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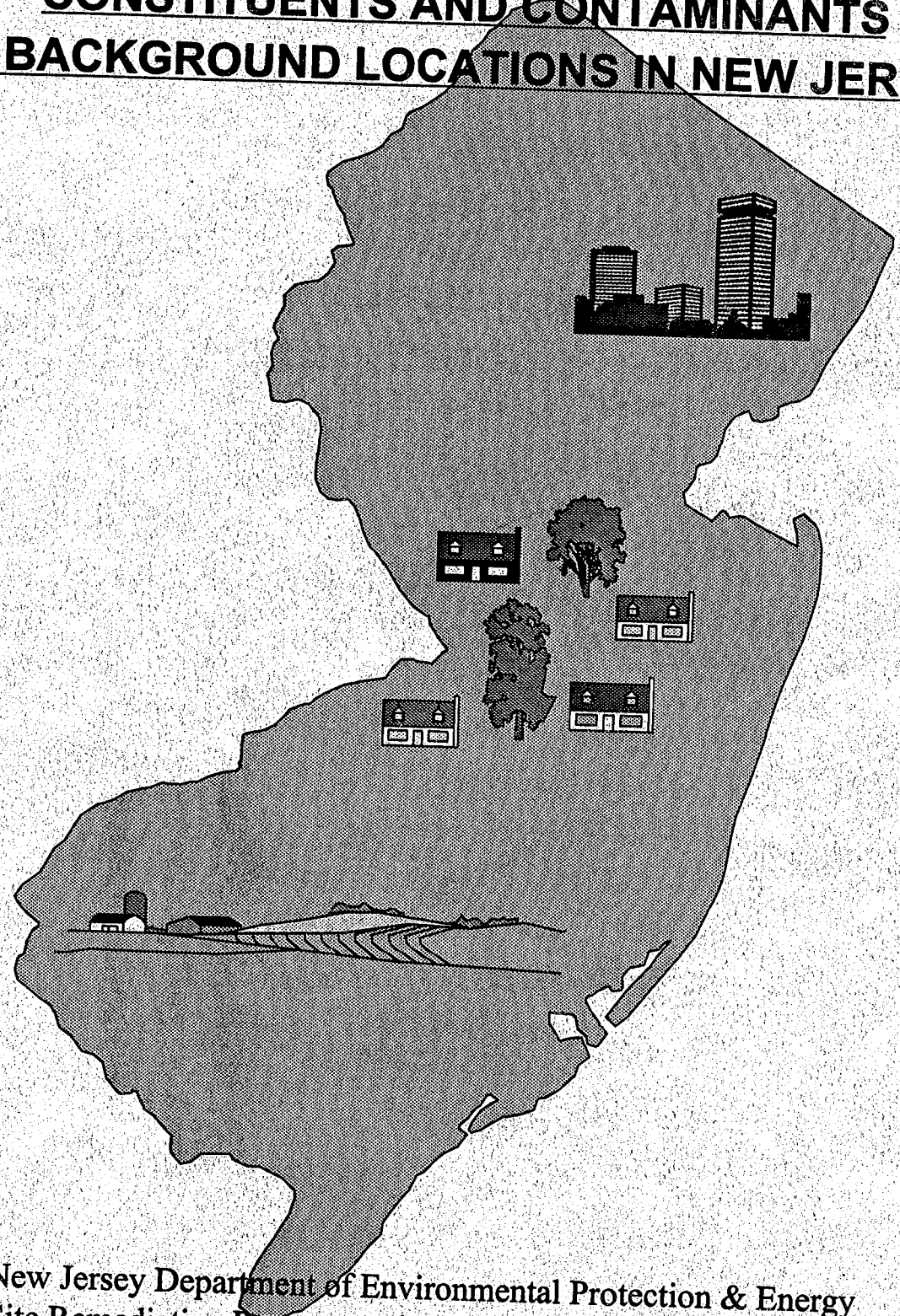
A SUMMARY OF SELECTED SOIL CONSTITUENTS AND CONTAMINANTS AT BACKGROUND LOCATIONS IN NEW JERSEY



New Jersey Department of Environmental Protection & Energy
Site Remediation Program and Division of Science & Research

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A SUMMARY OF SELECTED SOIL CONSTITUENTS AND CONTAMINANTS AT BACKGROUND LOCATIONS IN NEW JERSEY

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EXECUTIVE SUMMARY

A study of background soil concentrations of constituents and contaminants was carried out to support hazardous site cleanup efforts in New Jersey. The results presented here, from a representative survey of soil types in New Jersey, compare well with other previously developed data, and provide a reasonable indication of statewide background conditions.

