Santa Susana Field Laboratory (SSFL) Stormwater Dioxin Background Report

Executive Summary

The SSFL Stormwater Expert Panel (Panel) has reviewed the soil and stormwater sample results from the SSFL as part of its charge to develop recommendations on engineered natural treatment systems to address NPDES permit requirements at the SSFL. The data evaluated indicate that anthropogenic dioxins[1] originating from areas of the site where highly chlorinated compounds were burned have a unique congener signature that is distinguishable from background dioxins. The Panel believes that the current tetrachlorodibenzodioxin (TCDD) Toxicity Equivalent (TEQ)-based limits do not serve as definitive indicators of how effectively the source removal and other stormwater quality management practices are for addressing local industrial sources of dioxins at the SSFL. To do this, it is necessary to remove the background dioxin signature from the permit limits. The inclusion of this background dioxin signature through use of the current TCDD TEQ-based limits would similarly trigger compliance issues if applied to both municipal site and reference site (i.e., open space watersheds with no known local industrial sources) runoff discharges. Our findings suggest how the available SSFL, urban, and reference site stormwater dioxin data could be used when setting NPDES stormwater permit limits that specifically address releases of dioxins from sites such as the SSFL where watersheds include industrial and natural areas. It is the Panel's judgment that attempting to use source removal and natural treatment systems for treating both background and anthropogenic dioxins together would improve water quality at the SSFL, however this approach would likely result in frequent occasions of non-compliance with the current TCDD TEQ-based dioxin permit limits solely because of background dioxin sources. However, if dioxin limits were more specifically targeted to local industrial sources of dioxin – as would be the case with a limit that uses the 2,3,7,8-TCDD congener only – this would provide a better measure of the effectiveness of any ongoing or proposed source removal and engineered natural treatment systems at the SSFL related to the anthropogenic sources of greatest interest at the site.

Findings

The Panel's key findings and recommendations related to the issue of regulating dioxins in stormwater, particularly with respect to the SSFL NPDES permit are:.

1. Based on SSFL reference site monitoring data and published urban runoff studies, dioxins are ubiquitous in stormwater runoff, both onsite and offsite. To support this finding, Figure 1 is a box and whisker plot showing the range of total TCDD TEQ[2] concentrations from stormwater samples collected at four SSFL outfalls (2004-2009 results shown for outfalls 001, 002, 008, and 009, which

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[1] The general term "dioxins" is used here to describe the class of organic compounds that include both the polychlorinated dibenzodioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs).

[2] TEQ is a calculated value that is determined by multiplying the laboratory analytical result for each detected congener by the corresponding TCDD Toxicity Equivalent Factor (TEF) for that congener, then summing the results for all 17 congeners included in the TEQ calculation.

are larger, mostly undeveloped watersheds that lack treatment BMPs at their outlets[3]), urban runoff monitoring sites (reported in three published studies – Fisher *et al*, 1999; Suarez *et al*, 2006; and Wenning *et al*, 1999), and nearby reference sites (based on unpublished Southern California Coastal Water Research Project [SCCWRP] and Boeing data for 8 open space watershed sampling locations[4], all of which were post-wildfire[5]). Total TCDD TEQ values were computed using the 1998 World Health Organization (WHO) Toxic Equivalency Factors (TEFs)[6]. For plotting purposes, non-detect (ND) and detected but not quantified (DNQ) congener results were not included in the TEQ calculations, and for samples in which all congener results were ND or DNQ, the TCDD TEQ is shown as 10^{-9} µg/L. It is not known whether the published urban runoff studies included DNQ results in their reported values.

Figure 1 shows that these four SSFL outfalls have lower dioxin TEQ concentrations than urban runoff sites, and comparable or lower concentrations than post-fire reference sites. Outfall 008 has the lowest TEQ concentrations of these SSFL outfalls, an observation that is consistent with the Panel's understanding that 008 is located within a watershed that lacks significant dioxin-contaminated areas or upstream affected watersheds. Outfall 009 has the greatest TEQ concentrations of these SSFL outfalls, an observation that is also consistent with the Panel's understanding that the 009

[3] Outfalls 001 and 002 are in the buffer zone and are located downstream of outfalls 011 and 018, respectively. Outfalls 011 and 018 are watersheds that contain RCRA Feasibility Investigation (RFI) areas but have multimedia stormwater filtration systems in place.

[4] The reference sites were located in primarily open land with no known industrial sources (beyond regional atmospheric deposition). The reference sites include 7 sites where 16 storm runoff samples were collected after fires by Boeing and 1 site where 1 storm runoff sample was collected after fire by SCCWRP. Pre-fire dioxin data were not available for any of the reference sites. For more information on these sites see the Flow Science SSFL stormwater dioxin report [2010].

[5] For literature review discussion and SSFL data analysis of wildfire effects on stormwater dioxin concentrations, see the Flow Science's SSFL stormwater dioxin report (2010). One relevant finding from this report was the following, "The range of TCDD TEQ concentrations in storm water samples collected onsite before fires cannot be distinguished from the range of concentrations collected onsite following fires." This finding is based on limited available pre- and post-fire SSFL stormwater monitoring data which are based on grab sample results rather than composite samples, which are known to be more representative and less variable. Regardless of this finding, the Panel notes that significant literature is available to demonstrate that wildfires in general increase runoff volumes and sediment yields from burnt watersheds (USFS, 2005; WWE, 2003; WWE 2007), particularly during the first year post-fire, and given the strong association between dioxins and soils, it is reasonable to conclude that wildfires at the SSFL site and elsewhere expose and disturb soils, increasing erosion rates and TSS levels in runoff, and bound contaminants are therefore more available for discharge during storms.

[6] More recent (2005) WHO TEF values are available, however because the 1998 values are discussed in the CTR and are used in the SSFL NPDES permit for compliance determination purposes, these are used here. The same analysis was conducted (results not shown here) using 2005 WHO TEFs but this did not change the conclusions.

watershed contains potential RFI sources (which are currently being addressed through the Interim Source Removal Action [ISRA]). For reference, Table A-1 in Attachment A summarizes the percentile results, and 95% confidence intervals for the medians, for all datasets summarized in Figure 1.

