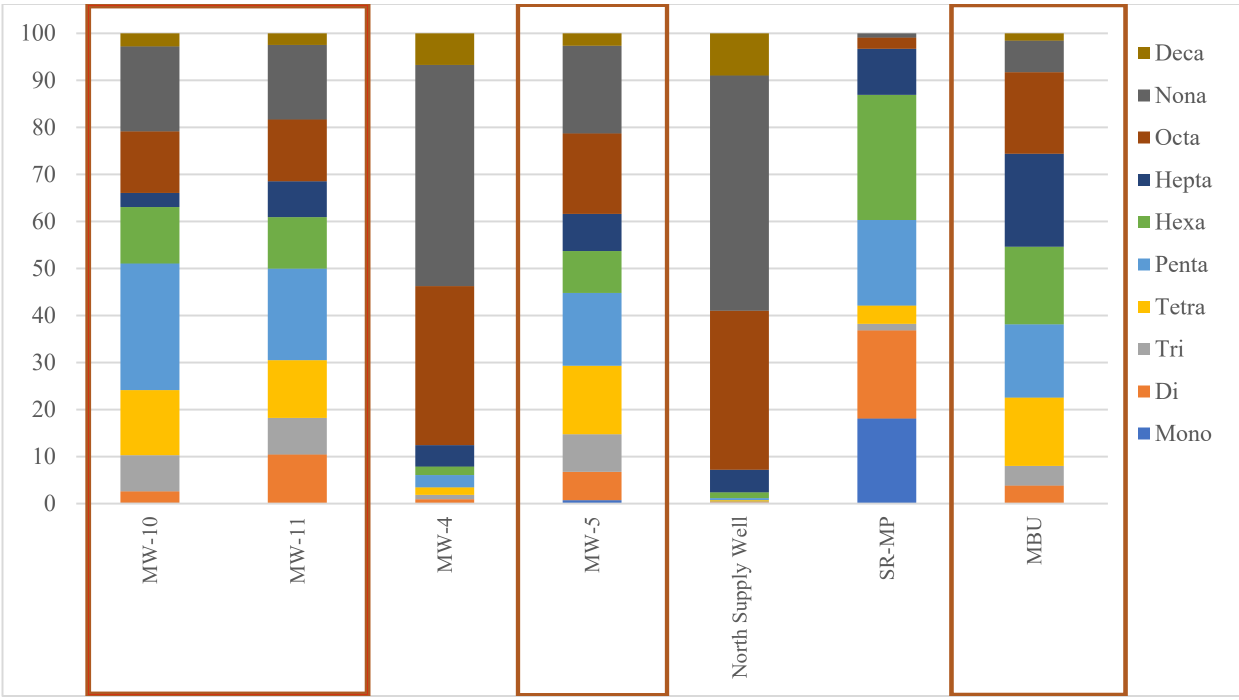

Figure 33. Average Total PCB - Biofilm MBU and similar Homolog Pattern 2 of groundwater.

