River loads of dioxin-like compounds WY 2011 update

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Dioxin Strategy Team meeting
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Sampling design

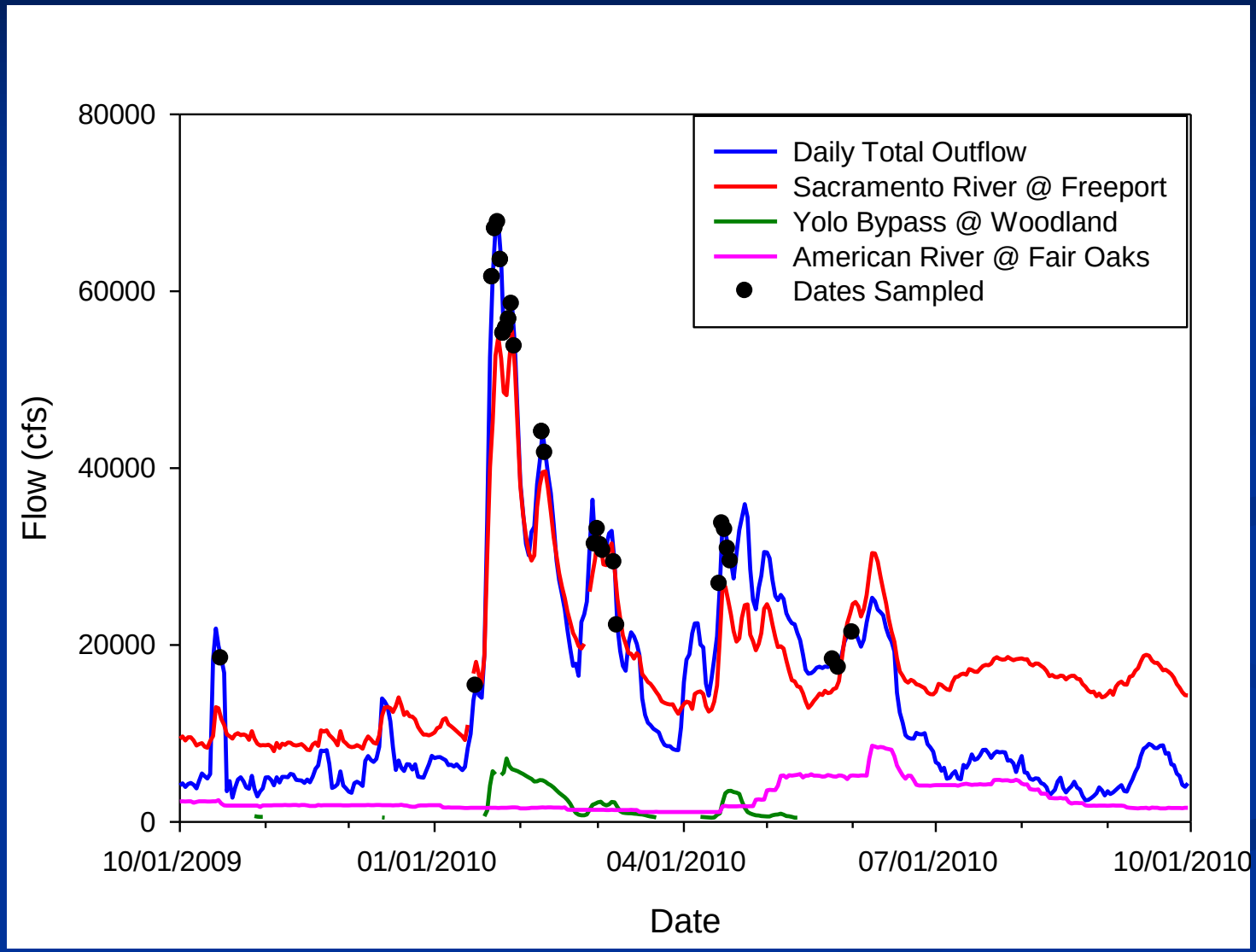
- **Sacramento River**
  - 14 samples during high flow
  - USGS turbidity
  - DWR day flow
- **Guadalupe River**
  - Hwy 101: 14 samples; Foxworthy: 7 samples (during high flow)
  - USGS turbidity and flow
- Z4LA, flood channel in Hayward
  - 13 samples during high flow
  - SFEI turbidity and flow

Loads calculation methods

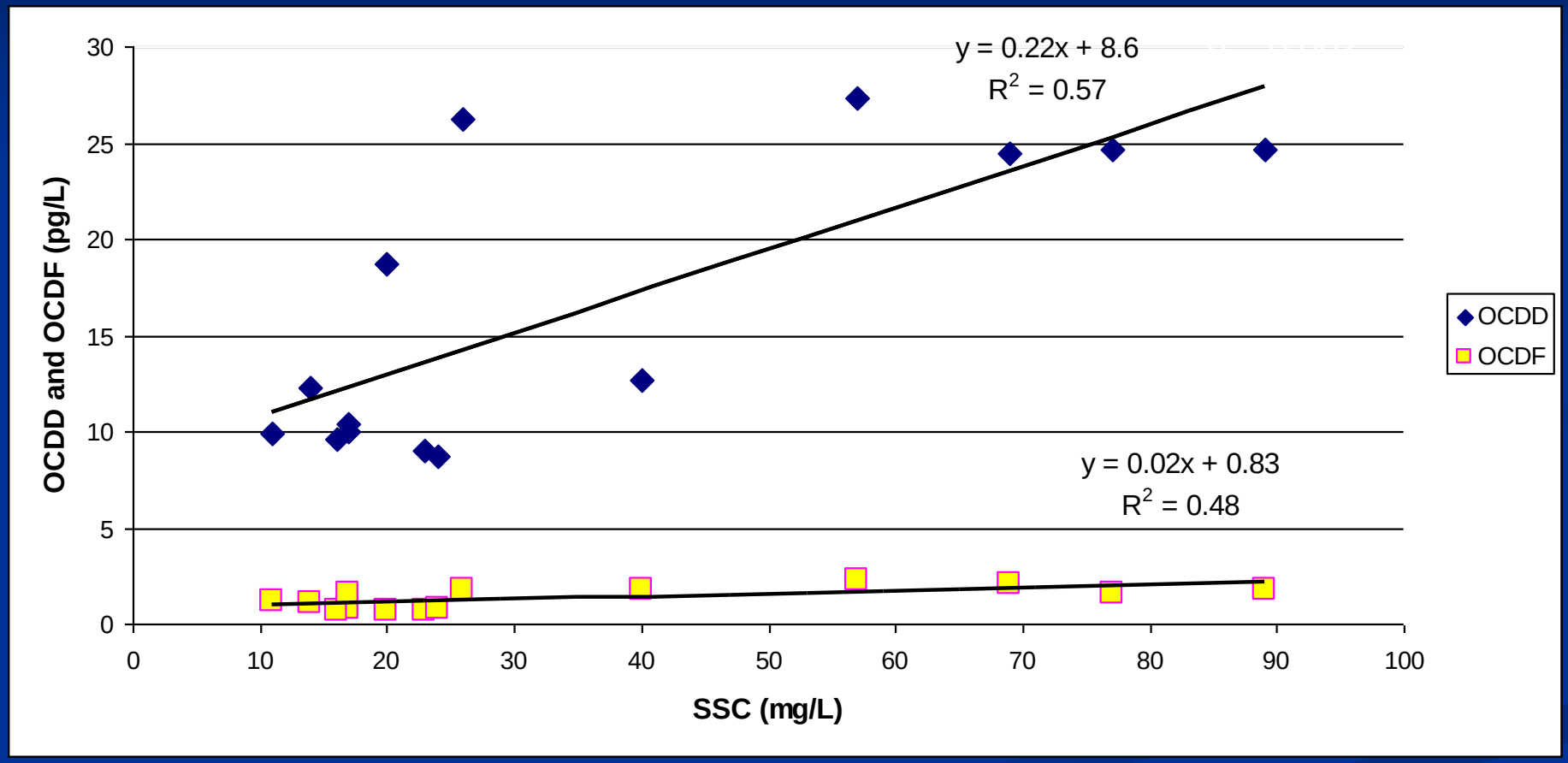
- Turbidity surrogate regression (15 min discharge and turbidity)
- Linear interpolation (Preferred method for contaminants)
- FWMC – when the preferred methods are not possible
- Equipment failures
  - Discharge versus SSC regression estimator
  - Load versus flow estimator

Sacramento River at Mallard Island

WY 2010 flow


80000
60000
40000
20000
0
Flow (cfs)
10/01/2009
01/01/2010
04/01/2010
07/01/2010
10/01/2010
Date
Daily Total Outflow
Sacramento River @ Freeport
Yolo Bypass @ Woodland
American River @ Fair Oaks
Dates Sampled

Dioxin/furan concentrations



TEQ concentrations – Mallard Is.

