Memorandum

Date: 10 January 2012

To: Karen Keeley, USEPA

Copies to: Lori Blair, Carl Bach, and Brian Anderson, The Boeing Company; Jim Fitzpatrick, Black & Veatch; and Joe Kalmar, Landau

From: Jon Jones, Michael Stenstrom, and Robert Pitt, NBF Stormwater Expert Panel; jointly with Geosyntec Consultants

Subject: Amended Monitoring Approach Recommendations for North Boeing Field Long-Term Stormwater Treatment System

---

Introduction

Using a static mass balance analysis approach to determine PCB and solids mass loading to Slip 4 from the North Boeing Field (NBF) Lift Station discharge (including the Long Term Stormwater Treatment [LTST] system), the NBF Stormwater Expert Panel (Panel), jointly with Geosyntec Consultants, proposed an alternative interim goal, which consists of a flow-weighted average annual concentration (FWAAC) for total PCBs in water of 0.018 µg/L that is expected to prevent recontamination of Slip 4 sediments (NBF Stormwater Expert Panel and Geosyntec, 2011). This alternative goal is intended to replace the solids interim goal (IG) of 100 µg total PCBs per kg solids (100 ppb) which was based on results from the SAIC Slip 4 sediment recontamination model (SAIC, 2010). This memo summarizes the Panel's recommended monitoring approach for assessing compliance with the proposed FWAAC IG. If this approach is accepted, it will be incorporated into the NBF LTST Sampling and Analysis Plan (SAP) (Landau, 2011).

Monitoring Approach Overview

The flow-weighted annual average concentration limit was determined by using a static mass balance to estimate the maximum average annual PCB mass loading rate that would remain protective of recontamination of Slip 4 surface sediments (i.e. exceedance of the State sediment standard – assumed to be 130 ppb total PCBs – would not occur until after approximately 50 years). This calculation was based on modeled stormdrain discharge volume data, whole water and filtered solids PCB data from monitoring of the Short Term Stormwater Treatment (STST) System, particle size distribution (PSD) data and Total Suspended Solids (TSS) data. This loading rate was then divided by the long-term average annual Lift Station discharge volume to arrive at a FWAAC IG. A key related finding and recommendation was that, as a result of how close the proposed FWAAC IG of 0.018 μg/L is to the typical aroclor method detection limit (0.01 μg/L for EPA Method 8082), non-detect results be treated as zero for the purpose of compliance assessment. This approach is currently being used for total PCBs compliance reporting for the STST.

The approach contained several general assumptions, which are believed to have resulted in a conservatively high estimation of long-term average surface sediment PCB concentrations in the Slip; however, it is important to determine whether these assumptions are reasonable and, in fact, conservative.

In addition, because the current flow scheme at the site includes treatment of a significant volume of off-site flow, this flow should be accurately characterized (both flowrate and PCB concentrations) to determine whether it should continue to be treated or if it should be re-routed around the treatment system.

Based on the above considerations, the monitoring approach described in this memo is intended to serve multiple purposes: 1) assess the LTST system for compliance with the proposed FWAAC IG, 2) confirm that the data used and the assumptions made to arrive at the proposed FWAAC IG were reasonably conservative and descriptive of site conditions, 3) confirm that treating non-detect values as zero is appropriate, and 4) accurately characterize the off-site stream from the King County North Lateral re-route in order to evaluate this load contribution to the Lift Station and LTST system.

For compliance assessment purposes, whole water PCB concentrations as well as continuous flow measurements should be taken according to the schedule described in the following section. In addition to whole water PCBs and flow data, additional data collection should include PSD, filtered solids PCB concentrations and Total Suspended Solids (TSS) concentrations to confirm assumptions of previous analyses. Specific sampling locations and analytical methods will be discussed in further detail in the following sections.

Sample Collection and Analysis

Sampling Locations

Samples should be taken from the Lift Station influent vault (which will be used to characterize the bypass flow), the chitosan enhanced sand filter (CESF) effluent, the North Lateral re-route influent to the Lift Station, and at the Lift Station Point of Compliance (POC), as illustrated in Figure 1. Obtaining representative concentration measurements through grab samples from the Lift Station influent vault may be difficult because of the challenges associated with ensuring that the vault is well-mixed. Because of this, it is recommended that water quality variation with depth in the vault be characterized early on to confirm the representativeness of long term sample collection methods.