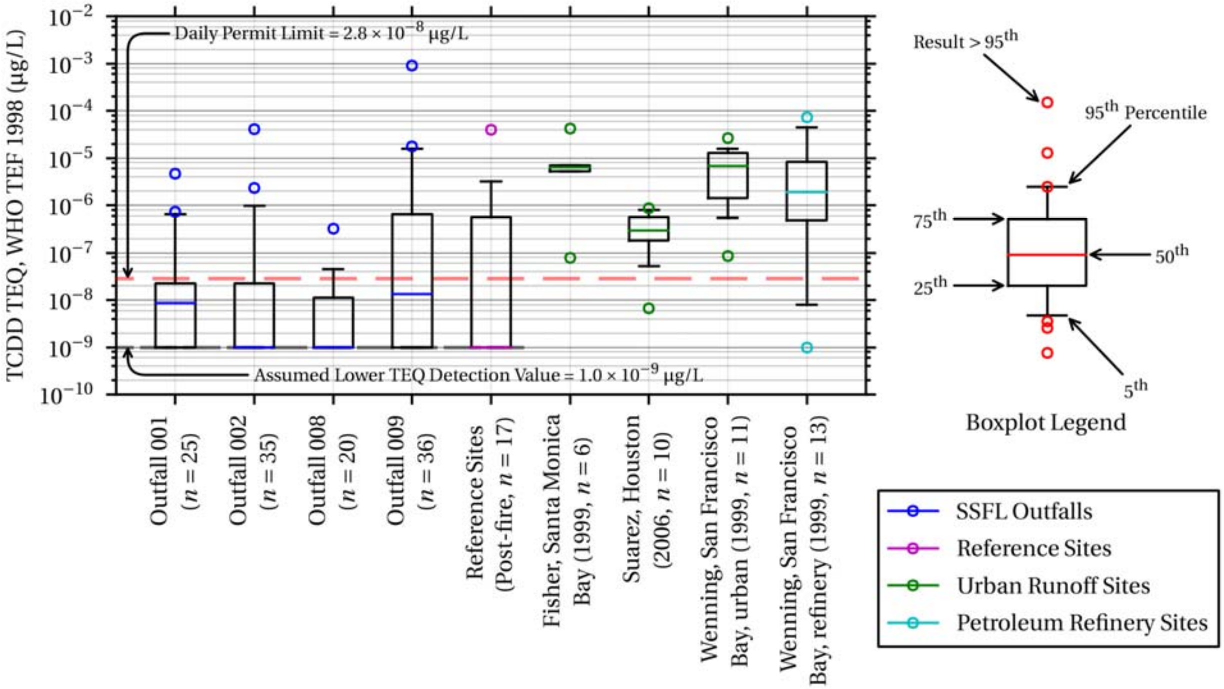

Figure 1: Box and whisker plots of total TCDD TEQ (1998 WHO TEFs were used, ND and DNQ congener results were not included in the TEQ calculations [it is not known whether published urban runoff studies included DNQ results], and for samples in which all congener results were ND or DNQ, the TCDD TEQ is shown as 10^{-9} µg/L). The SSFL reference sites included 8 nearby open space watersheds sampled by Boeing and SCCWRP (unpublished data) during wet-weather, post-fire conditions. The Fisher et al (1999) study included 6 wet weather urban runoff sampling sites in Santa Monica Bay drainage areas; this study did not include analysis of the 2,3,7,8-TCDD congener. The Suarez et al (2006) study includes 10 small flood control drainage channel sampling sites in Houston area, all sampled during wet weather. The Wenning et al (1999) study included 6 mixed urban/rural and 7 petroleum refinery stormwater outfall sampling sites in the San Francisco Bay area, all sampled during wet weather.

2. Known "background" dioxin sources to watersheds, including at the SSFL, include wildfires and atmospheric deposition from widespread offsite emissions. The atmospheric inventory receives contributions from automobiles, power plants, smelters, trash incineration, residential wood burning (e.g., home fireplaces), and all other combustion processes (ATSDR 1999; Clement and Tashiro 1991; Committee on the Implications of Dioxin in the Food Supply: National Research Council 2003; Dyke et al. 1997; Gullett et al. 2001; Gullett and Touati 2003; Gullett et al. 2003; Kim et al. 2001; Rappe et al. 1987; Tashiro et al. 1990; USEPA 2006)).

3. Dioxins are often measured in urban and reference site stormwater monitoring studies at concentrations above the SSFL NPDES permit limit value of 2.8×10^{-8} µg/L TCDD TEQ (daily maximum

limit). Figure 2 below shows the frequencies of exceedance of the TCDD TEQ permit limit for the SSFL outfalls, reference sites, and urban runoff studies. ND and DNQ congener results were not included in the TEQ calculations, but it is not known whether the published urban runoff studies included DNQ results in their reported values and their Detection Limits (DLs) varied. Figure 3 then shows the frequencies of exceedance of the permit limit when compared against 2,3,7,8-TCDD congener results alone. This most toxic congener has only been detected in SSFL runoff at these four outfalls a total of three times, one of which was a DNQ (estimated) result.

Figure 2 shows, similarly to Figure 1, that TCDD TEQ concentrations in SSFL runoff at these four outfalls exceed the SSFL daily maximum permit limits less frequently than urban runoff sites and with a frequency comparable to or less than nearby post-fire reference sites. Outfall 008 again recorded the lowest dioxin exceedance frequencies of the four SSFL outfalls, and outfall 009 recorded the highest. Figure 3 shows similar results for the 2,3,7,8-TCDD congener, with this chart demonstrating that detected and quantified 2,3,7,8-TCDD concentrations have not been observed at reference sites or the three SSFL outfalls that are without large RFI areas present in their watersheds or downstream of stormwater filtration systems (i.e., all but outfall 009). The Suarez study had the lowest 2,3,7,8-TCDD DLs of any datasets reported here; i.e., roughly 10^{-8} ug/L compared to roughly 10^{-6} ug/L which was used for the other urban runoff studies and SSFL datasets. With all their 2,3,7,8-TCDD detections being below 10^{-7} ug/L (i.e., below the SSFL lab reporting and detection limits), this greater detection sensitivity explains the greater 2,3,7,8-TCDD exceedance frequency that is reported in Figure 2 for this study.