A total of eighty soil samples were collected throughout the state. The soil types selected for sampling included forty-six of the most common soil types in New Jersey. USDA Soil Conservation Service (SCS) personnel aided in the selection of sampling sites and the identification of soil type and texture. The majority of the samples were collected from parklands throughout the state, and represent soils with no direct source of pollution other than atmospheric deposition. Thirty-five of the samples were collected from rural, undisturbed areas of the state. Thirty-seven samples were collected from urban (19) and suburban (18) parks in areas representing a broad range of population densities. Several additional samples were collected from golf course greens (5) and agricultural land (3). Many of the non-rural soils did not display natural soil profiles due to historical regrading of top soils when many of the parks were built. The sampled areas were, in general, not impacted directly by industry or other point sources of pollution.

Samples were characterized according to land use, soil series and soil (surface horizon) textural type. In addition, general soil characteristics such as pH, loss on ignition, and percent sand, silt, and clay, were determined. Target chemical parameters include: priority pollutant and other selected metals, polychlorinated biphenyls (PCB), chlorinated pesticides, polycyclic aromatic hydrocarbons (PAH), organophosphate pesticides, and chlorinated herbicides. The data are grouped by land use category comprising rural (35 samples), suburban (18), urban (19), golf course (5), and agricultural land (3).

The results, presented on a land use basis, indicated a general trend of increasing contamination with increasing human activity. All of the metals included in the survey, with the exceptions of beryllium, chromium and selenium, displayed significantly higher concentrations in the urban soils than in the rural soils sampled. Several metals also showed significantly higher concentrations in suburban versus rural soils, as determined by nonparametric statistical analysis. Similar trends were also seen for certain chlorinated pesticides which have had wide historical use. A limited number of samples were collected from amended soils on golf greens. These data indicated that levels of certain inorganics and pesticides were as high or higher on the golf greens as in the urban soils.

In general, the arithmetic means of the inorganic data in the present study agreed reasonably well with other available data sets. The ranges of the different inorganic parameters are reasonably representative of statewide background conditions, which are seen to include both natural background, and background modified by diffuse anthropogenic pollution.

No PCBs, organophosphate pesticides or chlorinated herbicides were detected in this study, while polycyclic aromatic hydrocarbons (PAH) were detected at or below the low part per million level. Laboratory quality assurance problems, however, limit the utility of the PCB and PAH data.

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INTRODUCTION

A major responsibility of the New Jersey Department of Environmental Protection and Energy is the mitigation of uncontrolled hazardous waste sites and contaminated industrial sites under its jurisdiction. Central to any cleanup strategy is the issue of "How clean is clean?". Health-based soil cleanup objectives must be compared to both background soil concentrations and available analytical detection limits to determine practical enforceable cleanup standards. When the health-based objective is less than background, the standard must be set at a different value, either a background value or the detection limit, whichever is higher. Utilizing a distribution of soil values throughout the state allows the selection of a threshold value, such that a concentration in excess of this is likely to be of human rather than natural origin.

Cleanup standards which are protective of human health consider various potential routes of exposure. Common routes of human exposure associated with contaminated soils involve direct contact with soil pollutants via incidental soil ingestion and inhalation of soil and dust particles, as well as, inhalation of substances volatilized to the atmosphere. Soil contaminants can also be transported to potable water aquifers, which can result in the ingestion of contaminated groundwater.

Since significant potential exposure pathways are associated with surface soils, the soils sampled for this project were collected to a depth of twelve inches (30.5 cm). Soil contaminants that result from atmospheric deposition can produce relatively elevated concentrations in the upper few centimeters of the soil profile. Therefore, the level of contaminants measured in the homogenized twelve-inch core samples for this study may represent a lower average concentration in comparison to surface contamination resulting from atmospheric deposition. Similarly, a larger homogenized core segment (e.g., 0-24") may represent an even greater degree of dilution relative to the immediate surface. The widespread distribution, via atmospheric deposition, of several pollutants such as trace elements (Friedland, et al., 1984), PCBs (Creaser and Fernandes, 1986), and polycyclic aromatic hydrocarbons (PAH) (Prahl, et al., 1984, Blumer, et al., 1977) in urban soils has been documented.

