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Compilation and Evaluation of Existing Stormwater Quality Data from Oregon

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Prepared for

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K/J Project No. 0891020.00

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Executive Summary

The Oregon Association of Clean Water Agencies (ACWA) hired Kennedy/Jenks Consultants (Kennedy/Jenks) to evaluate stormwater data to determine the prevalence of various pollutants, and correlation with traffic volumes and land uses. Stormwater data from 25,247 samples were provided to Kennedy/Jenks by 15 Oregon public agencies and three stormwater technical reports. The data consisted of 45 analytes collected between 1990 and 2008, and included stormwater from Municipal Separate Storm Sewer Systems as well as stormwater collected before entering Underground Injection Control (UIC) devices. Data was compiled into a single Access database for statistical analysis.

Of the 45 analytes sampled, only 10 exceeded one or more of the three screening levels of interest by the Oregon Department of Environmental Quality's (DEQ) UIC Program: Oregon Administrative Rule Numerical Groundwater Reference Level (OAR 340-0020), Environmental Protection Agency Maximum Contaminant Level (MCLs), and DEQ Drywell Compliance: Maximum Allowable Discharge Limit (MADL). Only lead, Pentachlorophenol (PCP), and Bis(2-ethylhexyl)phthalate (DEHP) exceeded one or more of these screening levels in more than 1% of samples analyzed. Lead exceeded its OAR Reference Level and MADL in 12.7% of samples and its MCL in 4.4% of samples. PCP and DEHP exceeded their respective MCLs and MADLs in 11.7% and 4.7% of samples, respectively. OAR Reference Levels are not established for PCP and DEHP. The other seven analytes (antimony, arsenic, benzo(a)pyrene [B(a)P], cadmium, chromium, nitrate-nitrogen [NO3-N], and zinc) exceeded one or more of the screening levels less than 1.0% of the time. Our analysis of these data suggests that lead, PCP, and DEHP warrant mitigative, modeling, and/or monitoring measures within a stormwater UIC implementation program. The other seven analytes do not warrant the same degree of attention due to their minimal detection.

Statistical analyses of five analytes (lead, PCP, DEHP, B(a)P, and NO3-N) was conducted in order to compare concentrations between vehicle trip classes (greater and less than 1,000 vehicle trips per day). Concentrations of all five analytes were significantly higher at sample locations associated with greater than 1,000 vehicle trips per day, compared to sample locations associated with less than 1,000 vehicle trips per day. These analytes were also compared among land use types reported by the agencies (commercial, industrial, residential, transportation, mixed, and open space). Significant differences in concentrations among some land use types were apparent for some analytes. However, because of the non-standardized land use type assignment among the agencies, the large variation in the number of locations associated with each land use type, and the limited amount of location-specific metadata provided by each municipality, generalizations regarding possible effects of land use type on analyte concentrations are not appropriate. One could, however, hypothesize that industrial, transportation, and commercial land uses would have higher concentrations than others because of the nature of the chemicals and their typical applications. Because vehicle trip class is already strongly associated with land use, it was not appropriate to combine these two factors for statistical analysis.

Section 1: Introduction

Kennedy/Jenks Consultants (Kennedy/Jenks) is providing professional services for the Oregon Association of Clean Water Agencies (ACWA) Underground Injection Control (UIC) Water Pollution Control Facilities (WPCF) Technical Services Project. The Project involved evaluating stormwater data to determine the prevalence of various pollutants, and correlation with traffic volumes and land uses. Stormwater data from 25,247 samples were provided to Kennedy/Jenks by 15 Oregon public agencies and three stormwater technical reports. The data consisted of 45 analytes collected between 1990 and 2008, and included stormwater from Municipal Separate Storm Sewer Systems as well as stormwater collected before entering UIC devices. Data was compiled into a single Access database for statistical analysis.

There are currently 11 public agencies involved in this contract through ACWA including: the Cities of Bend; Canby; Eugene; Gresham; Keizer, Milwaukie; Redmond and Troutdale; Clackamas County; Multnomah County; and TriMet.

In support of the ACWA UIC WPCF Technical Services Project, Kennedy/Jenks performed a data review and statistical analysis of stormwater data provided by members of ACWA. Sources of the data are listed in Attachment A. A list of sampling stations and their associated vehicle trip class and land use is provided as Attachment B. Kennedy/Jenks compiled stormwater data from the sources listed in Attachment A into a single Access database and then constructed queries in the database to obtain the following information:

- List of analytes sampled
- Analytes with concentrations exceeding one or more of the following screening levels:
    - Environmental Protection Agency (EPA) Maximum Contaminant Level (MCL)
    - Oregon Administrative Rule Numerical Groundwater Reference Level (OAR-340-40-0020)
    - Oregon Department of Environmental Quality (DEQ) Drywell Compliance: Maximum Allowable Discharge Limit (MADL)
- Percentage of screening level exceedances for each analyte
- Number of samples for each land use and traffic count category.

Notes:

“Maximum Contaminant Level” means the maximum permissible level of a contaminant in water which is delivered to any user of a public water system. Reference: EPA’s National Primary Drinking Water Standards 40 CFR Part 141.

"Reference Level" means the contaminant concentration level used to evaluate the significance of a particular contaminant in groundwater. A reference level generally indicates when groundwater may not be suitable for human consumption. Reference: DEQ’s OAR 340-40-0010.

“Maximum Allowable Discharge Limit” refers to the maximum permissible level of a contaminant in stormwater at the point of compliance for an underground injection system. Reference: DEQ’s Pollution Control Facilities Permit for Class V Underground Injection Control Systems.

“Oregon Department of Environmental Quality Drywell Compliance: Maximum Allowable Discharge Limit” refers to the maximum allowable concentration of a regulated pollutant at the point of underground injection.

Section 2: Methods and Results

Approximately 25,247 stormwater sample results were compiled from approximately 213 sampling points and comprising a total of 45 analytes. In most cases multiple analytes were measured at each sampling point. Each sampling point accounted for multiple analytes. Not every sample measured each analyte. Table 1 lists the 45 analytes that were part of the analysis along with their application/sources in the environment and number of samples.

Table 1: List of Analytes

Analyte	Application/Example Sources [ab]	Number of Samples
1,2,4-Trichlorobenzene	Chemical intermediate; heat transfer fluid; high boiling solvent; dielectric fluid, insecticide and fungicide; coolant in electrical installation; glass tempering; dye carrier; transformer oils; lubricants	870
1,3-Dichlorobenzene	Fumigant; insecticide; solvent; chemical intermediate to manufacture dyes, agrochemicals, pharmaceuticals	870
2,4-D	Herbicide; Soil	641
Alachlor	Herbicide; Soil	35
Antimony	May be found in a variety of applications including: flame retardant; activator in glass industry; flocculant in titanium dioxide production; paints and adhesives; pigments, ceramic frites	339
Arsenic	Alloys; integrated circuits; laser and light-emitting diodes; pesticides; wood preservatives; glass making; printing; tanning; bronzing; pyrotechnics	836
Atrazine	Herbicide; Soil	35
Barium	Television and other electronic tubes; gamma-ray detectors; superconductors; spark plug wire; fluorescent lamps. Used in hundreds of industrial applications	206
Benzene	Oils; tires; carpets; compact discs; pharmaceuticals	933
Benzo(a)pyrene	Exhaust fumes; incomplete combustion of organic material; charbroiled food; wood burning	740
Beryllium	Alloys; x-ray tubes; aerospace material; rocket nozzles; telescopes	55
Bis(2-chloroethyl) ether	Fungicides; solvent, paint/rust remover; metal cleaner; degreasers	35
Bis(2-chloroisopropyl) ether	Dyes, resins, pharmaceuticals; fungicides, wood preservative	35
Cadmium	Batteries; coatings; plating; stabilizers	1593
Carbofuran	Pesticide; Soil	35

Analyte	Application/Example Sources [ab]	Number of Samples
Carbon tetrachloride	Freon refrigerants; propellants for aerosol cans; dry cleaning solvent; fire extinguishers	836
Chlordane (alpha)	Pesticide; Soil	34
Chlordane (gamma)	Pesticide; Soil	34
Chlordane (tech)	Pesticide; Soil	34
Chlorobenzene	Pesticide; herbicide; solvents	836
Chromium	Metallurgy; dye; pigments; tanning; refractory material	1216
Copper	Hundreds of applications including: piping; electrical; household products; coinage; biomedical; chemicals; automobile brakes	1636
Cyanide	Manufacturing of paper, textiles, plastics; chemicals for photographs; metallurgy for electroplating, metal cleaning, removing gold from its ore	85
Dalapon	Herbicide; Soil	35
Di(2-ethylhexyl) phthalate	Plasticizer in manufacturing of PVC	641
Dinoseb	Herbicide; Soil	641
Diquat	Herbicide; Soil	35
Endothall	Aquatic herbicide	35
Ethylbenzene	Production of styrene; polystyrene	933
Gamma-BHC(Lindane)	Insecticide; lice and scabies treatments	34
Glyphosate	Herbicide; Soil	35
Lead	Car batteries; ceramic glazes; coating of electrical cords; fishing sinkers; shielding from radiation; organ pipes; electrodes; solder for electronics; high voltage power cables; oil-based paints; roofing material, cladding, flashings, gutters; statues; semiconductors; photovoltaic cells; wheel balances	1766
m,p-Xylene	Solvent; printing; rubber; leather industries; polymers; cleaning agent for steel, silicon wafers and chips; pesticide; paint thinners; varnishes	853
Mercury	Barometers; manometers; thermometers; switches; vapor lamps; electric batteries; dental amalgam; insecticide; skin ointments; detonators; atmospheric deposition; mining; fluorescent light bulbs	630
Nitrate-Nitrogen	Organic wastes; fertilizers	619
o-Dichlorobenzene	Herbicides, insecticides, fertilizers	869
o-Xylene	Foam insulation; herbicides; lubricating oils; floor and wall coverings; rugs; bathmats; wood office furniture	853

