2022

Loop Quality Data Summary

Turn your dirt around

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1.0 Introduction

Biosolids are the nutrient-rich organic products of the wastewater treatment process. Biosolids contain water, organic matter, sand, nutrients, microorganisms, trace metals, and trace organic compounds. Because of their moisture content, carbon-rich characteristics, essential nutrients for plants, and very low levels of pollutants, biosolids are an effective, high quality, and sustainable fertilizer replacement and soil amendment for forest trees and agricultural crops, and an ingredient in compost for landscaping.

The King County Wastewater Treatment Division began conducting research and recycling biosolids through land application in 1973. The program has grown to beneficially recycle 100% of the over 120,000 wet tons (or approximately 30,000 dry tons) produced annually in agriculture, forestry, soil reclamation, and/or compost.

King County's biosolids have been called Loop® since 2011 to reflect the nature of biosolids and the benefits of returning carbon and nutrients to the land.

Both state and federal regulations (WAC 173-308 and 40 CFR Part 503) apply to biosolids. Biosolids are classified as Class A or Class B based on the level of pathogen reduction. Class A biosolids are treated to eliminate pathogens and can be used in landscaping and home gardens. Class B biosolids are treated to significantly reduce, but not eliminate, pathogens. Therefore, use of Class B biosolids requires application site permits which include public access and crop harvest restrictions to allow for die-off of pathogens to non-detectable levels after application. These regulatory requirements make the use of Class A and Class B biosolids equally safe in regards to pathogens. Loop meets all the regulatory requirements for Class B biosolids.

To ensure the safety and efficacy of Loop, we routinely monitor its physical, chemical, and microbial characteristics. This monitoring is performed monthly in order to characterize the biosolids, evaluate changes over time, provide data to determine appropriate application rates for Loop biosolids, and satisfy regulatory testing requirements.

Summary data for all parameters is included in the appendix of this report and raw data is available on request from King County. All data included in tables have been rounded in accordance with the accuracy of the specific analytical procedure. Unless otherwise noted, all concentrations are reported on a dry weight basis. Concentrations of metals, nutrients, and organic compounds are reported in terms of parts per million (mg/kg) dry. Microbiological data are reported in terms of organisms per gram or organisms per 4 grams on a dry weight basis.

This report summarizes the 2022 monitoring of Loop biosolids from West Point Treatment Plant, South Treatment Plant, and Brightwater Treatment Plant. Loop meets the most stringent quality standards for metals, as well as the anaerobic digestion process requirements for Class B pathogen reduction and vector attraction reduction.

Regular quality testing not only fulfills our regulatory requirements, but also ensures that we are providing a safe and effective product to our partners and customers.

2.0 Metals

Every month, the King County Environmental Lab analyzes Loop samples from all three plants for the presence and concentrations of 18 metals. Eight of these metals are regulated under state and federal biosolids rules: arsenic, cadmium, copper, lead, mercury, nickel, selenium and zinc. Molybdenum is also regulated, but only has a ceiling limit for land application rather than a cumulative loading rate. We began collecting metals data as soon as we began biosolids production (since 1981 at West Point, 1988 at South Plant, and 2012 at Brightwater).

Throughout 2022 the concentrations of the eight regulated metals in Loop biosolids fell well below the most stringent state and federal regulatory levels (Figure 1). Since 1990, there has been a statistically significant decrease in all regulated metals. All treatment plant levels of molybdenum were significantly below the 75 mg/kg ceiling limit in 2022 (7 mg/kg at Brightwater, 8 mg/kg at South Plant, and 13 mg/kg at West Point).

The overall reduction in concentration of many metals in Loop over time is attributed to King County's source control efforts, managed the Industrial Pretreatment Program.