Sampling of receiving waters or Slip 4 sediments is not recommended. Because there are a number of non-Boeing discharges to the Slip (for instance, discharges from the Georgetown Steam Plant Roof and drainage from I-5, as well as substantial solids contributions from the LDW), there is no way to determine what portion of any PCB concentrations found in the receiving waters or sediments can be directly attributed to the stormdrain discharges from NBF.

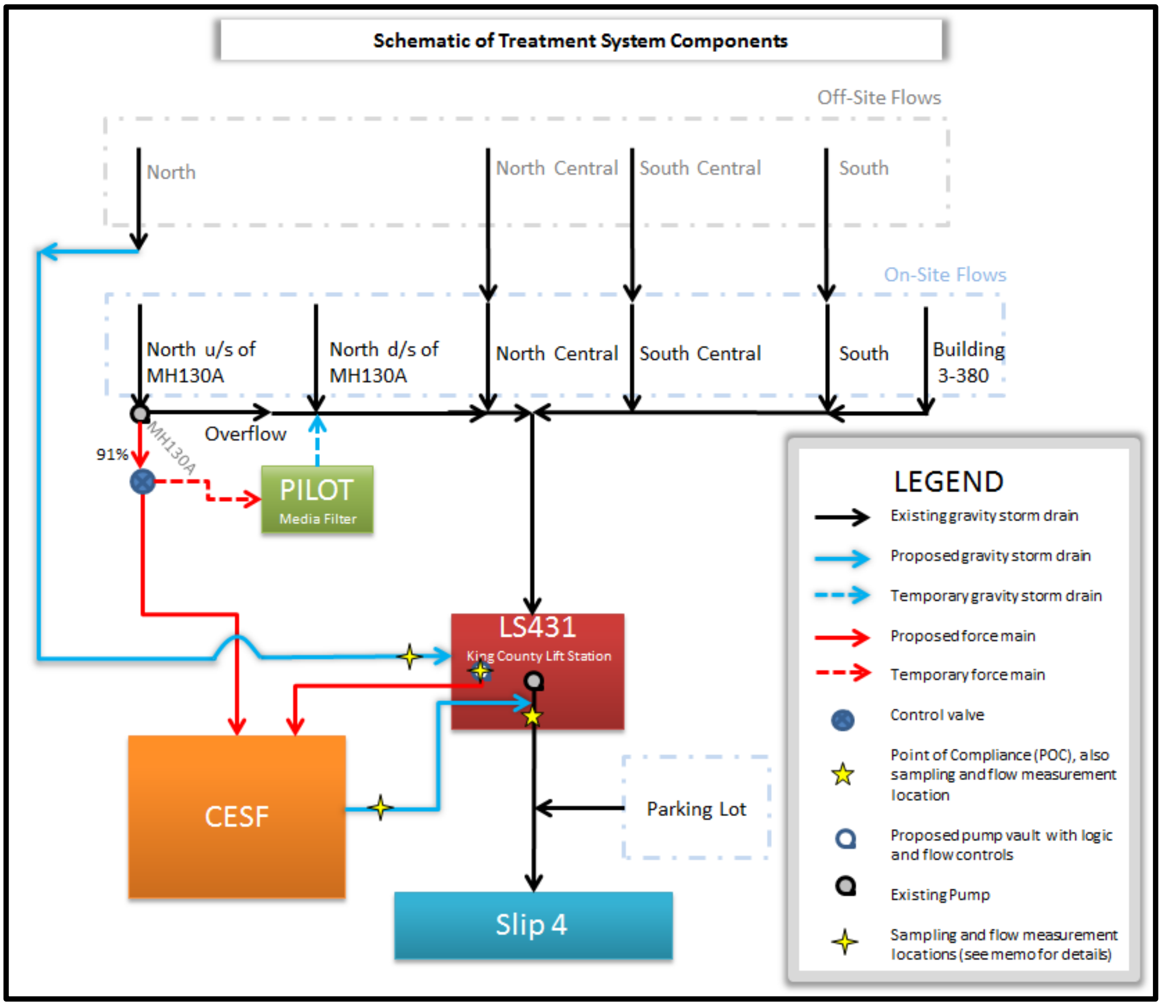

Figure 1. Schematic of flows to Slip 4 (taken from Remedial Action Work Plan (RAWP) Addendum [Geosyntec, 2011]). Proposed sampling locations shown at influent and effluent to CESF, North Lateral re-route line as well as at Point of Compliance at Lift Station.