Analyte	Application/Example Sources [ab]	Number of Samples
p-Dichlorobenzene	Insecticide; industrial deodorants; insecticide; fungicide; plastics; dyes; pharmaceuticals	869
Pentachlorophenol	Pesticide; wood preservative	675
Picloram	Herbicide; Soil	641
Selenium	Glass; ceramics; rubbers; photocopying; photocells; light meters; solar cells; surge protectors; x-ray technology	239
Thallium	Pesticide; photocells; infrared detectors	217
Toluene	Solvent	933
Xylenes	Solvent	80
Zinc	Alloys; galvanize metals; dry batteries; roof cladding; coinage; paints; rubber; cosmetics; pharmaceuticals; floor coverings; plastics; inks; soap; textiles; ointments; X-ray and TV screens; fluorescent lights; automobile brakes	1645

Notes:

a References: www.epa.gov, www.scorecard.org, www.chemicalland21.com, en.wikipedia.org, www.bt.cdc.gov; www.atsdr.cdc.gov; www.webelements.com

b Table provides multiple examples but not an all encompassing list of sources

2.1 Screening Level Analysis

Of the 45 analytes, 10 analytes had at least one exceedance of regulatory screening levels. The screening levels included: Oregon Administrative Rule Numerical Groundwater Reference Level (OAR-340-0020), EPA Maximum Contaminant Level (MCLs), and DEQ Drywell Compliance (MADL): Maximum Allowable Discharge Level. Table 2 below lists the analytes that have exceeded one or more screening levels.

The majority of the exceedances were for lead, pentachlorophenol (PCP), and di(2-ethylhexyl)phthalate (DEHP), at 12.7%, 11.7%, and 4.7% of the total number of samples, respectively. Seven of the analytes (Antimony, Arsenic, Benzo(a)pyrene (B(a)P), Cadmium, Chromium, Nitrate-Nitrogen (NO_3-N), and Zinc) exceeded one or more of the screening levels less than 1.0% of the time.

Table 2: Analytes Exceeding Screening Levels [a]

Analyte[b]	Portland UIC Permit Analyte	Number of Exceedances[c]	Number of Samples	% Exceeding	OAR Reference Level (mg/L)	EPA MCL (mg/L)	Drywell MADL (mg/L)[f]
Antimony	Priority Pollutant	1 (1)	347	0.3	d	0.006	0.006
Arsenic	Common Pollutant	2 (2)	846	0.2	0.05	0.01	0.01
Benzo(a)pyrene	Common Pollutant	2 (2)	740	0.3	d	0.0002	0.0002
Cadmium	Common Pollutant	8 (8)	1609	0.5	0.01	0.005	0.005
Chromium	Common Pollutant	10 (3)	1226	0.8	0.05	0.1	0.1
Di(2-ethylhexyl) phthalate	Common Pollutant	30 (30)	641	4.7	d	0.006	0.006
Lead[e]	Common Pollutant	227 (78)	1782	12.7	0.05	0.015	0.05
NO3-N	Common Pollutant	2 (2)	633	0.3	10	10	10
Pentachlorophenol[e]	Common Pollutant	79 (79)	675	11.7	d	0.001	0.001
Zinc	Common Pollutant	1 (1)	1661	0.1	5	--	5

Notes:

a Screening Levels are Oregon Administrative Rule Numerical Groundwater Reference Level (OAR-340-0020), EPA Maximum Contaminant Level, and DEQ Drywell Compliance: Maximum Allowable Discharge Limit.

b Metals results were not differentiated between total and dissolved metals. Generally, dissolved metal concentrations are lower than total metal concentrations.

c # of Exceedances = # of detected concentrations greater than screening level(s). Values in parentheses are exceedances of MADL.

d No screening level is available.

e Analytes in **bold** had more than 10% of samples exceeding the screening level(s).

f Refers to the maximum allowable concentration of a regulated pollutant at the point of underground injection.

In the case of four analytes, detection limits sometimes exceeded one or more regulatory screening levels. In such cases, it was not possible to conclude with certainty that screening level exceedances did not occur. Table 3 lists these chemicals, along with the frequency of detection levels exceeding one or more screening levels.

Kennedy/Jenks focused data analysis on the analytes with the majority of screening level exceedances (lead, PCP and DEHP). In addition to lead, PCP, and DEHP, analyses were also performed on B(a)P and NO_3-N to represent all major classes of chemicals in the dataset.

The specific analyte, the class of chemicals to which it belongs, and some typical applications or sources of this analyte in the environment are listed below. This information is also stated in Table 1.

- Lead – metal

  Car batteries; ceramic glazes; coating of electrical cords; fishing sinkers; shielding from radiation; organ pipes; electrodes; solder for electronics; high voltage power cables; oil-based paints; roofing material, cladding, flashings, gutters; statues; semiconductors; photovoltaic cells; wheel balances

- PCP – phenol

  Wood treatment product found in telephone poles; pesticide

- DEHP – phthalate

  Plasticizer in the manufacturing of PVC

- B(a)P – polynuclear aromatic hydrocarbon

  Exhaust fumes; incomplete combustion of organic material; charbroiled food, wood burning

- Nitrate-Nitrogen (NO_3-N) – nutrient

  Organic wastes; fertilizers

Table 3: Detection Limits Exceeding Screening Levels [a]

Analyte	Number of Samples	Number of Nondetects	Range of Detection Limits (mg/L)	OAR Reference Level (mg/L)	EPA MCL (mg/L)	Drywell MADL (mg/L)	Number of Nondetects Exceeding one or more Screening Levels	% of Detection Limits Exceeding One or More Screening Levels
Antimony	347	190	0.001 - 0.1	--	0.006	0.006	50	26
Bis(2-chloroethyl)ether	35	35	0.00025 - 0.00253	--	--	0.0003	4	11
Selenium	249	234	0.0005 - 3	0.01	0.05	0.05	22	9
Thallium	225	223	0.0004 - 0.8	--	0.002	0.002	80	36

Note:

a Screening Levels are Oregon Administrative Rule Numerical Groundwater Reference Level (OAR-340-0020), EPA Maximum Contaminant Level, and DEQ Drywell Compliance: Maximum Allowable Discharge Limit.

2.2 Statistical Analysis

Statistical analyses were performed on lead, PCP, DEHP, B(a)P, and NO_3-N to explore the relationship between land use and analyte concentrations, and also the relationship between number of vehicle trips and analyte concentrations.

The expected results, based on the nature and sources of the analytes, are listed below:

- Concentrations will be significantly higher in locations with greater than 1,000 vehicle trips per day than in locations with less than 1,000 vehicle trips per day.

- Concentrations in industrial, transportation, and commercial land uses will be significantly higher than in residential, open, and mixed land uses.

Summary statistics and distribution testing for each of the above-listed analytes showed that data generally followed a non-parametric distribution, meaning they did not follow a normal (bell-shaped) distribution.

To test for the relationship between concentrations for each analyte and vehicle trips, concentrations were compared between the two vehicle trip classes that DEQ currently implements for all UIC rule authorization and permitting processes (greater than or less than 1,000 vehicle trips per day) using the Mann-Whitney U test. The Mann-Whitney U test is a non-parametric significance test for assessing whether two independent samples of observations are from the same population. A 95% significance value was used to determine statistical relationships between vehicle trips and concentrations. For a 95% significance value, the results of the Mann-Whitney U test were compared to a probability (p) value of 0.05, which signifies that there is at least a 95% probability that the independent samples are not from the same population (i.e., that the samples are statistically significantly different from each other). The smaller the p value, the less likely it is that the independent samples came from the same population. The results of the Mann-Whitney U test are provided in Table 4 below, and in the attached box plots (Attachment C). As anticipated, concentrations were significantly higher for the data sets including locations with greater than 1,000 vehicle trips per day, with p values of less than 0.05.