Analyte	WHO 2005 TEF	Detection out of 14	Minimun (pg/L)	Maximum (pg/L)	FWMC (pg/L)	WHO'05 TEQ (pg/L)
TCDD, 2,3,7,8-	1	0	<MDL	<MDL	<MDL	-
PeCDD, 1,2,3,7,8-	1	4	<MDL	0.098	0.028	0.028
HxCDD, 1,2,3,4,7,8-	0.1	10	<MDL	0.33	0.097	0.010
HxCDD, 1,2,3,6,7,8-	0.1	13	0.070	0.26	0.20	0.020
HxCDD, 1,2,3,7,8,9-	0.1	13	0.094	0.25	0.19	0.019
HpCDD, 1,2,3,4,6,7,8-	0.01	14	1.2	3.3	2.5	0.025
OCDD, 1,2,3,4,6,7,8,9-	0.0003	14	8.7	27	19	0.0058
Sum of Dioxins			4.6	32	22	0.11
TCDF, 2,3,7,8-	0.1	6	<MDL	0.12	0.057	0.0057
PeCDF, 2,3,4,7,8-	0.3	9	<MDL	0.082	0.022	0.0067
PeCDF, 1,2,3,7,8-	0.03	4	<MDL	0.11	0.057	0.0017
HxCDF, 1,2,3,4,7,8-	0.1	13	0.059	0.21	0.12	0.012
HxCDF, 1,2,3,6,7,8-	0.1	9	<MDL	0.15	0.065	0.0065
HxCDF, 1,2,3,7,8,9-	0.1	4	<MDL	0.15	0.033	0.0033
HxCDF, 2,3,4,6,7,8-	0.1	8	<MDL	0.22	0.075	0.0075
HpCDF, 1,2,3,4,6,7,8-	0.01	14	0.32	1.1	0.70	0.0070
HpCDF, 1,2,3,4,7,8,9-	0.01	7	<MDL	0.33	0.084	0.00084
OCDF, 1,2,3,4,6,7,8,9-	0.0003	14	0.68	2.3	1.5	0.00046
Sum of Furans			1.1	15	3.1	0.051
Sum of Dioxins and Furans			12	35	25	0.16

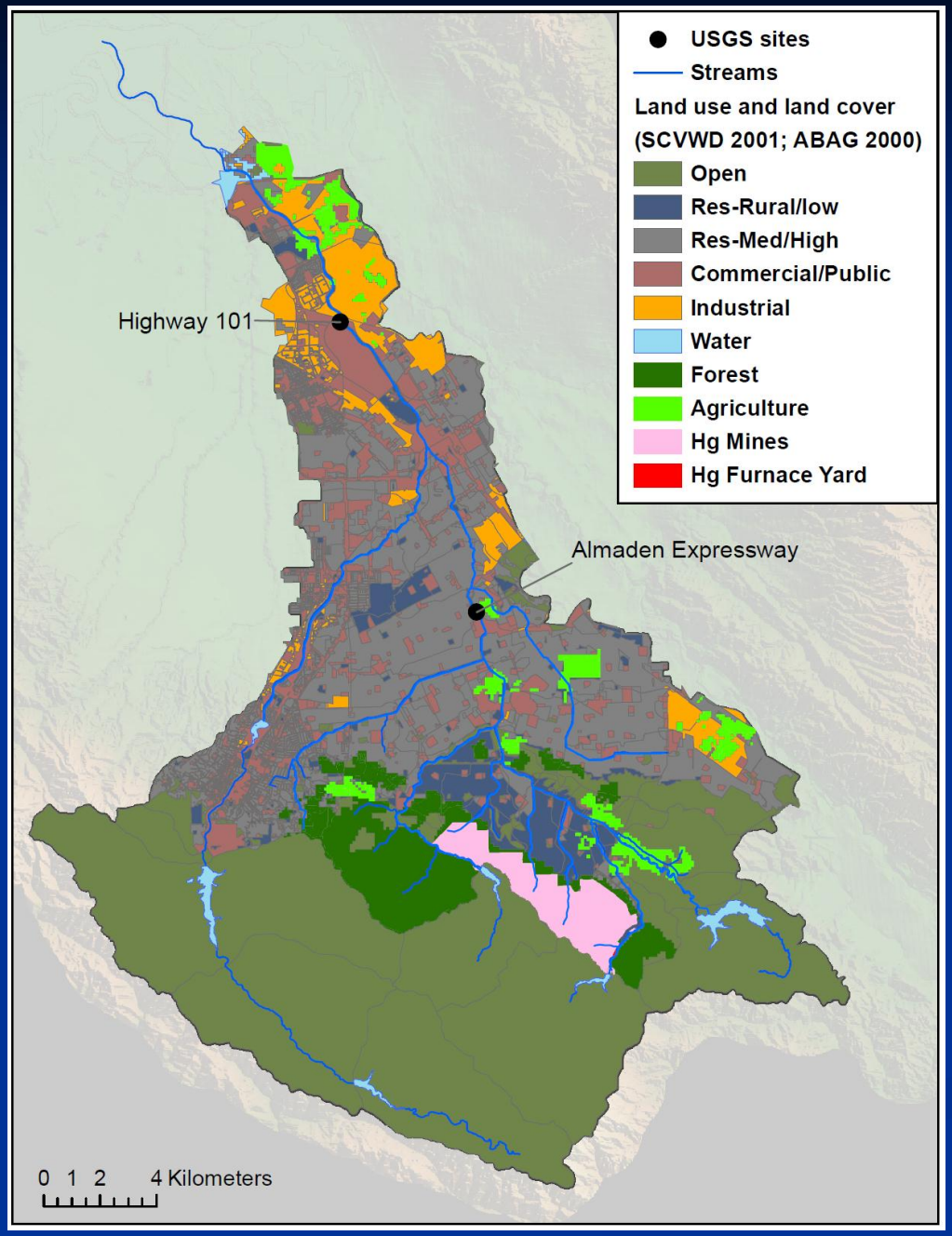
Preliminary data and analysis

TEQ loads – Mallard Is.

Analyte	WHO 2005 TEF	Detection out of 14	FWMC (pg/L)	Annual Load (g)	WHO'05 TEQ Load (g)
TCDD, 2,3,7,8-	1	0	<MDL	-	-
PeCDD, 1,2,3,7,8-	1	4	0.028	1.1	1.1
HxCDD, 1,2,3,4,7,8-	0.1	10	0.097	1.5	0.15
HxCDD, 1,2,3,6,7,8-	0.1	13	0.20	2.6	0.26
HxCDD, 1,2,3,7,8,9-	0.1	13	0.19	2.5	0.25
HpCDD, 1,2,3,4,6,7,8-	0.01	14	2.5	33	0.33
OCDD, 1,2,3,4,6,7,8,9-	0.0003	14	19	250	0.075
Sum of Dioxins			22	477	2.2
TCDF, 2,3,7,8-	0.1	6	0.057	1.3	0.13
PeCDF, 2,3,4,7,8-	0.3	9	0.022	1.1	0.33
PeCDF, 1,2,3,7,8-	0.03	4	0.057	0.90	0.027
HxCDF, 1,2,3,4,7,8-	0.1	13	0.12	1.6	0.16
HxCDF, 1,2,3,6,7,8-	0.1	9	0.065	1.3	0.13
HxCDF, 1,2,3,7,8,9-	0.1	4	0.033	1.7	0.17
HxCDF, 2,3,4,6,7,8-	0.1	8	0.075	1.5	0.15
HpCDF, 1,2,3,4,6,7,8-	0.01	14	0.70	9.2	0.092
HpCDF, 1,2,3,4,7,8,9-	0.01	7	0.084	1.6	0.016
OCDF, 1,2,3,4,6,7,8,9-	0.0003	14	1.5	20	0.0060
Sum of Furans			3.1	66	1.2
Sum of Dioxins and Furans			25	543	3.4

