SUPPLEMENTAL MATERIALS

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Hydrodynamic Simulations for Trash Loading in Southern California's Dense Urbanized Watersheds

Kian Bagheri, Hassan Davani, Trent Biggs, and Hilary McMillan

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Sensitivity Analysis/ Model Calibration

The Morris modified screening method has been utilized in hydrologic models to test sensitivity and was selected as the method for our study (Equation S1). Baseline parameters were selected based on initial estimates. Parameters were then adjusted in 5% increments. The SA was conducted for a lumped model using a single land use rather than a distributed model with multiple land uses. The SA was conducted for each parameter (B_{max}, K_B, K_w, N_w).

$$S = \frac{1}{n-1}\sum_{i=0}^{n-1}\frac{(y_{i+1}-y_i)/y_0}{(d_{i+1}-d_i)/100} \qquad \text{(S1)}$$

where

S = parameter sensitivity index

y_i = the output after the parameter is changed for the ith model run

y_{i+1} = the output after the parameter is changed for the i+1th model run

y_0 = is the simulated initial value of the model output

d_i = the incremental change in the model parameter for the ith model run

d_{i+1} = the incremental change in the model parameter for the i+1th model run

n = number of simulations

The Environmental Protection Agency's Storm Water Management Model (SWMM) manual (2016), also referred as Rossman (2016), acknowledges that simulation of urban runoff quality is inexact, where large uncertainties arise when developing and representing processes. Therefore, local data needs to be used for calibration and validation, and if given sufficient data, the equations used in these models may usually be manipulated to reproduce measured concentrations and loads (Rossman, 2016). It may be difficult to calibrate washoff paramters to match observed data on a storm by storm basis (Rossman, 2016). We tested this by modeling litter washoff for commercial land use in the LARW. With our developed washoff parameters, we ran the model for the two sampling years, from November 10th through May 5th (2002-2003) and November 3rd through April 5th (2003-2004). The time period used for validation was from July 2016 to November 2017, based on the San Diego Special Study (Michael Baker International, 2018).

Rather than calibrate for individual storm events, a group of storm events, 9 storms from 2002-2003 and 5 storms in 2003-2004, were simulated and a target annual loading value was used for calibration. The same washoff parameters developed for the LARW were used in the BCW. The available data did not clearly depict how many days led up to the first storm event once trash capture devices were installed; therefore, the first flush of the season was not included in our analysis. An average of the calibrated parameters was applied to model litter loading for the LSDRW. In our case, simulation results were calibrated to be within an acceptable percent difference from the predicted estimates based on observed data.

Furthermore, information on the remaining buildup and storage in the watershed after a storm event is lacking in the literature. Without data on the residual buildup after a storm, it is difficult to calibrate and validate washoff parameters.

Figures in this section show linear and power trend lines for the average washoff loads for each land use, sampling year, and watershed. Additionally, figures show washoff loads in each land use, watershed, and sampling year across all sampling sites. For the figures that show washoff loads across all site locations, the legend shows the site names. These site names follow the convention presented by the LA County Baseline Monitoring Study (2004).

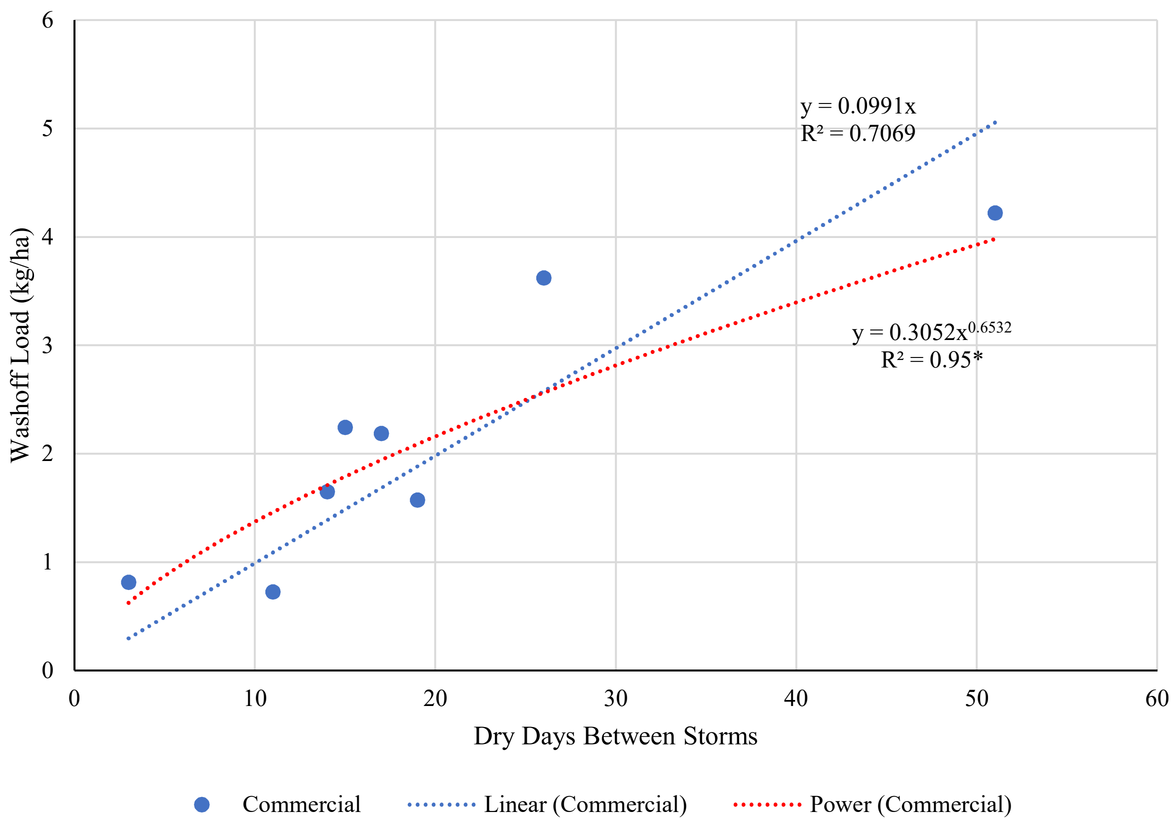

Figure S1. Linear and Power Trendline for Average Washoff Load: Commercial Land Use LARW 2002-2003. Asterisk indicates manually calculated R^2 value.

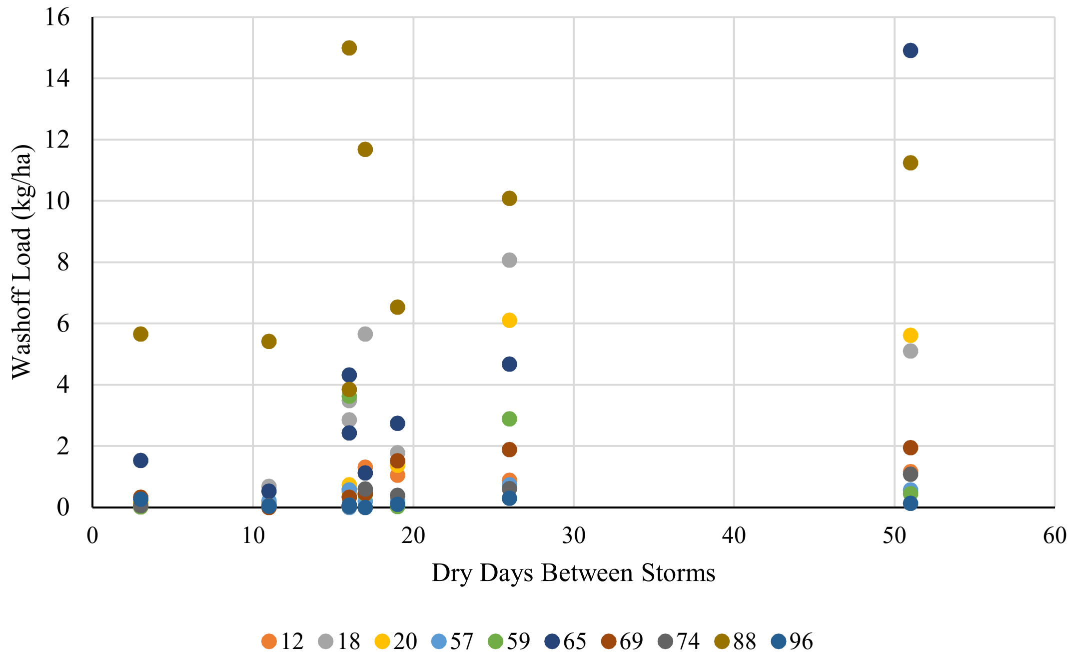

Figure S2. Washoff for Commercial Land Use LARW 2002-2003. The average values from each storm were used to determine trend lines in Figure S1.

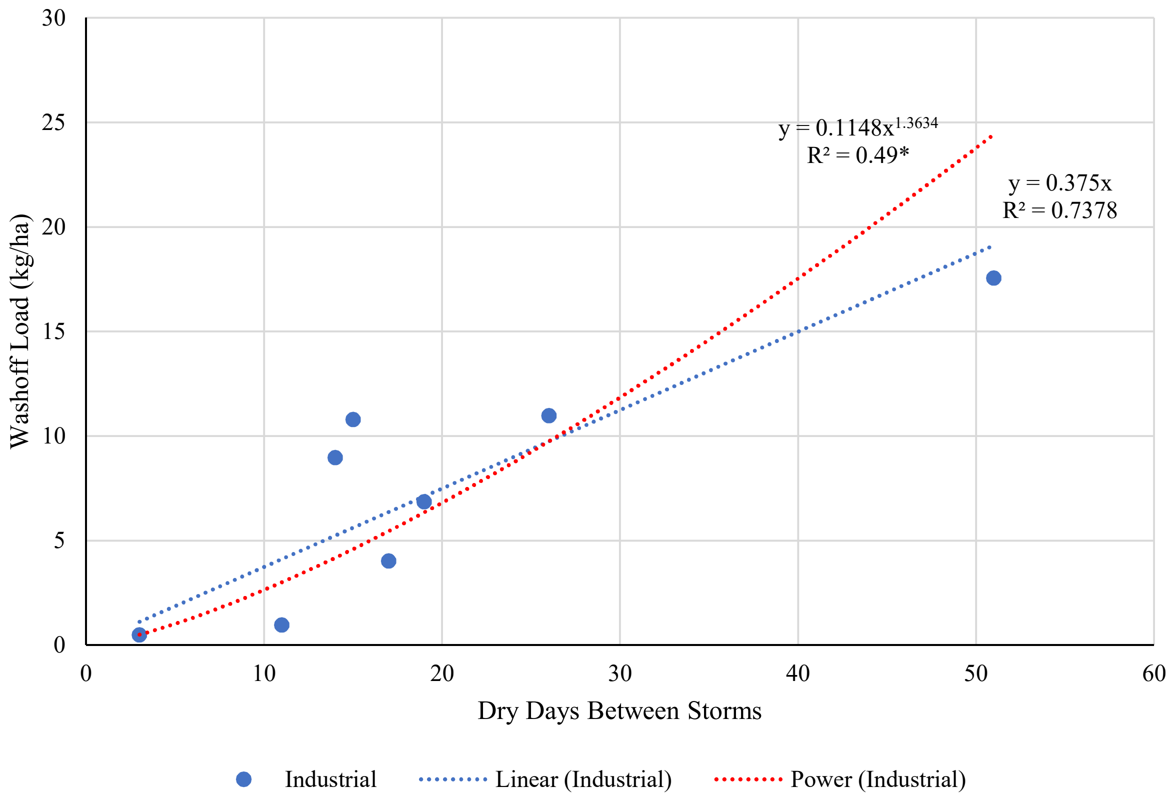

Figure S3. Linear and Power Trendline for Average Washoff Load: Industrial Land Use LARW 2002-2003. Asterisk indicates manually calculated R^2 value.