Parameters Measured

We recommend that the following parameters and characteristics be monitored as part of the monitoring program. Note that all calculations referenced are described in further detail in the addendum to this memo.

1) Continuous flow measurements should be taken at the Lift Station Point of Compliance, the North Lateral re-route, and the CESF effluent, both during dry and wet weather. The

volume of bypass flow may be calculated by subtraction of the CESF effluent flow from the Lift Station discharge. We also emphasize the need here for these to be reliable, calibrated flow measurements. These flow measurements will be used to validate hydrologic results from the Storm Water Management Model (SWMM) runs that were used as a basis for expected annual flow volumes from the Lift Station.

2) Whole-water PCB concentrations should be measured at all sampling locations. During storm events, whole-water sampling at the Lift Station influent vault will consist of composite samples. The intervals between sample collection will be described in the revised SAP. Storm event sampling at the Lift Station POC will consist of flow-weighted composite samples.

3) PSD data should be collected from all sampling locations.

4) TSS concentrations should be measured at all sampling locations.

5) PCB concentrations should be measured in filtered solids samples collected from the CESF effluent and the Lift Station influent vault.

Filtered solids and TSS data would be used to confirm the proposal to treat non-detected results from whole water samples as zero. An estimate of whole water concentrations can be calculated by multiplying the concentration of PCBs of the filtered solids by the concentration of TSS in the water. Since most PCBs in water are associated with solids, this method can provide a value that is often much lower than the whole water detection limit for PCBs, though it should be noted that the accuracy of this number is dependent on the effectiveness of solids capture. In addition, because it is a calculated number rather than a direct measurement, there is a potential for greater error in the value. Due to these issues, this method should not be used for compliance assessment purposes, but rather to get a sense of whether the non-detect assumption is reasonable.

Sample Handling and Analysis

The following discussion is a summary of the detailed information on sampling handling and analyses methods contained in the June draft of the SAP. Sample handling methods as well as quality assurance/control procedures for the most part should be conducted as described in the draft SAP. As described in a previous section, grab samples may not serve to accurately characterize concentrations in the Lift Station influent vault due to the difficulty in ensuring that the vault is well-mixed vertically. It is therefore recommended that an initial investigation of this well-mixed assumption be conducted early on. Samples collected at the influent vault will consist of composites (or multiple grabs or “aliquots” that are then composited) as opposed to single instantaneous grabs. The Panel will provide more specific guidance on composite sample collection procedures at a later time for integration into the final SAP.

TSS in water will be analyzed using Standard Method 2540, as described in the draft SAP. Filtered solids will be collected using 1 µm filter bags (nominal rating, not absolute). PSD will be collected from filtered solids samples using the PSEP-PS method and confirmed through whole water measurements collected in the field and/or lab (e.g., via laser or coulter counter). Continuous flow measurements will be collected using a flow meter (currently testing a Flo-Dar sensor) that is installed at the Lift Station Point of Compliance, with calibration conducted early on to ensure accurate flow measurements. Flow measurements at the CESF discharge will be collected every 15 minutes using a magmeter. Flow measurements at the KC bypass line will be taken using a weir and pressure transducer.

It is recommended that PCB concentrations in whole water samples and on filtered solids be analyzed using EPA Method 8082. Since the Panel is proposing that any non-detect results for whole water PCBs be treated as zero, it is important that analytical methods for this constituent and aroclor method detection limits (particularly for those aroclors that are routinely detected) are relatively consistent between samples and consistent with previous (pre-LTST) sample results. If it is found that this is not possible, the zero assumption may need to be reevaluated.