Preliminary data and analysis

Guadalupe River

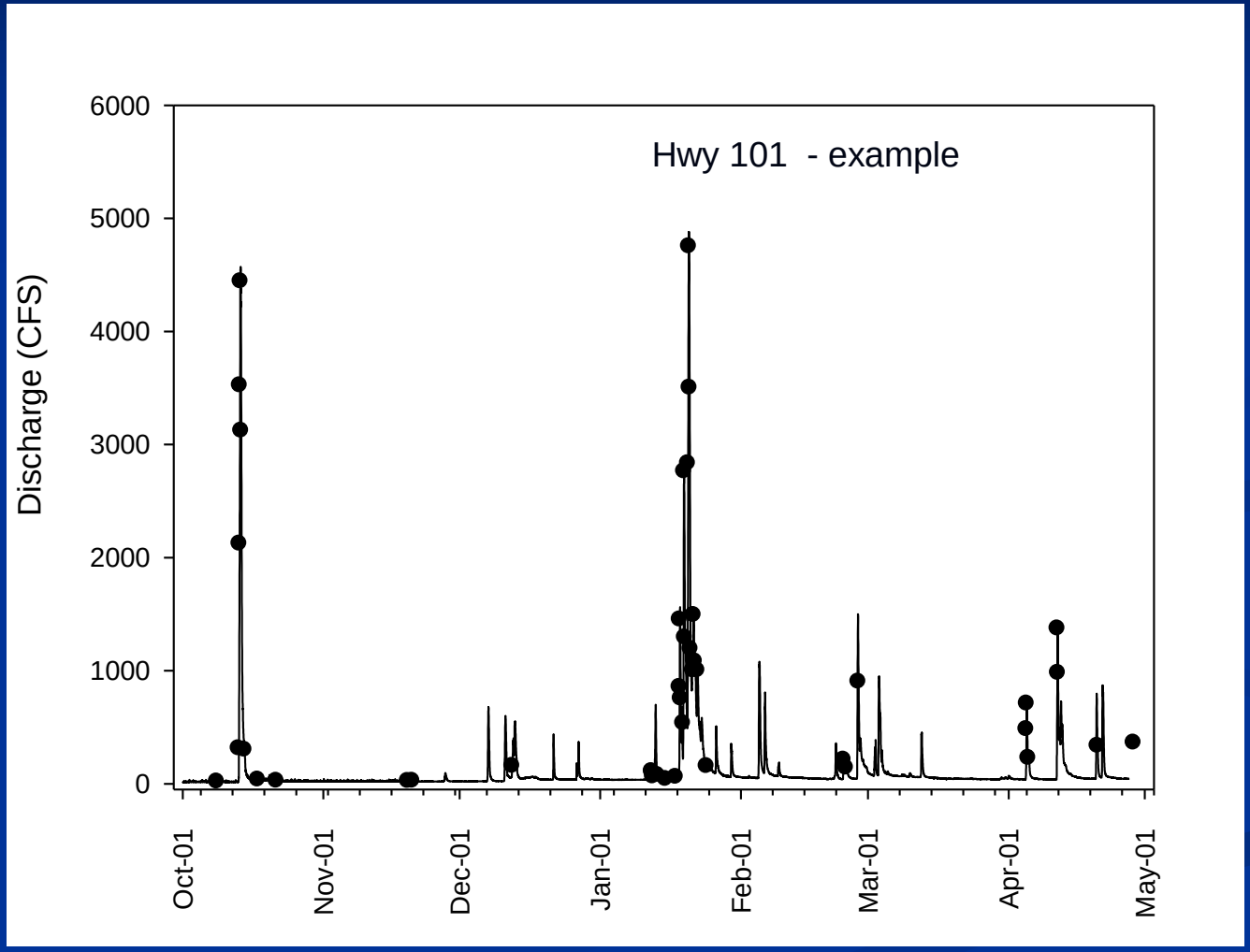


Sampling locations and land use

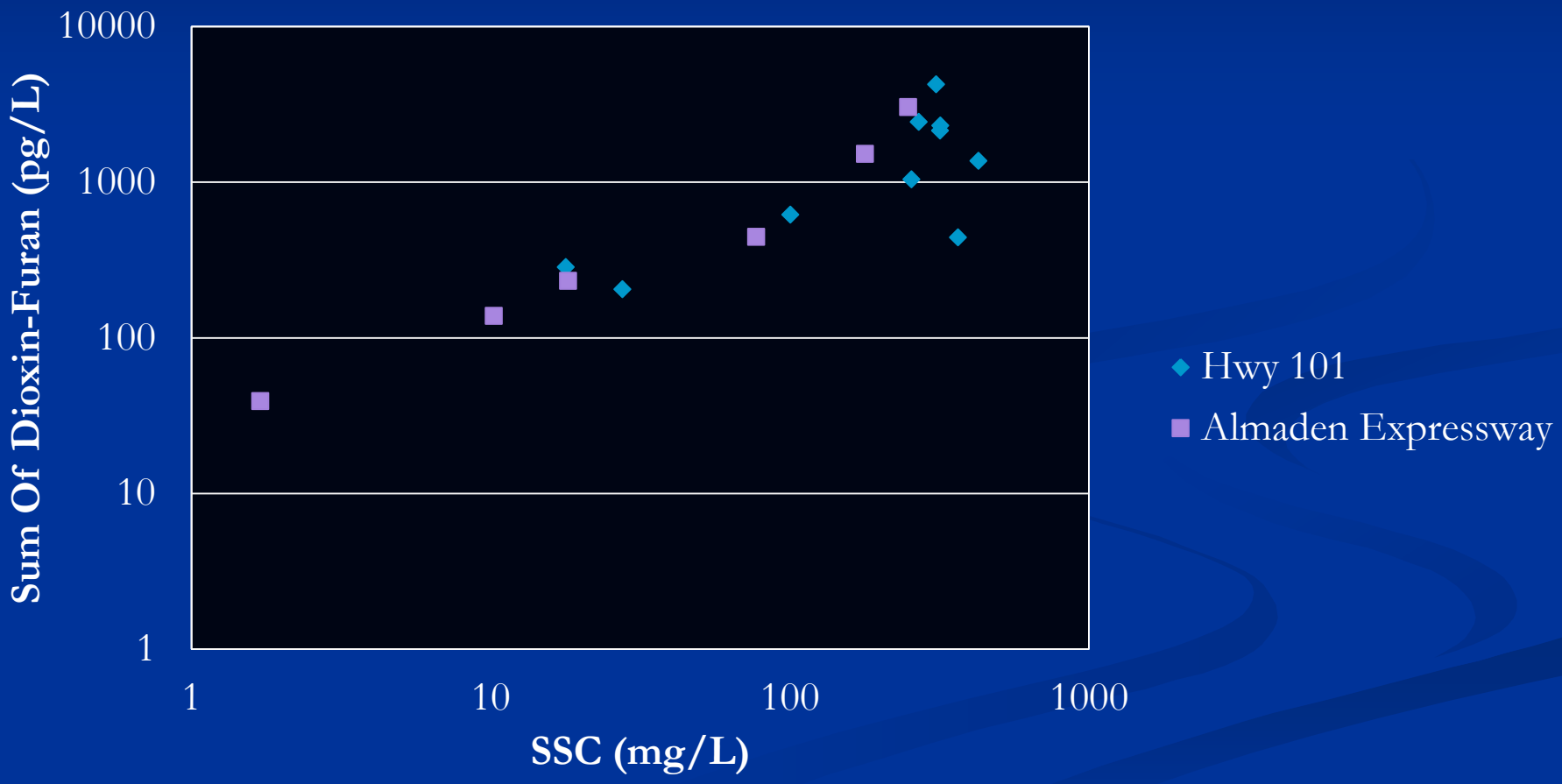
Guadalupe River land use summary

	Upstream of Highway 101		Upstream of Almaden Expressway		Land between two gages	
Land use	km^2	%	km^2	%	km^2	%
OPEN	30	13%	20	26%	9.8	6.10%
RES-RURAL-LOW	22.1	9.20%	14	17%	8.5	5.30%
RES-MED-HI	93.4	39%	5.6	7.10%	87.8	55%
COMM-PUBLIC	37.9	16%	2.9	3.60%	35	22%
FOREST	36.2	15%	32	41%	4.2	2.60%
AGRICULTURE	8.3	3.50%	4.4	5.50%	3.9	2.50%
INDUSTRIAL	10.6	4.40%	0.06	0.08%	10.5	6.60%
Total	238	100%	79	100%	160	100.00%