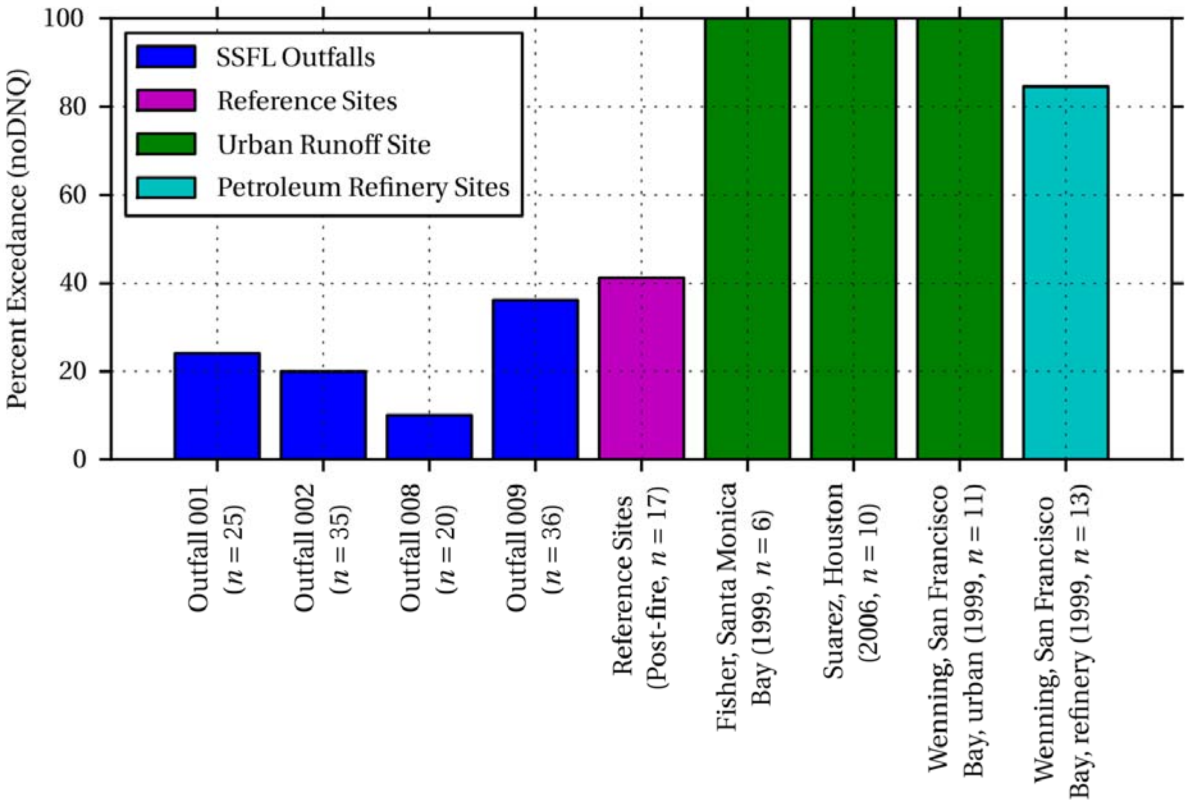

Figure 2: Bar chart showing percent of samples having detected concentrations exceeding 2.8×10^{-8} µg/L TCDD TEQ for SSFL stormwater outfalls (blue), post-fire stormwater reference sites (purple), and urban (green) and petroleum refinery (aqua) runoff monitoring sites. 1998 WHO TEFs were used, and ND and DNQ congener results were not included in the TEQ calculations [it is not known whether published urban runoff studies included DNQ results however]. Fisher study did not include analysis of the 2,3,7,8-TCDD congener.

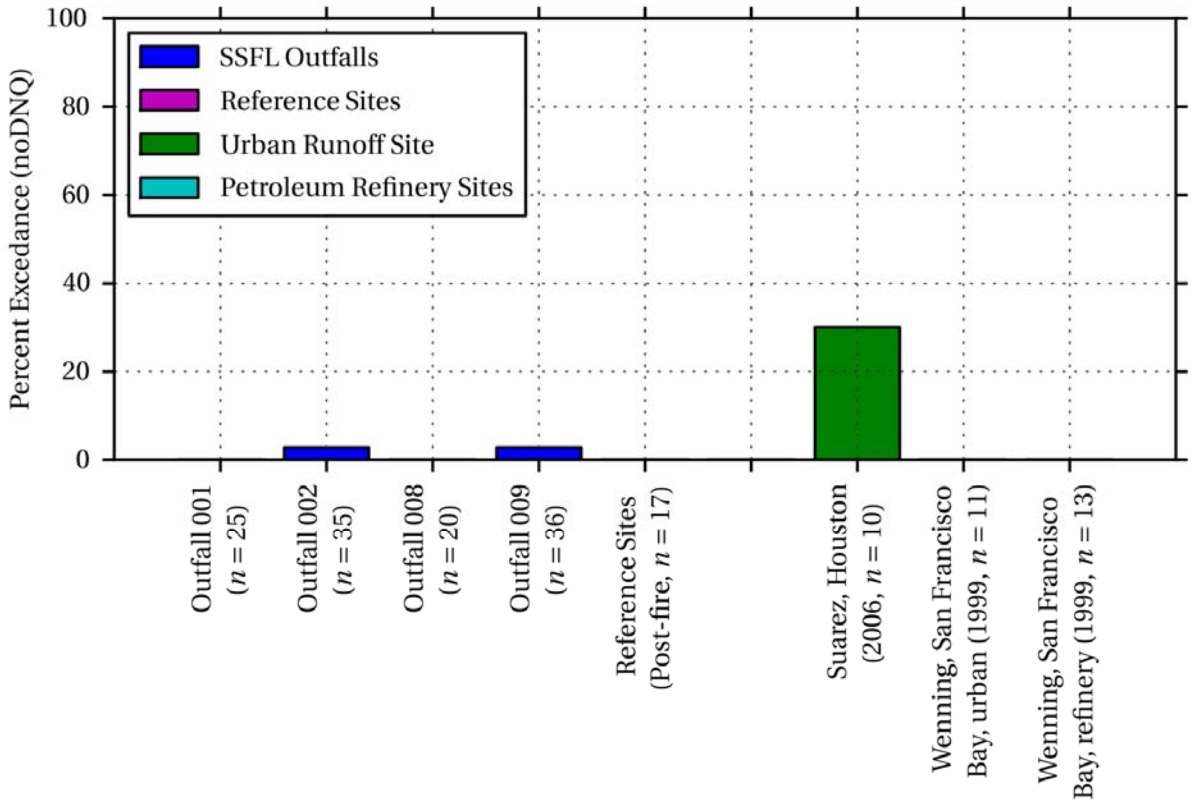

Figure 3: Bar chart showing percent of samples exceeding 2.8 × 10^{-8} µg/L for 2,3,7,8-TCDD for SSFL stormwater outfalls (blue), post-fire stormwater reference sites (purple), and urban (green) and petroleum refinery (aqua) runoff monitoring sites. ND and DNQ congener results were not included in the TEQ calculations [it is not known whether published urban runoff studies included DNQ results however]. Fisher et al (1999) study not shown as it did not include analysis of the 2,3,7,8-TCDD congener. Suarez et al (2006) study used lower lab DLs (roughly 10^{-8} ug/L) than all other datasets, explaining the greater detection frequency observed.

4. These results indicate that the current SSFL limits for TEQ would be exceeded at many if not most municipal, industrial, construction, parks, and other open space areas in southern California. The complexity of regulating dioxins in NPDES discharges has been demonstrated through the ongoing dioxin TMDL development process for the San Francisco Bay, which has been delayed while the Regional Board and EPA complete various dioxin studies and first implement a PCB TMDL for the Bay (which was adopted by the Board in October 2009). For more information on dioxin sources to the San Francisco Bay and studies conducted to support the dioxin TMDL effort for the Bay, see http://www.epa.gov/region09/water/dioxin/sfbay.html.

5. As part of the Interim Source Removal Action (ISRA), Boeing is removing surface soil dioxin sources in the outfall 008 and 009 watersheds to approximately three times the current SSFL soil

background level of is 0.87 ppt TEQ[7] (MWH, 2005), nearly 2 orders of magnitude below the current proposed EPA Preliminary Remediation Goal (PRG) of 72 ppt TEQ and significantly below the existing EPA PRG of 1000 ppt TEQ for residential soils. The proposed residential PRG of 72 ppt TEQ is based on non-cancer exposures since EPA has acknowledged the difficulty of setting a residential PRG based on cancer since the PRG (approximately 3.7 ppt TEQ) would be within the range of observed background soil dioxins levels (0.2 to 11.4 ppt TEQ).

6. The Panel acknowledges that measured TCDD TEQ concentrations at SSFL outfalls 001, 002, 008, and 009 have occasionally exceeded the permit limit by 10-1,000 times, and in one instance (at 009, immediately following the onsite wildfire in 2005) by over 10,000 times. Nonetheless, these concentrations are similar to levels observed for the reference and urban runoff sites (see Figure 1 for comparison).

   The highest observed TCDD TEQ results (>10^{-6} µg/L) at these SSFL outfalls have consistently occurred in samples with high TSS concentrations (>100 mg/L), further supporting the assertion that natural background soils are a significant source of dioxins in stormwater at the SSFL. To demonstrate the rough positive correlations between dioxins and TSS at SSFL outfalls 001, 002, 008, and 009, a chart showing TCDD TEQ versus TSS concentrations is included as Figure A-1 in Attachment A.