Sampling Frequency

The sampling schedule described in Table 2 of the June 2011 draft SAP includes monthly sampling of stormwater and solids from the Lift Station POC between September 2011 and April 2012, after which a revised sampling schedule would be proposed by Boeing to EPA based on results of the initial sampling period. In addition, the draft SAP specifies that two 24-hour storm events with rainfall of 0.5 inches or greater will be sampled by April 30, 2012.

Sampling of whole water from the influent and effluent of the LTST facility is proposed by the draft SAP to occur twice monthly for PCBs and TSS through the end of 2011, and then on a monthly basis in 2012. A specific number of sampled storm events at the LTST facility is not specified in the draft SAP, however, it does state that effort should be taken to collect whole water samples during storm events, at various points during the storm and during various sizes/intensities of storms. Filtered solids samples are to be collected from the LTST facility twice a month through the end of 2011 and monthly starting in 2012.

The Panel believes that, though the sampling schedule included in the draft SAP was adequate for the system and compliance limits in place previously, for the purposes of compliance assessment and confirmatory sampling for the newly proposed FWAAC IG, it is recommended that the required monitoring period be extended, and additional storm sampling be conducted.

The Panel recommends that all sampling at the Lift Station POC take place on a monthly basis through 2012 and all sampling at the Lift Station influent vault and CESF discharge take place on a twice monthly basis through 2011 and then on a monthly basis in 2012. This sampling frequency will then be evaluated for years two and three.

In addition to this monthly sampling, the Panel also recommends sampling at these locations during a minimum of five (5) bypass-producing storm events during the first year. This number of storm samples will then be evaluated for years two and three. Sampling at the Lift Station POC will consist of flow-weighted composites while sampling at the Lift Station influent vault will consist of time-weighted composites. The composite sample collection procedures will be specified in the final SAP. The intent is to collect data for bypass-producing storm events of varying sizes. The purpose of these sampling data and how they will be used in the FWAAC calculation are described in further detail in the addendum to this memo.

It is recommended that sampling at the North Lateral re-route be conducted during a minimum of half of the regular monthly sampling events at the Lift Station Point of Compliance, as well as two additional sampling events to coincide with storm sampling at the Lift Station Point of Compliance.

Determination of Flow-weighted Annual Average Effluent Concentration

After a one year period of sampling has taken place, whole water PCB concentration data and continuous flow measurements will be used to calculate the flow-weighted annual average concentration:

$$FWAAC = \frac{C_{baseflow\_average}V_{baseflow} + \sum C_{storm\_sampled}V_{storm\_sampled} + \sum C_{storm\_unsampled}V_{storm\_unsampled}}{V_{total}}$$

where $C_{baseflow}$ is the whole water PCB concentration in monthly baseflow samples collected. It is understood that some monthly baseflow sampling may occur during wet weather, however since the CESF was designed to have the capacity to treat all baseflow volume, as long as no bypass occurs, monthly sampling data taken during wet weather may be used to approximate $C_{baseflow}$. Alternatively, concentrations measured in the CESF effluent may be used for $C_{baseflow}$ if all monthly sampling happens to coincide with wet weather days where bypass occurs. $C_{storm\_sampled}$ refers to concentrations measured during the five storm events which are sampled annually. Storm flow events that do not coincide with sampling events will be split into two portions: 1) the volume of the storm that was treated and 2) the volume (if any) that bypassed treatment, illustrated in the sample hydrograph shown in Figure 2 as the peak area above the horizontal line (placed at roughly 3.3 cfs, which corresponds to 1500 gpm, the capacity of the CESF system). The PCB contribution from the storm is then calculated using the annual average concentration measured from CESF effluent and the annual average concentration measured in the Lift Station influent vault (used to represent bypass flows), with each concentration weighted based on the volume of treated and untreated flows respectively. This calculation is described in further detail in the addendum to this memo.