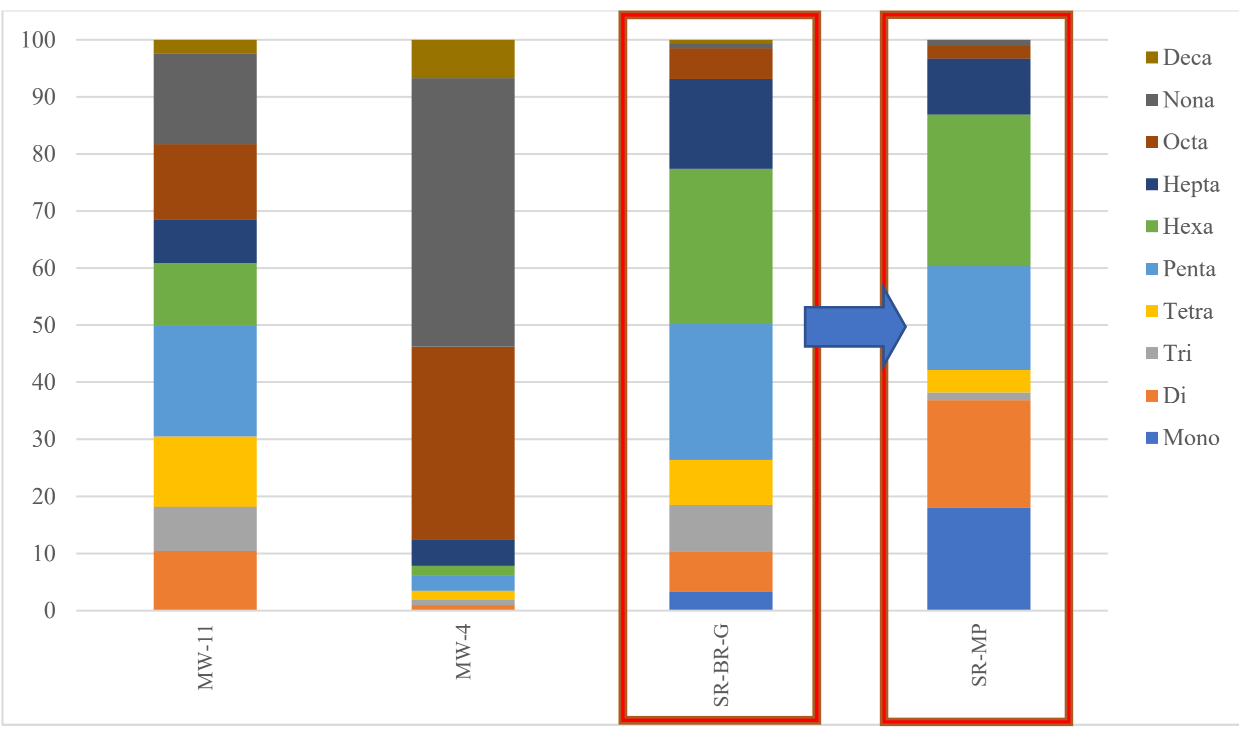

Figure 34. Average Total PCB – Surface water homolog patterns for Barker Bridge and Mirabeau stations.