Concentrations were also compared among land uses (residential, commercial, industrial, open space, mixed, and transportation), using the Kruskall-Wallis one-way analysis of variance, a non-parametric method for testing equality of population medians among three or more independent groups. Concentrations of some analytes were significantly higher in some land uses than others at a 95% significance level. In general, industrial and transportation land uses had higher concentrations than residential land uses. However, the sample size among different land use groups was not consistent, with the number of samples collected from residential land uses exceeding the number of samples from other land uses by an order of magnitude in many cases. Results of this analysis are shown in Table 4 and Attachment C. The number of samples representing each land use or vehicle trip class (N) is included in parentheses on the boxplots in Attachment C.

Below the p-value matrix for each analyte is a rank of the median concentration in each land use. This ranking can be a helpful tool; however, it is important to note that it does not necessarily coincide with statistically significant differences in concentrations among land uses.

Using lead as an example, Table 4 shows that the median concentration of lead was highest in the transportation land use. This relationship was statistically significant when comparing transportation with all other land uses except commercial. Concentrations in commercial land uses were statistically significantly higher than concentrations in industrial, residential, open space, and mixed land uses. Concentrations of lead in open space and residential land uses were not statistically significantly different from each other.

Table 4: Summary of Statistical Significance [abc]

Lead

Vehicle Trips	<1000 (621)[d]
>1000 (827)	<0.05

Land Use	Commercial (177)	Industrial (331)	Residential (877)	Open Space (71)	Mixed (238)	Transportation (26)
Commercial	x					
Industrial	<0.05	x				
Residential	<0.05	<0.05	x			
Open Space	<0.05	<0.05	>0.05	x		
Mixed	<0.05	<0.05	<0.05	>0.05	x	
Transportation	>0.05	<0.05	<0.05	<0.05	<0.05	x

Trans (4.9E-02) > Comm (1.1E-02) > Ind (7.0E-03) > Open (4.5E-03) > Res (3.1E-03) > Mixed (3.0E-03)[e]

Benzo(a)pyrene

Vehicle Trips	<1000
>1000	<0.05

Land Use	Commercial (48)	Industrial (25)	Residential (522)	Open Space (40)
Commercial	x			
Industrial	>0.05	x		
Residential	<0.05	<0.05	x	
Open Space	>0.05	>0.05	>0.05	x

Ind (2.9E-05) > Comm (2.1E-05) > Open (1.5E-05) > Res (1.0E-05)

Di(2-ethylhexyl)phthalate

Vehicle Trips	<1000
>1000	<0.05

Land Use	Commercial (54)	Industrial (38)	Residential (587)	Open Space (40)
Commercial	x			
Industrial	>0.05	x		
Residential	<0.05	<0.05	x	
Open Space	>0.05	>0.05	<0.05	x

Comm (2.3E-03) > Ind (2.3E-03) > Open (1.7E-03) > Res (1.0E-03)

Nitrate-Nitrogen (NO_3-N)

Vehicle Trips	<1000
>1000	<0.05

Land Use	Commercial (86)	Industrial (114)	Residential (161)	Open Space (30)	Mixed (168)	Transportation (25)
Commercial	x					
Industrial	>0.05	x				
Residential	>0.05	<0.05	x			
Open Space	<0.05	<0.05	<0.05	x		
Mixed	>0.05	>0.05	<0.05	<0.05	x	
Transportation	>0.05	>0.05	>0.05	<0.05	>0.05	x

Open (1.2E+00) > Trans (3.0E-01) = Ind (3.0E-01) > Mixed (3.0E-01) > Comm (2.8E-01) > Res (1.6E-01)

Pentachlorophenol

Vehicle Trips	<1000
>1000	<0.05

Land Use	Commercial (50)	Industrial (26)	Residential (549)	Open Space (43)
Commercial	x			
Industrial	>0.05	x		
Residential	<0.05	<0.05	x	
Open Space	<0.05	>0.05	>0.05	x

Comm (1.0E-03) > Ind (9.9E-04) > Open (3.7E-04) > Res (2.3E-04)

Notes:

a Statistically Significant Difference Measured at 95% Confidence Interval

b Statistical Tests: Vehicle Trips - Mann-Whitney and Land Use - Kruskal Wallis

c Significant p-values (<0.05) are shown in red

d Sample size, N, is presented in parentheses after the vehicle trip or land use class

e Median concentrations are ranked by land use class. Concentrations are presented in milligrams per liter (mg/L)
Ranking does not necessarily infer a statistically significant relationship among land uses

It was requested that a statistical analysis on the interaction between land use class and number of vehicle trips be performed, in order to ascertain whether land use, number of vehicle trips, or a combination of both factors is best at predicting concentrations of lead, PCP, and DEHP. It was not possible to perform a factorial analysis of variation, as the two groups (land use class and vehicle trip class) were not completely independent. For example, all commercial, mixed, and transportation land use locations corresponded with the greater than 1,000 vehicle trip class.

Of the land use classes with both greater than and less than 1,000 vehicle trips per day included, concentrations were generally higher in samples collected from the locations with greater than 1,000 vehicle trips per day.

The results of the statistical analyses indicated vehicle trip class is a stronger predictor of concentrations than land use, as the relationship was consistent among all analytes for which the test was performed. Furthermore, the differences based on vehicle trips were statistically more significant than differences in concentrations based on land use. Because vehicle trip class is essentially embedded in land use information, these factors are not independent. Table 5 presents information on the categorization of vehicle trip classes associated with each land use class.

Table 5: Land Use and Vehicle Trip Classes

Land Use Class	Total Number of Stations	Number of Stations with <1000 Vehicle Trips per Day	Number of Stations with >1000 Vehicle Trips per Day	Number of Stations without Vehicle Trip Class Assignment
Commercial	25	0	21	4
Industrial	22	3	14	5
Residential	109	66	35	8
Open Space	6	1	4	1
Mixed	19	0	14	5
Transportation	6	0	5	1

Section 3: Summary and Conclusions

Kennedy/Jenks compiled and analyzed stormwater data collected from several municipalities throughout Oregon. Of 25,247 samples and 45 analytes, only 10 exceeded one or more of the three regulatory screening levels of DEQ's Underground Injection Control Program: Oregon Administrative Rule Numerical Groundwater Reference Level (OAR-340-0020), EPA Maximum Contaminant Level (MCLs), and DEQ Drywell Compliance: Maximum Allowable Discharge Limit (MADL). Only lead, PCP, and DEHP have exceeded one or more of these screening levels in more than 1% of samples analyzed. Lead exceeded its OAR Reference Level and MADL in 12.7% of samples, and its MCL in 4.4% of samples. PCP and DEHP exceeded their respective MCLs and MADLs in 11.7% and 4.7% of samples, respectively. OAR Reference Levels are not established for PCP and DEHP. The other seven analytes (antimony, arsenic, benzo(a)pyrene, cadmium, chromium, NO_3-N, and zinc) exceeded one or more of the screening levels less than 1.0% of the time. Our analysis of these data suggests that lead, PCP, and DEHP warrant mitigative, modeling, and/or monitoring measures within a stormwater UIC implementation program. The other seven analytes do not warrant the same degree of attention due to the minimal detection of these constituents.

Anon-parametric statistical analyses for five analytes (lead, PCP, DEHP, B(a)P, and NO_3-N) in order to compare concentrations between vehicle trip classes (greater and less than 1,000 vehicle trips per day) was performed. Concentrations of all five analytes were significantly higher at sample locations associated with greater than 1,000 vehicle trips per day, compared to sample locations associated with less than 1,000 vehicle trips per day. A non-parametric statistical analysis for the same five analytes to compare concentrations among land use types reported by the municipalities (commercial, industrial, residential, transportation, mixed, and open space) was performed. Statistically significant differences in concentrations among some land use types were apparent for some analytes. However, because of the non-standardized land use type assignment among the public agencies, the large variation in the number of locations associated with each land use type, and the limited amount of location-specific metadata provided, generalizations regarding possible effects of land use type on analyte concentrations is not appropriate. One could, however, hypothesize that industrial, transportation, and commercial land uses would have higher concentrations than others because of the nature of the chemicals and their typical applications. Because vehicle trip class is already strongly associated with land use, it was not appropriate to combine these two factors for statistical analysis.

Attachment A

Stormwater Data Evaluation

Attachment A: Stormwater Data Evaluation

The stormwater data compiled by the Oregon Association of Clean Water Agencies (ACWA) for this evaluation includes data collected by 15 jurisdictions including:

- City of Bend
- City of Canby
- City of Eugene
- City of Gresham
- City of Keizer
- City of Portland
- City of Redmond
- City of Salem
- City of Troutdale
- Clackamas County Water Environment Services
- Clackamas County Department of Transportation & Development
- Clean Water Services (formerly Unified Sewerage Agency [USA])
- Multnomah County
- Oregon Department of Transportation
- TriMet

The sources of data for this preliminary stormwater evaluation include:

- *Final Report Analysis of Oregon Urban Runoff Water Quality Monitoring Data Collected from 1990 to 1996*. Prepared for the Oregon Association of Clean Water Agencies by Woodward-Clyde Consultants. June 1997.