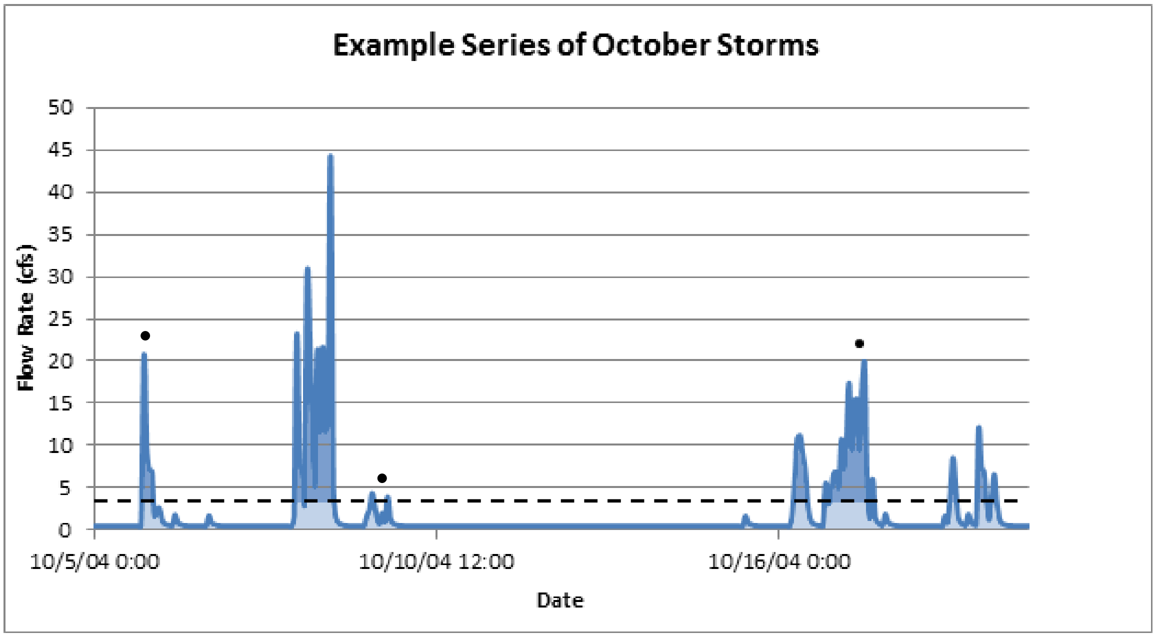

Figure 2. Example hydrograph generated by EPA SWMM model. Dashed line represents CESF treatment capacity (1500 gpm). The area under the blue flowrate line equals the total volume discharged. The darker shaded areas under this line but above the dashed line represent the volume of untreated or bypassed flows, which will discharge from the Lift Station influent vault via the King County pumps and the lighter shaded area below the dashed line represents the treated volume. Dots represent hypothetical sampled storm events. Storm samples will consist of composite samples which represent sample collection durations that are spread out over time but, given the relatively long time scale of this figure (two weeks), appear here as dots.

Each measurement taken will be compared to the water IG, which is the Washington State marine chronic water quality criterion of 0.03 µg/L total PCBs for protection of aquatic life. However assessment of compliance with the proposed FWAAC IG, or 0.018 µg/L, will only be done annually, using a flow-weighted average from individual sampling events that are collected over the course of the year as described above.

As described in the first section, because the proposed FWAAC IG is so close to the typical PCB individual aroclor method detection limit (0.01 µg/L for Method 8082), non-detect values will continue to be treated as zero for the purposes of compliance assessment, as is currently done for the purposes of STST compliance reporting. This assumption will be validated using filtered solids PCB concentrations and TSS data that will be collected.

Conclusion

As described above, the amended monitoring approach recommended by the Panel includes additional sampling above what is currently defined in the draft SAP. It is believed that this recommended approach will achieve not only compliance assessment purposes, but will serve to validate the method used to determine the proposed FWAAC IG and provide information critical to any future decisions that need to be made if conditions at the site change.

It is recommended that a full year of monitoring be performed to collect Lift Station sample results for both wet and dry weather seasons in order to evaluate the sampling methodology, the assumptions used to develop the load-based IG and to compare the average annual value to the recommended load-based IG. It is highly unlikely that a one-year monitoring period would lead to any significant environmental risk because increases in sediment PCB concentrations will occur very gradually over time and will not be potentially significant until decades into the future, if ever. Based on results of monitoring from the first year, sampling frequency for subsequent years will be evaluated.

References

Geosyntec Consultants, 2011. *Addendum to Removal Action Work Plan: Long-Term Stormwater Treatment (26 January 2011)*. March.