   To demonstrate how SSFL background soils may regularly contribute to exceedances of the SSFL NPDES permit limit, we provide an example calculation. SSFL background soils (i.e., having a soil dioxin concentration of 0.87 ppt), when suspended in a pristine sample of water at 30 mg/L Total Suspended Solids (TSS) or more, will result in total TCDD TEQ water sample measurements that exceed the 2.8×10^{-8} µg/L daily maximum permit limit. TSS concentrations of more than 30 mg/L are common in stormwater runoff samples at these steep, largely open space SSFL outfalls; in fact, these watersheds frequently discharge stormwater with 100 mg/L TSS or more, results that often are accompanied by high TCDD TEQ concentrations (see Figure A-1).

7. It is useful to evaluate "particulate strength" results when assessing dioxin concentrations in runoff from the SSFL site. "Particulate strength" is defined as the TEQ concentration for a given sample divided by the TSS concentrations for the same sample, and is a measure of the mass of dioxin per mass of suspended sediment. Median[8] SSFL stormwater runoff particulate strength concentrations for Outfalls 001, 002, 008, and 009 are shown in Table 1 below and are comparable with (i.e., within an order of magnitude of) the SSFL soil background comparison level (0.87 ppt), indicating that

[7] This soil background concentration was calculated using the 2005 WHO TEFs, consistent with DTSC requirements for the RCRA Facility Investigation program.

[8] Median, rather than mean, was used here as the central tendency (or "average") summary statistic given the extreme (log-normal-like) skew of the SSFL dioxin stormwater datasets.

stormwater permit limit exceedances are partly, if not largely, due to natural background soils that are suspended in stormwater discharges.

Outfall 009 had the highest dioxin TEQ particulate strengths, however a few relevant facts should be noted for this outfall. For instance, while the particulate strength results are based on historic SSFL NPDES stormwater monitoring data (i.e., 2004 – 2009), Boeing has more recently implemented various source removal efforts in the watershed. In 2008/09 they performed debris and contaminated soil removal along the northern drainage (in response to a Regional Board Cleanup and Abatement Order), and in 2010 they and NASA are planning to identify and remediate surface soils that have elevated dioxin levels (and metal NPDES pollutants of concern) throughout the 009 watershed as part of the ISRA. Furthermore, consistent with findings from Dr Pitt's SSFL metals background report (2009), estimates of pollutant mass per mass of suspended sediment may not be directly comparable with bulk soils samples (which are used for determination of the soil background comparison levels) because suspended sediments in stormwater have a different particle size distribution than bulk soils – i.e., suspended sediments are generally more fine-grained, and this size range has proportionally greater surface area and organic carbon content, and it tends to have greater concentrations of pollutants that are not from the natural soils. Therefore analysis of particulate strength data is included here for rough comparison purposes only (i.e., to demonstrate that stormwater sediment concentrations are comparable with background soil concentrations), but its usefulness is limited by data that predate recent source removal efforts as well as by inherent physio-chemical differences between suspended sediments and bulk soils.

Table 1 – Median TCDD TEQ Particulate Strengths (i.e., TEQ concentrations divided by TSS concentrations for the same samples to compute dioxin mass per mass of suspended sediment[9]) by SSFL Outfall (using 1998 WHO TEFs, DNQ congeners excluded)

SSFL Outfall	Watershed Area (acres)	Impervious-ness*	Known Operational Dioxin Source Areas in Watershed?	Number of Samples	Median TCDD TEQ Particulate Strength (ppt)	Lower 95% Conf. Interval	Upper 95% Conf. Interval
001	306**	8%	Yes for small area (and yes upstream of 011)	13	1.8	0.25	5.0
002	360**	5%	Yes for small area (and yes upstream of 018)	13	2.2	1.3	6.9
008	62	12%	No	4	0.17	0.02	2.9
009	536	17%	Yes	16	4.8	2.4	35

* Most of the imperviousness in outfall 001, 002, and 008 watersheds is natural (i.e., exposed bedrock); imperviousness in outfall 009 watershed is both natural and development-based (e.g., roads, buildings, parking lots, etc.).

** Outfall 001 and 002 watershed areas (acres) shown do not include areas for outfall 011 and 018 watersheds, which are located upstream of outfalls 001 and 002, respectively, are regulated as separate NPDES compliance monitoring outfalls, include numerous RCRA Feasibility Investigation (RFI) areas, and currently have multimedia stormwater filtration systems in place.

8. Some congeners that often are associated with local industrial contamination (including the most toxic congener, 2,3,7,8-TCDD) are very rarely detected in stormwater samples from SSFL or open space watershed reference sites. Figure 3 above shows the frequency of exceedance of the 2.8×10^{-8} µg/L limit for the SSFL stormwater outfalls when just looking at 2,3,7,8-TCDD – there have been only two quantifiable detections out of 116 total stormwater samples at these four outfalls, one at outfall 002 during a mudslide (TSS in this sample was measured at 33,000 mg/L) and another at outfall 009 immediately after the 2005 Topanga fire[10] (TSS again was very high). More recently in 2009 there was a detection of 2,3,7,8-TCDD at outfall 009, but this was a DNQ (estimated) result. The fact that rare detections of 2,3,7,8-TCDD occurred at outfall 009 but not at 008 is consistent with the Panel's understanding of known industrial dioxin source areas at the SSFL, which are present in the 009 watershed (e.g., ash pile RFI area) but have not been identified in the 008 watershed, further demonstrating the usefulness of this congener for indicating potential

[9] For this analysis, only samples in which both TSS and dioxin concentrations were concurrently measured were included. Of those samples, DNQ congeners were not included in the calculation of TEQ, results with no detected congeners were excluded entirely, and a value of 5 mg/L (half the detection limit) was substituted when TSS was not detected. Calculation inherently conservatively assumes 100% of dioxin mass is in particulate phase (rather than dissolved), which is a good assumption given the very high partitioning characteristics of dioxins.

[10] For information regarding wildfire effects on dioxin levels in stormwater runoff, see footnote #5 in this dioxin findings document.

contamination by local industrial sources. Also note the above discussion regarding recent and ongoing dioxin source removal efforts in this watershed.

9. Congener profiles in stormwater and soil samples evaluated fit one of two patterns: one pattern exhibits higher concentrations of heavily chlorinated and less toxic congeners (e.g., OCDD), while the second pattern exhibits higher concentrations of less chlorinated and more toxic congeners (e.g., 2,3,7,8-TCDD). The first pattern is seen in stormwater from onsite and offsite locations (both pre- and post-fire), from background soil samples, from surface samples collected from evaluated contaminated areas of the site, and from literature reports of particulate samples, lake sediment samples, and runoff in other areas. The second pattern is seen only in samples collected at depth from two areas of known dioxin contamination at the SSFL site: the Area I former burn pit (burn pit), where highly chlorinated wastes, including solvents and fuels, were burned in concrete and earthen ponds; and the Area II former Incinerator Ash Pile (ash pile), where paper that likely contained PCBs in the form of paper whitener was burned (soil sample congener data shown in Figure A-6). The second pattern, not seen in the surficial soil or surface water samples, appears to indicate that the source of dioxins in these soil samples is different and shows a congener "signature" representative of local contamination associated with these historical industrial activities at the site. To demonstrate this, dioxin congener percent contribution bar charts are included in Attachment A; these were taken from Flow Science's (2010) stormwater dioxin report. These site observations are consistent with findings from peer-reviewed literature on other dioxin-contaminated sites (Kannan, 2008) and Flow Science's SSFL dioxin report (2010) based on observations from Hites (1990)[11] who