- Underground Injection Control Program data (Annual Stormwater Discharge Monitoring Reports, Permit Years 1 – 3, Water Pollution Control Facilities [WPCF] Permit No. 102830, Class V Stormwater Underground Injection Control Systems) provided to Kennedy/Jenks Consultants by the City of Portland Bureau of Environmental Services (BES), in accordance with the letter agreement dated 3 September 2008 between the City of Portland BES, the Oregon Association of Clean Water Agencies, and Kennedy/Jenks Consultants.

- Individual *Excel* and *Access* files provided to Kennedy/Jenks Consultants by Oregon Association of Clean Water Agencies. 2009.

Attachment B

Stormwater Sampling Locations and Land Use

Attachment B: Stormwater Sampling Locations and Land Use

Jurisdiction/Program	Location Description	Site ID	Land Use	Vehicle Trips
City of Canby	1624 Se 11th Place	CA01	Residential	<1000
City of Bend	Pageant Park Small		Mixed	>1000, ADT
City of Bend	Newport		Commercial	>1000
City of Bend	Pilot Butte Filter (Pre)		Mixed(Institutional/Open Space)	>1000
City of Eugene	6th Street & Olive Street	C1	Commercial	>1000
City of Eugene	1st Avenue & Seneca Road		Industrial	>1000
City of Eugene	1st Avenue and Wallis Street		Industrial	>1000
City of Eugene	5th Avenue & HWY 99		Industrial	>1000
City of Eugene	5th Avenue East & Seneca Road		Industrial	>1000
City of Eugene	5th Avenue West & Wallis Street		Industrial	>1000
City of Eugene	Wallis Street		Industrial	>1000
City of Eugene	5th Street & Wallis Street	I1	Industrial	>1000
City of Eugene	Bertlesen and A-3 Channel[a]	I2	Industrial	>1000
City of Eugene	Polk Street & Bailey Avenue		Mixed	>1000
City of Eugene	Royal	A3	Mixed	>1000
City of Eugene	Amazon (Royal)	Amazon	Mixed	>1000
City of Eugene	Knickerbacker Bike Bridge	Knickerbacker	Mixed	>1000
City of Eugene	Polk Street & Baily Street	M1	Mixed	>1000
City of Eugene	29th & Amazon Creek	M2	Mixed	>1000
City of Eugene	Springfield Bridge	Springfield Bridge	Mixed	Not Available
City of Eugene	Upstream UBG	Upstream UBG	Mixed	>1000
City of Eugene	Willamette (Downstream)	Willamette (Downstream)	Mixed	>1000
City of Eugene	Willamette (Owosso)	Willamette (Owosso)	Mixed	>1000
City of Eugene	Willow Creek	Willow Creek	Mixed	>1000
City of Eugene	Anderson Ln near 395 Briana Ln	EU01	Residential	<1000
City of Eugene	Andersen Lane & Briana Lane		Residential	Not Available
City of Eugene	Coetivy Street & Terry Street	R1	Residential	<1000
City of Gresham	858 NE 166th Ave	GR01	Residential	<1000
City of Gresham	City Park	M-16	Commercial	>1000
City of Gresham		14R	Mixed	>1000
City of Gresham	Boeing - Interstate 84 near NE 181st Ave.	E-3	Mixed	>1000
City of Gresham	14th & Riverview	I-13	Mixed	>1000
City of Gresham	Fairview Park	K-4	Residential	Not Available
City of Keizer	1685 Lucinda Ave NE	KE01	Not Available	<1000
City of Portland	Parkrose Sandfilter - Commercial		Commercial	Not Available
City of Portland	Jantzen Beach	C-1	Commercial	Not Available
City of Portland	SW 1st Ave & SW Salmon	C-2	Commercial	Not Available
City of Portland		OF19	Industrial	Not Available
City of Portland	Whitaker Pond - Industrial		Industrial	Not Available
City of Portland	NW Yeon Ave & NW 135th St	I-1	Industrial	Not Available
City of Portland	Ensign Ct-Swan Island	I-2	Industrial	Not Available
City of Portland		M-3	Mixed	Not Available
City of Portland		S45U / JCF	Mixed	Not Available
City of Portland	NE 122nd Ave at Columbia Slough	M-1	Mixed	Not Available
City of Portland	SE Milport Ave at Johnson Creek	M-2	Mixed	Not Available
City of Portland		OP-1	Open Space	Not Available
City of Portland	Balch Creek-Forest Park	OP-1	Open Space	Not Available
City of Portland		R-3	Residential	Not Available
City of Portland	Russell Pond - Residential		Residential	Not Available
City of Portland	Fanno Creek at SW 56th Street	R-1	Residential	Not Available
City of Portland	141st Ave & Sandy	R-2	Residential	Not Available
City of Portland	NW Yeon Ave & NW 135th St	T-1	Transportation	Not Available
City of Salem		1	Commercial	>1000
City of Salem		42472295	Commercial	>1000
City of Salem		42474202	Commercial	Not Available
City of Salem	100 block of Cottage St. SE.	Cottage	Commercial	Not Available
City of Salem		36474204	Industrial	>1000
City of Salem		D42468-224	Industrial	>1000
City of Salem	Patterson Ace. NW and Edgewater St.	Edgewater	Industrial	Not Available
City of Salem		42458210	Mixed	>1000
City of Salem	Commercial Street SE	Commercial	Mixed	Not Available
City of Salem		33450212	Residential	<1000
City of Salem		D33478-226	Residential	<1000
City of Salem		D42464-262	Residential	>1000
City of Salem		D45476-206	Residential	>1000
City of Salem	Red Leaf Drive SE at Serend Court	Redleaf	Residential	<1000
City of Salem		36474202	Not Available	Not Available
City of Troutdale	2211 SW Larsson Ave	TR01	Residential	<1000
City of Wilsonville	Wilsonville Road near Public Library	Wilson Road	Commercial	Not Available
Clackamas County	S.E. Last Road & 98th Ave.	Cow Creek	Industrial	Not Available
Clackamas County	Bell Ave. & S.E. Overland Street	Bell Station	Residential	>1000
City of Lake Oswego	Bryant Road near Lake Oswego Canal	Lake Oswego	Residential	Not Available
City of Milwaukie	Roswell & S.E. 28th Place	Milwaukie	Residential	Not Available
City of Oregon City	Coffee Creek Watershed at Chapin Park	Oregon City	Residential	Not Available
Clean Water Services		7301021	Commercial	>1000
Clean Water Services		7301041	Commercial	>1000
Clean Water Services		7301031	Industrial	>1000
Clean Water Services		7106001	Residential	<1000
Clean Water Services		7106002	Residential	<1000
Clean Water Services		7106201	Residential	<1000
Clean Water Services		7106202	Residential	<1000
Clean Water Services		7301011	Residential	<1000
Clean Water Services		7301081	Residential	<1000
Clean Water Services		7501001	Residential	<1000
Clean Water Services		7501002	Residential	<1000