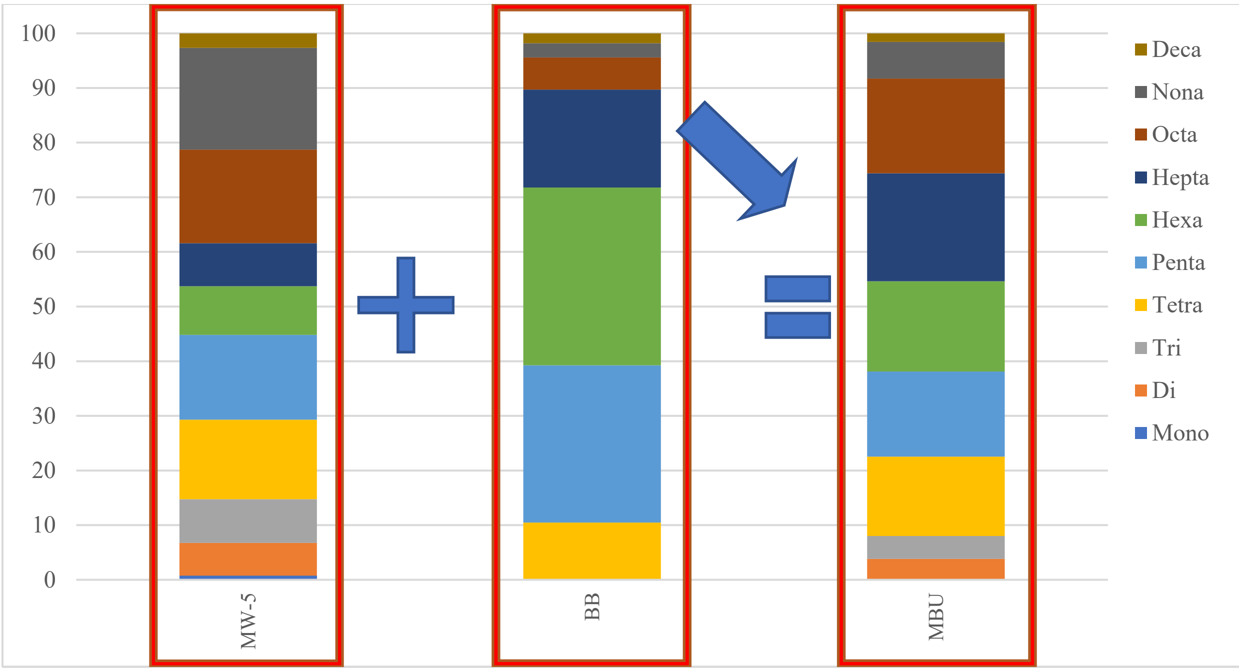

Figure 35. Average Total PCB – Biofilm homolog patterns for Barker Bridge and Mirabeau stations and similar pattern 2 of groundwater.

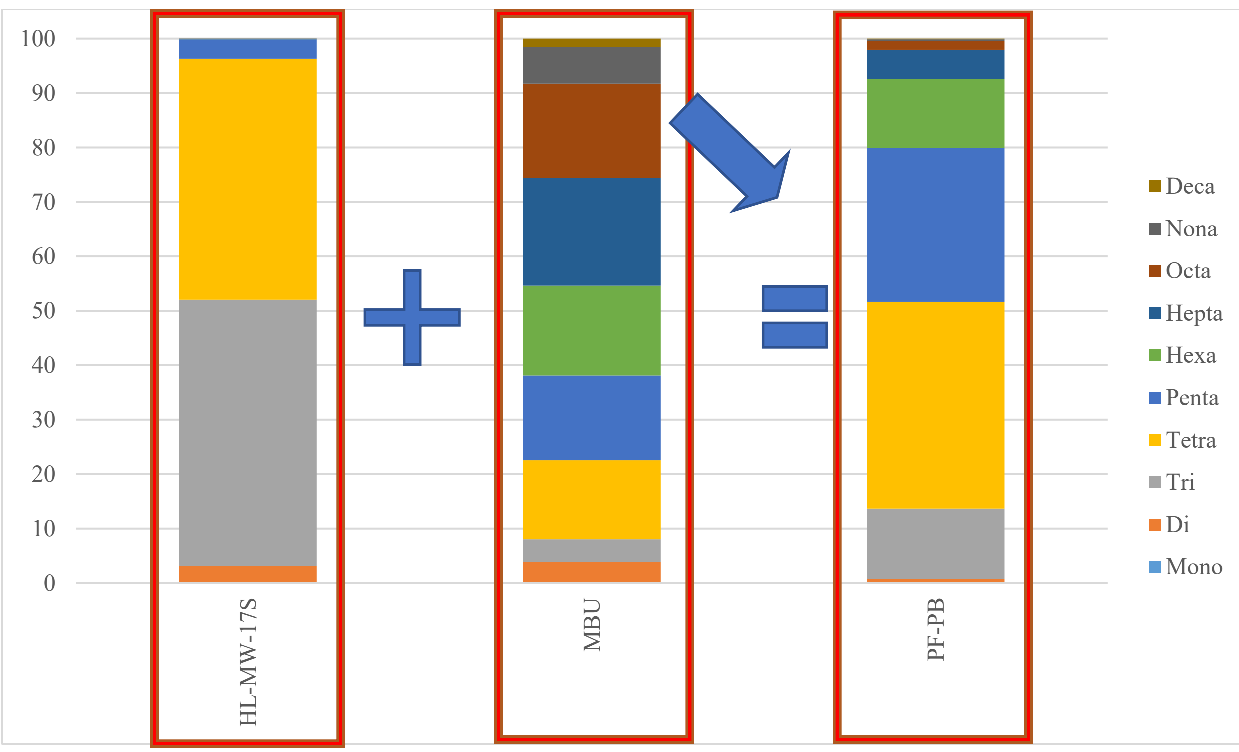

Figure 36. Average Total PCB – Biofilm homolog patterns for Mirabeau stations and Plantes Ferry and similar pattern 1 of groundwater.