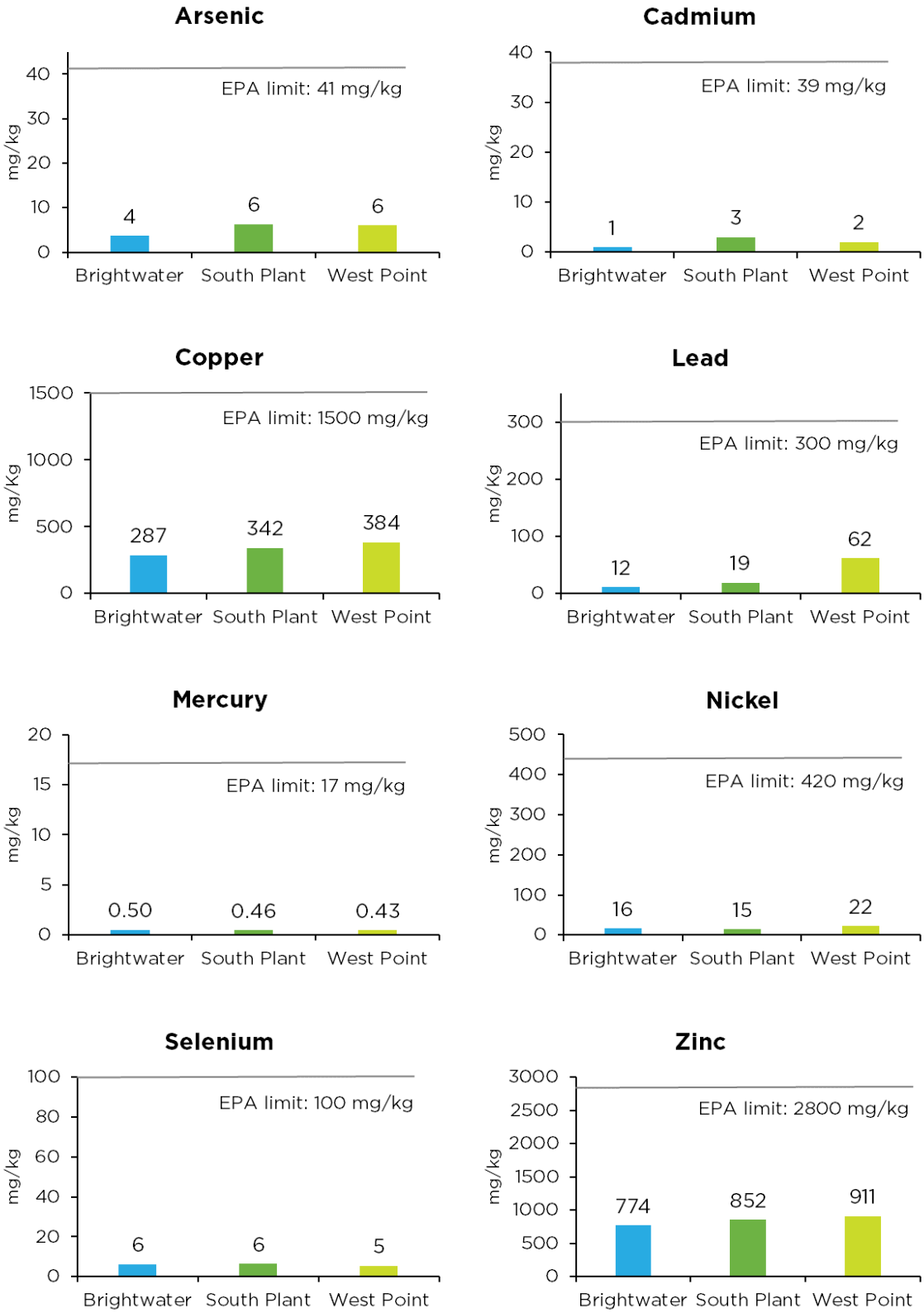


Figure 1. Average metal concentrations in 2022, compared to EPA safety limits.

3.0 Conventional Constituents

3.1 Nutrients

In order to calculate application rates and the value of Loop as a fertilizer replacement, we test for nitrogen, phosphorus, sulfate, and potassium on a monthly basis. Nitrogen is limiting factor on which we base all application rates. 2022 levels of nitrogen, phosphorus, sulfur, and potassium are comparable to previous years (Figure 2).