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METHODS

The soil samples, which were collected during the period 1985-1987, were distributed throughout the state with two to six samples collected per county (Figure 1). Rural samples were collected in undisturbed forests, woodlots and meadows; the majority of sampled sites were located on public lands including state parks and forests. One muck sample, collected from a Pine Barrens bog, has been included in the rural sample set. Suburban sampling sites included areas with a moderate amount of human activity, such as parks and playgrounds in small towns. The urban samples were collected in parks, in densely populated, developed areas of the state. Areas obviously impacted directly by a nearby industry or other point source were avoided. Two soil samples (samples # 26 and 66) did contain fill material (i.e., disturbed soils containing cinders and debris) of uncertain origin; these samples were included in the database under the urban land use category and will be discussed separately in the results section.

A. Sample Collection Procedures

Sampling was concentrated in areas which were non-locally impacted (i.e., sites did not have any known or direct sources of pollution as determined by DEPE and SCS sampling personnel). Many of the sites sampled are utilized for recreational purposes. A total of eighty samples were collected during this study. The majority of the samples were collected from forests and parks located in areas that ranged from land which has never been developed, to densely populated areas. In addition, a few samples were collected from golf courses and farms as examples of soils likely to be amended with fertilizers and pesticides.

Information on soil types and acreage in the state was provided by the USDA Soil Conservation Service. From these data, 46 major soil types were selected, which account for over 70 percent of the land area in New Jersey. This was done to measure soil constituents and contaminants in a variety of soil types even though concentrations of many of these elements and compounds are known to vary widely within any given soil classification.

Final sampling locations were determined by SCS soil scientists. Typical examples of the major soil types were selected. SCS personnel also provided soil taxonomy, texture and color information for each sample. Table 1 includes sampling locations, soil types, land use categories, and soil texture information for the samples included in this study. In addition, a description of each sampling site, state plane coordinates, SCS soil survey sheet number and soil color were recorded for each sampling locale (Data on file at DEPE.)

The majority of the soil samples were collected utilizing a stainless steel soil coring device (1 in. diameter x 12 in. depth). Between samples the corer was thoroughly cleaned with acetone and distilled water. A composite of ten soil cores was usually required to obtain an adequate amount of sample (approximately 500 grams). The number of samples per composite varied as a function of the depth to bedrock and the ease of coring in various areas of the state. For impervious and very rocky soils, a four-inch bucket auger was utilized for sample collection. All samples were placed in acid-rinsed, solvent-cleaned and baked, teflon-lined, screw-top glass jars. All samples were taken in the presence of a Rutgers University Environmental Science Department staff member, who accompanied them back to the laboratory. Samples were stored at 4° C until analyses were conducted. Extractions and digestions were performed within one week of receipt. Analyses were then performed within five days.