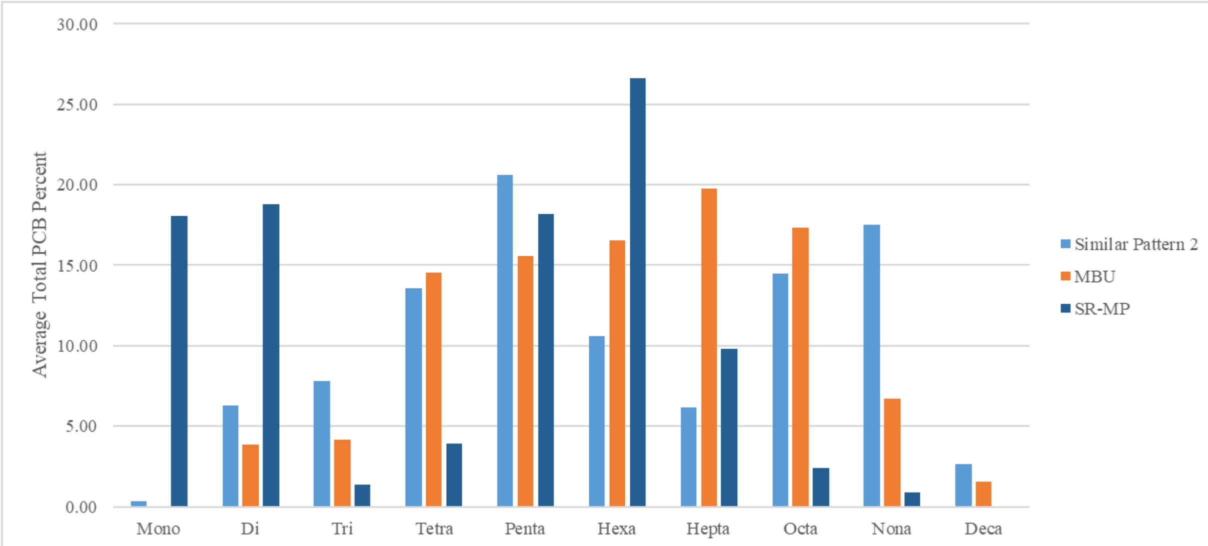

Figure 37. Average Total PCB (%) – Biofilm and surface water homolog patterns for Mirabeau and similar pattern 2 of groundwater.

7.0 CONCLUSION

Environmental data were evaluated to characterize the PCB loading to the Spokane River adjacent to Kaiser-Trentwood facility. Analytical results from surface water samples, biofilm samples, and groundwater well samples were analyzed and compared. Distinct patterns of PCB homolog groups were identified among the monitoring well samples from the Kaizer-Trentwood site, representing both background concentrations and direct contamination from the groundwater plume at the facility. A downstream monitoring station (Plantes Ferry) showed a distinctly different pattern of PCB homolog groups than the upstream (Barker Bridge) and mid-site (Mirabeau) stations. While patterns between the Barker Bridge and Mirabeau sites were similar, Mirabeau samples showed greater PCB loading overall, with some variations in homolog distribution. Patterns between the surface water, biofilm, and groundwater homolog patterns were also evaluated, confirming the signature contribution of groundwater observed in wells at the Kaizer-Trentwood site, as well as other potential sources contributing to the river.

A low-flow condition estimate of PCB loading in surface water by homolog group was conducted for August of 2014, 2015, and 2018 at each of the Spokane River stations. A mass balance demonstrated net increases in PCB loading for both the reach between Barker Bridge and Mirabeau, and the reach between Mirabeau and Plantes Ferry. Monitoring well data and estimations of river surface elevations were also used to produce estimations of PCB loading from groundwater for portions of each reach. The average August loading from the Kaiser-Trentwood groundwater plume was estimated at 353 mg/day. The average August loading for the segment between Sullivan Road and Mirabeau, upstream of the Kaiser-Trentwood groundwater plume, was estimated at 12.0 mg/day.

8.0 REFERENCES

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