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[11] The Flow Science report (2010) also discusses processes that affect the distribution of dioxin congeners in the environment: "Hites et al. (1990) analyzed core samples of sediment from the Great Lakes and concluded that homolog profiles from combustion sources did not match homolog profiles in sediment, which were dominated by OCDD and where TCDD was assumed to derive primarily from atmospheric deposition. The homolog profiles for sediment samples closely resembled the average distribution from sources when the vapor and particle phases of the combustion samples were added together. Highly chlorinated congeners (especially OCDD/F) accumulate on atmospheric particles due to their high hydrophobicity and low vapor pressure. Less chlorinated congeners have higher vapor pressures and are found to a greater extent in the vapor phase. Hites et al. (1990) also found that the more highly chlorinated congeners have a greater tendency to be deposited via dry- and wet-deposition. Thus, environmental processing favors the development of congener patterns that are enriched in congeners with higher degrees of chlorination. This environmental processing makes it difficult to identify the primary source of PCDD/Fs in storm water samples using congener pattern analysis." In other words, stormwater and other highly processed or weathered environmental samples may tend to be dominated by the more highly chlorinated dioxin congeners regardless of dioxin source. In light of this, the Panel acknowledges the uncertainty associated with relying on stormwater dioxin congener patterns alone to assess contamination sources. The Panel therefore relies on a weight of evidence to assess stormwater dioxins at the SSFL by considering concentrations in stormwater, stormwater particulate strengths, presence of contaminated source areas in the watersheds, reference site and urban runoff comparison samples, and NPDES permit precedent, in addition to congener patterns as the basis for findings and recommendations contained in this paper. Measuring only the 2,3,7,8-dioxin congener in discharge waters simplifies the weight-of-evidence evaluations without compromising the validity of compliance monitoring.

compared congener group, or homolog, signatures of combustion sources with environmental sinks such as ambient air, rain, and lake surface sediments.

10. Both the California Toxics Rule (CTR) criterion (for protection of human health for consumption of organisms) and the US EPA Maximum Contaminant Level (MCL) drinking water standard are expressed for the single 2,3,7,8-TCDD congener. The SSFL permit limit however is for TCDD TEQ, or the sum of all dioxin congener concentrations multiplied by their WHO TEFs. It is not clear whether this permit limit is an appropriate application of the water quality criterion, and a review by a qualified toxicologist and regulatory specialist (or EPA representative) is recommended.

    Precedent also exists for regulating dioxins in NPDES permits using 2,3,7,8-TCDD as the dioxin compliance parameter, with a number of Western U.S. examples found in particular for TMDL-based dioxin permit limits. This would be the case for NPDES permits subject to dioxin TMDLs such as in the state of Oregon for the Columbia River dioxin TMDL (see http://www.deq.state.or.us/wq/tmdls/columbia.htm) and in the state of Washington for the Lower Snohomish River dioxin TMDL (see http://www.deq.state.or.us/wq/tmdls/columbia.htm). 2,3,7,8-TCDD limits were also observed in several other NPDES permits for discharges of wastewater and stormwater from across the U.S., including permit numbers FL0002526, LA0007561, and NC0000272.

    More recently, in February 2010, the San Francisco Regional Water Quality Control Board adopted Order number R2-2010-0054 to modify municipal and industrial NPDES permits throughout the region and provide new direction concerning dioxin reporting to incorporate bioaccumulation equivalency factors (BEFs) into existing TEQ calculations. The amendment imposes consistent monitoring and reporting requirements for compliance purposes. This is a new and alternative, yet protective approach to regulating dioxins. By incorporating BEFs into the TEQ calculations there is acknowledgement of and adjustment for the fact that not only do dioxin congeners exhibit different toxicity effects, but they also exhibit different bioaccumulation patterns. This is significant given that food chain bioaccumulation is the relevant exposure pathway to affect human health, the protection of which is the intended purpose of the CTR dioxin criteria upon which the SSFL permit limit is based.

Recommendations

Our current understanding and the data available indicate that dioxin congener profiles often differ between stormwater runoff from sites having only atmospheric deposition or wildfire sources and soils from sites with actual local industrial sources of dioxin contamination, such as uncontrolled burning of chlorinated substances. The Panel believes that it is not the intent of the regulations to control natural sources[12] of dioxins and recommends that 2,3,7,8-TCDD serve as the single compliance parameter for regulating dioxins in stormwater runoff at the SSFL. This would be consistent with other NPDES permits from elsewhere in the United States, as well as consistent with the CTR criterion for dioxin, which is based on the single congener 2,3,7,8-TCDD. This would also be technically appropriate and protective given that 2,3,7,8-TCDD was absent from post-fire reference watershed runoff samples (and has only been rarely detected at the four SSFL outfalls and published urban runoff monitoring sites), yet was present at the SSFL in soils known to be impacted by local industrial activities. 2,3,7,8-TCDD is the most toxic congener and is an appropriate indicator of dioxins for samples contaminated by local industrial sources. If the current TCDD TEQ-based permit limit were to be applied to all stormwater dischargers in the region, it is likely that there would be widespread non-compliance issues, even at sites lacking any obvious dioxin contamination beyond background sources.

Acknowledgements

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[12] For example, the Los Angeles Regional Board has previously adopted regulations that exclude natural or background sources of bacteria – e.g., allowing “natural background exceedances” for bacteria in various Los Angeles region bacteria TMDLs.

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ATTACHMENT A

Table A-1. TCDD TEQ percentile summary statistics for stormwater runoff monitoring datasets. For the SSFL data, 2004-2009 NPDES monitoring data used, 2008 WHO TEFs used, ND and DNQ results not included in TEQ calculations, 10^{-9} ug/L substituted for TCDD TEQ when all congener results were ND or DNQ for a sample.

Location	number of samples	Percentiles (µg/L)						
		5	25	lower CI	50	upper CI	75	95
SSFL Outfall 001	25	1.00E-09	1.00E-09	1.00E-09	8.74E-09	1.47E-08	2.25E-08	7.15E-07
SSFL Outfall 002	35	1.00E-09	1.00E-09	1.00E-09	1.00E-09	1.78E-08	2.25E-08	1.37E-06
SSFL Outfall 008	20	1.00E-09	1.00E-09	1.00E-09	1.00E-09	6.00E-09	1.11E-08	5.83E-08
SSFL Outfall 009	36	1.00E-09	1.00E-09	6.02E-09	1.33E-08	1.88E-07	6.52E-07	1.61E-05
SSFL Reference Sites	17	1.00E-09	1.00E-09	1.00E-09	1.00E-09	5.60E-07	5.60E-07	1.05E-05
Fisher et al (1999), Santa Monica urban runoff	6	1.09E-06	5.15E-06	7.77E-08	6.47E-06	4.21E-05	7.03E-06	3.51E-05
Suarez et al (2006), Houston urban runoff	10	2.49E-08	1.80E-07	5.22E-08	2.96E-07	7.93E-07	5.56E-07	8.35E-07
Wenning et al (1999), San Fran. urban runoff	11	2.89E-07	1.42E-06	7.93E-07	6.75E-06	1.39E-05	1.27E-05	2.14E-05
Wenning et al (1999), San Fran. petroleum refinery runoff	13	4.85E-09	4.84E-07	4.45E-07	1.91E-06	8.54E-06	8.29E-06	5.73E-05

* 95% Confidence Intervals (CIs) are provided for the 50th percentile statistics.