Jurisdiction/Program	Location Description	Site ID	Land Use	Vehicle Trips
Multnomah County	SE Stark & E Burnside	MC01	Commercial	>1000
ODOT	I-5 North of Ashland	Ashland	Transportation	>1000
ODOT	Hwy-101 Columbia River Bridge	Astoria	Transportation	>1000
ODOT	Hwy-20 in Corvallis	Corvallis	Transportation	Not Available
ODOT	I-105 near Owens Rose Garden	Eugene	Transportation	>1000
ODOT	Hwy-101 North of Neskowin	Neskowin	Transportation	>1000
ODOT	I-5 near Oregon Convention Center	Portland	Transportation	>1000
ODOT	Hwy-42 East of Remote	Remote 42	Transportation	Not Available
City of Portland UIC	10064 SE Woodstock Blvd	P6_8	Industrial	<1000
City of Portland UIC	20 SE 160th Ave	P1_8	Manufacturing	<1000
City of Portland UIC	10720 NE Wygant St	P6_10 YR1	Manufacturing	<1000
City of Portland UIC	15000 NE Klickitat St	SP2_2	Manufacturing	<1000
City of Portland UIC	13400 SE Raymond St	SP2_4	Manufacturing	<1000
City of Portland UIC	6940 N Macrum Ave	P1_1	Residential	<1000
City of Portland UIC	1160 SE 140th Ave	P1_11	Residential	<1000
City of Portland UIC	6507 N Princeton St	P1_13	Residential	<1000
City of Portland UIC	6125 N Mississippi Ave	P1_15	Residential	<1000
City of Portland UIC	2510 N Buffalo St	P1_2	Residential	<1000
City of Portland UIC	7120 SE 67th Ave	P1_4	Residential	<1000
City of Portland UIC	1840 SE 164th Ave	P1_6	Residential	<1000
City of Portland UIC	4740 NE 57th Ave	P1_9	Residential	<1000
City of Portland UIC	1406 NE Skidmore St	P6_11	Residential	<1000
City of Portland UIC	2913 SE 118th Ave	P6_12 YR1	Residential	<1000
City of Portland UIC	14350 NE Knott St	P6_13	Residential	<1000
City of Portland UIC	940 NE Portland Blvd	P6_2 YR1	Residential	<1000
City of Portland UIC	4541 NE 80th Ave	P6_3	Residential	<1000
City of Portland UIC	9090 SE Claybourne St	P6_4	Residential	<1000
City of Portland UIC	5201 N Emerson Dr	P6_6	Residential	<1000
City of Portland UIC	3617 SE 168th Ave	P6_9	Residential	<1000
City of Portland UIC	5003 SE 58th Ave	P2_11	Residential	<1000
City of Portland UIC	7003 NE Everett St	P2_12	Residential	<1000
City of Portland UIC	13075 NE Weidler St	P2_15	Residential	<1000
City of Portland UIC	1337 NE Shaver St	P2_6	Residential	<1000
City of Portland UIC	7930 SE Henry St	P2_7	Residential	<1000
City of Portland UIC	2905 SE 143rd Ave	P2_9	Residential	<1000
City of Portland UIC	4312 NE Emerson St	SP1_10	Residential	<1000
City of Portland UIC	15424 SE Tibbetts St	SP1_4	Residential	<1000
City of Portland UIC	6002 SE 140th Ave	SP1_6	Residential	<1000
City of Portland UIC	14814 SE Rhone St	SP1_8	Residential	<1000
City of Portland UIC	15913 SE Grant St	SP1_9	Residential	<1000
City of Portland UIC	6310 SE Franklin St	P3_10	Residential	<1000
City of Portland UIC	315 N Holland St	P3_11	Residential	<1000
City of Portland UIC	7346 SE 46th Ave	P3_12	Residential	<1000
City of Portland UIC	1600 NE Beech St	P3_14	Residential	<1000
City of Portland UIC	8003 SE 11th Ave	P3_15	Residential	<1000
City of Portland UIC	11759 SE Taylor St	P3_2	Residential	<1000
City of Portland UIC	4320 SE 101st Ave	P3_8	Residential	<1000
City of Portland UIC	14746 SE Rhone St	SP2_3	Residential	<1000
City of Portland UIC	3024 SE 154th Ave	SP2_6	Residential	<1000
City of Portland UIC	3905 SE 147th Ave	SP2_7	Residential	<1000
City of Portland UIC	608 NE 87th Ave	P6_7	Not Available	<1000
City of Portland UIC	3500 SE 112th Ave	P6_1	Commercial	>1000
City of Portland UIC	4289 NE Prescott St	P6_14	Commercial	>1000
City of Portland UIC	12220 SE Holgate Blvd	P2_3	Commercial	>1000
City of Portland UIC	5518 N Campbell Ave	P3_5	Commercial	>1000
City of Portland UIC	2321 SE 122nd Ave	P3_9	Commercial	>1000
City of Portland UIC	10150 Se Ankeny St	P2_5	Industrial	>1000
City of Portland UIC	15839 E Burnside St	P1_12	Manufacturing	>1000
City of Portland UIC	2513 SE 153rd Ave	P6_5	Manufacturing	>1000
City of Portland UIC	5015 NE Killingsworth St	P2_2	Manufacturing	>1000
City of Portland UIC	490 NE 106th Ave	P2_4	Manufacturing	>1000
City of Portland UIC	635 SE 84th Ave	P3_7	Manufacturing	>1000
City of Portland UIC	5502 NE 13th Ave	P6_10	Manufacturing	>1000
City of Portland UIC	8036 SE Grand Ave	SP2_1	Manufacturing	>1000
City of Portland UIC	4549 SE 122nd Ave	SP2_5	Manufacturing	>1000
City of Portland UIC	11847 SE Powell Blvd	SP2_9	Manufacturing	>1000
City of Portland UIC	6433 NE Tillamook St	P1_7	Open Space	>1000
City of Portland UIC	13500 NE Glisan St	P6_15	Open Space	>1000
City of Portland UIC	14800 NE Halsey St	P3_6	Open Space	>1000
City of Portland UIC	3740 SE 104th Ave	P6_2	Open Space	>1000
City of Portland UIC	7380 NE Prescott St	P1_14	Residential	>1000
City of Portland UIC	3716 NE 112th Ave	P1_3	Residential	>1000
City of Portland UIC	7002 SE 45th Ave	P1_5	Residential	>1000
City of Portland UIC	6400 SE 137th Ave	P2_1	Residential	>1000
City of Portland UIC	5934 NE Cleveland Ave	P2_10	Residential	>1000
City of Portland UIC	4107 SE Reedway St	P2_13	Residential	>1000
City of Portland UIC	8409 N Woolsey Ave	P2_14	Residential	>1000
City of Portland UIC	3938 SE 130th Ave	P2_8	Residential	>1000
City of Portland UIC	550 SE 130th Ave	P6_12	Residential	>1000
City of Portland UIC	6400 SE 137th Ave	SP1_1	Residential	>1000
City of Portland UIC	5436 SE 108th Ave	SP1_2	Residential	>1000
City of Portland UIC	13140 NE Glisan St	SP1_3	Residential	>1000
City of Portland UIC	13743 NE San Rafael St	SP1_5	Residential	>1000
City of Portland UIC	1520 NE 141st Ave	SP1_7	Residential	>1000
City of Portland UIC	2810 N Buffalo St	P3_1	Residential	>1000
City of Portland UIC	6738 NE 22nd Ave	P3_13	Residential	>1000
City of Portland UIC	4940 N Willis Blvd	P3_3	Residential	>1000
City of Portland UIC	3150 NE Regents Dr	P3_4	Residential	>1000
City of Portland UIC	6112 SE Clatsop St	SP2_10	Residential	>1000
City of Portland UIC	4406 SE 136th Ave	SP2_8	Residential	>1000
City of Portland UIC	10634 E Burnside St	P1_10	Not Available	>1000
City of Redmond		Site #01 In	Commercial	>1000
City of Redmond		Site #01 DW	Commercial	>1000

Jurisdiction/Program	Location Description	Site ID	Land Use	Vehicle Trips
City of Redmond		Site #02	Residential	<1000
City of Redmond		Site #03	Commercial	>1000
City of Redmond		Site #03 In	Commercial	>1000
City of Redmond		Site #03 DW	Commercial	>1000
City of Redmond		Site #04	Residential	<1000
City of Redmond		Site #05	Commercial	>1000
City of Redmond		Site #06	Industrial	>1000
City of Redmond		Site #07	Industrial	<1000
City of Redmond		Site #08	Airport Parking Lot	>1000
City of Redmond		Site #09	Airport Parking Lot	>1000
City of Redmond		Site #10	Airport Tarmac	>1000
City of Redmond		Site #11	Not Available	Airport Tarmac
TriMet	3705 SE 99th Ave	TM01	Industrial	Not Available
USA[b]	Cornell Road	UC1b	Commercial	>1000
USA	Wash. Square	UC2	Commercial	>1000
USA	Forest Grove	UC3	Commercial	Not Available
USA	74th & Durham	UI1	Industrial	>1000
USA	Western & Allen	UI2	Mixed	>1000
USA	Fanno Creek	UM1	Mixed	Not Available
USA	Foothills Park	UR1	Mixed	<1000
USA	Teton Avenue	UR2	Residential	<1000
Water Environment Services	7521 SE Lamphier St	CC01	Residential	>1000
Water Environment Services	SE Pheasant Court Outfall (outfall #12)	outfall #12	Mixed	Not Available
Water Environment Services	SE Tolbert Street Outfall (outfall #26)	outfall #26	Mixed	Not Available
Water Environment Services		SW9	Open Space	<1000
Water Environment Services	Kellogg Creek at SE Webster Road (outfall #19)	outfall #19	Residential	Not Available
Water Environment Services	SW Brookman Road Outfall		Residential	Not Available
Water Environment Services	SW Childs and Terry Outfall		Residential	Not Available
Water Environment Services		SW10	Residential	>1000
Water Environment Services		SW1I	Residential	<1000
Water Environment Services		SW2I	Residential	>1000
Water Environment Services		SW3I	Residential	<1000
Water Environment Services		SW5	Residential	<1000