WY 2010 sample collection



Sum of dioxin/furan concentrations (WY 2010)



TEQ Hwy 101 concentrations

Analyte	WHO 2005 TEF	Detection /14	Minimum (pg/L)	Maximum (pg/L)	FWMC (pg/L)	TEQ concentration (pg/L)
TCDD, 2,3,7,8-	1	8	<MDL	1.2	0.23	0.23
PeCDD, 1,2,3,7,8-	1	12	0.38	7.2	1.4	1.4
HxCDD, 1,2,3,4,7,8-	0.1	12	0.57	9.8	2.0	0.20
HxCDD, 1,2,3,6,7,8-	0.1	13	1.2	23	5	0.48
HxCDD, 1,2,3,7,8,9-	0.1	13	1.3	22	4.4	0.44
HpCDD, 1,2,3,4,6,7,8-	0.01	14	21	369	79	0.79
OCDD, 1,2,3,4,6,7,8,9-	0.0003	14	155	3360	654	0.20
Sum of dioxins					746	3.7
TCDF, 2,3,7,8-	0.1	13	0.066	1.1	0.25	0.025
PeCDF, 2,3,4,7,8-	0.3	9	<MDL	1.6	0.31	0.094
PeCDF, 1,2,3,7,8-	0.03	12	0.082	0.81	0.23	0.0069
HxCDF, 1,2,3,4,7,8-	0.1	12	0.36	5.3	1.2	0.12
HxCDF, 1,2,3,6,7,8-	0.1	12	0.34	4.9	1.0	0.10
HxCDF, 1,2,3,7,8,9-	0.1	9	<MDL	0.19	0.08	0.0082
HxCDF, 2,3,4,6,7,8-	0.1	12	0.32	4	0.9	0.088
HpCDF, 1,2,3,4,6,7,8-	0.1	14	7.4	101	24	2.4
HpCDF, 1,2,3,4,7,8,9-	0.01	11	<MDL	6.9	1.4	0.014
OCDF, 1,2,3,4,6,7,8,9-	0.003	14	17	329	70	0.21
Sum of Furans					99	3.0
Sum of dioxins and furans					845	6.7

TEQ Almaden Expressway concentrations

Analyte	WHO 2005 TEF	Detection out of 6	Minimum (pg/L)	Maximum (pg/L)	FWMC (pg/L)	WHO'05 TEQ (pg/L)
TCDD, 2,3,7,8-	1	3	<MDL	0.62	0.18	0.18
PeCDD, 1,2,3,7,8-	1	5	<MDL	4.1	1.2	1.2
HxCDD, 1,2,3,4,7,8-	0.1	6	0.12	7.1	2.0	0.20
HxCDD, 1,2,3,6,7,8-	0.1	6	0.26	17	5	0.49
HxCDD, 1,2,3,7,8,9-	0.1	6	0.29	16	4	0.44
HpCDD, 1,2,3,4,6,7,8-	0.01	6	4.5	300	86	0.86
OCDD, 1,2,3,4,6,7,8,9-	0.0003	6	34	2360	692	0.21
Sum of dioxins			39	2704	790	3.6
TCDF, 2,3,7,8-	0.1	5	<MDL	0.65	0.21	0.021
PeCDF, 2,3,4,7,8-	0.3	0	<MDL	<MDL	-	-
PeCDF, 1,2,3,7,8-	0.03	4	<MDL	0.83	0.25	0.0074
HxCDF, 1,2,3,4,7,8-	0.1	6	0.10	4.8	1.4	0.14
HxCDF, 1,2,3,6,7,8-	0.1	6	0.092	3.9	1.1	0.11
HxCDF, 1,2,3,7,8,9-	0.1	5	<MDL	0.32	0.10	0.010
HxCDF, 2,3,4,6,7,8-	0.1	5	<MDL	3.3	0.9	0.094
HpCDF, 1,2,3,4,6,7,8-	0.1	5	<MDL	90	26	2.60
HpCDF, 1,2,3,4,7,8,9-	0.01	3	<MDL	5.4	1.5	0.015
OCDF, 1,2,3,4,6,7,8,9-	0.003	5	<MDL	227	64	0.19
Sum of Furans			0.19	336	96	3.2
Sum of dioxins and furans			39	3040	886	6.7

TEQ loads - Hwy 101

Analyte	WHO 2005 TEF	Detection /14	FWMC (pg/L)	Load (g)	TEQ load (g)
TCDD, 2,3,7,8-	1	8	0.23	0.012	0.012
PeCDD, 1,2,3,7,8-	1	12	1.4	0.074	0.074
HxCDD, 1,2,3,4,7,8-	0.1	12	2.0	0.11	0.011
HxCDD, 1,2,3,6,7,8-	0.1	13	4.8	0.26	0.026
HxCDD, 1,2,3,7,8,9-	0.1	13	4.4	0.24	0.024
HpCDD, 1,2,3,4,6,7,8-	0.01	14	79	4.3	0.043
OCDD, 1,2,3,4,6,7,8,9-	0.0003	14	654	35	0.011
Sum of dioxins			746	40	0.20
TCDF, 2,3,7,8-	0.1	13	0.25	0.013	0.0013
PeCDF, 2,3,4,7,8-	0.3	9	0.31	0.017	0.0051
PeCDF, 1,2,3,7,8-	0.03	12	0.23	0.012	0.00037
HxCDF, 1,2,3,4,7,8-	0.1	12	1.2	0.065	0.0065
HxCDF, 1,2,3,6,7,8-	0.1	12	1.0	0.056	0.0056
HxCDF, 1,2,3,7,8,9-	0.1	9	0.082	0.0044	0.00044
HxCDF, 2,3,4,6,7,8-	0.1	12	0.88	0.048	0.0048
HpCDF, 1,2,3,4,6,7,8-	0.1	14	24	1.3	0.13
HpCDF, 1,2,3,4,7,8,9-	0.01	11	1.4	0.078	0.00078
OCDF, 1,2,3,4,6,7,8,9-	0.003	14	70	3.8	0.011
Sum of Furans			99	5.4	0.16
Sum of dioxins and furans			845	46	0.37