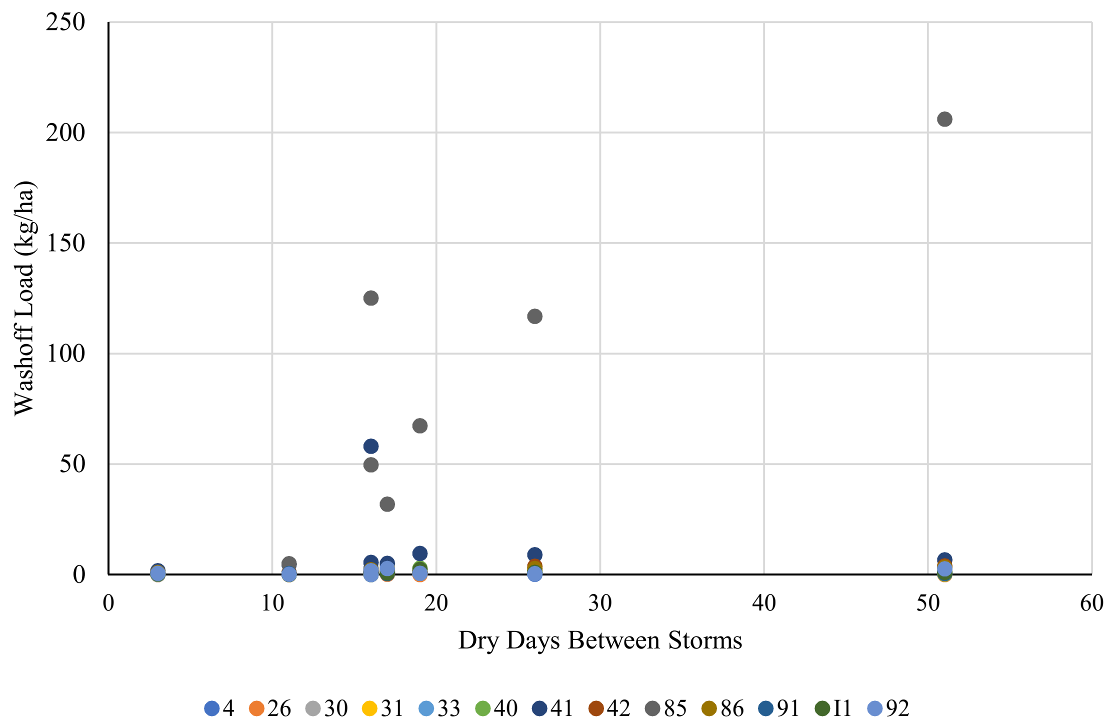

Figure S4. Washoff for Industrial Land Use LARW 2002-2003. The average values from each storm were used to determine trend lines in Figure S3.

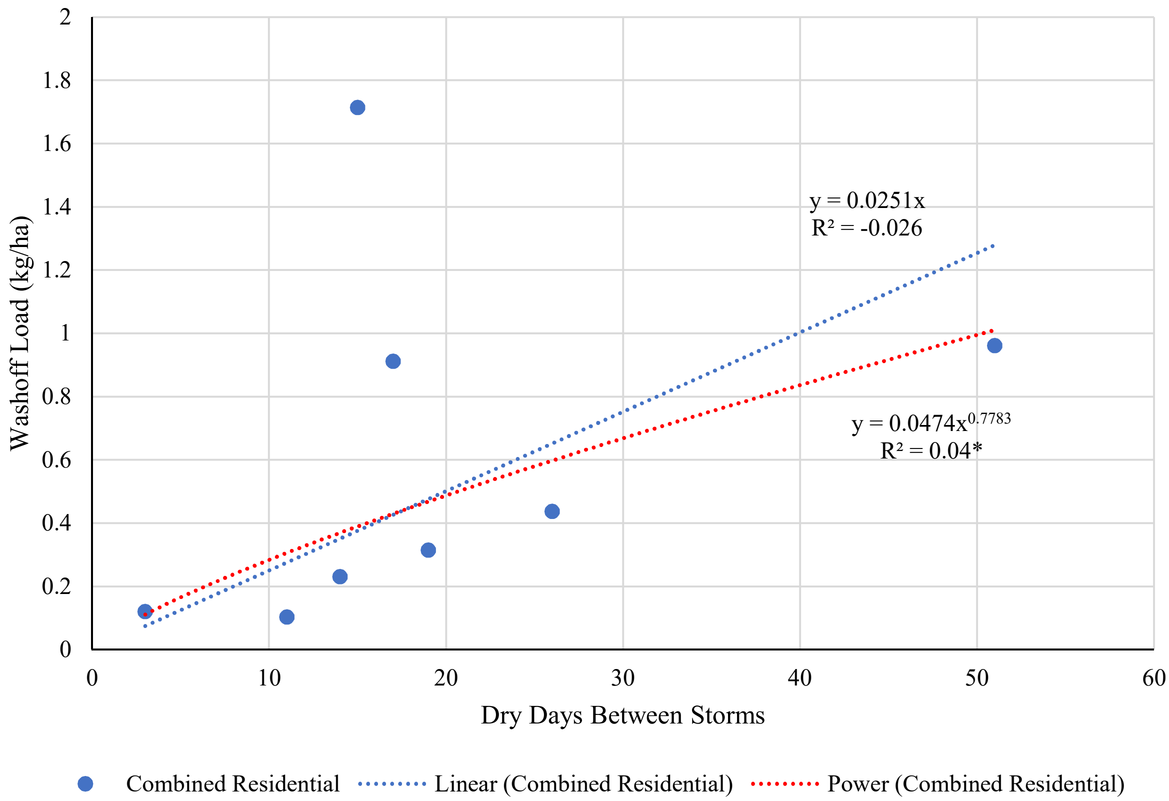

Figure S5. Linear and Power Trendline for Average Washoff Load: Combined Residential Land Use LARW 2002-2003. Asterisk indicates manually calculated R^2 value.

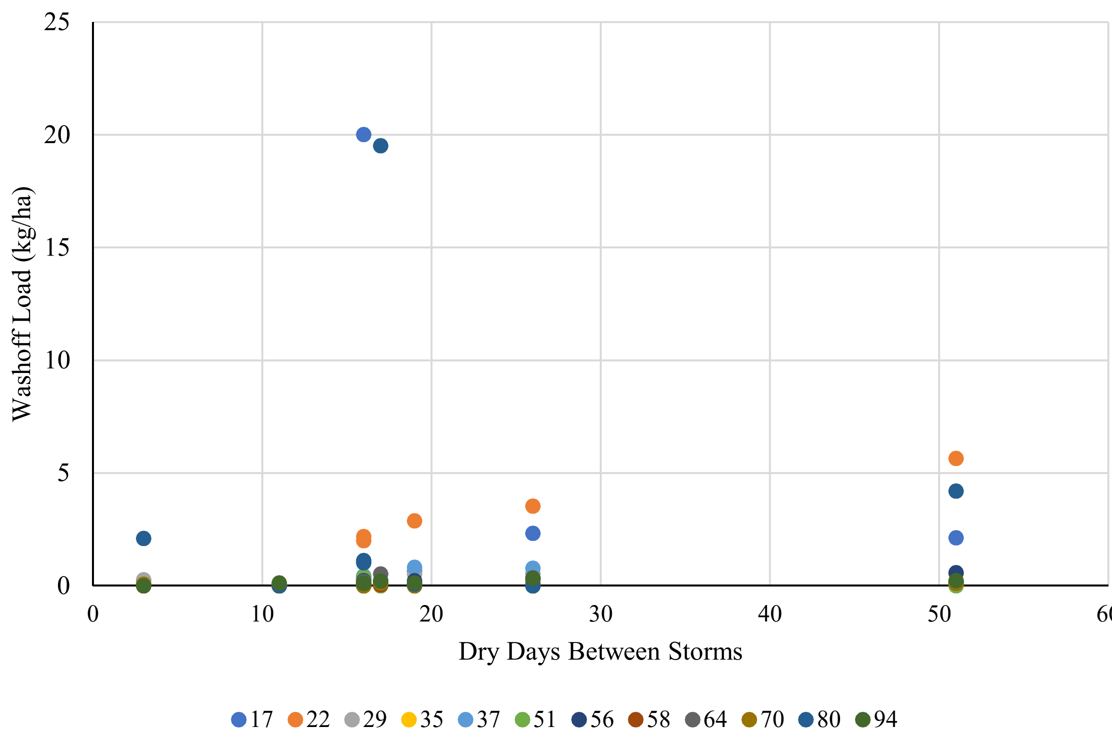

Figure S6. Washoff for HDSF Residential Land Use LARW 2002-2003. The average values for HDSF and LDSF (next plot) were calculated from each storm and used to determine trend lines in Figure S5.

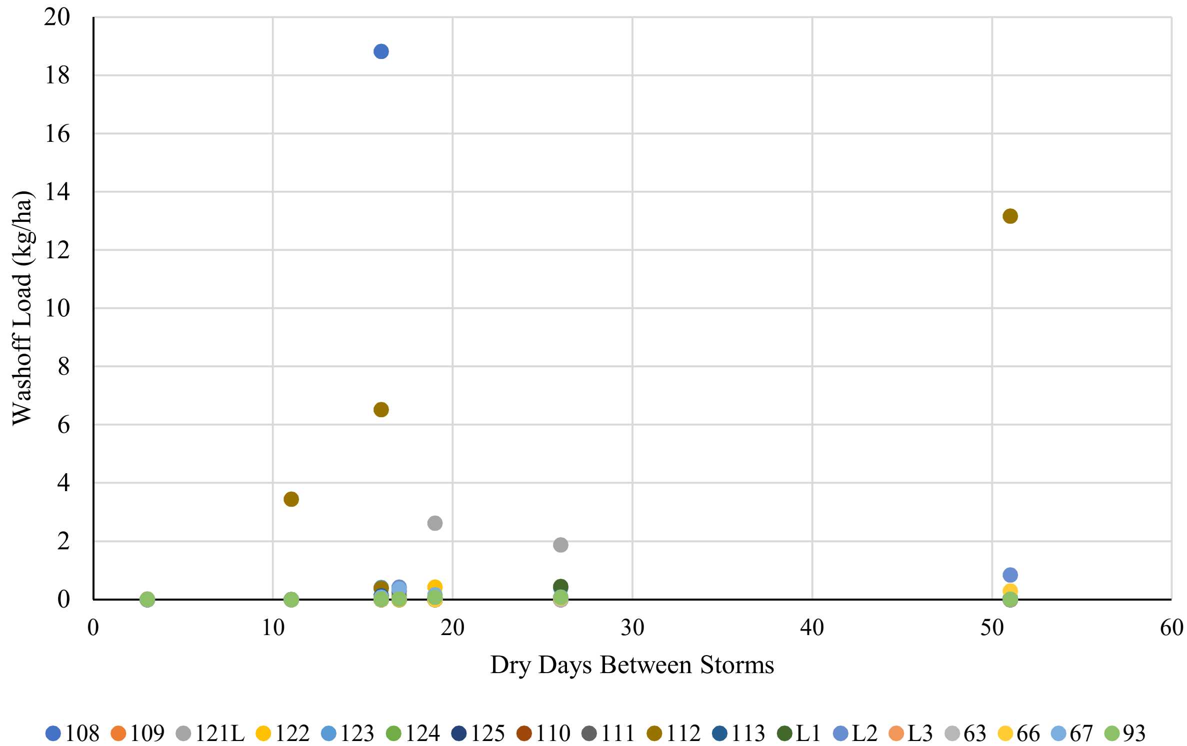

Figure S7. Washoff for LDSF Residential Land Use LARW 2002-2003. The average values for HDSF and LDSF were calculated from each storm and used to determine trend lines Figure S5.

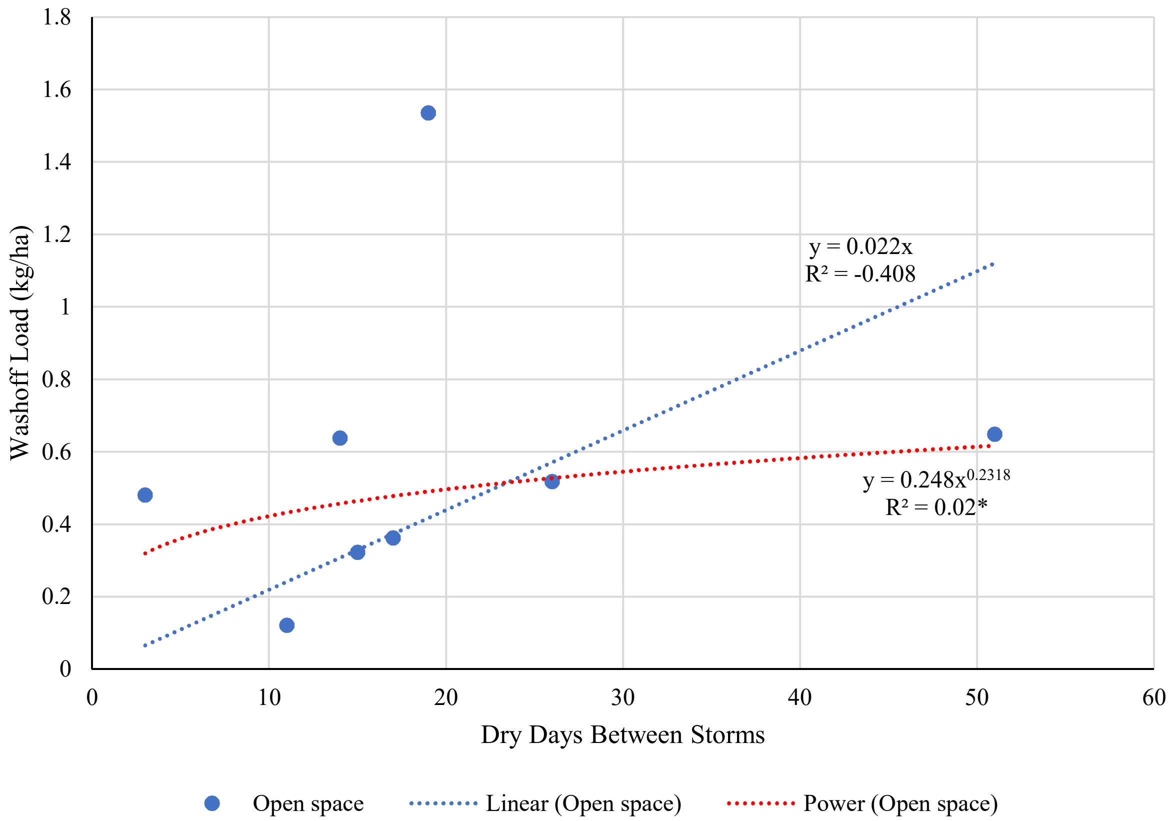

Figure S8. Linear and Power Trendline for Average Washoff Load: Open Space Land Use LARW 2002-2003. Asterisk indicates manually calculated R^2 value.