Landau Associates, 2011. *Sampling and Analysis Plan, Long-Term Stormwater Treatement, North Boeing Field, Seattle, Washington*. June.

NBF Stormwater Expert Panel and Geosyntec, 2011. *Alternative Interim Goal Recommendations for Protection of Slip 4 Sediment Recontamination*. October.

SAIC, 2010. *North Boeing Field/Georgetown Steam Plant Site Remedial Investigation/ Feasibility Study – Slip 4 Sediment Recontamination Modeling Report.* September.

* * * * *

Addendum

Sample Calculation to Determine Compliance with Proposed Discharge Limit for Protection of Slip Sediments

As described in the Amended Monitoring Approach Recommendations memo (NBF Stormwater Expert Panel and Geosyntec, 2011), compliance with the proposed alternative interim goal (IG, 0.018 µg/L for total PCBs in water) will be assessed by determination of the flow-weighted annual average concentration (FWAAC) of the NBF LTST discharge to Slip 4. The following describes how the FWAAC will be calculated using sampling data collected over the course of a year at the NBF LTST.

FWAAC Formula and Sources of Data

Recognizing that mass is the product of concentration and volume, the FWAAC will be calculated according to the following formula, where C is the PCB concentration, and V is volume:

$$FWAAC = \frac{C_{baseflow\_average}V_{baseflow} + \sum C_{storm\_sampled}V_{storm\_sampled} + \sum C_{storm\_unsampled}V_{storm\_unsampled}}{V_{total}} \quad (1)$$

where:

$$C_{storm\_unsampled}V_{storm\_unsampled} = C_{storm\_treated\_average}V_{storm\_treated} + C_{storm\_untreated\_average}V_{storm\_untreated} \quad (2)$$

These variables and their source are summarized in Table 1 below. Figure 1 is a sample hydrograph illustrating the division of flow volume between baseflow, and treated and untreated portions of storm events. The dots represent sampling events.

Table 1. Variables from FWAAC calculation and source of data.

Variable	Source
$C_{baseflow\_average}$	Average concentration of PCB (typically µg/L) from monthly sampling at POC, or from monthly sampling at CESF effluent if monthly sampling occurs during a wet weather event with bypass.
$C_{storm\_sampled}$	Concentration of PCB (typically µg/L) from LTST Point of Compliance (POC) flow-weighted composite sampling during storm events
$C_{storm\_treated\_average}$	Average concentration of PCB (typically µg/L) from CESF effluent grab samples during storm events
$C_{storm\_untreated\_average}$	Average concentration of PCB (typically µg/L) from Lift Station influent vault during storm events
$V_{baseflow}$	Volume of baseflow from hydrograph – area under red dotted line on Figure 2, excluding storm events
$V_{storm\_sampled}$	Volume of sampled storm event from hydrograph – area under peak on sampled storm events
$V_{storm\_treated}$	Volume of treated storm event from hydrograph – area under black dotted lines on Figure 2
$V_{storm\_untreated}$	Volume of untreated storm event from hydrograph – area under peak above black dotted line on Figure 2