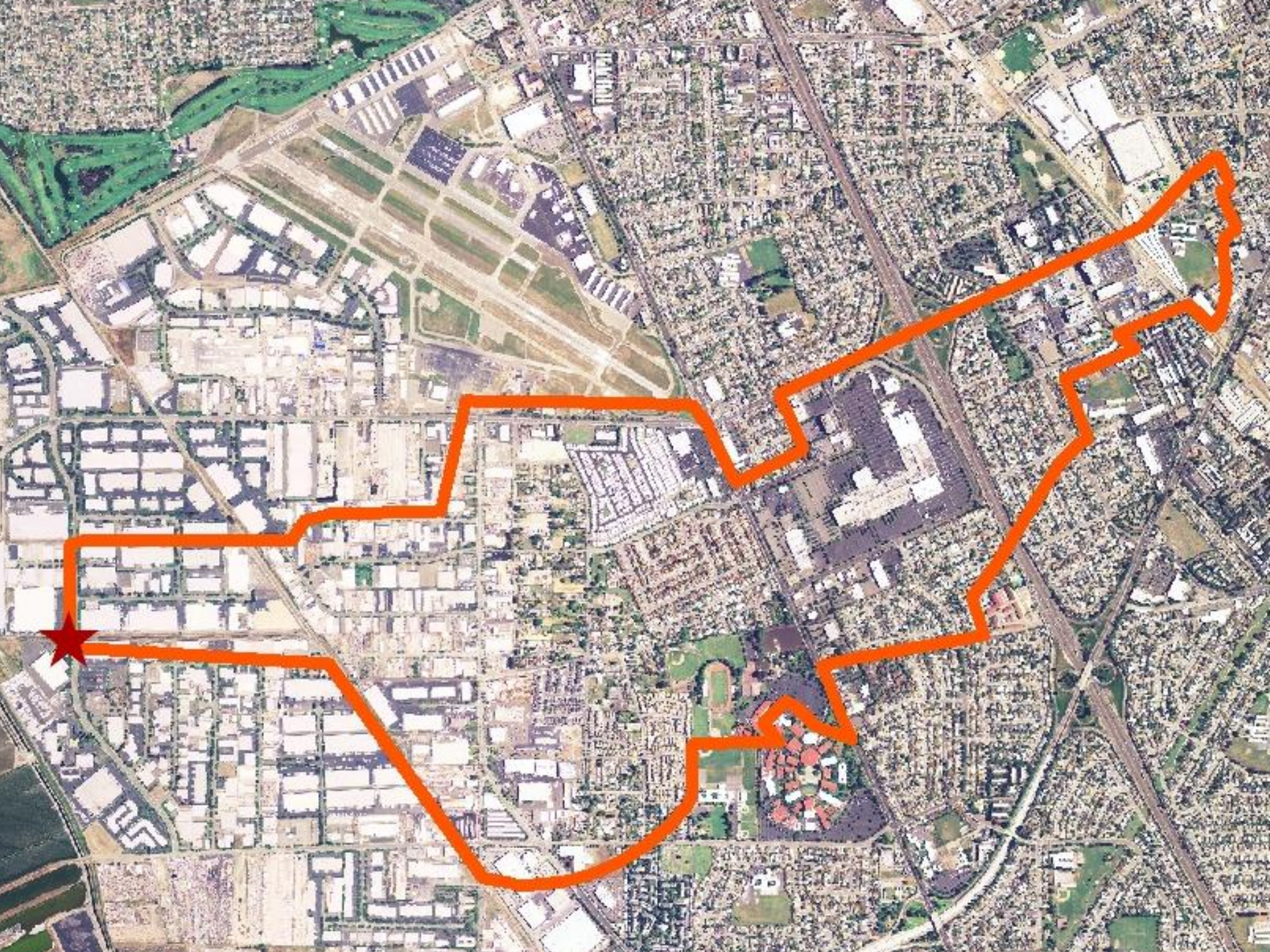
Preliminary data and analysis

TEQ loads – Almaden Expressway

Analyte	WHO 2005 TEF	Detection out of 6	FWMC (pg/L)	Load (g)	WHO'05 TEQ load (g)
TCDD, 2,3,7,8-	1	3	0.18	0.0041	0.0041
PeCDD, 1,2,3,7,8-	1	5	1.2	0.027	0.027
HxCDD, 1,2,3,4,7,8-	0.1	6	2.0	0.045	0.0045
HxCDD, 1,2,3,6,7,8-	0.1	6	5	0.11	0.011
HxCDD, 1,2,3,7,8,9-	0.1	6	4	0.10	0.0099
HpCDD, 1,2,3,4,6,7,8-	0.01	6	86	1.9	0.019
OCDD, 1,2,3,4,6,7,8,9-	0.0003	6	692	15	0.0046
Sum of dioxins			790	18	0.080
TCDF, 2,3,7,8-	0.1	5	0.21	0.0046	0.00046
PeCDF, 2,3,4,7,8-	0.3	0	-	-	-
PeCDF, 1,2,3,7,8-	0.03	4	0.25	0.0055	0.00017
HxCDF, 1,2,3,4,7,8-	0.1	6	1.4	0.030	0.0030
HxCDF, 1,2,3,6,7,8-	0.1	6	1.1	0.025	0.0025
HxCDF, 1,2,3,7,8,9-	0.1	5	0.10	0.0021	0.00021
HxCDF, 2,3,4,6,7,8-	0.1	5	0.9	0.021	0.0021
HpCDF, 1,2,3,4,6,7,8-	0.1	5	26	0.58	0.058
HpCDF, 1,2,3,4,7,8,9-	0.01	3	1.5	0.034	0.00034
OCDF, 1,2,3,4,6,7,8,9-	0.003	5	64	1.4	0.0043
Sum of Furans			96	2.1	0.071
Sum of dioxins and furans			886	20	0.15

Preliminary data and analysis

Zone 4 Line A
(Storm drain in Hayward)



TEQ Z4LA concentrations

Analyte	WHO 2005 TEF	Detection out of 13	Minimum (pg/L)	Maximum (pg/L)	FWMC (pg/L)	WHO'05 TEQ (pg/L)
TCDD, 2,3,7,8-	1	12	<MDL	10	1.5	1.5
PeCDD, 1,2,3,7,8-	1	13	0.19	68	10	9.9
HxCDD, 1,2,3,4,7,8-	0.1	13	0.32	47	11	1.1
HxCDD, 1,2,3,6,7,8-	0.1	13	0.82	135	27	2.7
HxCDD, 1,2,3,7,8,9-	0.1	13	0.74	151	28	2.8
HpCDD, 1,2,3,4,6,7,8-	0.01	13	20	839	360	3.6
OCDD, 1,2,3,4,6,7,8,9-	0.0003	13	182	4610	2584	0.78
Sum of dioxins					3021	22
TCDF, 2,3,7,8-	0.1	13	0.12	1.2	0.55	0.055
PeCDF, 2,3,4,7,8-	0.3	13	0.10	2.5	1.1	0.34
PeCDF, 1,2,3,7,8-	0.03	12	<MDL	3.0	1.0	0.031
HxCDF, 1,2,3,4,7,8-	0.1	13	0.29	11	6.2	0.62
HxCDF, 1,2,3,6,7,8-	0.1	13	0.25	11	5.9	0.59
HxCDF, 1,2,3,7,8,9-	0.1	11	<MDL	0.51	0.32	0.032
HxCDF, 2,3,4,6,7,8-	0.1	12	<MDL	8.5	3.9	0.39
HpCDF, 1,2,3,4,6,7,8-	0.1	13	5.9	227	136	14
HpCDF, 1,2,3,4,7,8,9-	0.01	13	0.429	13	7.9	0.079
OCDF, 1,2,3,4,6,7,8,9-	0.003	13	14.6	797	421	1.3
Sum of Furans					585	17
Sum of dioxins and furans					3606	39