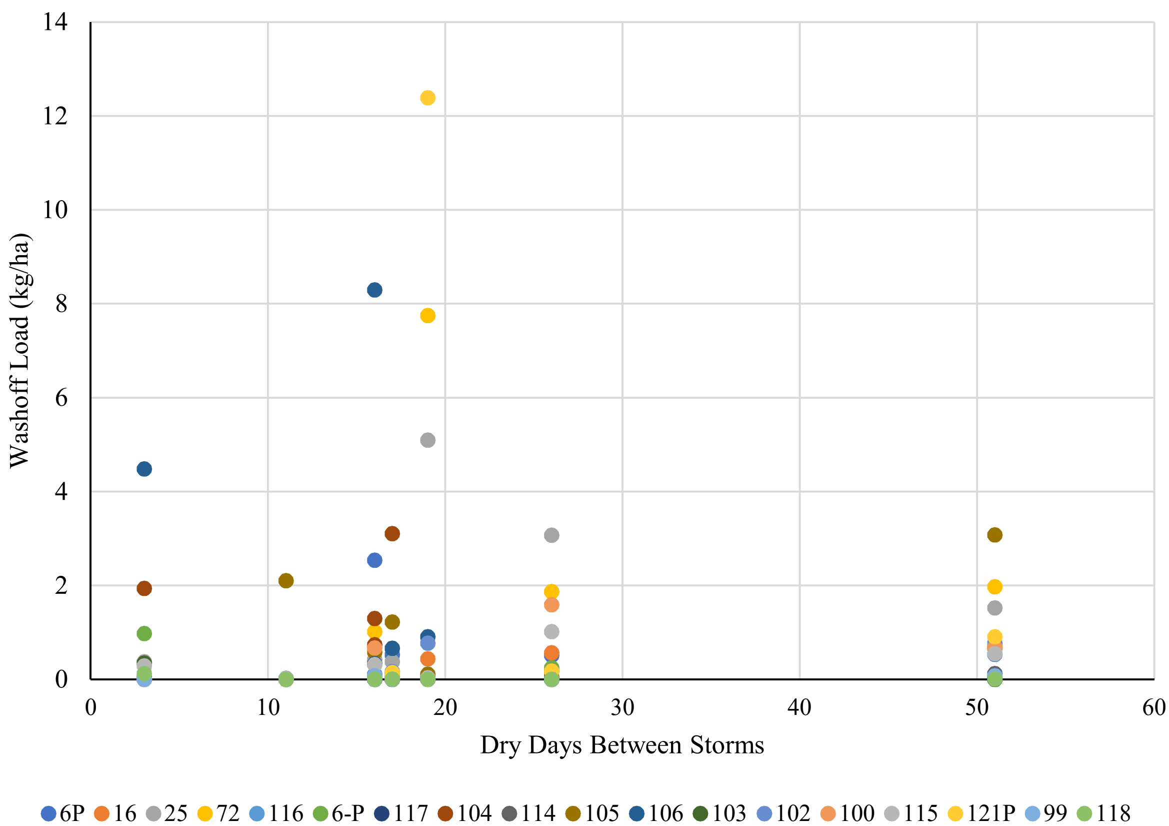

Figure S9. Washoff for Open Space Land Use LARW 2002-2003. The average values from each storm were used to determine trend lines in Figure S8.

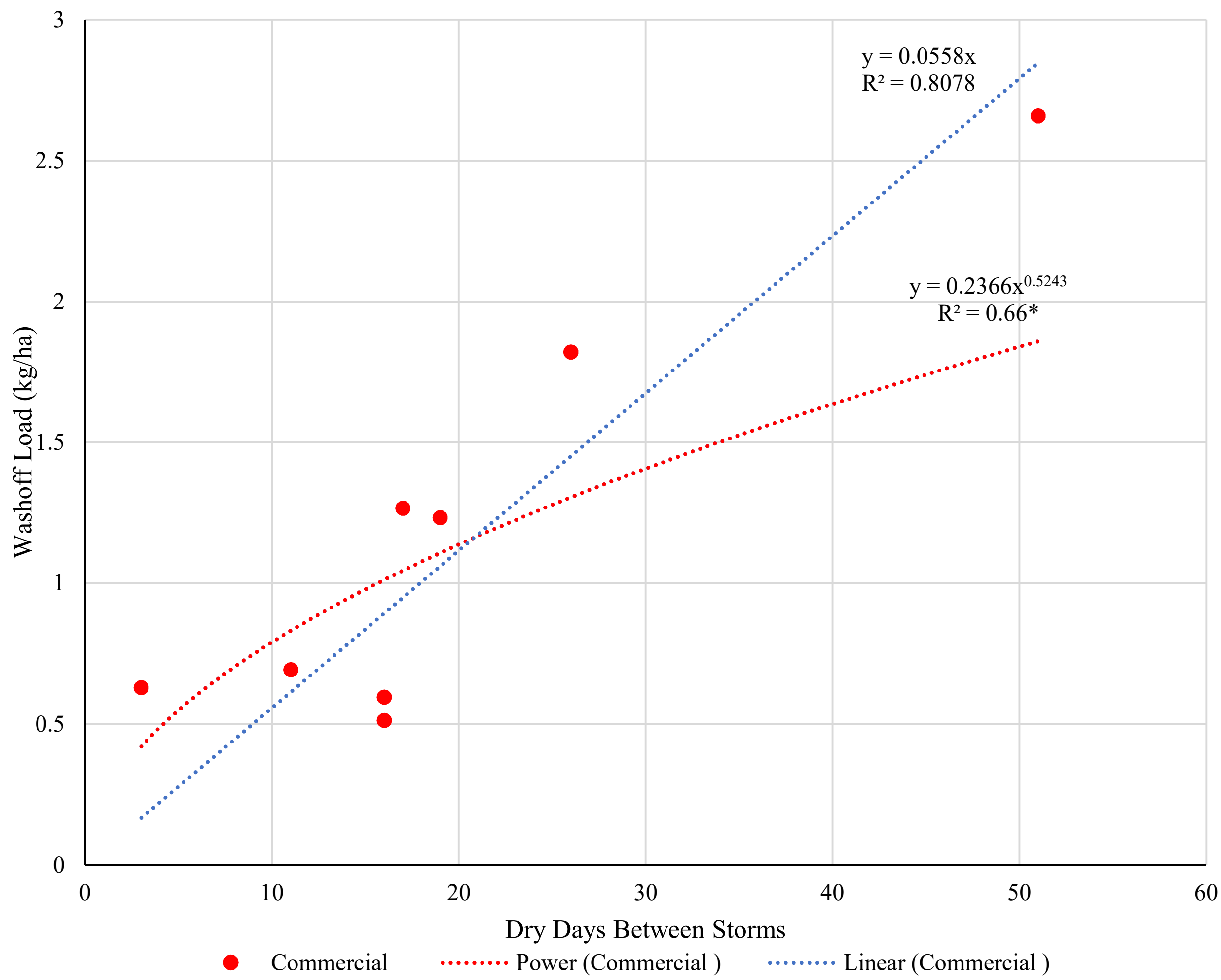

Figure S10. Linear and Power Trendline for Average Washoff Load: Commercial Land Use BCW 2002-2003. Asterisk indicates manually calculated R^2 value.

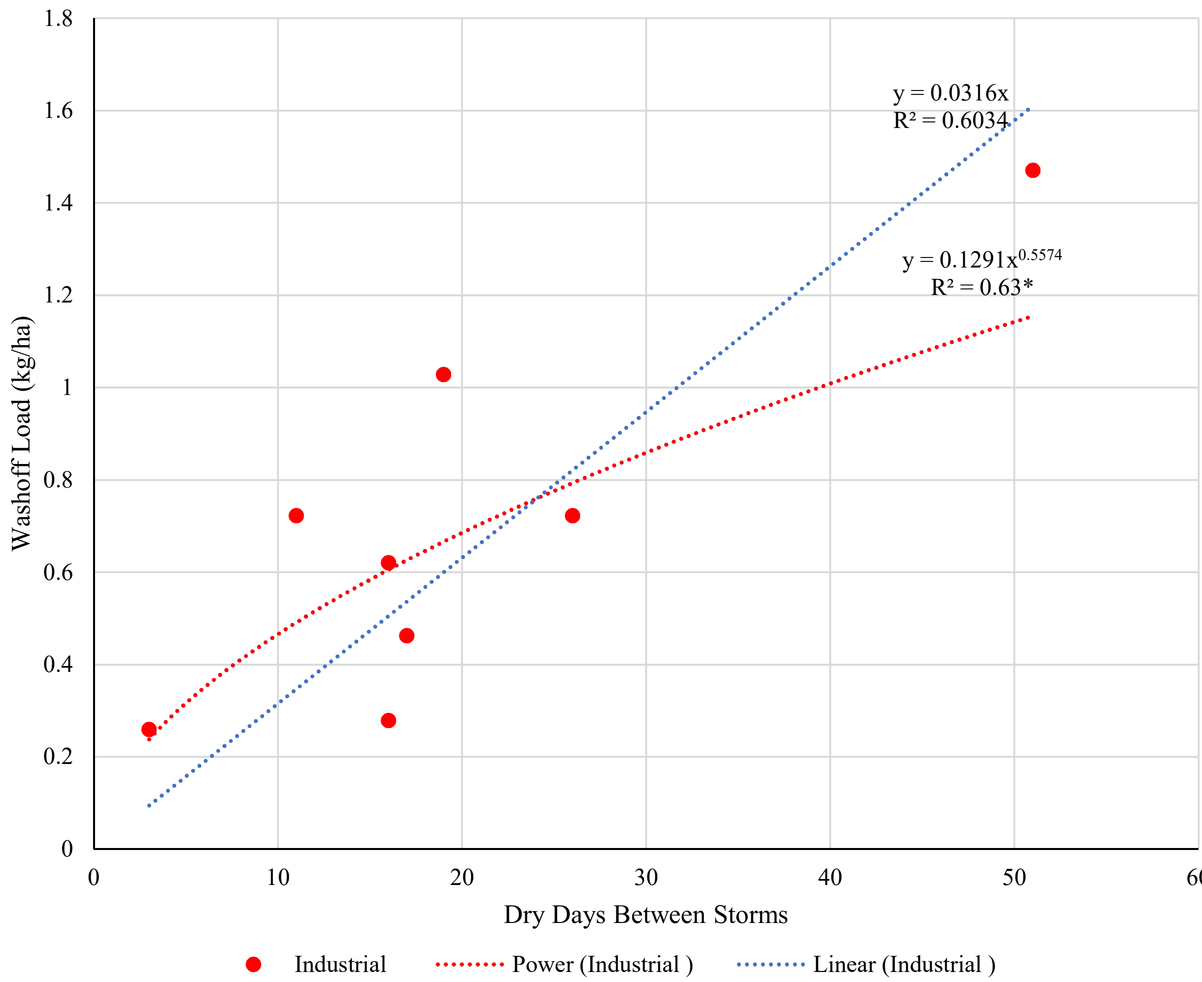

Figure S11. Linear and Power Trendline for Average Washoff Load: Industrial Land Use BCW 2002-2003. Asterisk indicates manually calculated R^2 value.