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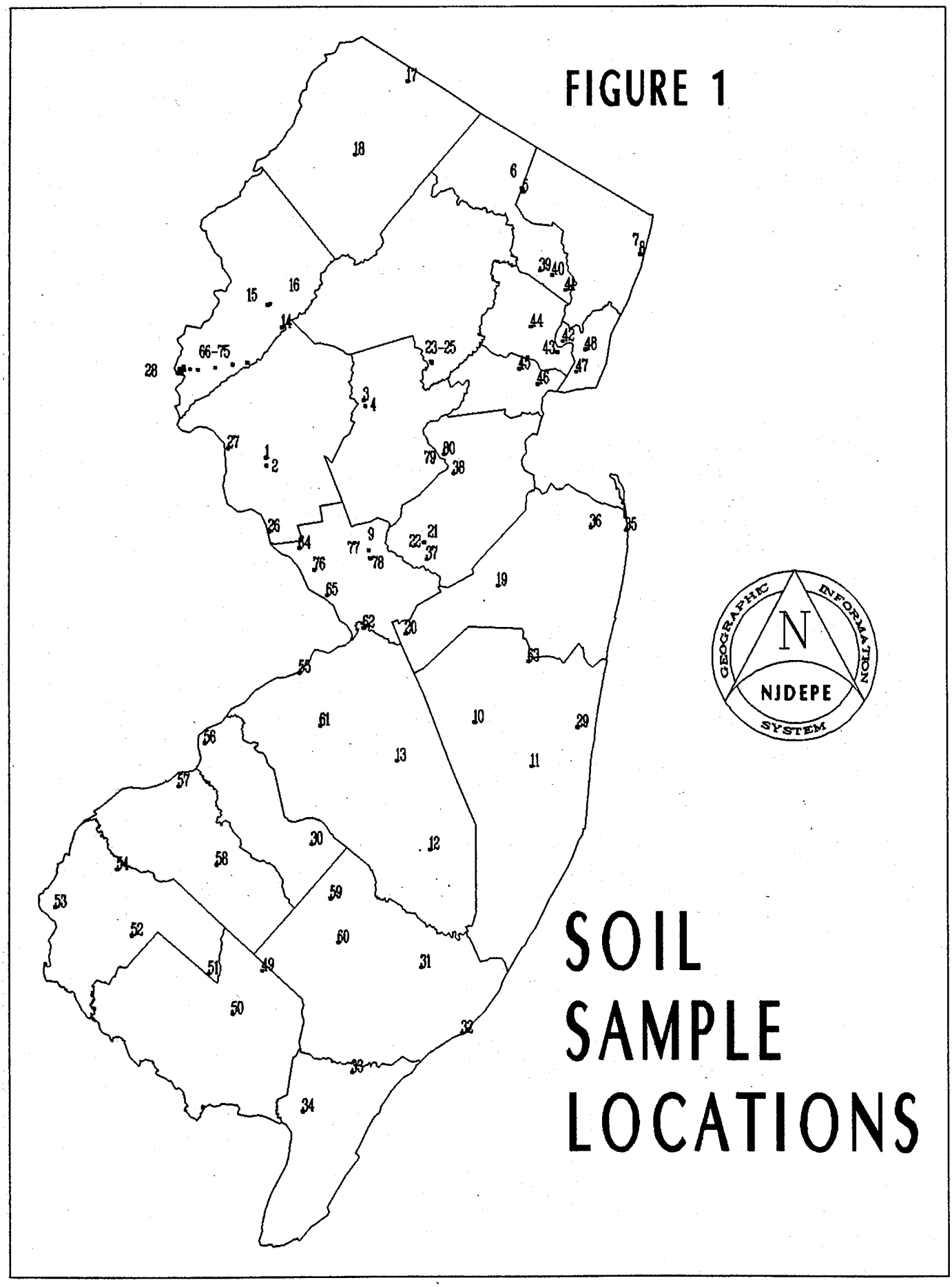

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Table 1 ***General Soil Sample Information***

Sample #	County	Township	Land Use[1]	Soil Series	Texture[2]
001	Hunterdon	Franklin	R	Chalfont	SiL
002	Hunterdon	Delaware	R	Rowland	SiL
003	Somerset	Branchburg	R	Penn	SiL
004	Somerset	Branchburg	R	Klinesville	SiL
005	Bergen	Oakland	R	Rockaway	Gr-L
006	Passaic	Ringwood	R	Hibernia	Gr-L
007	Bergen	Alpine	S	Haledon	SiL
008	Bergen	Alpine	S	Boonton	SiL
009	Mercer	Princeton	R	Bucks	SiL
010	Ocean	Manchester	R	Manahawkin	M
011	Ocean	Lacey	R	Downer	LS
012	Burlington	Washington	R	Woodmansie	S
013	Burlington	Pemberton	R	Atsion	S
014	Warren	Mansfield	R	Washington	L
015	Warren	Mansfield	R	Califon	Gr-SiL
016	Warren	Mansfield	R	Parker	Gr-L
017	Sussex	Wantage	R	Bath	Gr-SiL
018	Sussex	Frankford	R	Hazen	L
019	Monmouth	Manalapan	R	Freehold	LS
020	Monmouth	Upper Freehold	R	Keyport	SiL
021	Middlesex	Cranbury	R	Woodstown	SL
022	Middlesex	Cranbury	R	Fallsington	SiL
023	Morris	Harding	R	Biddeford	SiL
024	Morris	Harding	R	Whippany	SiL
025	Morris	Harding	R	Parsippany	SiL
026[3]	Hunterdon	Lambertville	U	Dist. Soil[4]	L
027	Hunterdon	Frenchtown	S	Pope	SiL
028	Warren	Phillipsburg	U	Washington	L
029	Ocean	Dover	S	Dist. Soil	LS
030	Camden	Waterford	R	Lakewood	S
031	Atlantic	Galloway	R	Berryland	S
032	Atlantic	Atlantic City	U	Dist. Soil	LS
033	Cape May	Upper	R	Pocomoke	SL
034	Cape May	Dennis	R	Sassafras	LS
035	Monmouth	Rumson	S	Holmdel	SL
036	Monmouth	Middletown	S	Adelphia	L
037	Middlesex	Cranbury	S	Sassafras	Gr-L
038	Middlesex	New Brunswick	U	Klinesville	L
039	Passaic	West Paterson	S	Dist. Soil	L
040	Passaic	Clifton	S	Dist. Soil	L
041	Passaic	Passaic	U	Boonton	SiL
042	Hudson	Kearny	U	Dist. Soil	SiL
043	Essex	Newark	U	Dist. Soil	SiL
044	Essex	West Orange	U	Dist. Soil	L