Notes

a Bertlesen and A-3 Channel data should not be used in statistical analysis

b Formally Unified Sewerage Agency, now Clean Water Services

ADT = Average Daily Trips

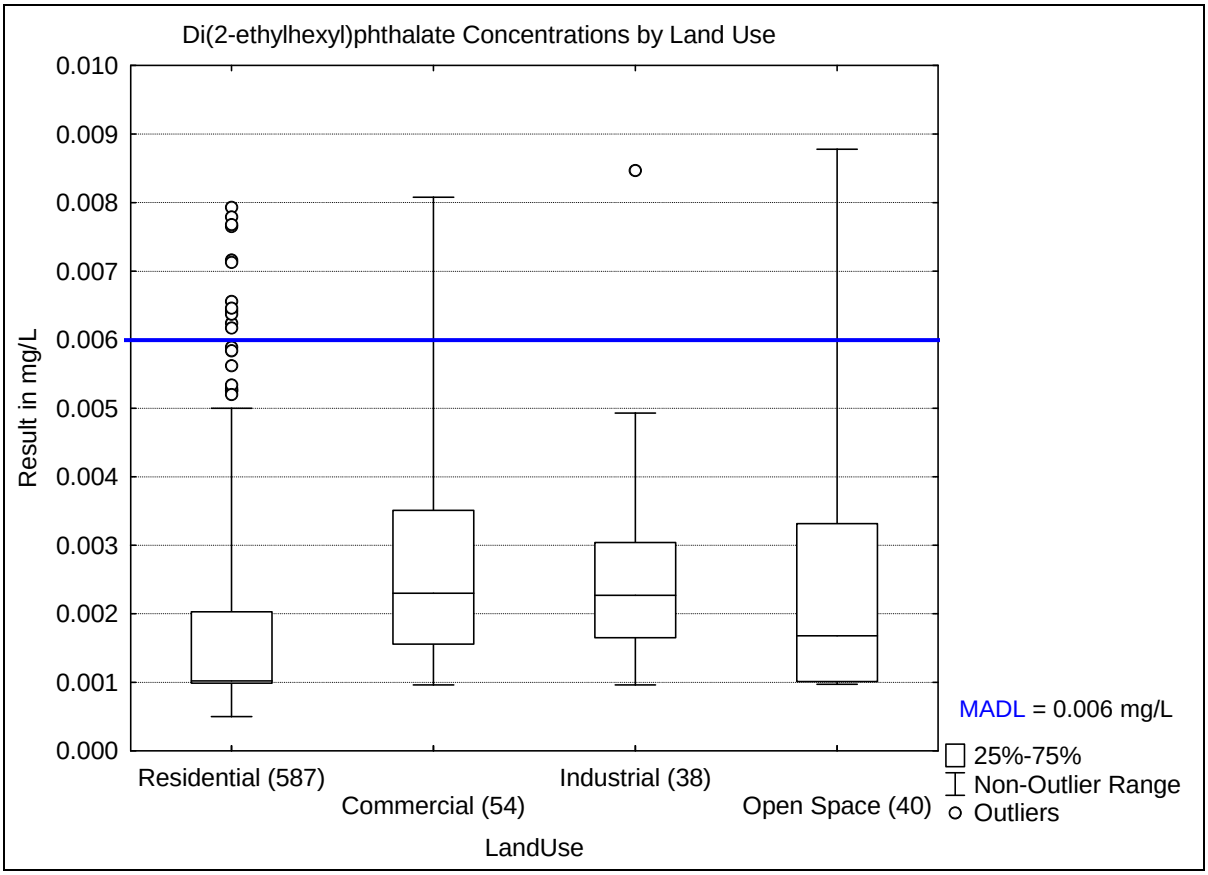
Land use categories were consolidated as listed in the following table:

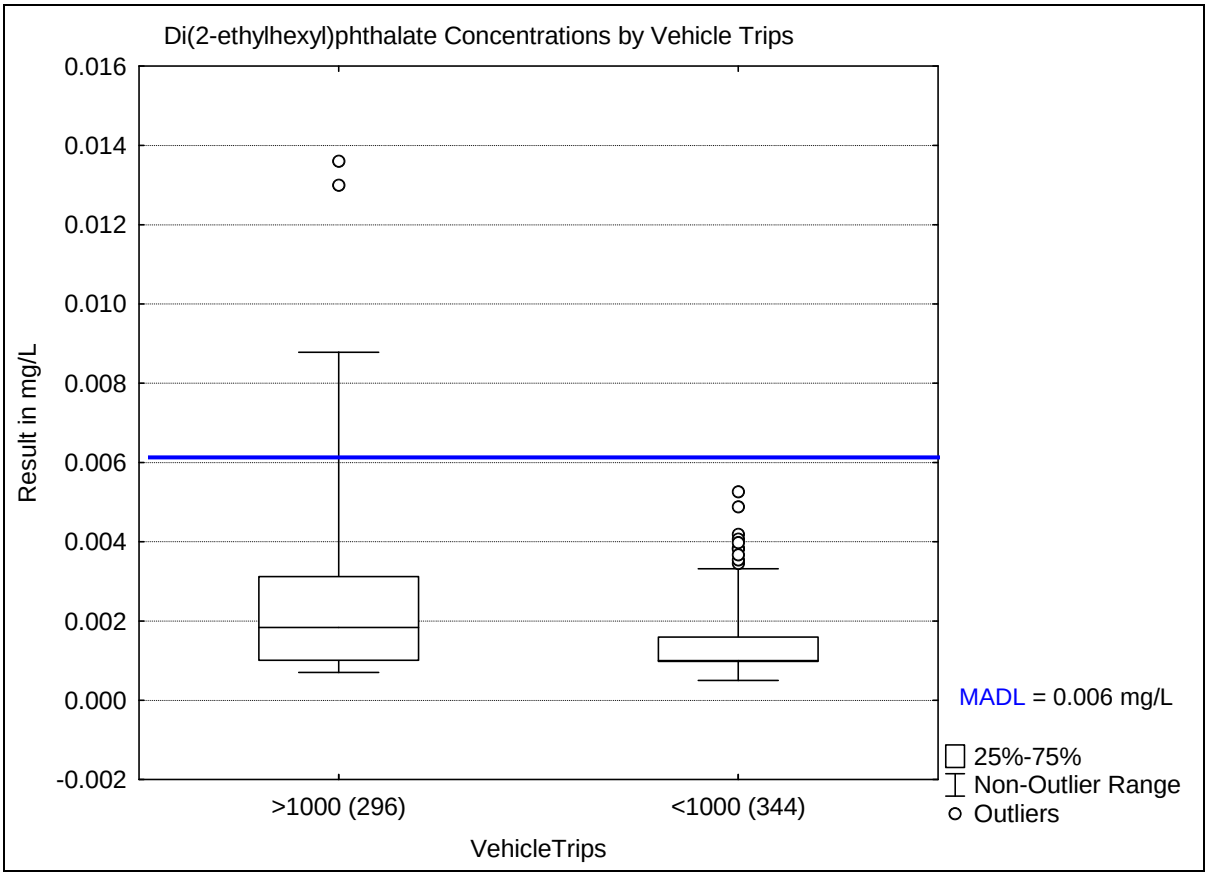
Land Use Category	Land Use Codes Provided by ACWA
Residential	RES, rural RES, R, SFR, Residential
Industrial	IND, LI, HI, Light Industrial
Commercial	COM, C, Commercial
Manufacturing	MFR
Mixed	M, MIX
Open Space	OP, O, POS
Transportation	T

Attachment C

Boxplots

Attachment C: Boxplots





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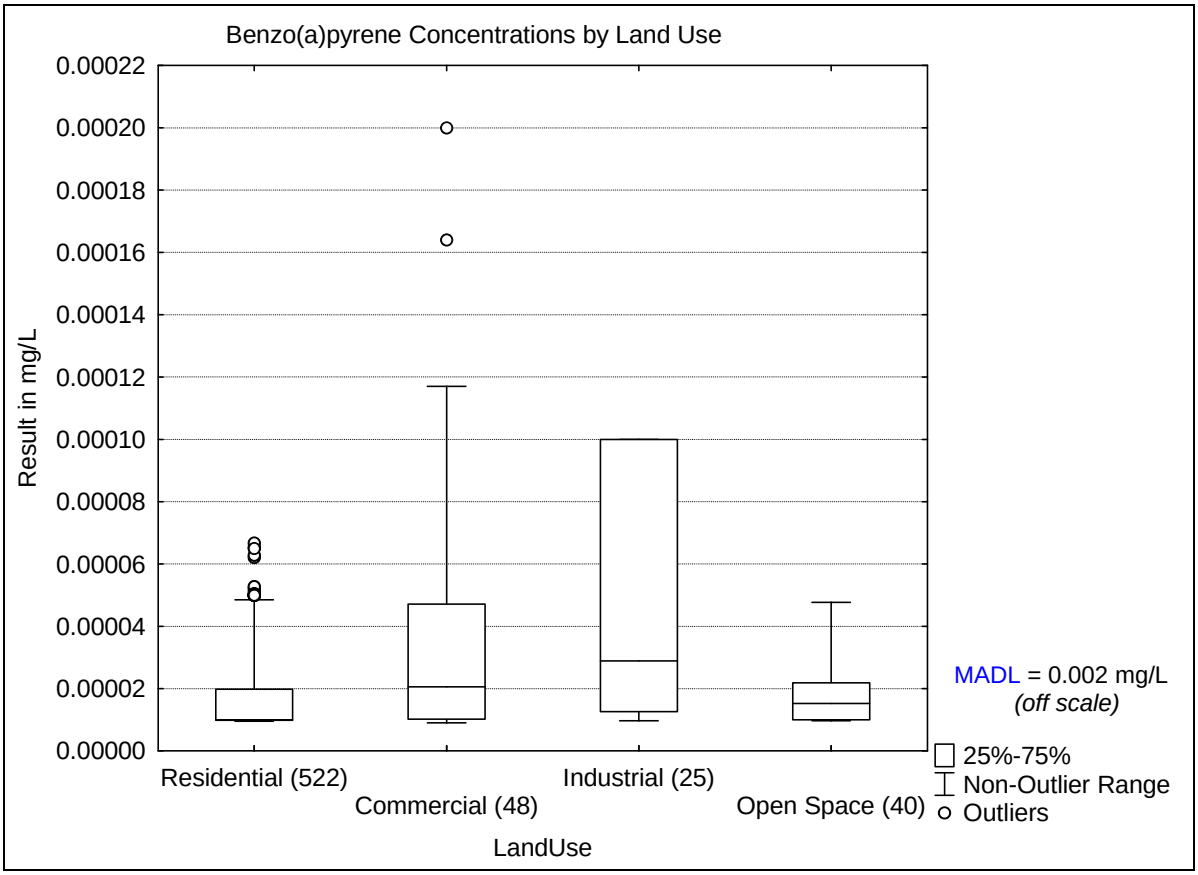