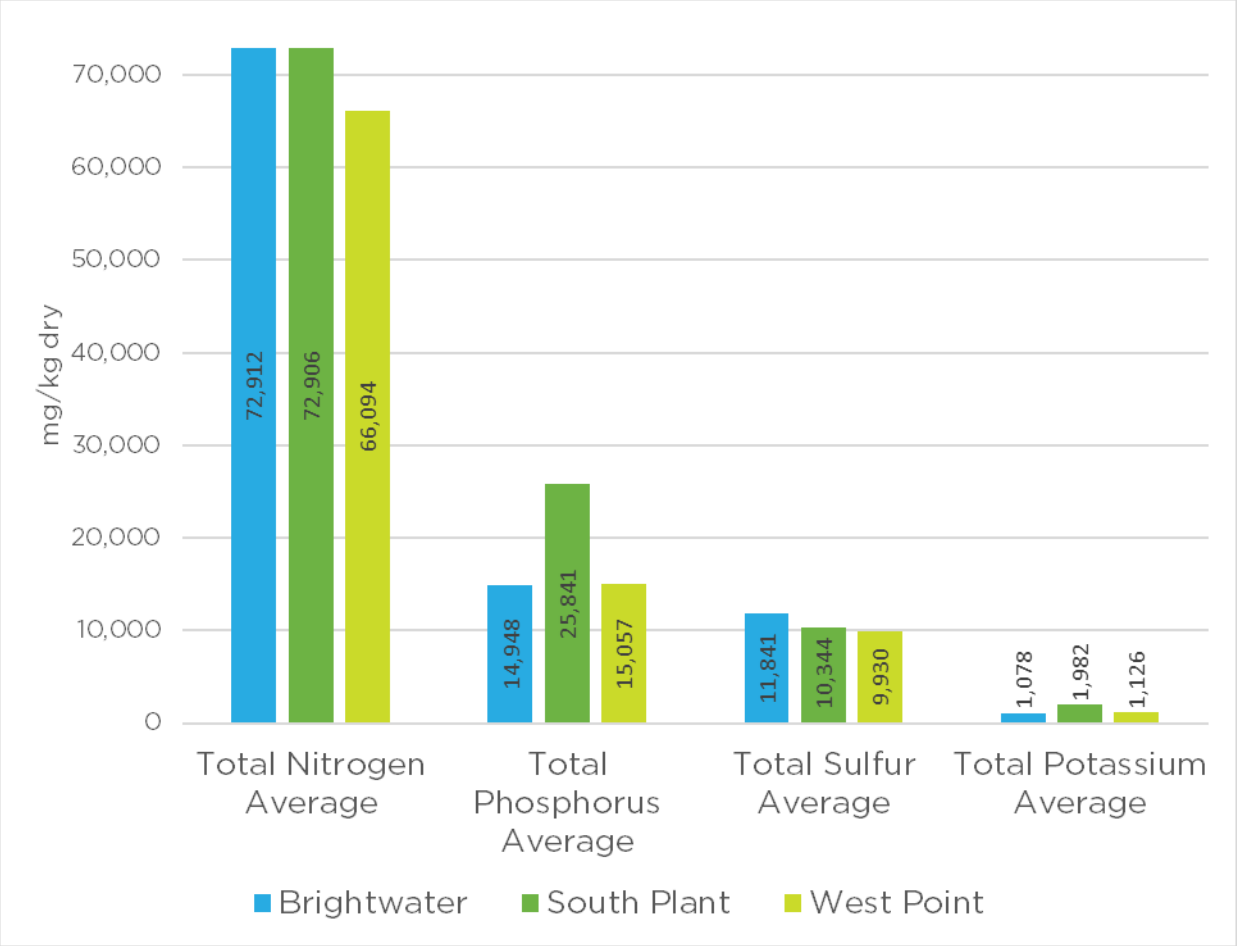


Figure 2. Average 2022 nitrogen, phosphorus, sulfate, and potassium levels of Loop.

3.2 pH

Average pH values of biosolids in 2022 at Brightwater, South Plant, and West Point were 9.0, 8.9, and 8.8 respectively. The pH of biosolids at all the treatment plants has changed little over time.