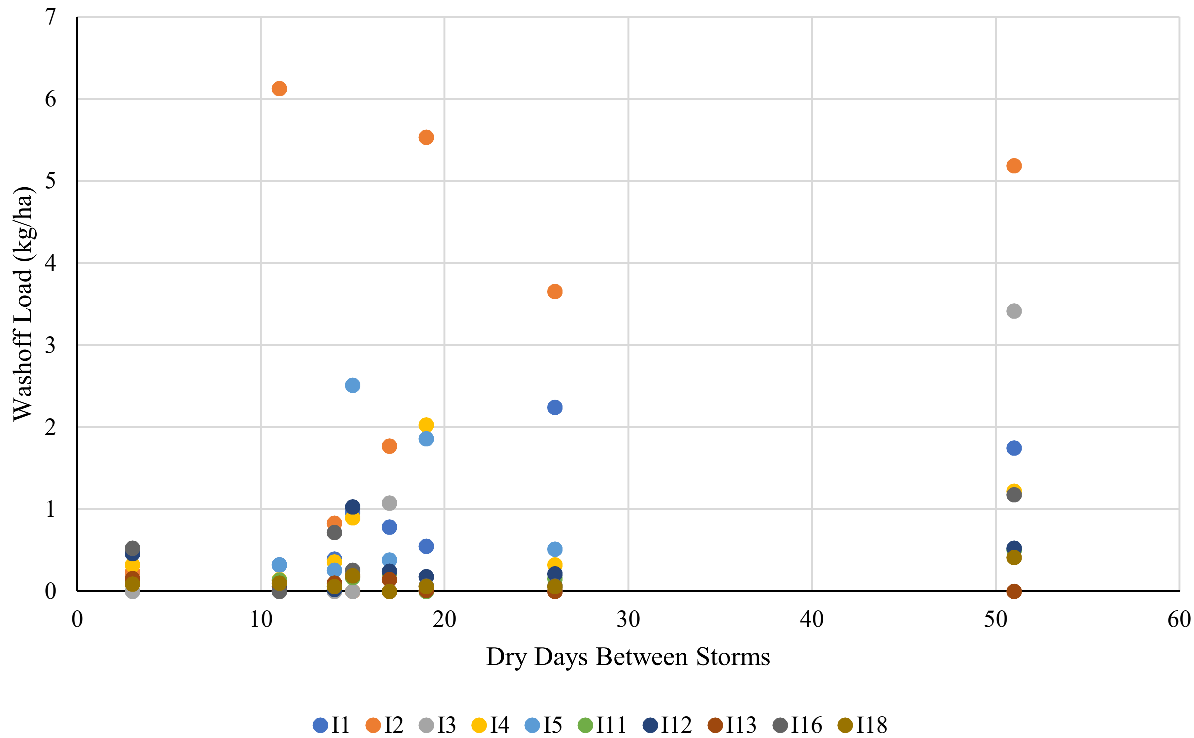

Figure S12. Washoff for Industrial Land Use BCW 2002-2003. The average values from each storm were used to determine trend lines in Figure S11.

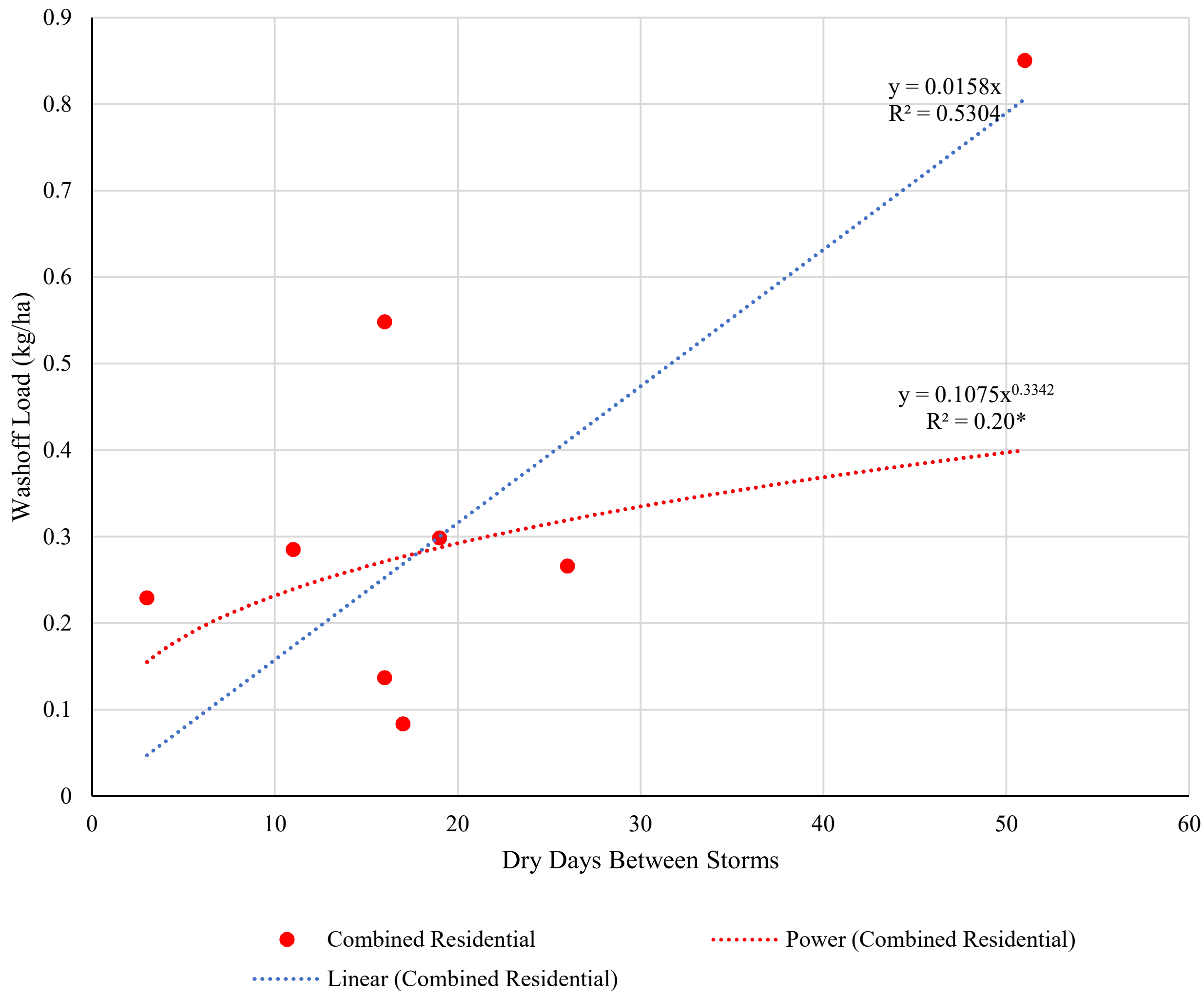

Figure S13. Linear and Power Trendline for Average Washoff Load: Combined Residential Land Use BCW 2002-2003. Asterisk indicates manually calculated R^2 value.

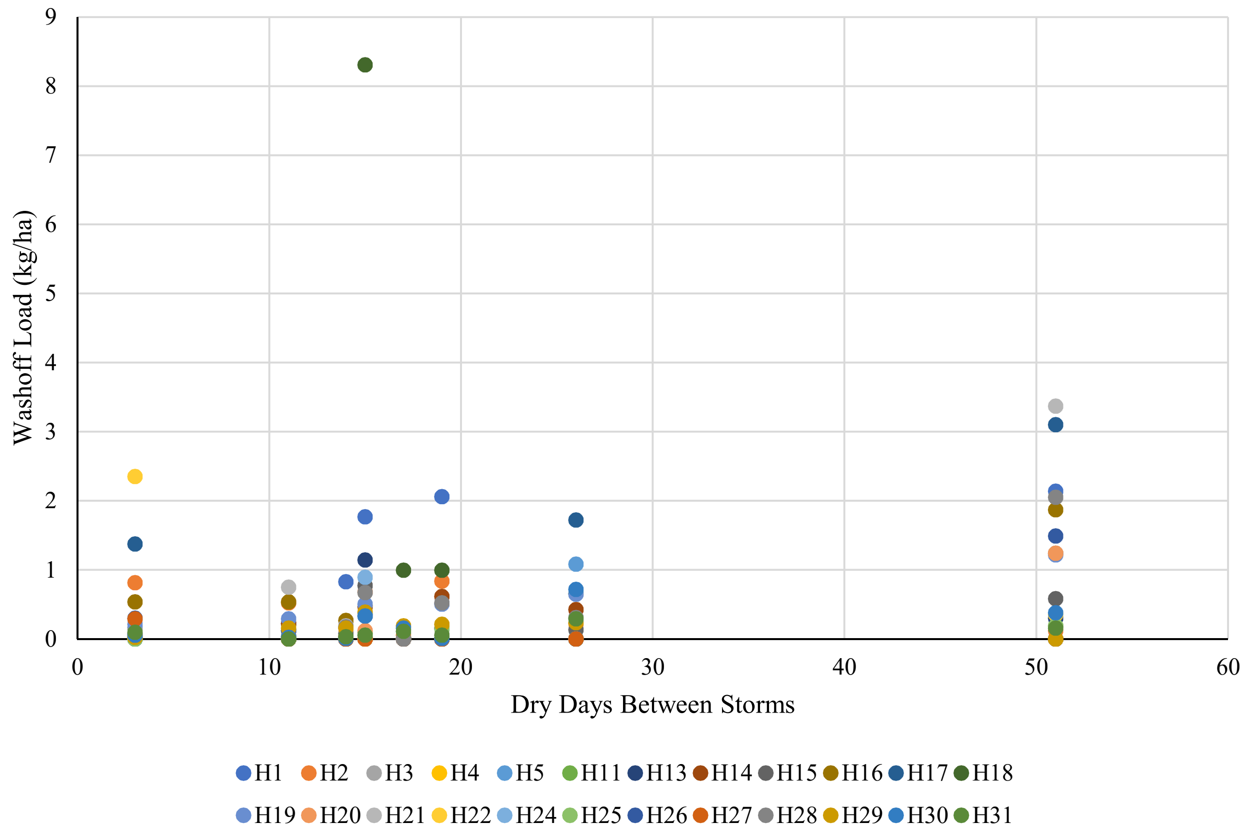

Figure S14. HDSF Residential Land Use BCW 2002-2003. The average values for HDSF and LDSF (next plot) were calculated from each storm and used to determine trend lines in Figure S13.

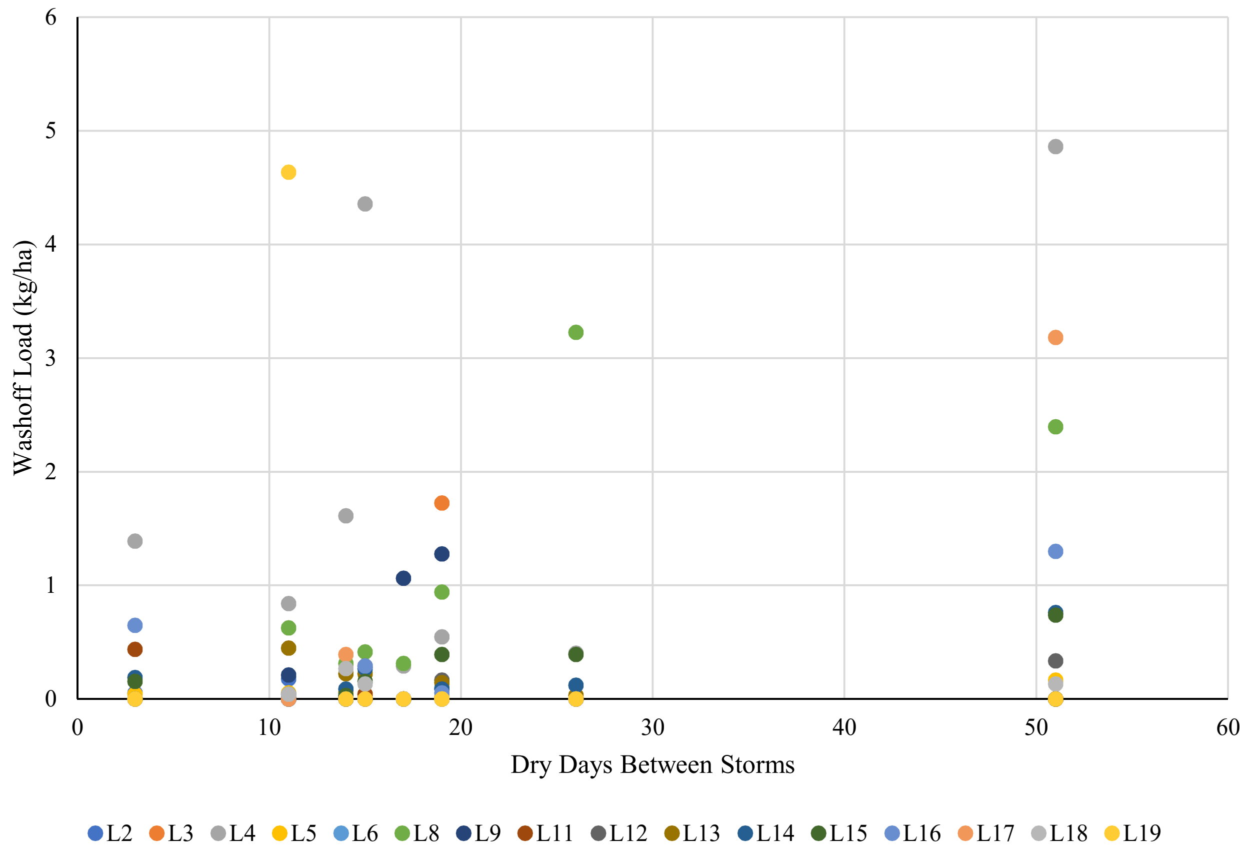

Figure S15. LDSF Residential Land Use BCW 2002-2003 The average values for HDSF and LDSF were calculated from each storm and used to determine trend lines in Figure S13.