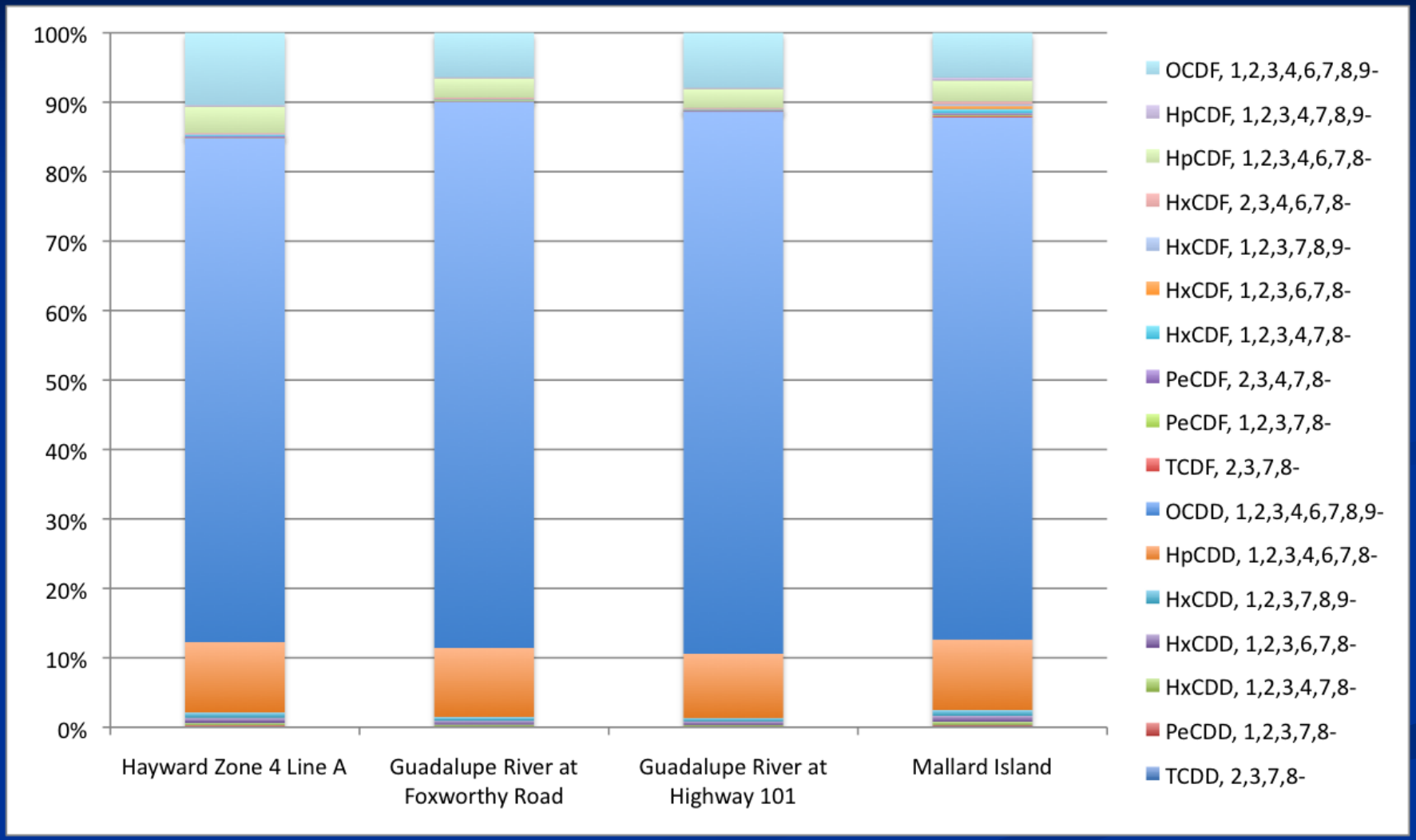
TEQ loads – Z4LA

Analyte	WHO 2005 TEF	Detection out of 13	FWMC (pg/L)	Load (g)	WHO'05 TEQ load (g)
TCDD, 2,3,7,8-	1	12	1.5	0.0010	0.0010
PeCDD, 1,2,3,7,8-	1	13	9.9	0.0063	0.0063
HxCDD, 1,2,3,4,7,8-	0.1	13	11	0.0073	0.00073
HxCDD, 1,2,3,6,7,8-	0.1	13	27	0.017	0.0017
HxCDD, 1,2,3,7,8,9-	0.1	13	28	0.018	0.0018
HpCDD, 1,2,3,4,6,7,8-	0.01	13	360	0.23	0.0023
OCDD, 1,2,3,4,6,7,8,9-	0.0003	13	2584	1.7	0.00050
Sum of dioxins			3021	1.9	0.014
TCDF, 2,3,7,8-	0.1	13	0.55	0.00035	0.000035
PeCDF, 2,3,4,7,8-	0.3	13	1.1	0.00073	0.00022
PeCDF, 1,2,3,7,8-	0.03	12	1.0	0.00066	0.000020
HxCDF, 1,2,3,4,7,8-	0.1	13	6.2	0.0040	0.00040
HxCDF, 1,2,3,6,7,8-	0.1	13	5.9	0.0038	0.00038
HxCDF, 1,2,3,7,8,9-	0.1	11	0.32	0.00021	0.000021
HxCDF, 2,3,4,6,7,8-	0.1	12	3.9	0.0025	0.00025
HpCDF, 1,2,3,4,6,7,8-	0.1	13	136	0.087	0.0087
HpCDF, 1,2,3,4,7,8,9-	0.01	13	7.9	0.0051	0.00005
OCDF, 1,2,3,4,6,7,8,9-	0.003	13	421	0.27	0.00081
Sum of Furans			585	0.37	0.011
Sum of dioxins and furans			3606	2.3	0.025

Preliminary data and analysis

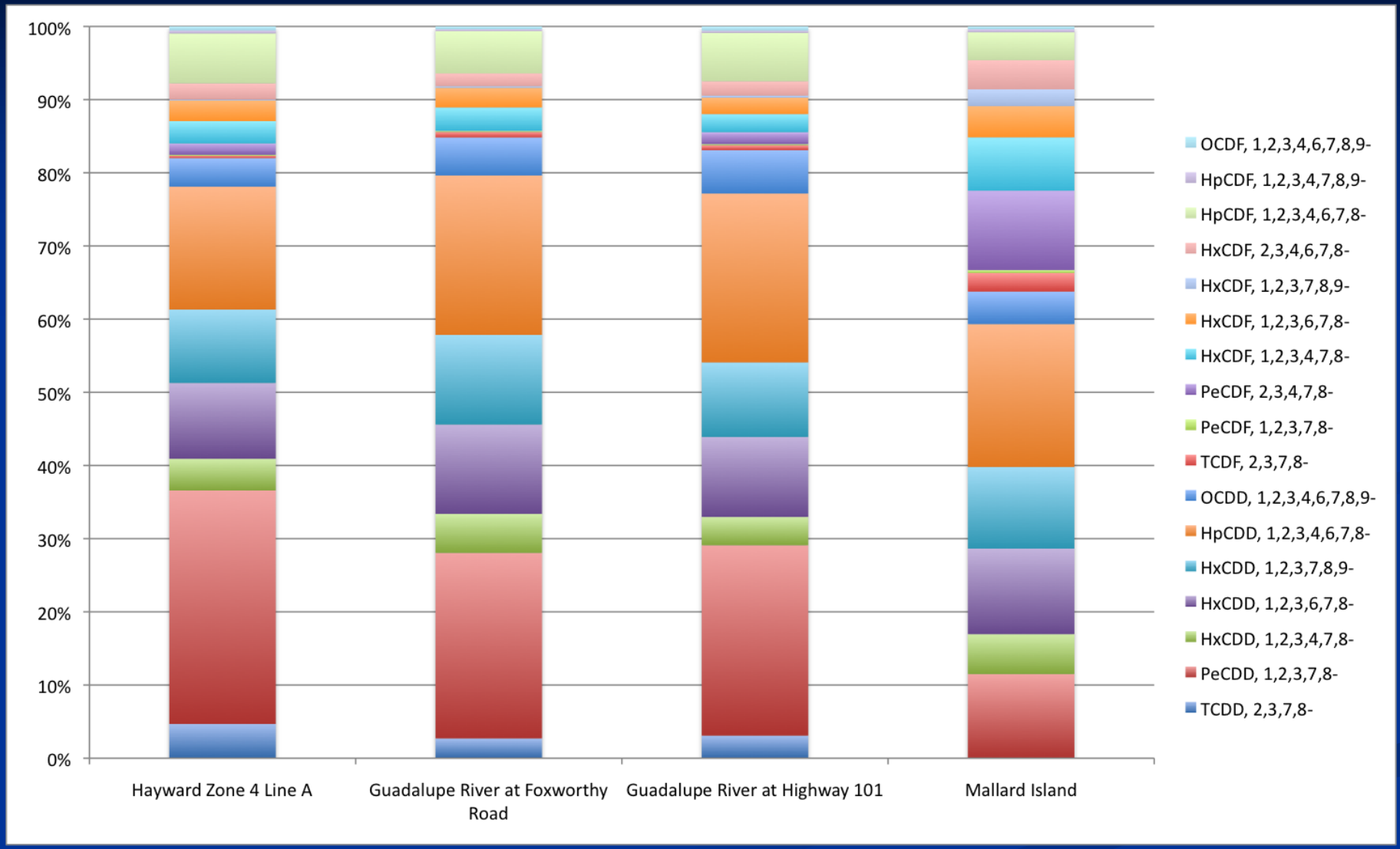
Comparisons between locations

Total Dioxins congener profile (pg/L)