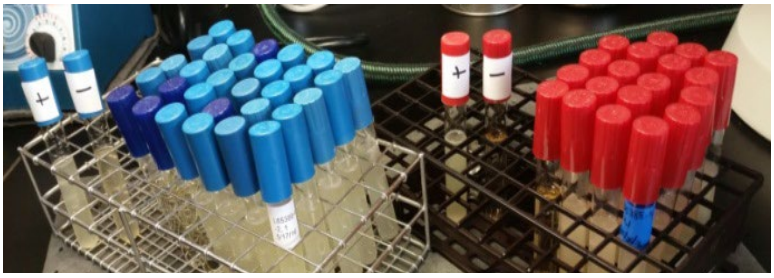
3.3 Volatile Solids Reduction

Volatile solids represent the organic matter fraction of the biosolids that can be degraded by microorganisms over time and they are responsible for many of the odors in wastewater. Volatile solids reduction ensures that vectors, such as insects and rodents, are not attracted to the biosolids, thereby reducing the spread of pathogens and diseases. Brightwater, South Plant, and West Point reduced their volatile solids by 59%, 60%, and 63% respectively, well above the 38% required by the EPA.

4.0 Microbial Constituents

Loop biosolids are digested for the required time and at specific temperatures to meet the Class B regulatory requirement to significantly reduce pathogens. Since the anaerobic digestion used at our treatment plants is known to be effective, we are not required to test for microbial properties of Loop.

Regardless, we monitor for fecal coliform and Salmonella monthly. The presence of fecal coliform can indicate that some pathogens remain after wastewater treatment, which is expected in Class B biosolids and managed through land application regulations. The levels of fecal coliform at all treatment plants fell well below the acceptable two million most probable number (MPN)/gram for Class B biosolids.



Blue tubes show the presumptive and confirmatory testing done for fecal coliform. Positive results are indicated by turbidity (cloudiness) and small gas bubbles.

Loop is tested quarterly for the presence of enteric viruses and several parasites with public health significance. These parasites include *Ascaris species, Giardia lamblia*, hookworm, *Hymenolepis species, Taenia species, Trichuris trichiura and Toxocara species.*

It is not uncommon for Class B biosolids to have some parasite eggs present, but the viability of these eggs can be greatly reduced through wastewater treatment. It is important to note that the analysis can only determine if parasite eggs are present, not if the eggs are viable. In 2022, hookworm was detected at all three plants in all quarterly samples. *Ascaris species* was detected in four samples from Brightwater and West Point, and in two samples from South Plant. In 2022, we found no detectable viruses.

5.0 Trace Organic Constituents

Loop was analyzed for 148 trace organic compounds, many of which are identified by EPA as priority pollutants. Fifteen of these 148 organic compounds were detected at very small concentrations in Loop. This degree of testing for trace organics, though not required by federal or state regulations for biosolids use, provides additional information and assurance as to the high quality of the Loop product.

The following types of organic compounds were detected in very low concentrations during 2022:

- Phthalates, which are plasticizers used in many products (including food wrap, cosmetics, and PVC), are prevalent in the environment. Phthalates do not persist in soils and are rapidly removed by volatilization and microbial decomposition.

- Solvents, such as phenol, acetone, toluene, and carbon disulfide are widely used in both residences and industry, and are commonly found in high concentrations in commercial products such as paint and resins. Concentrations in biosolids are very low. Solvents degrade or volatilize rapidly in soil, and land application of biosolids is not considered a significant pathway of human exposure.

- Polycyclic Aromatic Hydrocarbons (PAHs) are a product of incomplete combustion and are ubiquitous environmental pollutants due to their transport in the atmosphere. Natural sources include forest fires and volcanic eruptions, while anthropogenic sources include creosote, asphalt, and burning of fossil fuels and biomass, including residential wood burning and automobiles. Transfer of PAHs from soil has been shown to be minimal for root crops, and essentially zero for above-ground crops. Total PAH concentrations in Loop are small and similar to urban soil background concentrations.

- Although EPA banned manufacture and commercial use of polychlorinated biphenyls, also called PCBs or aroclors, in 1979, these compounds are persistent in the environment. PCBs enter wastewater from atmospheric deposition and stormwater runoff and may be found in very low concentrations in biosolids. In 2022, the total aroclors detected in Loop at all three treatment plants had concentrations ranging from 0.04 to 0.15 mg/kg dry.