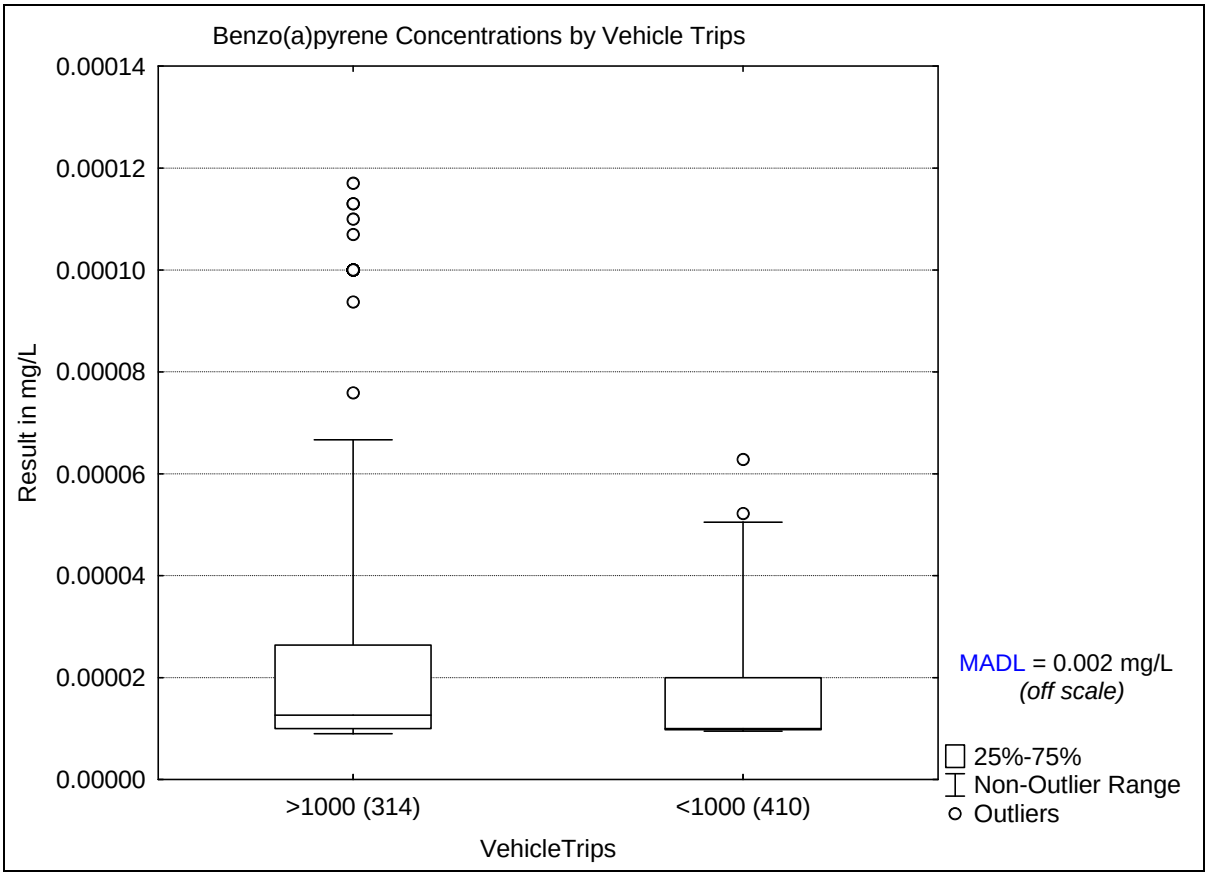

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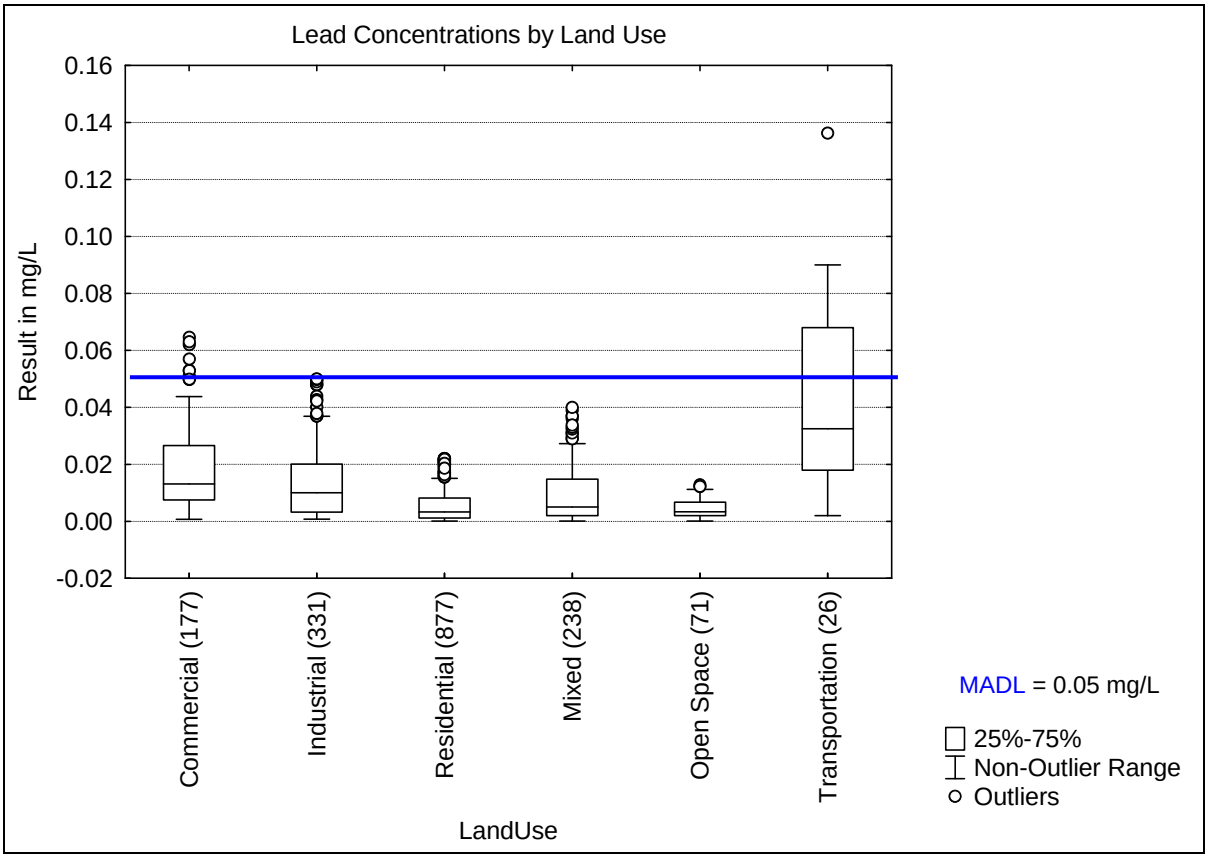