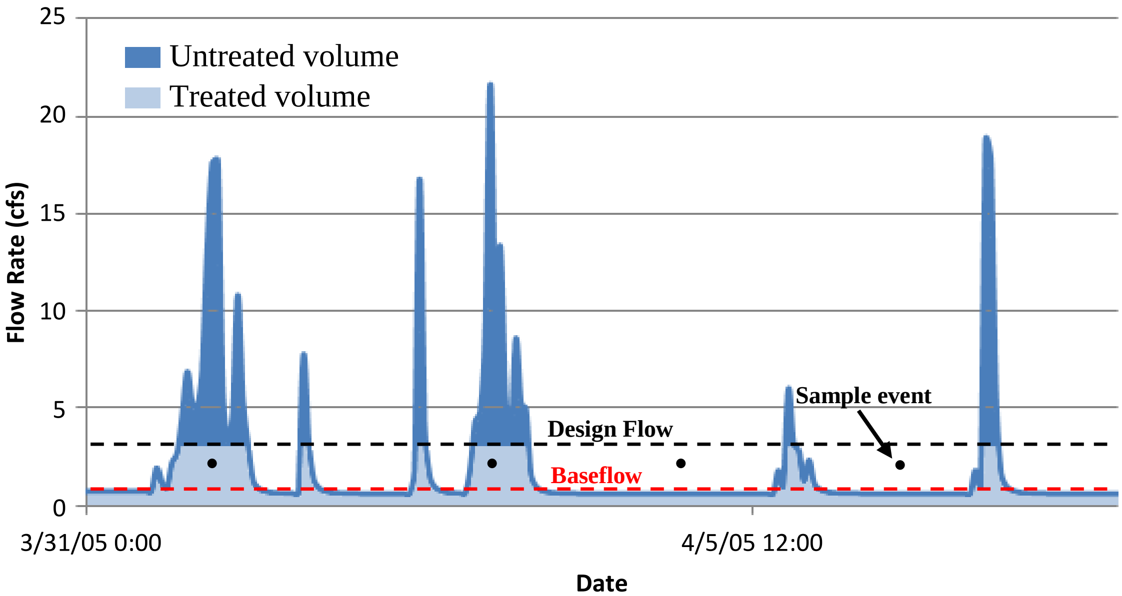

Figure 1. Example NBF discharge hydrograph. Dashed black line represents capacity of CESF system (1500 gpm or 3.3 cfs), so flow volume below line (shaded in light blue) is treated, and above line (shaded in dark blue) is untreated. Dashed red line represents average baseflow rate. Black dots represent POC sampling events.

Calculating PCB Mass Loads from Different Categories of Flow Events

For the purposes of this calculation, PCB mass loads fall into one of three categories: 1) baseflow contributions, 2) contributions from sampled storm events, and 3) contributions from unsampled storm events. Figure 2 shows the same hydrograph as in Figure 1 with the three 'categories' of PCB contributions marked with diagonal shading.

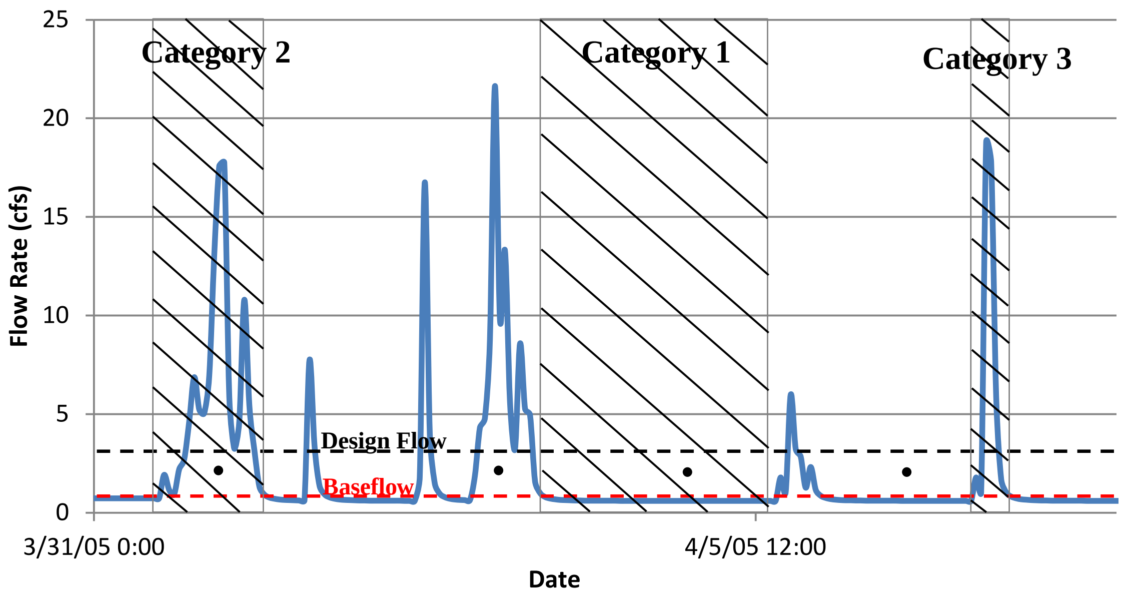

Figure 2. Sample hydrograph. Dashed black line represents capacity of CESF system, so flow volume below line is treated, and above line is untreated. Dashed red line represents baseflow. Black dots represent sampling events. Diagonal shading indicates examples of the three categories of PCB contributions to the total LTST discharge. Category 1 represents a baseflow event, category 2 is a storm event during which sampling occurred and category 3 is a storm event which is not sampled.