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Table 1 (continued) ***General Soil Sample Information***

Sample #	County	Township	Land Use[1]	Soil Series	Texture[2]
045	Union	Union	U	Dist. Soil	L
046	Union	Elizabeth	U	Dist. Soil	L
047	Hudson	Bayonne	U	Dist. Soil	SiL
048	Hudson	Jersey City	U	Ellington	SL
049	Cumberland	Vineland	S	Hammonton	SL
050	Cumberland	Millville	S	Dist. Soil	LS
051	Salem	Pittsgrove	R	Evesboro	S
052	Salem	Alloway	R	Matapeake	SiL
053	Salem	Pennsville	R	Mattapex	SiL
054	Salem	Pilesgrove	R	Fort Mott	S
055	Burlington	Burlington	S	Dist. Soil	LS
056	Camden	Camden	U	Galestown	LS
057	Gloucester	West Deptford	S	Klej	S
058	Gloucester	Franklin	R	Aura	SL
059	Atlantic	Hammontown	S	Dist. Soil	SL
060	Atlantic	Hamilton	R	Lakehurst	S
061	Burlington	Lumberton	S	Tinton	S
062	Burlington	Bordentown	S	Tinton	S
063	Ocean	Lakewood	S	Dist. Soil	LS
064	Mercer	Hopewell	R	Neshaminy	SiL
065	Mercer	Trenton	U	Matapeake	L
066[3,4]	Warren	Phillipsburg	U	Dist. Soil	SL
067	Warren	Phillipsburg	U	Dist. Soil	SiL
068	Warren	Phillipsburg	U	Dist. Soil	SiL
069	Warren	Phillipsburg	U	Washington	SiL
070	Warren	Phillipsburg	U	Washington	Gr-SL
071	Warren	Lopatcong	S	Washington	SiL
072	Warren	Greenwich	A	Washington	SiL
073	Warren	Franklin	A	Washington	SiL
074	Warren	Franklin	R	Annandale	L
075	Warren	Franklin	A	Wassaic	SiL
076	Mercer	West Trenton	GG	Dist. Soil	LS
077	Mercer	Princeton	GG	Dist. Soil	SL
078	Mercer	Princeton	GG	Dist. Soil	SL
079	Middlesex	Piscataway	GG	Dist. Soil	SL
080	Middlesex	Piscataway	GG	Dist. Soil	SL

[1] Land Use R = Rural, S = Suburban, U = Urban, GG = Golf Green, A = Agricultural Land

[2] Texture S = Sand, L = Loam, M = Muck, SiL = Silt Loam, LS = Loamy Sand, Gr-L = Gravelly Loam, Gr-SiL = Gravelly Silt Loam, SL = Sandy Loam

[3] Samples # 26 and 66 contained fill material of unknown origin, as determined by the presence of cinders and debris.

[4] Dist.Soil = Disturbed Soil- Indicates that the native soil profile was not present. This does not imply that contamination has occurred or that soils are not native to the site.

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B. General Soil Parameters

The soil profiles sampled were classified to the series level. Color and texture were determined in the field by SCS soil scientists. All samples were thoroughly homogenized prior to analyses. General soil characteristics that were determined in the laboratory (APHA, 1985) included loss on ignition, pH and sand, silt and clay content. Loss on ignition, reflects loss of moisture and organic matter, as well as alterations in soil minerals that result in weight losses. Therefore, although loss on ignition roughly estimates organic content, it will be somewhat higher than the actual exclusive organic content. These basic soil parameters were measured to determine if loss on ignition, or sand, silt and clay content had relevant statistical correlation with observed constituent or contaminant concentrations.

C. Chemical Analysis

1. Metals

Analysis for trace elements utilized a 5 gram dry weight equivalent (dwe) aliquot, i.e., the weight of the sample after correction for loss on ignition was 5 grams. Analysis was conducted by either direct aspiration or graphite furnace atomic absorption spectroscopy (EPA, 1979) following HNO_3 digestion. Arsenic was analyzed by gaseous hydride atomic adsorption (EPA, 1979), following digestion with a H_2S0_4 and HNO_3 mixture. Analyses were performed using a Perkin-Elmer 503 Atomic Adsorption Spectrophotometer.