After extensive review of biosolids data, EPA chose not to establish criteria or monitoring requirements for organic compounds due to the low concentrations found in biosolids and the minimal risk to public health and the environment. Research on the bioavailability of trace organic compounds to plants indicates that the risk to humans consuming food crops grown on soils amended with biosolids is negligible.

6.0 Conclusions

Loop continues to be an excellent product, with respect to all relevant criteria. Concentrations of regulated metals were consistently well below the most stringent state and federal standards for land application of biosolids. Loop from all three treatment plants may be used to effectively improve soils, sequester carbon, provide nutrients for agricultural crops and forest plantations, and make high-quality compost.

7.0 Appendix

Table 1: 2022 Summary of Metals, Conventional, Microbial, and Organics Data for Brightwater Loop

Table 2: 2022 Summary of Metals, Conventional, Microbial, and Organics Data for South Plant Loop

Table 3: 2022 Summary of Metals, Conventional, Microbial, and Organics Data for West Point Loop

Table 4: List of Organic Compounds Analyzed in Loop

Table 1. 2022 Summary of Metals, Conventional, Microbial, and Organics Data for Brightwater Loop

Metals	Number of Detections	Minimum	Median	Maximum	Standard Deviation	Mean	Regulatory Limits
Arsenic (mg/kg)	12	3	4	5	0.41	4	**41**
Barium (mg/kg)	12	125	147	188	18	150	
Beryllium (mg/kg)	12	0.10	0.20	0.20	0.02	0.20	
Boron (mg/kg)	12	55	72	93	12	73	
Cadmium (mg/kg)	12	1	1	1	0.12	1	**39**
Calcium (mg/kg)	12	15,804	19,841	29,049	3,694	20,452	
Chromium (mg/kg)	12	12	18	23	4	17	
Copper (mg/kg)	12	237	284	329	36	287	**1,500**
Iron (mg/kg)	12	7,512	8,768	10,870	934	8,996	
Lead (mg/kg)	12	10	12	14	1	12	**300**
Magnesium (mg/kg)	12	4,718	5,679	8,959	1,445	6,296	
Manganese (mg/kg)	12	675	847	1,005	84	849	
Mercury (mg/kg)	12	0.20	0.50	1.10	0.20	0.50	**17**
Molybdenum (mg/kg)	12	6	7	9	0.90	7	
Nickel (mg/kg)	12	13	16	20	2	16	**420**
Selenium (mg/kg)	12	4	6	8	1	3	**100**
Silver (mg/kg)	12	2	3	8	1	3	
Zinc (mg/kg)	12	624	718	1,041	143	774	**2,800**

Conventional	Number of Detections	Minimum	Median	Maximum	Standard Deviation	Mean
Total Solids (%)	12	19.80%	21.05%	22.10%	0.01	21.05%
Total Volatile Solids Reduction (%)	12	56.00%	58.80%	62.30%	2.08	59.00%
pH	12	8.8	9.0	9.2	0.12	9.0
Total Kjeldahl Nitrogen (mg/kg)	12	65,550	72,354	81,132	5,294	72,912
Ammonia Nitrogen (mg/kg)	12	8,038	9,780	10,868	848	9,589
Organic Nitrogen (mg/kg)	12	55,981	62,909	71,226	4,882	63,408
Total Phosphorus (mg/kg)	12	12,297	14,534	19,367	2,477	14,948
Total Potassium (mg/kg)	12	860	1,096	1,310	121	1,078
Total Sulfur (mg/kg)	12	10,146	11,578	14,541	1317	11,841

Microbiological	Number of Detections	Minimum	Median	Maximum	Geometric Mean
Fecal Coliform (org/g dry)	12	3,624	33,758	110,000	31,200
Salmonella (org/4g dry)	12	0.4	11.6	3,091.8	14.9
Total Viruses (PFU/4g dry)	0				
Parasites (no units)	4				