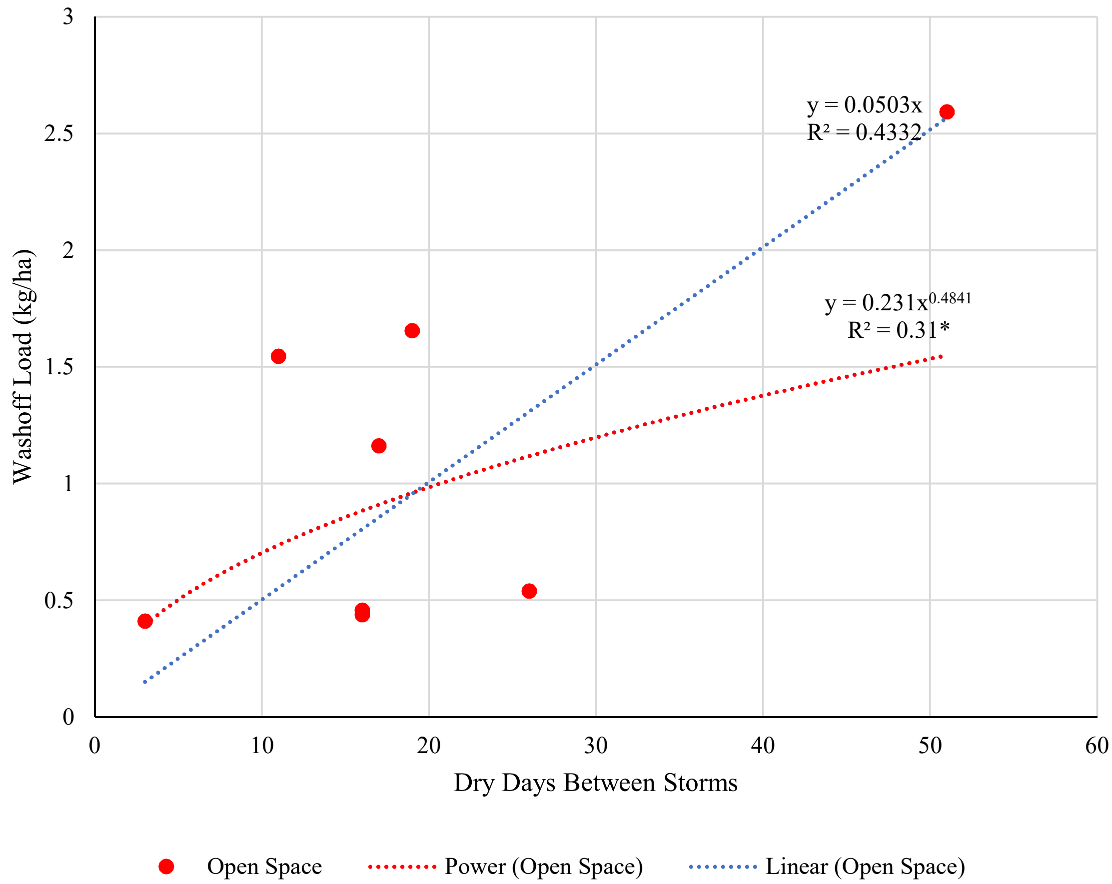

Figure S16. Linear and Power Trendline for Average Washoff Load: Open Space Residential Land Use BCW 2002-2003. Asterisk indicates manually calculated R^2 value.

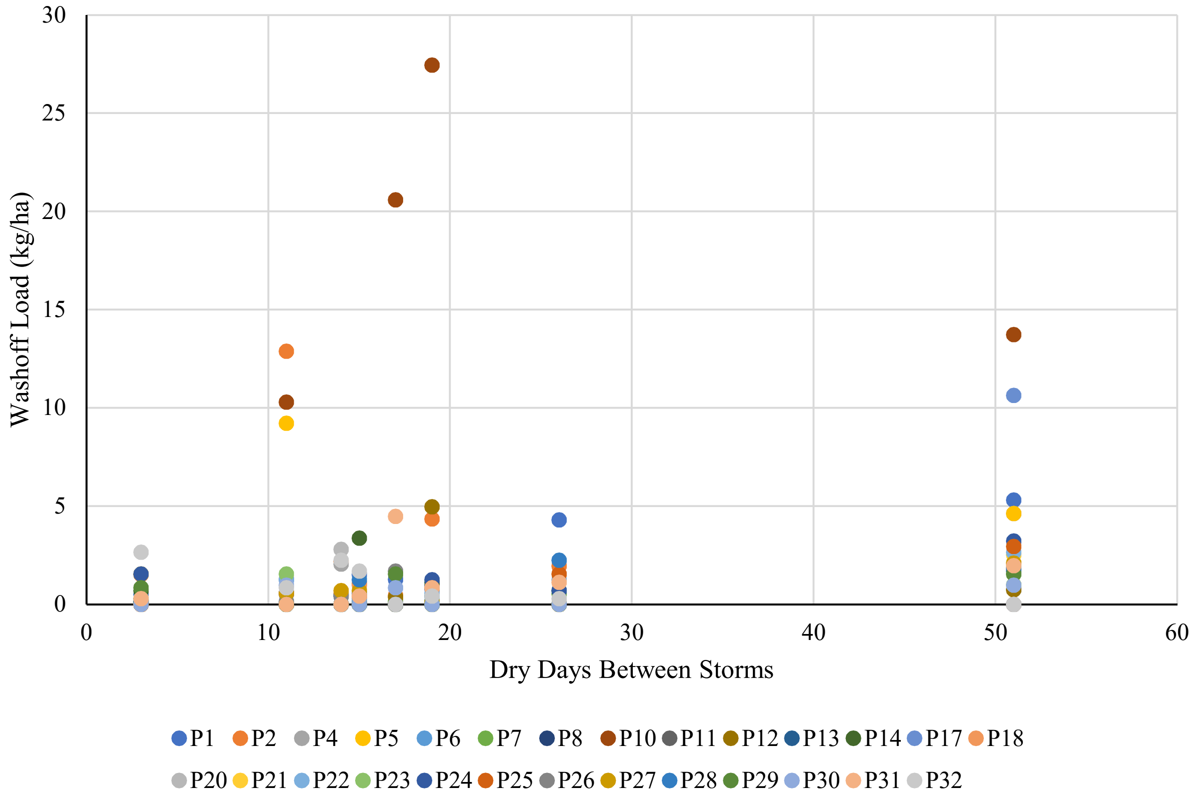

Figure S17. Open Space BCW 2002-2003. The average values from each storm were used to determine trend lines in Figure S16.

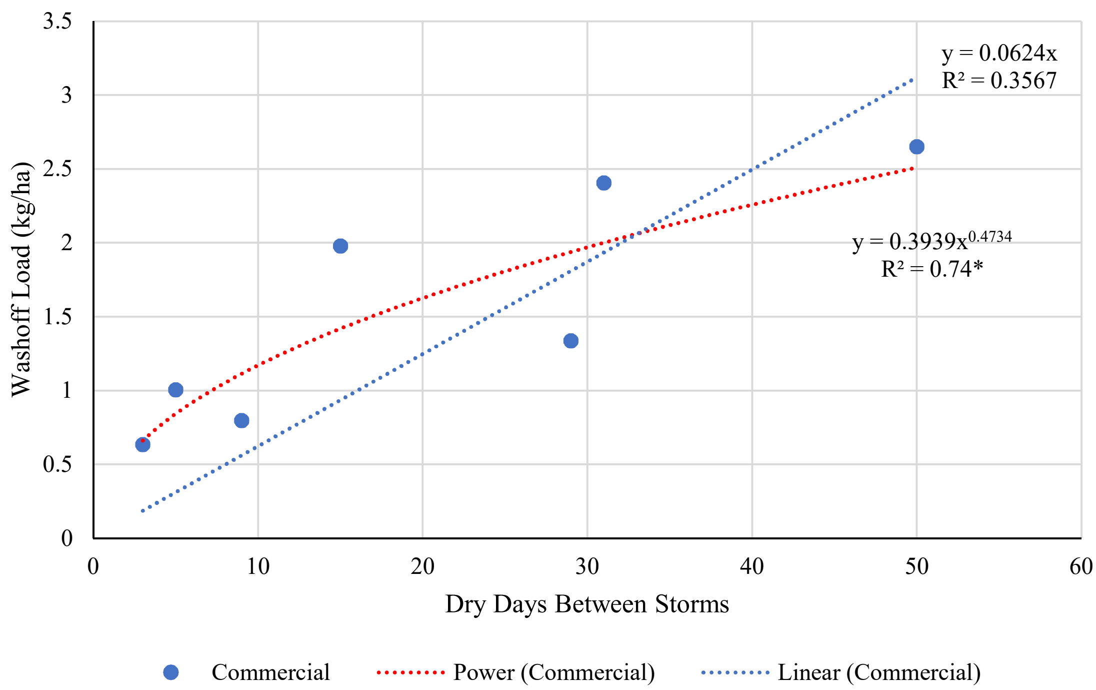

Figure S18. Linear and Power Trendline for Average Washoff Load: Commercial Land Use LARW 2003-2004. Asterisk indicates manually calculated R^2 value.

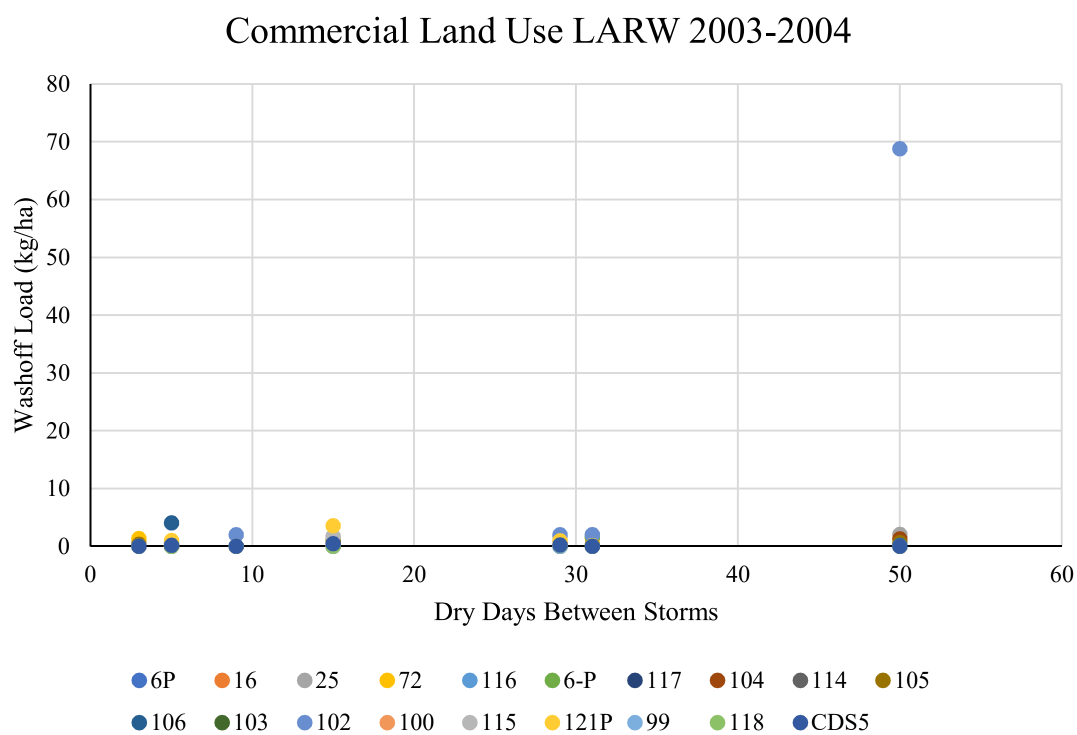

Figure S19. Commercial Land Use LARW 2003-2004. The average values from each storm were used to determine trend lines in Figure S18.