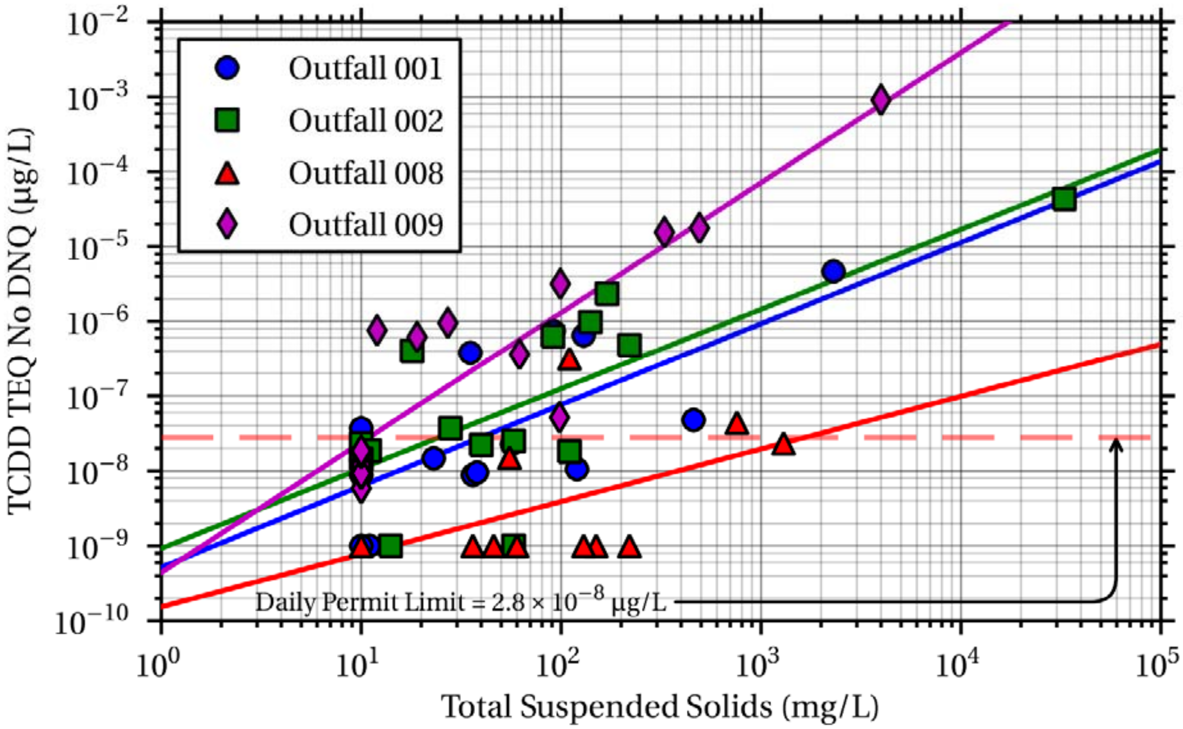

Figure A-1. Dioxin-TSS correlation chart for SSFL outfalls 001, 002, 008, and 009. 2004-2009 SSFL NPDES monitoring data used, 1998 WHO TEFs used, ND and DNQ results not included in TEQ calculations, 10^{-9} ug/L substituted for TCDD TEQ when all congener results were ND or DNQ for a sample. 10 mg/L DL substituted for ND TSS results. Samples not plotted when both TCDD TEQ and TSS results were ND.

Figures A-2 through A-6: Dioxin Congener Percent Contribution Bar Charts from Flow Science's SSFL Dioxin Report (2010). Unlike other charts and tables shown earlier in this report, DNQ congener results are included here so that sufficient congener percent contribution results are available for plotting purposes.

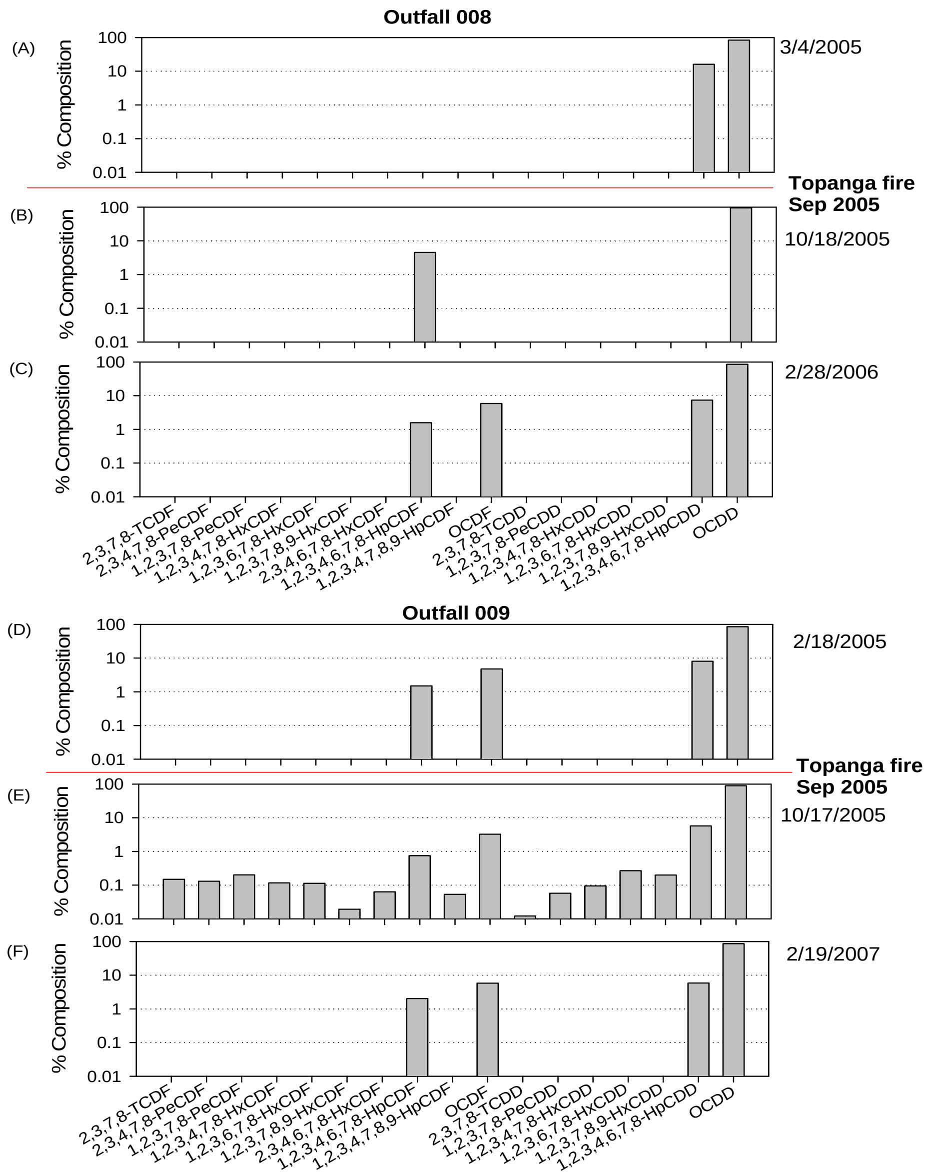

Figure A-2: Congener patterns of SSFL storm water runoff samples collected before and after the 2005 Topanga fire. The % composition is calculated as the concentration (with DNQ) of the congener divided by the sum of congener concentrations above detection limits (i.e., the total concentration). The Y axis has a log scale.