Organics	Compound Name	Number of Detections	Minimum	Median	Maximum	Standard Deviation	Mean
Volatiles (mg/kg)	2-Butanone (MEK)	4	0.05	0.40	1.00	0.42	0.50
	Acetone	4	0.30	2.60	4.70	1.93	2.60
	Carbon Disulfide	4	0.01	0.04	0.08	0.04	0.04
	n-Octadecane	3	4.10	12.80	17.80	6.90	11.60
	n-Decane	1					4.33
	Toluene	4	0.004	0.02	0.10	0.04	0.03
Semivolatiles (mg/kg)	Benzoic Acid	2	47.64	57.07	66.50	13.34	57.07
	Bis(2-Ethylhexyl) Phthalate	4	14.64	18.40	21.53	3.67	18.24
	Pentachlorophenol	1					6.26
	Phenol	1					7.79
PCBs (mg/kg)	Total Aroclors	4	0.04	0.05	0.05	0.004	0.05

Table 2. 2022 Summary of Metals, Conventional, Microbial, and Organics Data for South Plant Loop

Metals	Number of Detections	Minimum	Median	Maximum	Standard Deviation	Mean	Regulatory limits
Arsenic (mg/kg)	12	5	6	8	1.00	6	**41**
Barium (mg/kg)	12	125	154	174	12	153	
Beryllium (mg/kg)	0						
Boron (mg/kg)	12	16	22	28	4	22	
Cadmium (mg/kg)	12	1	1	7	2.00	3	**39**
Calcium (mg/kg)	12	18,738	23,311	26,343	1,864	23,038	
Chromium (mg/kg)	12	17	22	26	3	22	
Copper (mg/kg)	12	269	325	367	34	324	**1,500**
Iron (mg/kg)	12	14,533	18,201	22,300	2,681	18,001	
Lead (mg/kg)	12	15	19	23	3	19	**300**
Magnesium (mg/kg)	12	5,935	7,418	11,667	1,612	8,138	
Manganese (mg/kg)	12	354	488	592	70	478	
Mercury (mg/kg)	12	0.26	0.41	0.90	0.16	0.46	**17**
Molybdenum (mg/kg)	12	7	8	10	1.00	8	
Nickel (mg/kg)	12	12	15	18	2	15	**420**
Selenium (mg/kg)	12	5	6	7	1.00	6	**100**
Silver (mg/kg)	12	2	3	5	1	3	
Zinc (mg/kg)	12	664	817	1,019	112	852	**2,800**

Conventional	Number of Detections	Minimum	Median	Maximum	Standard Deviation	Mean
Total Solids (%)	12	21.20%	21.60%	23.30%	0.01	21.79%
Total Volatile Solids Reduction (%)	12	57.00%	59.50%	63.00%	1.86	60.00%
pH	12	8.7	8.9	9.0	0.09	9.0
Total Kjeldahl Nitrogen (mg/kg)	12	70,461	72,881	76,852	1,945	72,906
Ammonia Nitrogen (mg/kg)	12	8,772	11,837	13,099	1,247	11,539
Organic Nitrogen (mg/kg)	12	56,808	60,464	68,224	3,728	61,113
Total Phosphorus (mg/kg)	12	18,632	24,396	39,398	5,408	25,841
Total Potassium (mg/kg)	12	1,533	1,899	2,718	308	1,982
Total Sulfur (mg/kg)	12	8,318	10,643	11,574	978	10,344

Microbiological	Number of Detections	Minimum	Median	Maximum	Geometric mean
Fecal Coliform (org/g dry)	12	38,916	113,679	374,408	111,770
Salmonella (org/4g dry)	12	7	29	150	31
Total Viruses (PFU/4g dry)	0				
Parasites (no units)	4				

Organics	Compound Name	Number of Detections	Minimum	Median	Maximum	Standard Deviation	Mean
Volatiles (mg/kg)	2-Butanone (MEK)	8	0.06	0.34	1.18	0.38	0.44
	Acetone	8	0.30	1.43	4.86	1.64	1.91
	Carbon Disulfide	8	0.01	0.03	0.13	0.05	0.05
	n-Decane	1					5.75
	n-Octadecane	5	3.39	22.50	24.11	9.01	17.52
	Toluene	8	0.002	0.03	0.15	0.05	0.05
Semivolatiles (mg/kg)	Benzoic Acid	4	16.89	38.86	40.10	11.20	33.68
	Bis(2-Ethylhexyl) Phthalate	8	36.82	41.07	43.26	2.22	40.11
	Phenol	3	14.23	14.55	16.34	1.14	15.04
PCBs (mg/kg)	Total Aroclors	8	0.06	0.06	0.08	0.01	0.06