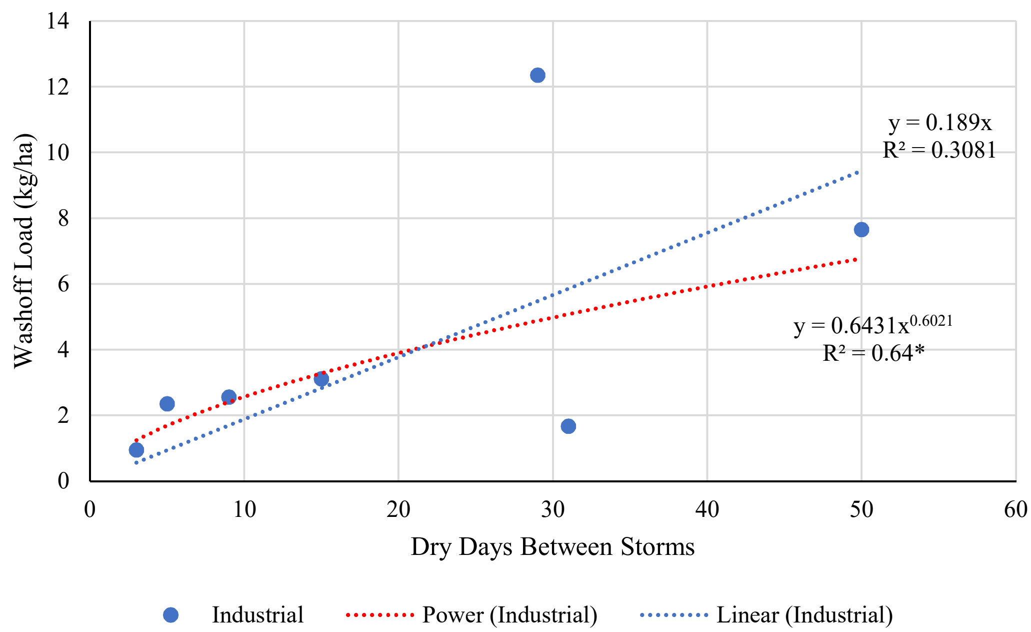

Figure S20. Linear and Power Trendline for Average Washoff Load: Industrial Land Use LARW 2003-2004. Asterisk indicates manually calculated R^2 value.

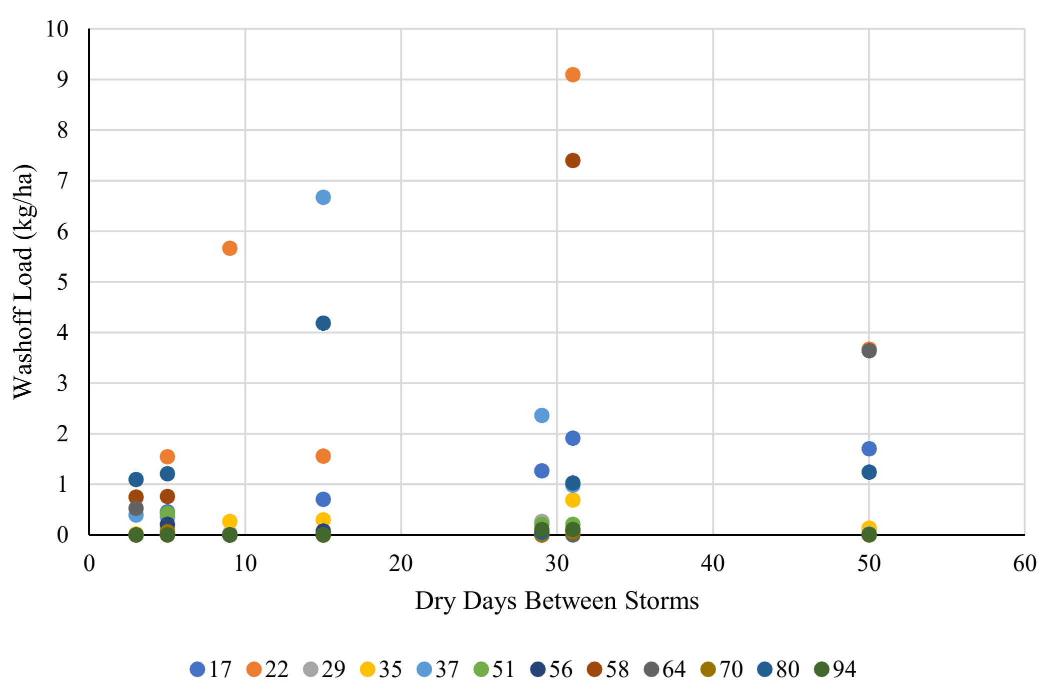

Figure S21. Industrial Land Use LARW 2003-2004. The average values from each storm were used to determine trend lines in Figure S20.

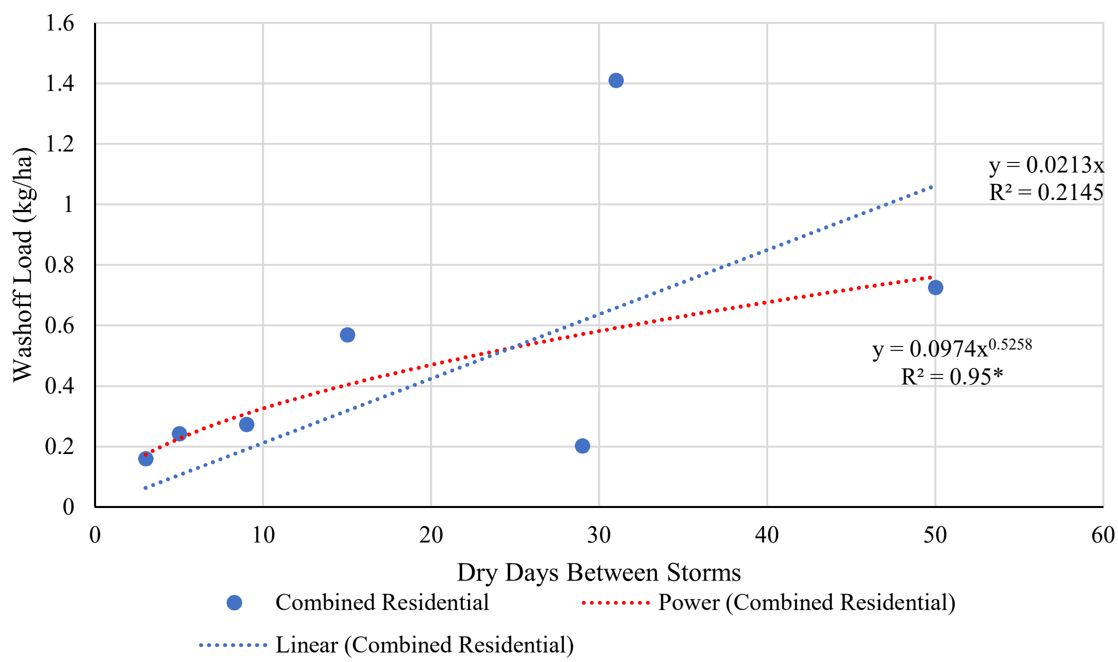

Figure S22. Linear and Power Trendline for Average Washoff Load: Combined Residential Land Use LARW 2003-2004. Asterisk indicates manually calculated R^2 value.

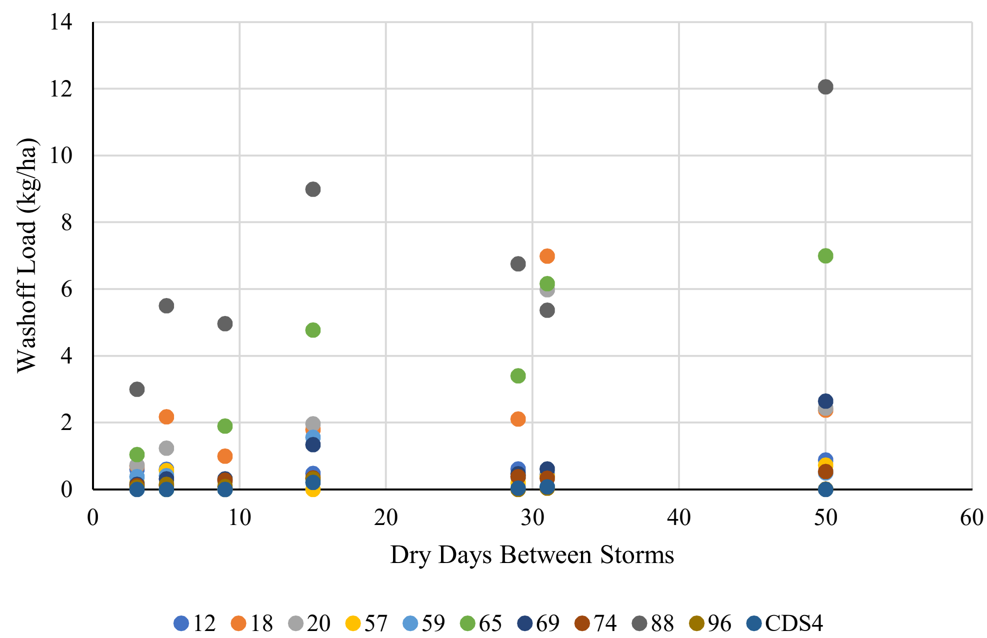

Figure S23. HDSF Land Use LARW 2003-2004. The average values for HDSF and LDSF (next plot) were calculated from each storm and used to determine trend lines in Figure S22.

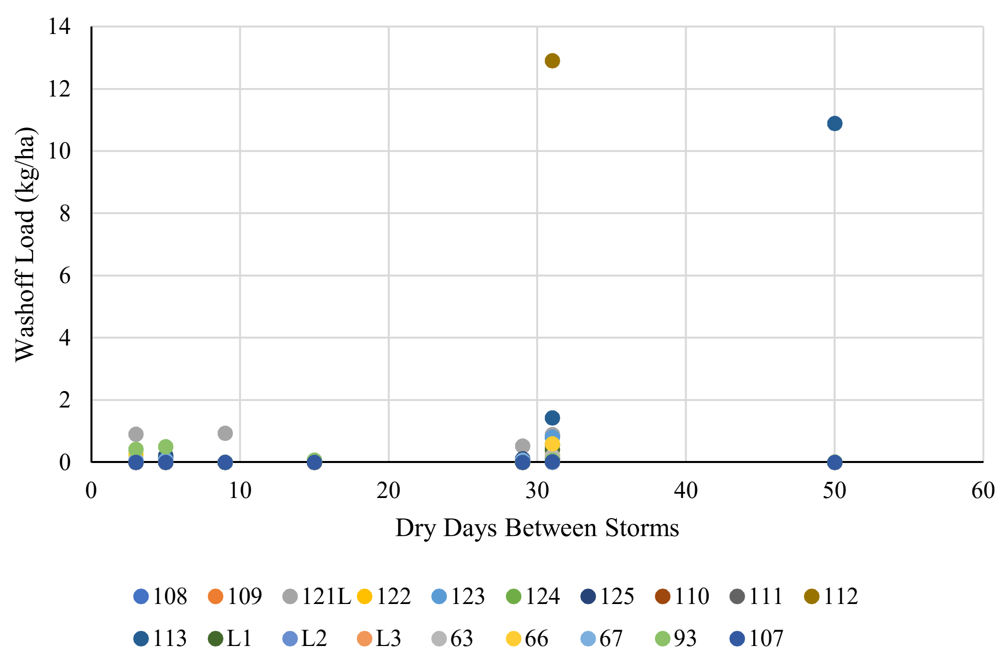

Figure S24. LDSF Land Use LARW 2003-2004. The average values for HDSF and LDSF (next plot) were calculated from each storm and used to determine trend lines in Figure S22.

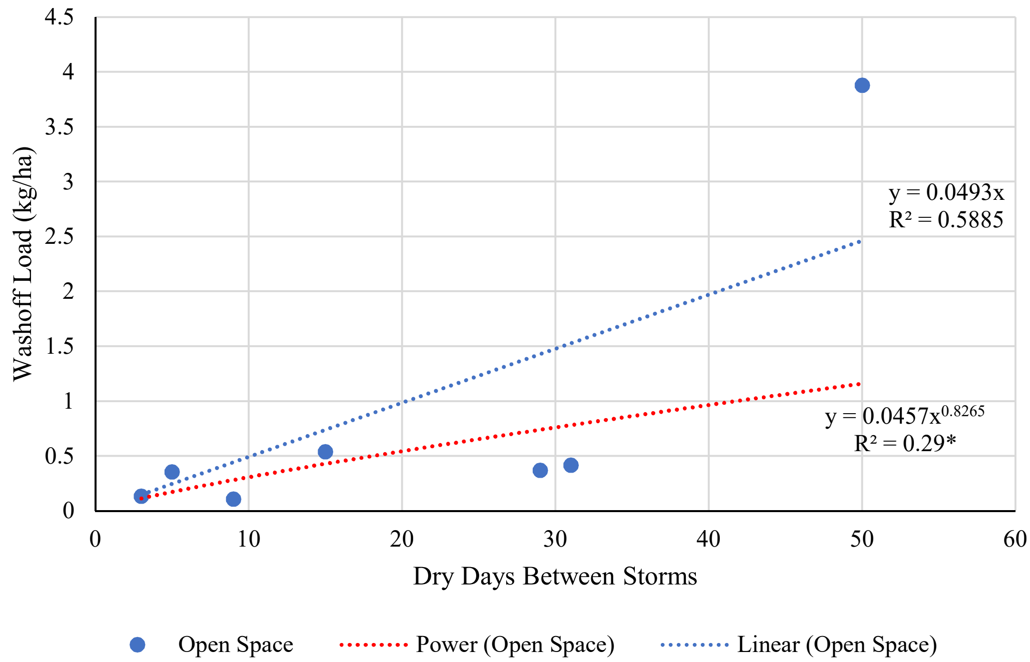

Figure S25. Linear and Power Trendline for Average Washoff Load: Open Space Land Use LARW 2003-2004. Asterisk indicates manually calculated R^2 value.