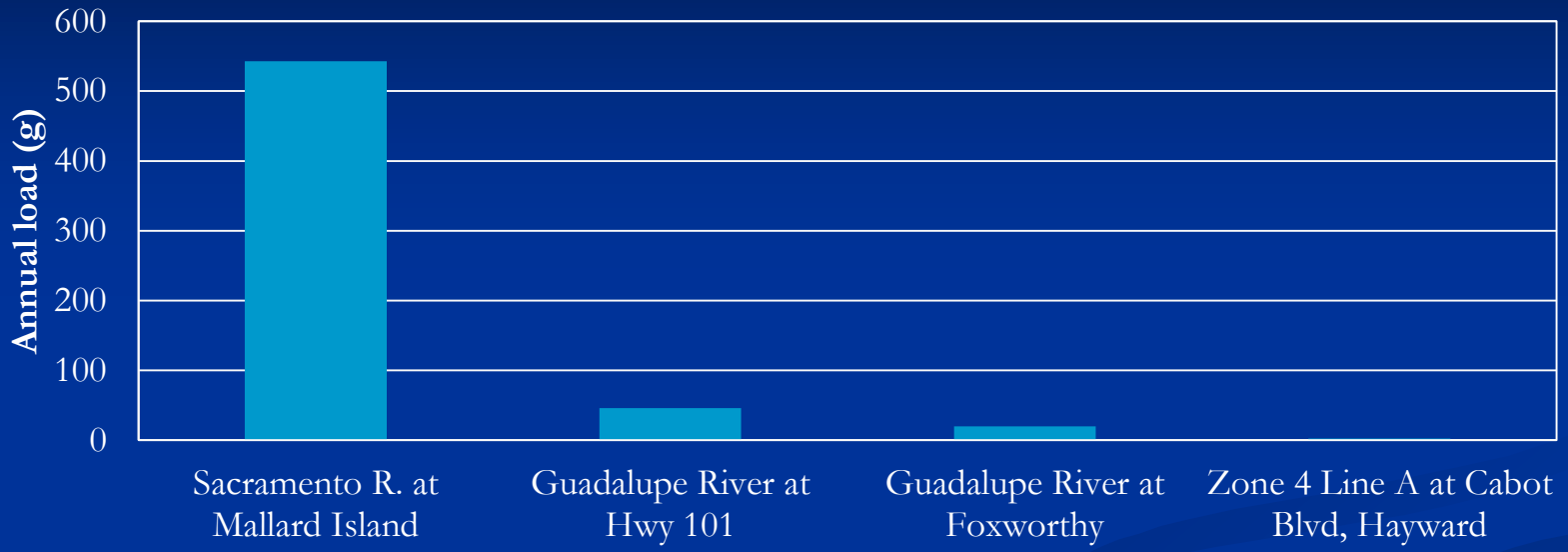
Preliminary data and analysis

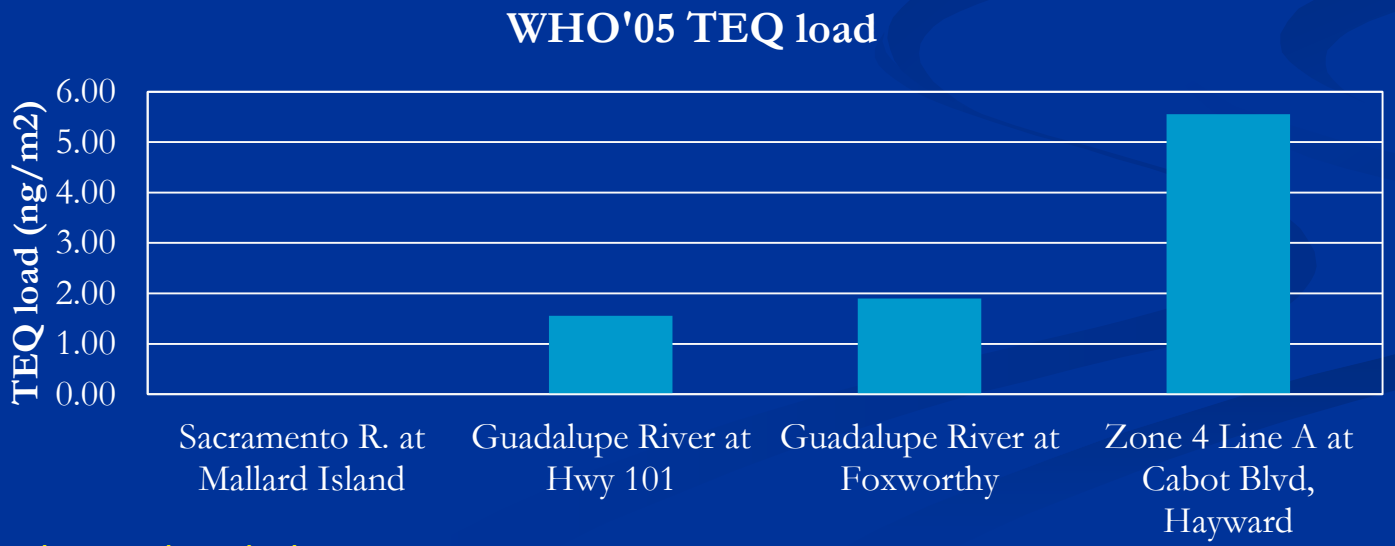
Total Dioxins (pg TEQ/L)



Preliminary data and analysis

Summary Loads (preliminary)





Preliminary data and analysis

Up-scaled TEQ loads

Preliminary draft for discussion purposes – waiting for peer-review

Locaition	Annual Load (g)	WHO'05 TEQ load (g)	Annual Load (ng/m2)	WHO'05 TEQ load (ng/m2)	Land use	Area (sqkm)	Annual Load (g)	WHO'05 TEQ load (g)
Sacramento R. at Mallard Island	543		3.5					
Guadalupe River at Hwy 101	46	0.37	192	1.55	"Urban"	2,130	409	3.3
Guadalupe River at Foxworthy	20	0.150	251	1.90	"Open / Ag"	4147	1039	7.9
Zone 4 Line A at Cabot Blvd, Hayward	2.3	0.0250	513	5.6	"Industrial"	374	192	2.08
					Total	6,651	1,640	13.3

Preliminary data and analysis

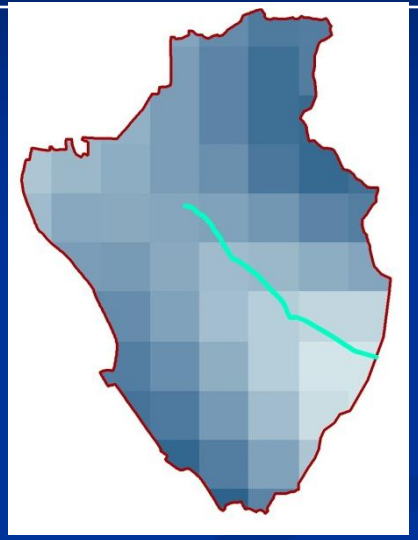
Improving estimates of regional loads – the spreadsheet model

Computing flow

Runoff Coefficient	x	Rainfall	=	Runoff

Approach 1
% impervious

x



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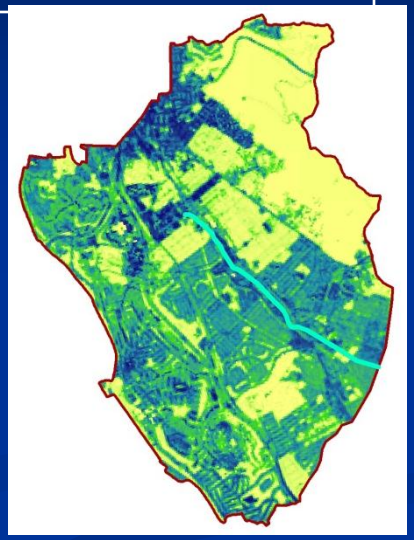
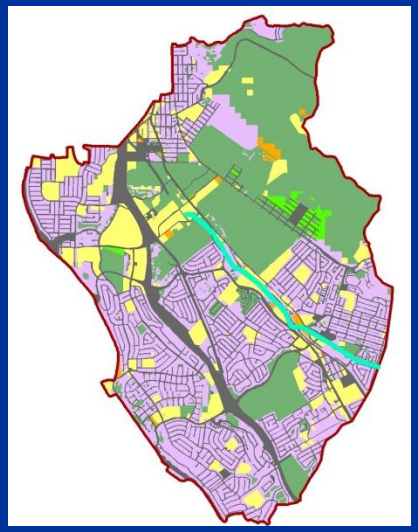
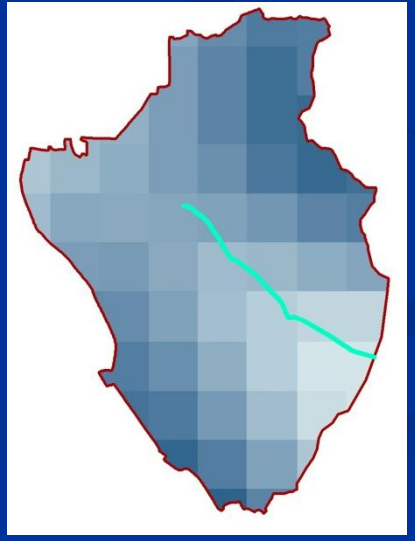