Table 3. 2022 Summary of Metals, Conventional, Microbial, and Organics Data for West Point Loop

Metals	Number of Detections	Minimum	Median	Maximum	Standard Deviation	Mean	Regulatory Limits
Arsenic (mg/kg)	12	5	6	7	1.00	6	**41**
Barium (mg/kg)	12	128	161	206	21	162	
Beryllium (mg/kg)	9	0.10	0.12	0.17	0.02	0.13	
Boron (mg/kg)	12	10	12	13	1.00	11	
Cadmium (mg/kg)	12	1	2	2	0.27	2	**39**
Calcium (mg/kg)	12	15,376	17,805	20,528	1,555	17,473	
Chromium (mg/kg)	12	18	25	33	5	26	
Copper (mg/kg)	12	313	369	505	56	384	**1,500**
Iron (mg/kg)	12	10,935	14,549	19,044	2,210	14,638	
Lead (mg/kg)	12	47	55	104	17	62	**300**
Magnesium (mg/kg)	12	3,798	4,798	6,545	1,024	5,123	
Manganese (mg/kg)	12	253	746	1,000	280	647	
Mercury (mg/kg)	12	0.27	0.42	0.61	0.11	0.43	**17**
Molybdenum (mg/kg)	12	7	10	27	6	13.0	
Nickel (mg/kg)	12	16	22	29	4	22	**420**
Selenium (mg/kg)	12	5	5	6	0.50	5	**100**
Silver (mg/kg)	12	2	3	3	0.38	3	
Zinc (mg/kg)	12	735	810	1,154	135	911	**2,800**

Conventional	Number of Detections	Minimum	Median	Maximum	Standard Deviation	Mean
Total Solids (%)	12	24.60%	27.75%	29.30%	0.01	27.44%
Total Volatile Solids Reduction (%)	12	54.20%	63.55%	69.70%	5	63.20%
pH	12	8.7	8.8	8.9	0.08	8.8
Total Kjeldahl Nitrogen (mg/kg)	12	57,679	66,036	71,910	4,571	66,094
Ammonia Nitrogen (mg/kg)	12	7,289	8,735	10,350	832	57,329
Organic Nitrogen (mg/kg)	12	49,829	57,025	62,921	4,456	57,329
Total Phosphorus (mg/kg)	12	13,532	14,847	16,498	967	15,057
Total Potassium (mg/kg)	12	898	1,085	1,444	146	1,126
Total Sulfur (mg/kg)	12	9,022	9,734	11,479	810	9,930

Microbiological	Number of Detections	Minimum	Median	Maximum	Geometric Mean
Fecal Coliform (org/g dry)	12	50,193	151,836	898,438	186,021
Salmonella (org/4g dry)	11	7	35	237	37
Total Viruses (PFU/4g dry)	0				
Parasites (no units)	4				

Organics	Compound Name	Number of Detections	Minimum	Median	Maximum	Standard Deviation	Mean
Volatiles (mg/kg)	2-Butanone (MEK)	3	0.56	0.67	0.71	0.08	0.65
	Acetone	4	0.92	5.77	8.58	3.36	5.26
	Carbon Disulfide	4	0.01	0.02	0.04	0.02	0.02
	n-Octadecane	4	3.94	20.88	33.99	12.39	19.92
	n-Decane	2	3.22	5.28	7.35	2.93	5.29
	Styrene	1					0.01
	Toluene	4	0.01	0.03	0.08	0.03	0.04
Semivolatiles (mg/kg)	Benzoic Acid	3	32.65	45.93	81.13	25.05	53.24
	Bis(2-Ethylhexyl) Phthalate	4	25.02	33.35	36.87	5.49	32.15
	Di-N-ButylPhthalate	1					20.28
	Phenol	1					11.08
PCBs (mg/kg)	Total Aroclors	4	0.12	0.14	0.15	0.01	0.14