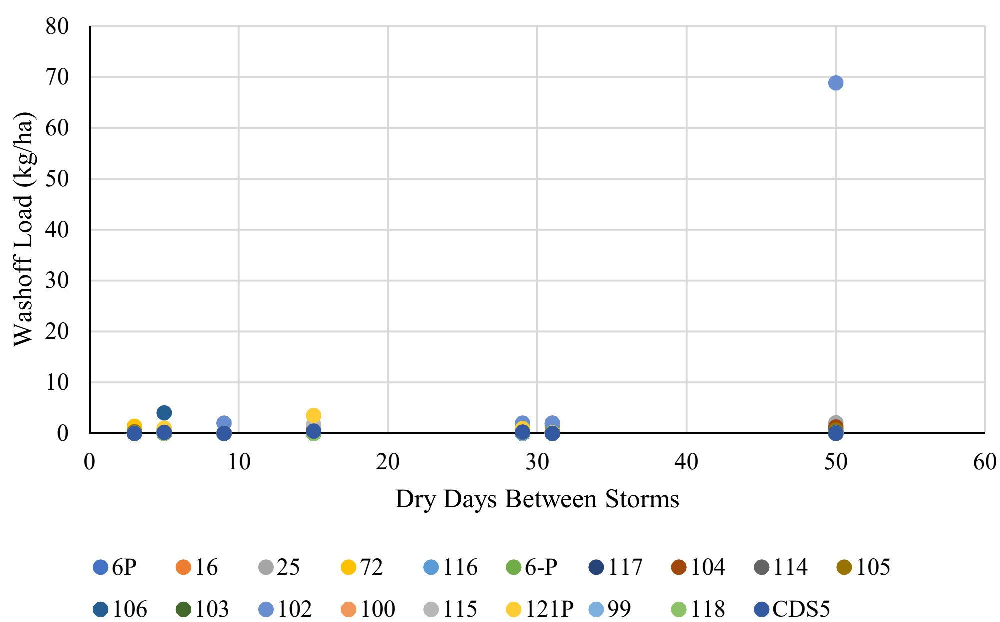

Figure S26. Open Space Land Use LARW 2003-2004. The average values from each storm were used to determine trend lines in Figure S25.

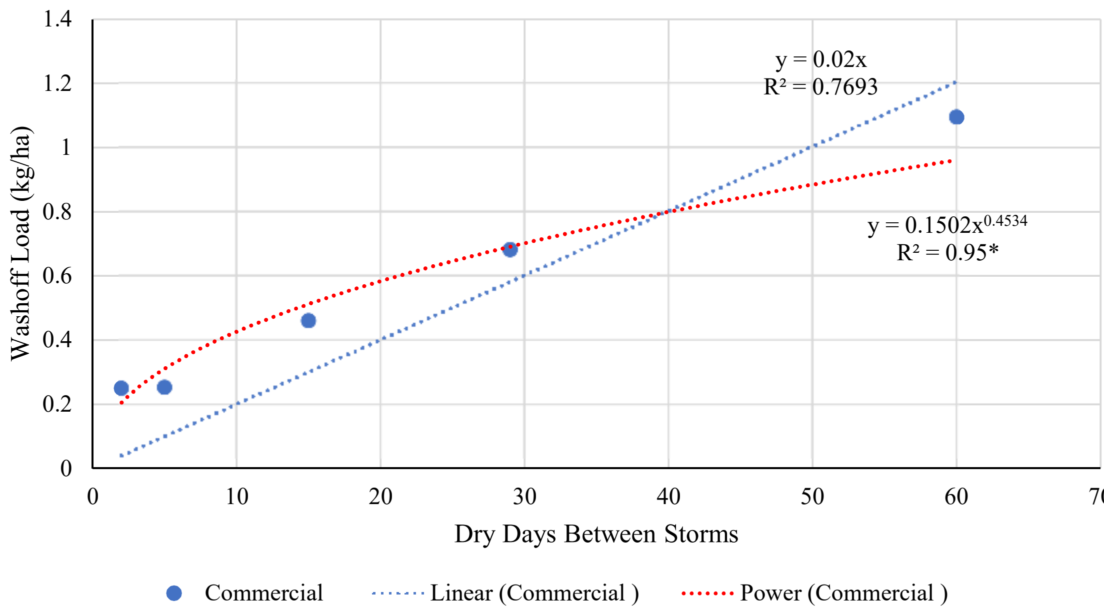

Figure S27. Linear and Power Trendline for Average Washoff Load: Commercial Land Use BCW 2003-2004. Asterisk indicates manually calculated R^2 value.

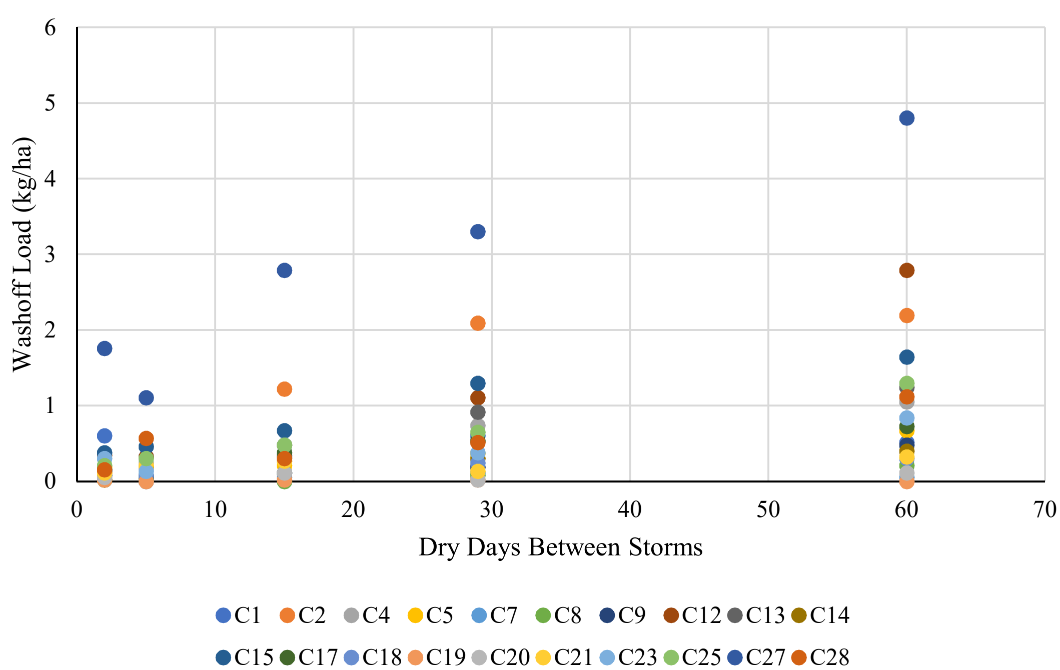

Figure S28. Commercial Land Use BCW 2003-2004. The average values from each storm were used to determine trend lines in Figure S27.

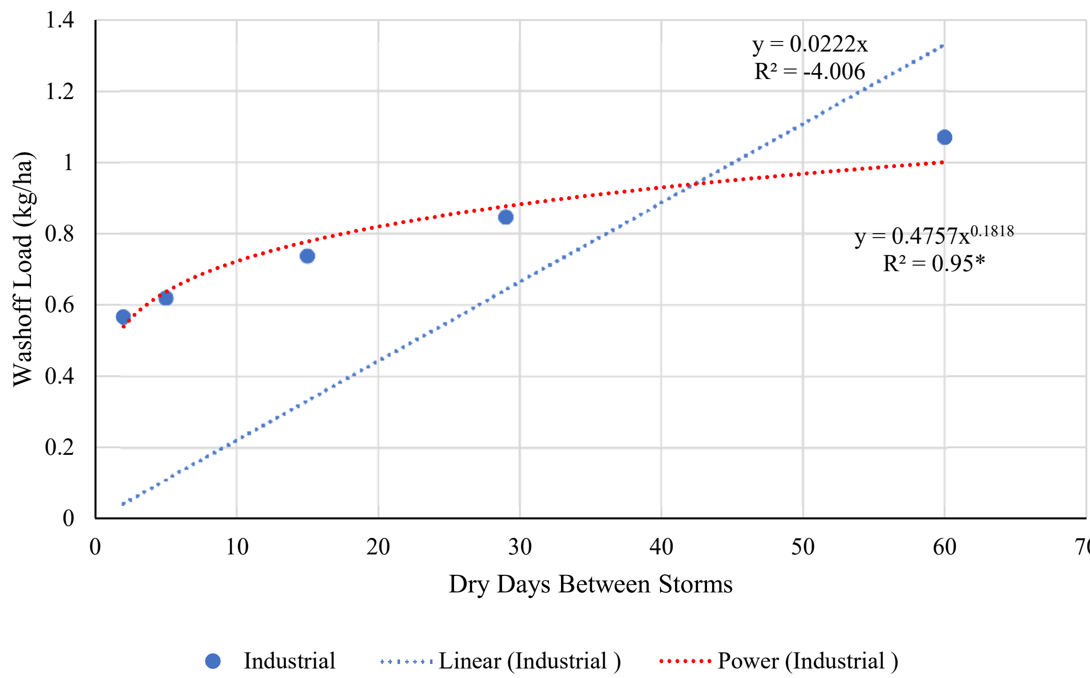

Figure S29. Linear and Power Trendline for Average Washoff Load: Industrial Land Use BCW 2003-2004. Asterisk indicates manually calculated R^2 value.

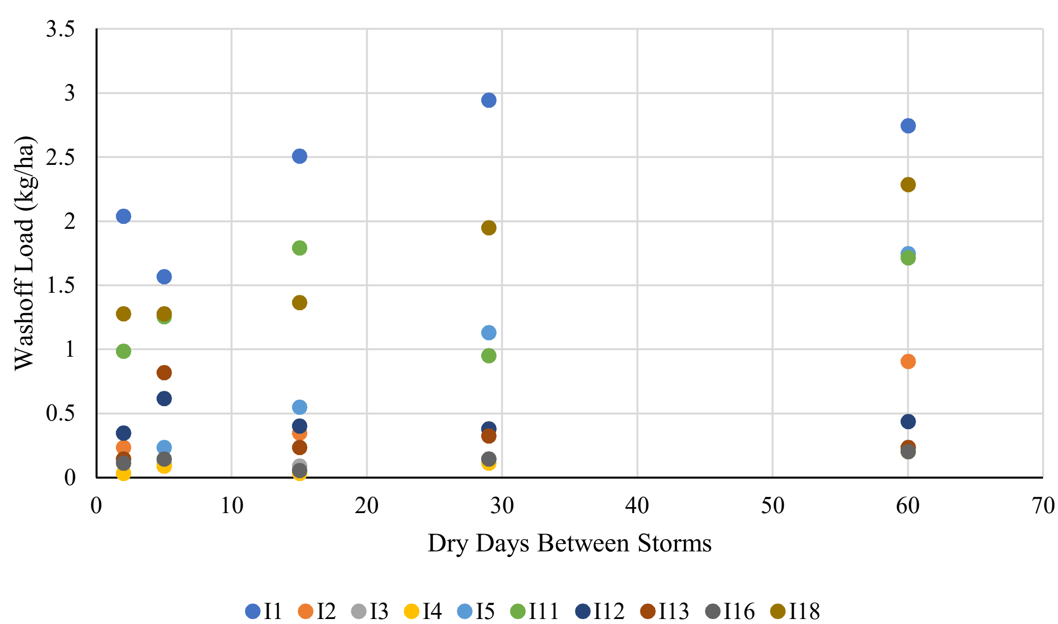

Figure S30. Industrial Land Use 2003-2004. The average values from each storm were used to determine trend lines in Figure S29.