Approach 2
land use type



x



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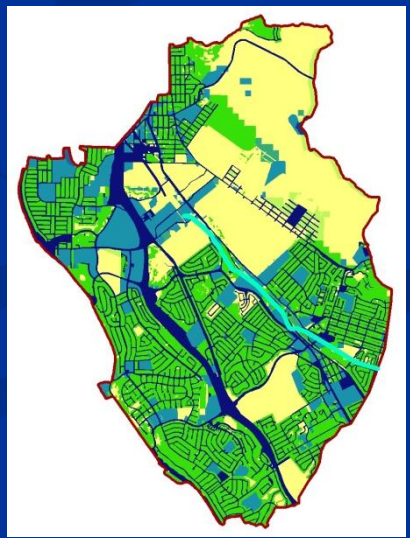
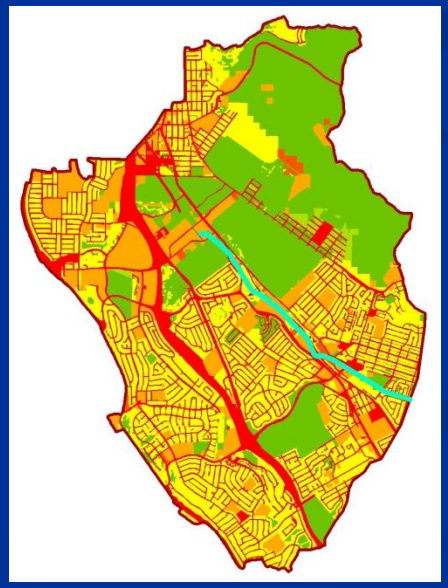


Computing loads

- Compile data on land-use / source specific pollutant concentrations
- Apply pollutant concentrations to generate loads:

Runoff volume	x	EMC	=	Load

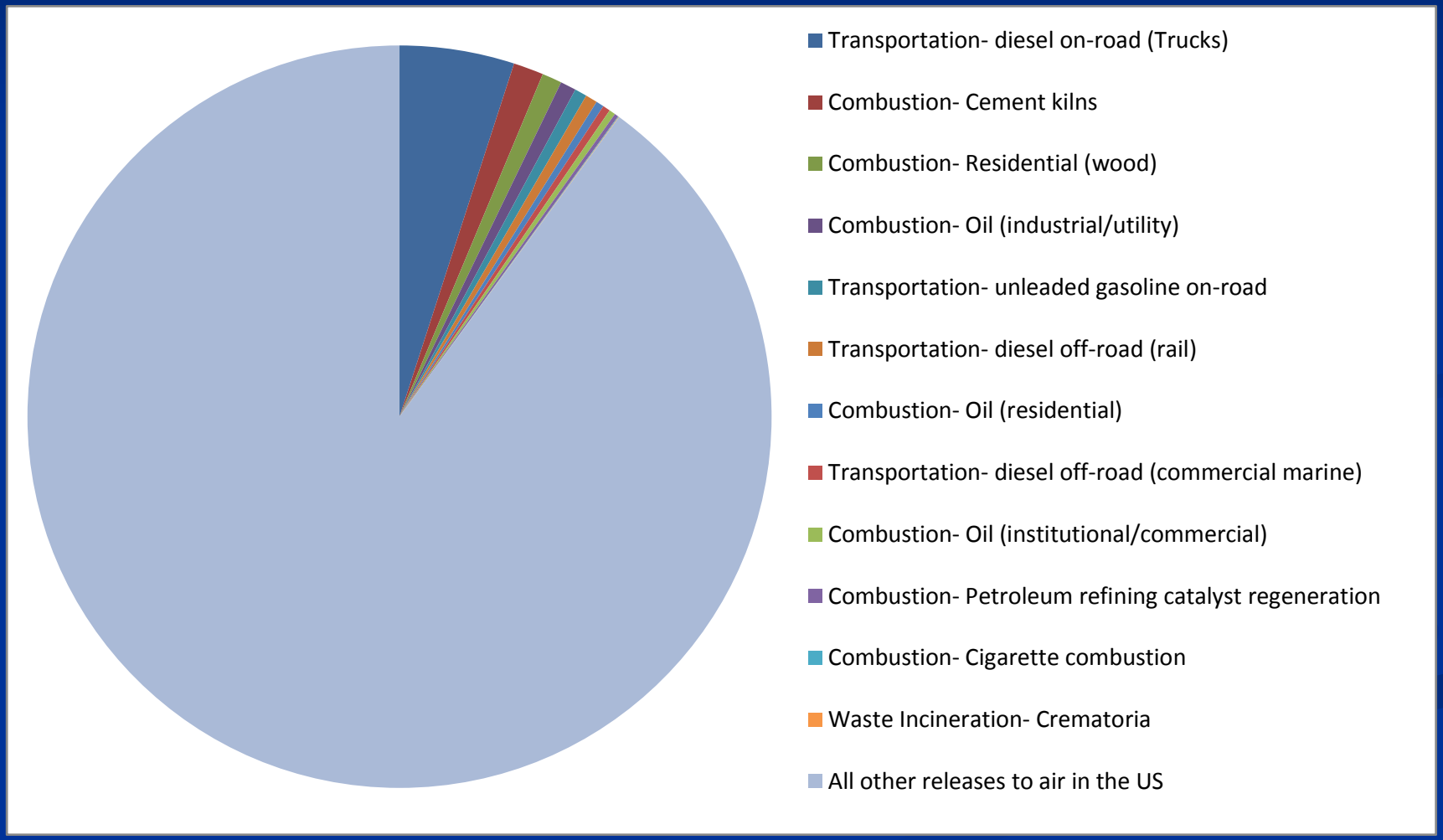


History and character

- Polychlorinated dibenzo-*p*-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) together form a series of 210 differently chlorinated compounds, or congeners, some of which are highly toxic
- Majority of the compounds are dibenzofurans
- Dioxins have never been produced for any commercial use, introduction via:
  - Impurities that result during the synthesis and chlorinated compounds
  - fossil fuel combustion
- Dioxins and furans form during combustion in the presence of
  - organic carbon, chlorine, and metals.
  - Some pass through occurs due to due to suboptimal temperatures and residence times
  - Most PCDDs and PCDFs form in the post combustion environment
    - gaseous phase
    - In the fly ash in the presence of $CuCl_2$ or other transition metals

National inventory (USEPA, 2006)

(Sources left itemized provide a source profile for the Bay Area)



Preliminary data and analysis

Available local data (pg/L)

Land Use Category	Reference	Loc.	Avg conc, EMC, or FWMC?	Minimum	Maximum	"Central tendency"
Industrial	Hunt and McKee, unpublished	Richmond pump station, Richmond, CA		10	19023	??
Urban	Gilbreath et al., 2011	Zone 4 Line A, Hayward, CA	FWMC	225	6,254	3606
Urban	Wenning et al., 1999	Benicia, CA	Median	18	3,005	68
Urban	Wenning et al., 1999	Oakland, CA	Median	42	10532	2382
Urban	Wenning et al., 1999	Sunnyvale channel, CA			2548	
Mixed	McKee et al., unpublished	Guadalupe R. (Hwy 101), San Jose, CA	FWMC	205	4246	845
Mixed	David et al., 2011	Sacramento R. at Mallard Is., CA		12	35	25
Mixed	McKee et al., unpublished	Guadalupe R. (Foxworthy), San Jose, CA	FWMC	39	3040	887
Mixed	Wenning et al., 1999	Fairfield, CA			164	
Mixed	Wenning et al., 1999	Guadalupe River, CA			1947	
Mixed	Wenning et al., 1999	CC channel, CA			1171	
Mixed	Wenning et al., 1999	Rheem Creek, CA			2704	

A story there?

- Studies limited (mostly not EMC) and pilot scale…
  - Highest at the Richmond pump station perhaps because of in situation near an oil refinery, rail yards, and the Port of Richmond?
  - Concentrations were also very high in Oakland samples perhaps because of the proximity to the rail yards and the Port of Oakland?
  - Concentrations appear to be intermediate in other general urban settings and lower in mixed and larger river settings.

Proposed local source areas

- Based on a review of USEPA source inventory and local "EMC" (concentration) data
  - Cement manufacture
  - Oil refining
  - Port and rail transport
  - Freeways

Preliminary recommendations for improved regional loads interpolation

Step 1: Conduct a thorough review of world literature and classify data into general urban categories (Industrial, other urban, mixed, and rural. Be critical of urban systems where there are known local point sources. Simultaneously review the urban soils literature to improve classification again ensuring point source influences are considered so that the data can be correctly interpreted for the Bay Area.

Step 2: Put effort into back calculating EMCs for spreadsheet model development using soils and water concentration information from the literature search.

Step 3: Evaluate model weaknesses through a sensitivity analysis (combinations of more and less source area classes and reasonable ranges of EMCs for each source class, hybrid models) and do further back calculations, literature search or design a field program to target weaknesses in model parameterization.

Acknowledgements

Funding

- Guadalupe River: RMP and Santa Clara Valley Water District
- Zone 4 Line A: RMP
- Sacramento River at Mallard Island: RMP

Oversight

- SPLWG