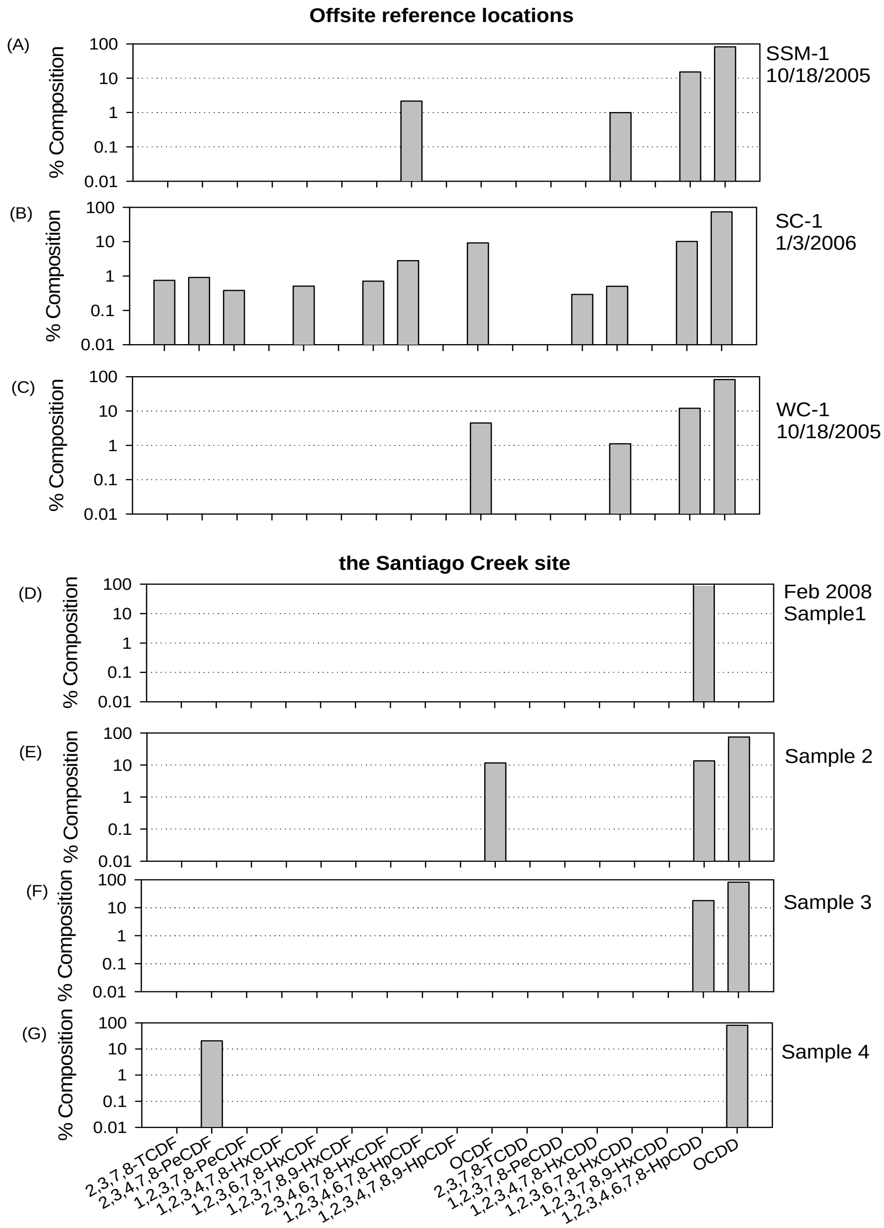

Figure A-3. Congener patterns of storm water runoff samples collected from offsite reference locations after fires. The % composition is calculated as the concentration (with DNQ) of the congener divided by the sum of congener concentrations. The Y axis has a log scale. Note that TCDD TEQ (no DNQ) concentrations for the samples from the Santiago Creek site were zero, and the congener patterns of these samples shown here are based on estimated concentrations.

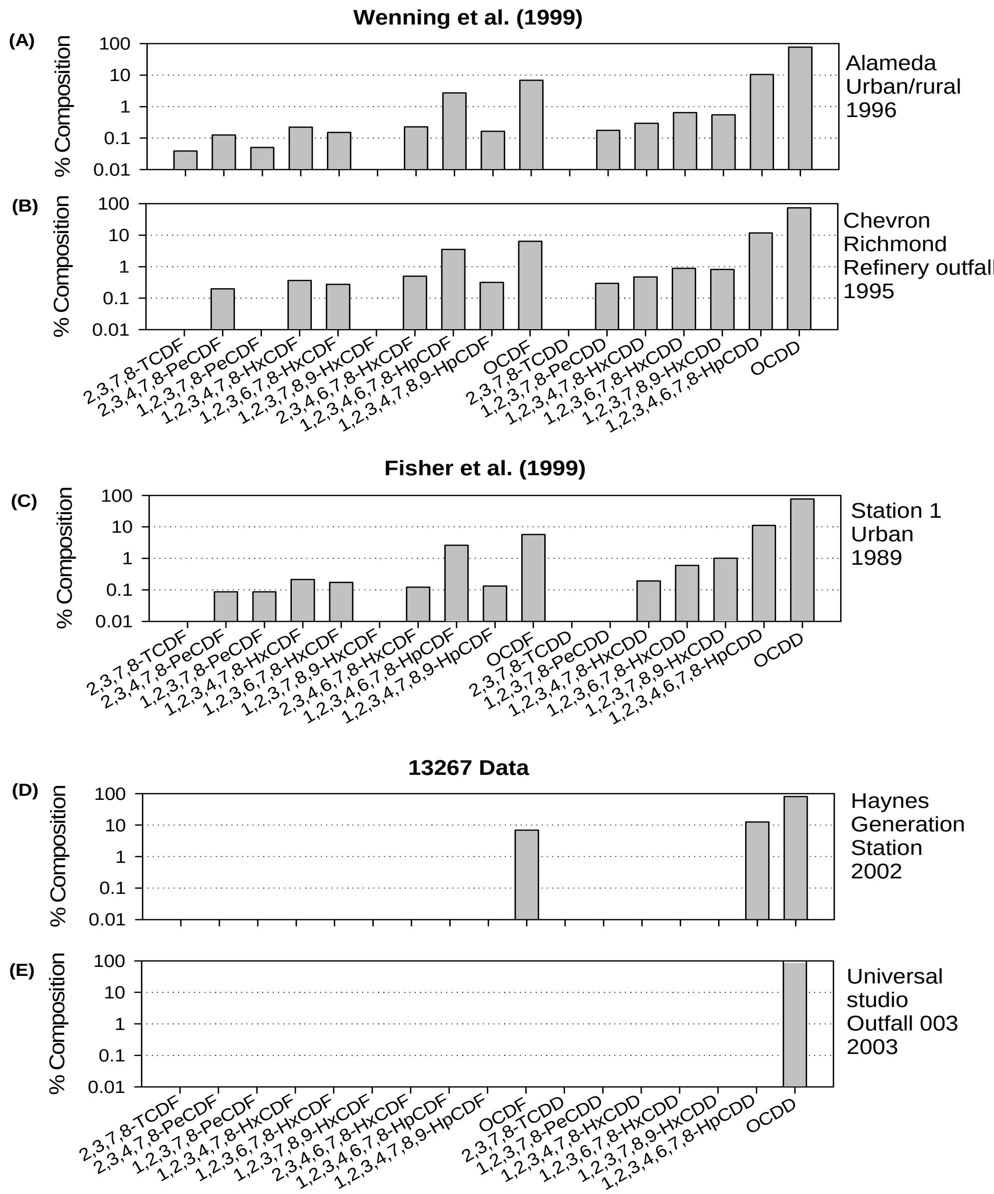

Figure A-4. Typical congener patterns for (A) storm water from storm outfalls in a mixed urban and rural area, (B) runoff from a refinery, (C) storm water in a storm drain to Santa Monica Bay, (D) runoff from a power generation station, and (E) runoff from a commercial area. The Y axis has a log scale.