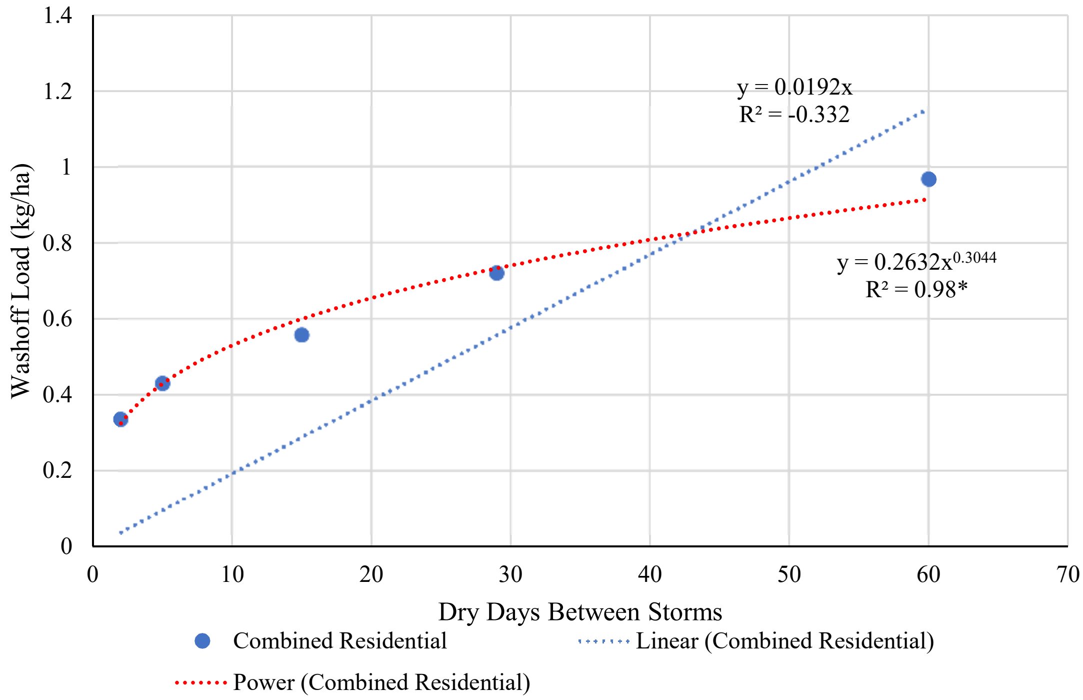

Figure S31. Linear and Power Trendline for Average Washoff Load: Combined Residential Land Use BCW 2003-2004. Asterisk indicates manually calculated R^2 value.

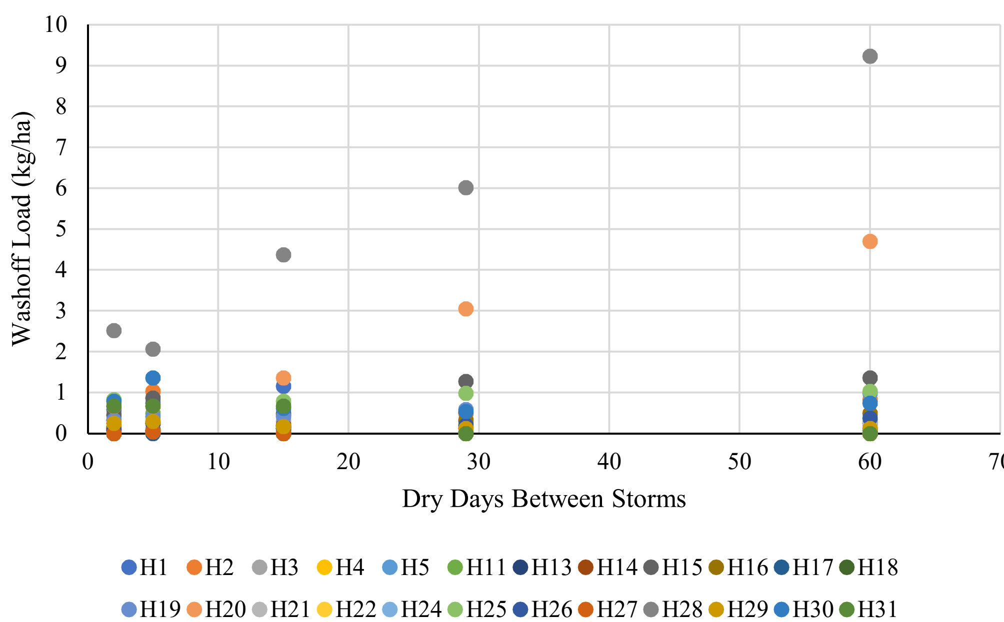

Figure S32. HDSF Residential Land Use BCW 2003-2004. The average values for HDSF and LDSF (next plot) were calculated from each storm and used to determine trend lines in Figure S31.

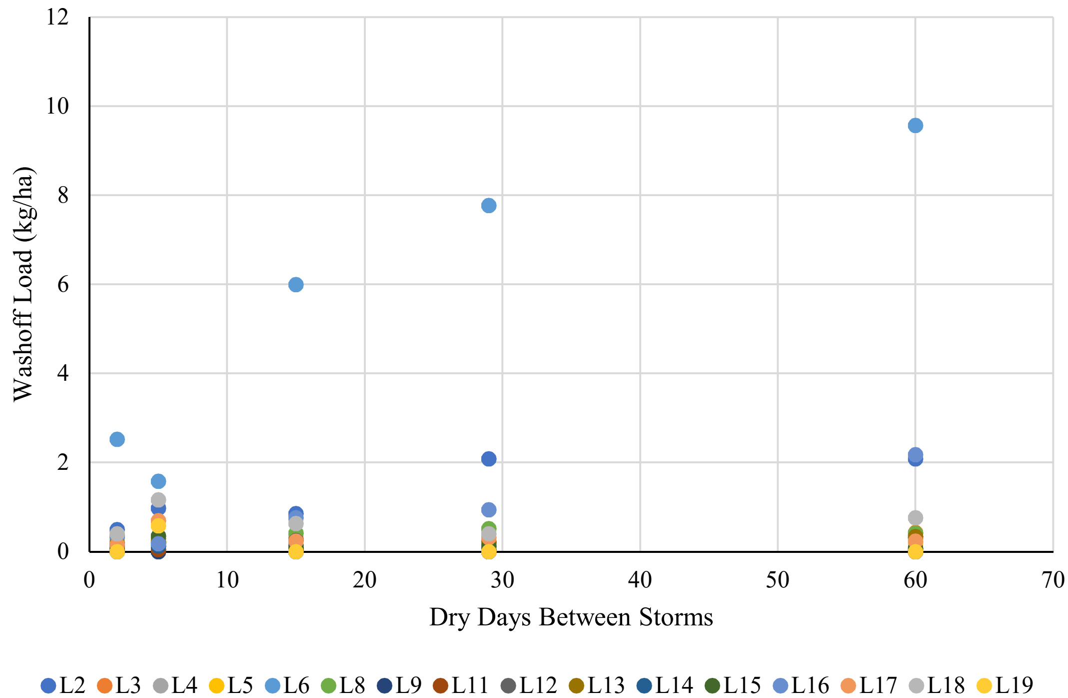

Figure S33. LDSF Residential Land Use 2003-2004. The average values for HDSF and LDSF were calculated from each storm and used to determine trend lines in Figure S31.

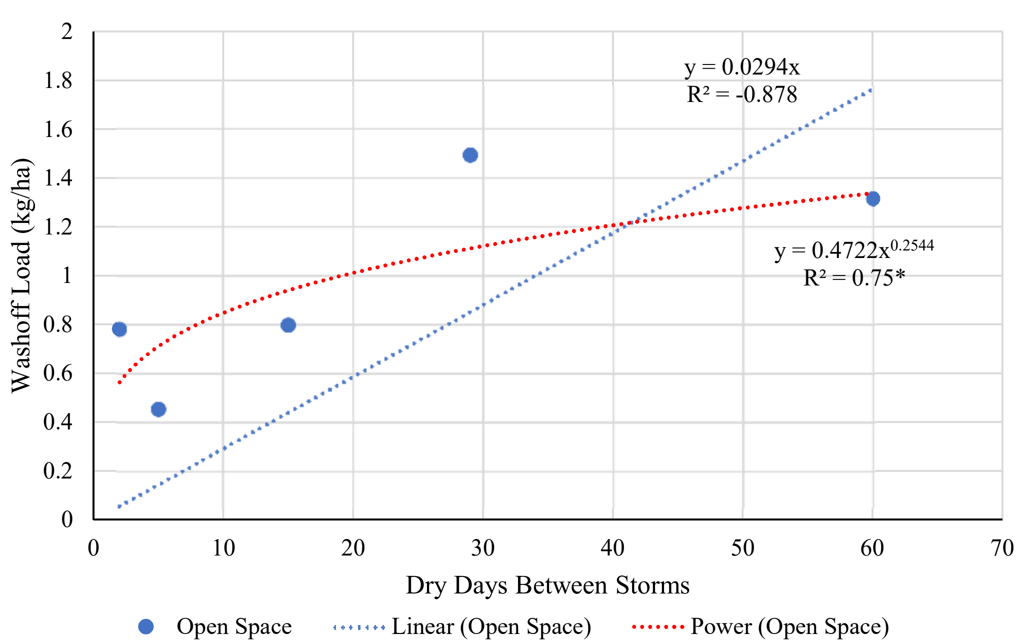

Figure S34. Linear and Power Trendline for Average Washoff Load: Open Space Land Use BCW 2003-2004. Asterisk indicates manually calculated R^2 value.

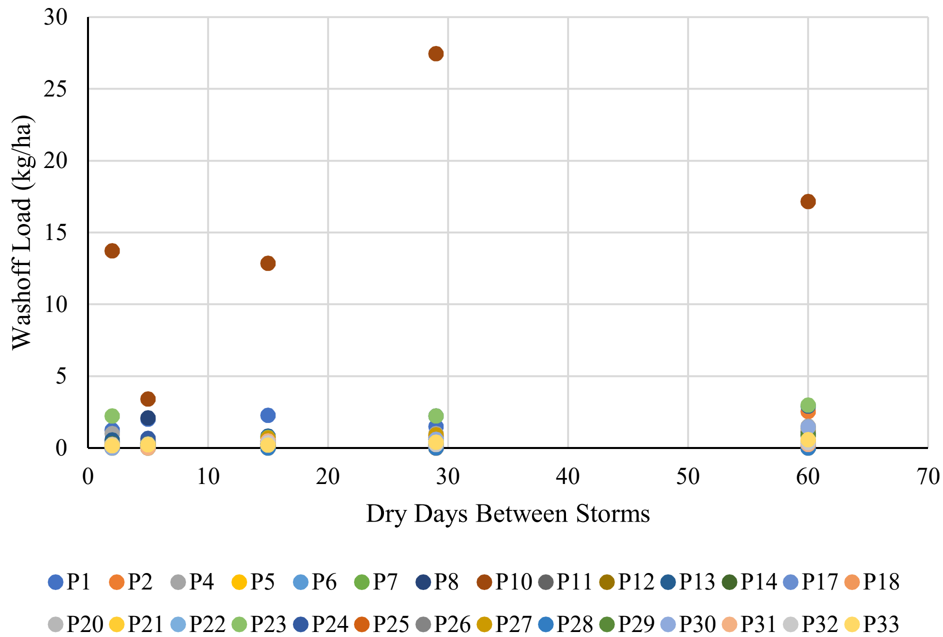

Figure S35. Open Space Land Use BCW 2003-2004. The average values from each storm were used to determine trend lines in Figure S34.

Table S1. Hydrologic Input Data for Infiltration Parameters, Rain Gage Stations, and Evaporation Climate Zones

Watershed	Subwatershed	Infiltration Parameters			Rain Gauges	CIMIS Climate Zones
		Suction Head (mm)	Conductivity (mm/hr)	Initial deficit (unitless)		
LARW	1	207.71	1.18	0.30	Hansen Dam, CA	4
	2	151.67	3.12	0.31	Whittier Narrows Dam, CA	6
	3	155.41	3.01	0.31	Long Beach Airport, CA	9
	4	204.81	1.42	0.30		14
	5	199.11	1.59	0.30		
	6	152.39	2.95	0.31		
BCW	1	212.31	1.05	0.30	Los Angeles Downtown, CA	4
	2	195.01	1.49	0.30		6
	3	196.06	1.56	0.30		9
	4	208.28	1.20	0.30		
	5	165.95	2.38	0.31		
	6	177.42	2.18	0.31		
LSDRW	1	207.82	1.37	0.30	Montgomery Field Airport, CA	4
	2	210.46	1.27	0.30		6
	3	227.76	0.67	0.30	Ramona Airport, CA	9
	4	212.86	1.16	0.30		
	5	212.76	1.17	0.30		
	6	173.93	2.24	0.31		
	7	166.64	2.59	0.31		

References

Michael Baker International. (2018). *Regional Trash Generation Rates for Priority Land Uses in San Diego County*.

Rossman, L., A., & Huber, W. C. (2016). *Storm Water Management Model Reference Manual - Water Quality*. Office of Research and Development