The total PCB load, L from Category 1, which are baseflow events, is calculated using $C_{baseflow\_average}$, which is the average whole water PCB concentration in monthly baseflow samples collected, and $V_{baseflow}$, the total volume of baseflow measured at the site over the course of a year (determined through continuous flow monitoring):

$$L_{baseflow} = C_{baseflow\_average} V_{baseflow} \quad (3)$$

It should be noted that based on past performance, concentrations at the CESF discharge (used to represent $C_{baseflow}$ since all baseflow should be treated based on the CESF design capacity) are expected to be non-detects (ND) in the majority of samples. Based on previous Panel recommendations, for the purpose of the FWAAC calculation, NDs will be treated as 0.

For Category 2, which are sampled storms, the monitoring plan calls for monitoring during 5 storm events per year, so $C_{storm\_sampled}$ is the flow-weighted composite concentration measured at the Point of Compliance at the LTST discharge during each sampled storm event, and $V_{storm\_sampled}$ is the volume of each measured storm event. The PCB load from sampled storm events is determined as:

$$L_{storm\_sampled} = C_{storm\_sampled} V_{storm\_sampled} \quad (4)$$

All sampled storm events are then summed to determine the annual contribution from this category.

The PCB contribution of the third category, storm events that are not monitored, will be determined by splitting the storm event into two portions: 1) the volume of the storm that was treated ($V_{storm\_treated}$) and 2) the volume (if any) that bypassed treatment ($V_{storm\_untreated}$). $V_{storm\_treated}$ is based on the capacity of the CESF treatment system and will be determined by effluent flow monitoring at the CESF discharge point. In other words, flow volumes within the capacity of the CESF are treated, and flow volumes that exceed the capacity are untreated (see Figure 1). The annual average concentration measured at the CESF discharge during storm events will be used to represent the treated portion of the storm ($C_{storm\_treated\_average}$), and the annual average of concentrations measured at the Lift Station influent vault (LSIV) during storm events will be used to represent the untreated portion ($C_{storm\_untreated\_average}$) since untreated bypass flows will have the same concentration as the treatment system influent. The PCB load from storm events that are not sampled is determined as:

$$L_{storm\_unsampled} = C_{storm\_unsampled} V_{storm\_unsampled} = C_{storm\_treated\_average} V_{storm\_treated} + C_{storm\_untreated\_average} V_{storm\_untreated} \quad (5)$$

As with the sampled storm events, all unsampled events are summed to determine the annual contribution from this category. As mentioned above, based on past performance, concentrations at the CESF discharge are expected to be ND in the majority of samples. Based on previous Panel recommendations, for the purpose of the FWAAC calculation, NDs will be treated as 0.

The sum of the PCB loads from the three categories represents the total PCB mass load to Slip 4:

$$L_{total} = L_{baseflow} + L_{storm\_sampled} + L_{storm\_unsampled} \quad (6)$$

Equations 3, 4 and 5 are substituted into equation 6, and then the total is then divided by the total flow volume over the course of the year, V_{total}, to arrive at the FWAAC (equation 1).

Validation of Non-Detect Assumption

As stated above, based on previous Panel recommendations, for the purpose of the FWAAC calculation (though not for calculation of $C_{storm\_untreated}$), ND results at the CESF discharge will be treated as zero. This assumption will be validated using whole water filtered solids data and TSS data collected at the CESF discharge. Multiplying these filtered solids data by TSS data may provide an estimate of total PCB concentrations in water:

$$\left(\frac{\mu g\ PCB}{g\ solids}\right)\left(\frac{g\ solids}{L\ water}\right) = \frac{\mu g\ PCB}{L\ water} \quad (6)$$

If it appears that the ND assumption results in a significant overestimate or underestimate of PCB concentrations in the CESF discharge, this assumption will be re-evaluated.