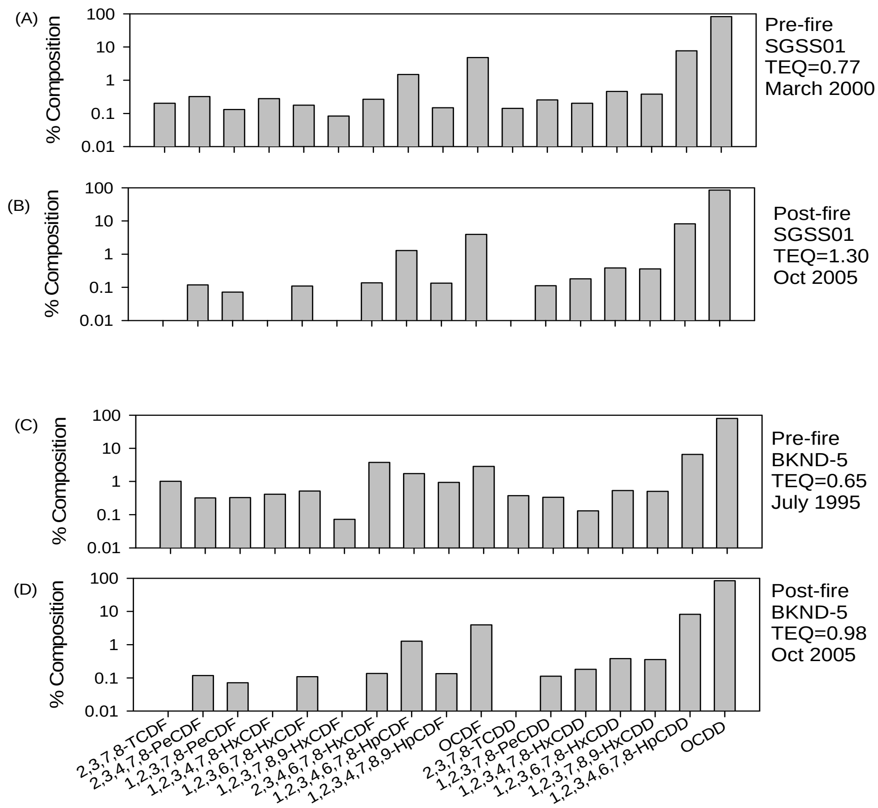

Figure A-5. Congener patterns of background soil samples collected before after the 2005 Topanga fire from DTSC-approved-background soil sampling sites within the SSFL (BKND-5) and outside of the SSFL (SGSS01). The % composition is calculated as the concentration (with DNQ) of the congener divided by the sum of congener concentrations above detection limits (i.e., the total concentration). The Y axis has a log scale. TEQ is TCDD TEQ (no DNQ) concentration (pg/g) in soil samples. Dates are when the samples were collected.

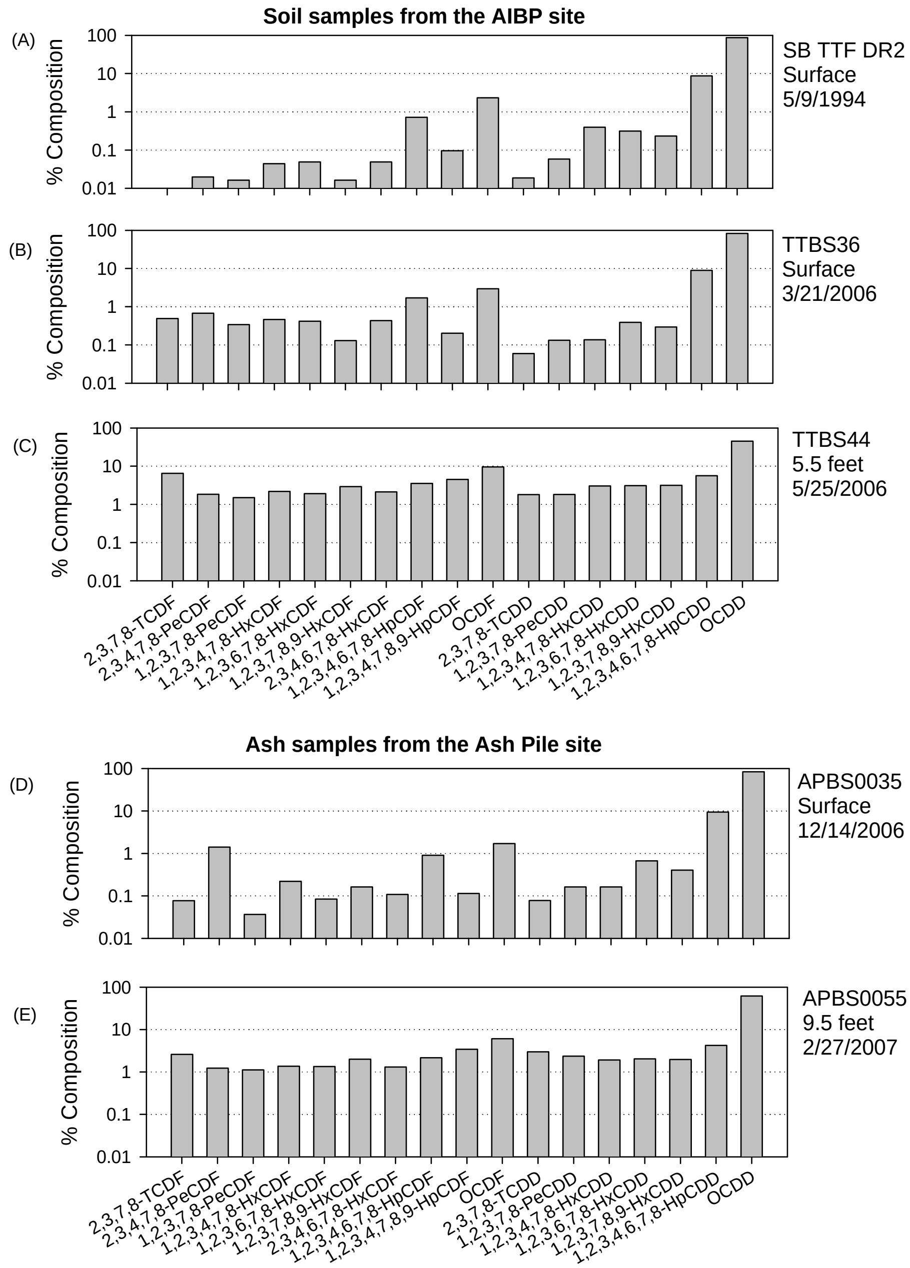

Figure A-6. Congener patterns of soil samples collected from the Area I Burn Pit (AIBP) site (A, B, C) and ash samples from the Ash Pile site (D, E) at SSFL. The Y axis has a log scale.