Table 4. List of Organic Compounds Analyzed in King County Biosolids

Pesticides and PCBS	Volatiles	Semivolatiles	
4,4-DDE	1,1-Dichloroethane	1,2-Dichlorobenzene	Bis(2-chloroethoxy) methane
4,4-DDD	1,1-Dichloroethylene	1,2-Diphenylhydrazine	Bis(2-chloroethyl)ether
4,4-DDT	1,2-Dichloroethane	1,3-Dichlorobenzene	Bis(2-chloroisopropyl)-ether
Aldrin	1,2-Dichloropropane	1,4-Dichlorobenzene	Bis(2-ethylhexyl)phthalate
Alpha-BHC	1,2-Trans-Dichloroethylene	1,2,4-Trichlorobenzene	Benzyl Butyl Phthalate
Alpha Chlordane	1,1,1-Trichloroethane	2-Chloronaphthalene	Carbazole
Total Aroclors**	1,1,2-Trichloroethane	2-Chlorophenol	Chrysene*
Beta-BHC	1,1,2-Trichloroethylene	2-Methylnaphthalene	Di-n-Butyl Phthalate
Delta-BHC	1,1,2,2-Tetrachloroethane	2-Methylphenol	Di-n-Octyl Phthalate
Dieldrin	1,3-Trans-Dichloropropene	2-Nitroaniline	Dibenzo(a,h)anthracene*
Endosulfan 1	2-Butanone (MEK)	2-Nitrophenol	Dibenzofuran
Endosulfan Sulfate	2-Chloroethylvinyl Ether	2,3-Dichloroaniline	Diethyl Phthalate
Endosulfan11	2-Hexanone	2,4-Dichlorophenol	Dimethyl Phthalate
Endrin	4-Methyl-2-Pentanone (MIBK)	2,4-Dimethylphenol	Fluoranthene*
Endrin Aldehyde	Acetate	2,4-Dinitrophenol	Fluorene*
Gamma-BHC	Acetone	2,4-Dinitrotoluene	Hexachlorobenzene
Heptachlor	Acrolein	2,6-Dinitrotoluene	Hexachlorobutadiene
Heptachlor Epoxide	Acrylonitrile	2,4,5-Trichlorophenol	Hexachlorocyclopentadiene
Methoxychlor	Benzene	2,4,6-Trichlorophenol	Hexachloroethane
Toxaphene	Bromodichloromethane	3-Nitroaniline	Indeno(1,2,3-c,d)pyrene*
Trans Chlordane	Bromoform	3-Methylcholanthrene	Isophorone
	Bromomethane	3,3-Dichloribenzidine	N-Nitroso-di-n-propylamine
	Carbon Disulfide	3,4-Methylphenol	N-Nitrosodimethylamine
	Carbon Tetrachloride	4-Bromophenyl Phenyl Ether	N-Nitrosodiphenylamine
	Chlorobenzene	4-chloro-3-methylphenol	Naphthalene*
	Chlorodibromoethane	4-Chloroaniline	Nitrobenzene
	Chloroethane	4-Chlorophenyl Phenyl Ester	Pentachlorophenol
	Chloroform	4-Nitroaniline	Phenanthrene*
	Chloromethane	4-Nitrophenol	Phenol
	Cis-1,3-Dichloropropane	4,6-Dinitro-O-Cresol	Pyrene*
	Ethylbenzene	Acenaphthene*	
	Methylene Chloride	Acenaphthylene*	
	N-decane	Aniline	
	N-Octadecane	Anthracene*	
	Styrene	Benzoic Acid	
	Tetrachloroethylene	Benzo(a)anthracene*	
	Toluene	Benzo(a)pyrene*	
	Total Xylenes	Benzo(b,j,k)fluoranthene*	
	Trichlorofluoromethane	Benzo(g,h,i)perylene*	
	Vinyl Chloride	Benzyl Alcohol	

* Polynuclear Aromatic Hydrocarbons (PAHs)

** Polychlorinated Biphenyls (PCBs)