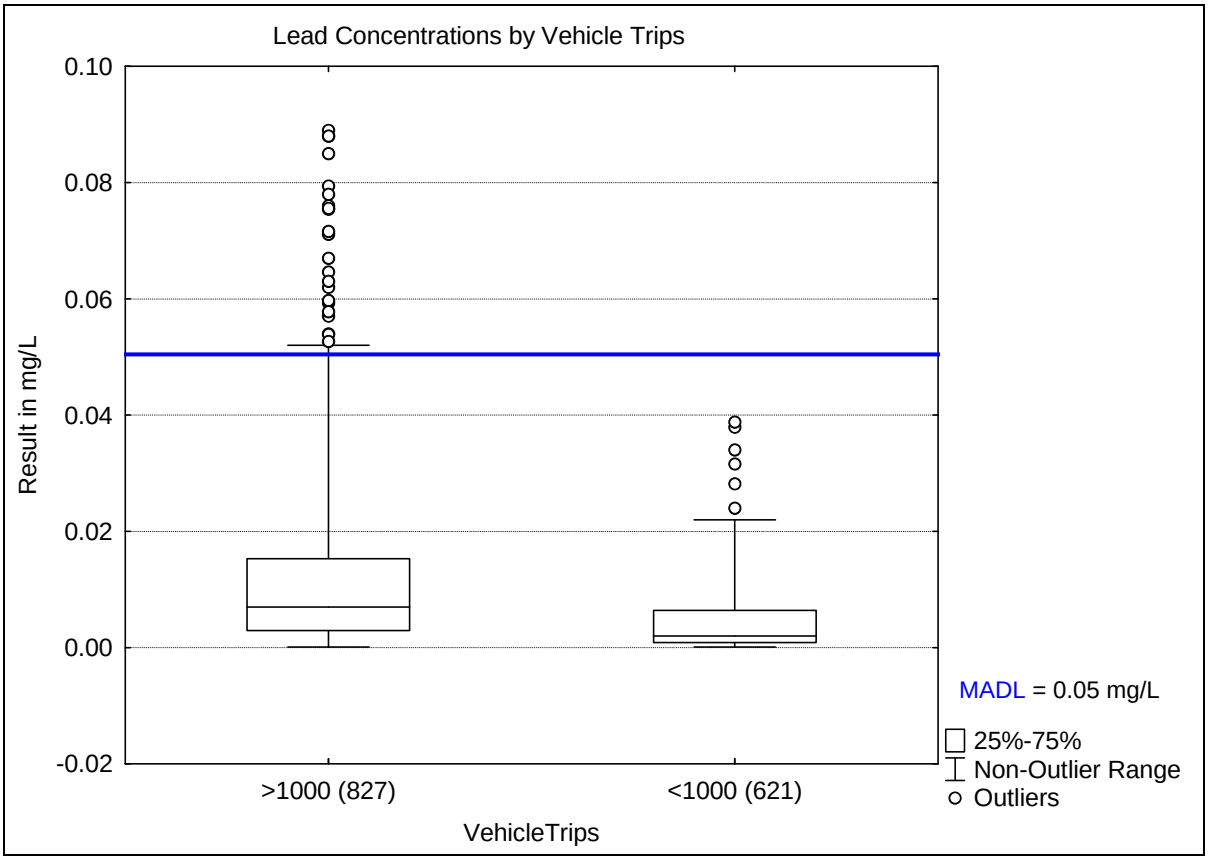

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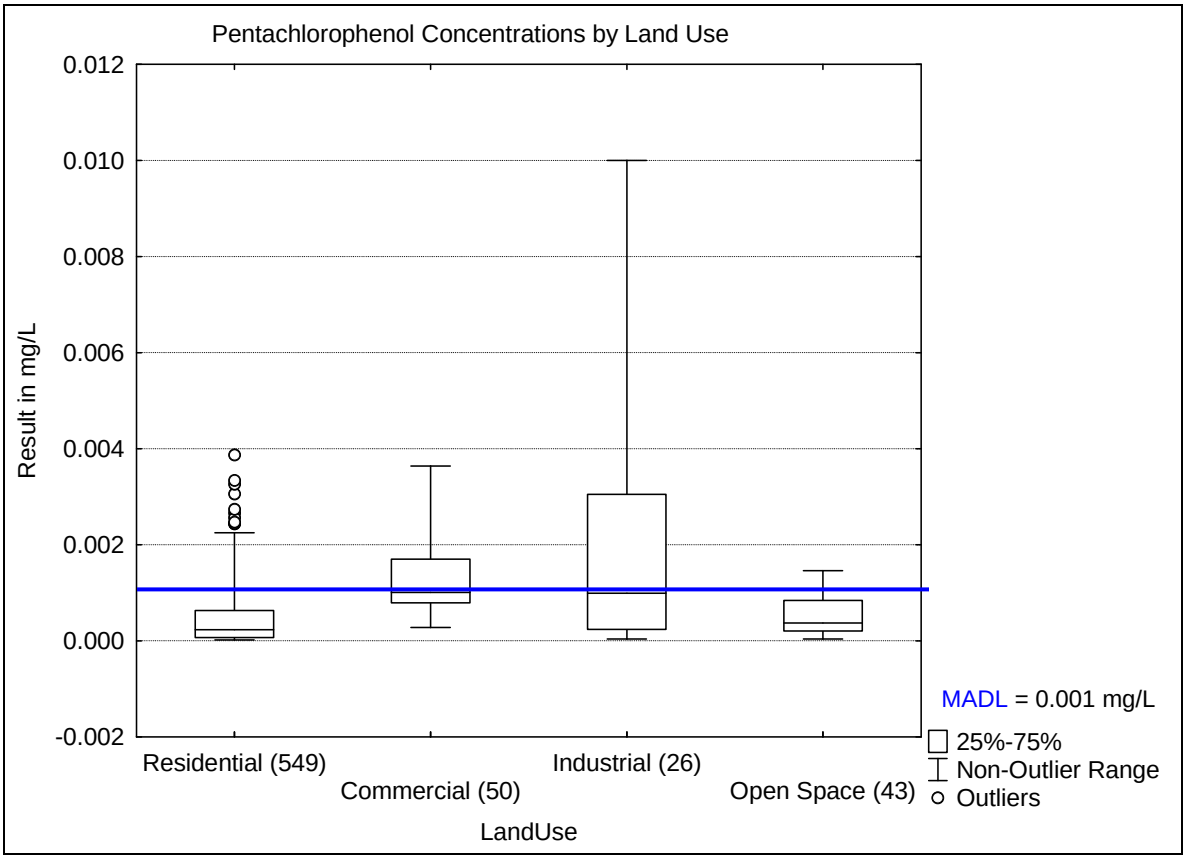

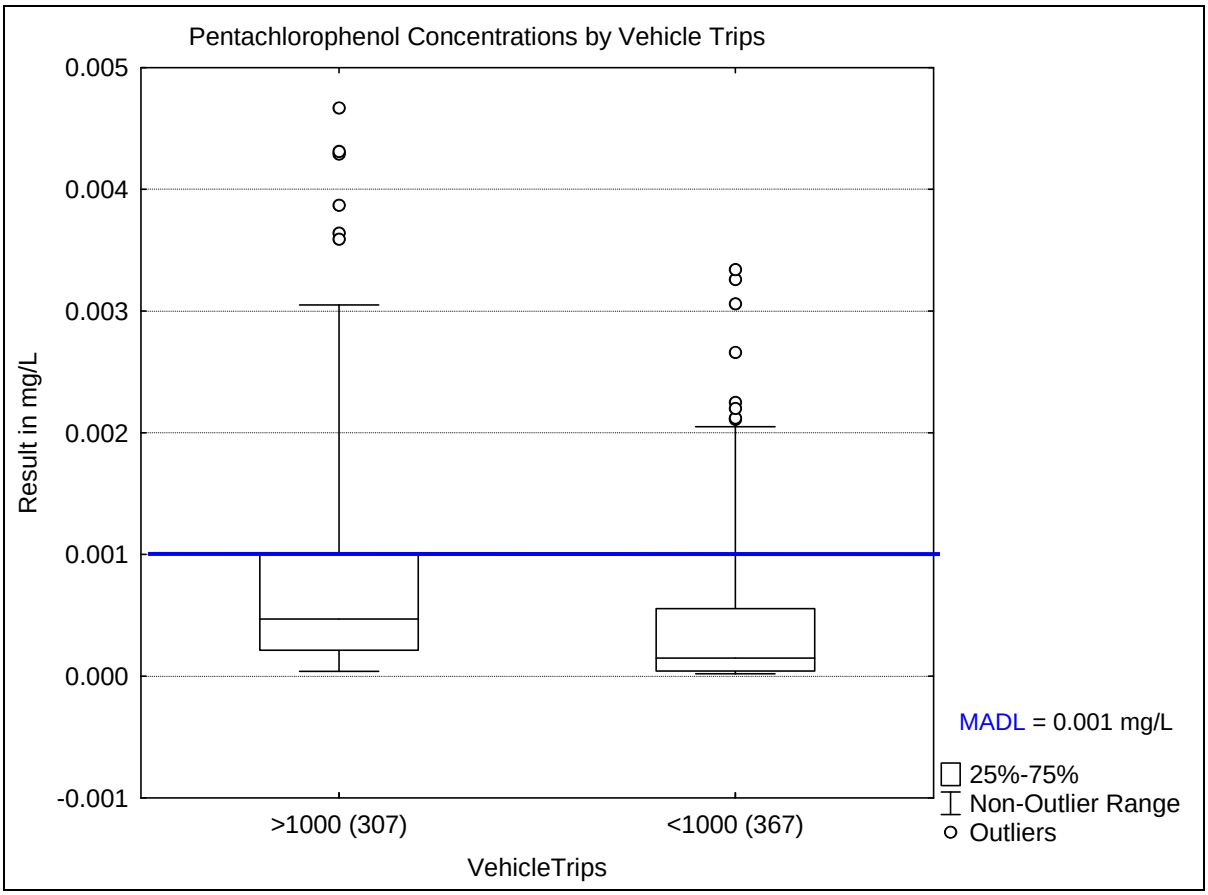

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