2. PCBs and Chlorinated Pesticides

A 2 gram (dwe) aliquot was utilized for this analysis which included a microscale exhaustive steam distillation extraction procedure with isooctane (Rutgers University, 1985a). Analyses were performed on a Varian 3700 GC equipped with either a 1.5% SP-2250 100/120 mesh column (primary) or a 3% SP-2100 100/120 mesh column (secondary) and an electron capture detector (ECD).

3. Polycyclic Aromatic Hydrocarbons

A 2 gram (dwe) aliquot was employed for this analysis, which used a microscale steam distillation/isooctane extraction procedure. Analyses were performed on a Hewlett Packard 5840A gas chromatograph equipped with a 30 m, 0.25 mm (id) capillary column with a SE-54 stationary phase, employing a flame ionization detector. Calibration was achieved utilizing external standards (Rutgers University, 1985b).

4. Organophosphate Pesticides

A 1.5 gram (dwe) aliquot was extracted with hexane and isopropanol in a sealed container placed in an ultrasonic bath. The solvent was partitioned with water, the hexane layer, then purified by column chromatography using a Florisil column, concentrated in a KD apparatus and quantitated using a Varian 3700 gas chromatograph employing a 6' x 2 mm (id) glass column packed with 1.5% SP-2250 and 1.95% SP-2401 on 100/120 mesh Supelcoport, and a Thermionic N/P detector (Rutgers University, 1985c).

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5. Chlorinated Herbicides

A 15 gram soil (dwe) aliquot was first hydrolyzed with NaOH in a sealed container at 55°C, then cooled and extracted with toluene. The sodium hydroxide hydrolysate was then acidified and the free chlorinated herbicide acids extracted into toluene, and esterfied with BF_3/methanol. The toluene solution was extracted with a sodium sulfate solution, and injected into a Hewlett Packard 5840 GC employing a 6' x 2 mm (id) column packed with 1.5% SP-2250 + 1.95% SP-2401 or 100/200 mesh Supelcoport employing an electron capture detector (Rutgers University, 1985d).

D. Quality Assurance

Data quality assurance procedures included the analysis of every tenth sample in duplicate. Spiked samples were analyzed at the rate of every tenth sample to determine percent recoveries. Method detection limits (MDL) studies were also conducted. Sensitivity, as used throughout this section, is defined as the instrument response equal to 5 times the baseline noise level, expressed in units of concentration. These values are a function of analytical sample size, and final extract volume, as well as instrument response. MDLs are a function of sensitivity, as given below. Quality assurance results are summarized in Tables 2 through 6.

Spike recoveries for inorganics, as shown in Table 2, are typically acceptable when the recoveries fall within a range of 75-125%. Additionally, percent relative deviation of duplicates is considered acceptable when values do not exceed 20%. Antimony, chromium, mercury, and silver results would be qualified due to low average percent recoveries and may have a possible low bias. Silver results would be qualified due to a high percent average deviation.

Minimum detection limits were not calculated for the PCB Aroclors. The values reported were sensitivities, which are presented in Table 3. Spike recoveries were not reported.

In Table 4, the average percent recovery was low and the coefficient of variation of percent recovery was high for methoxyclor. Results for methoxyclor would thus be qualified.

PAH spike recoveries, displayed in Table 5, were very good for compounds with low boiling points. Recoveries decreased with increasing analyte molecular weight. For five PAHs, benzo(k)fluoranthene benzo(a)pyrene, indeno(1,2,3-cd)pyrene, dibenzo(a,h)anthracene and benzo(g,h,i)perylene, recoveries were negligible. Generally, MDLs closely approximate sensitivities. In the present case, the MDLs are significantly greater than the sensitivities. This is indicative of either poor precision in the MDL determinations, or the use of fortification solutions with concentrations substantially greater than the sensitivities. Nonetheless, sensitivities represent a lower bound of what can be seen by an instrument. In such situations in which reported concentrations fall between the MDL and sensitivity, the resulting values need not be ignored, but should be interpreted cautiously. Therefore, in order to maximize the utility of the data, reported values less than the MDLs have been presented. It should be noted that the steam distillation based method used in this analysis is different from the extraction techniques which are currently used in environmental analyses that are cited in the EPA Contract Laboratory Program and EPA SW-846.

All recoveries for organophosphate pesticides and chlorinated herbicides were acceptable. The MDLs are provided in Table 6.

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Table 2 ***Quality Assurance Results for Metals***

	Average % Recovery[1]	% Relative Average Deviation of Replicates	MDL[2] mg/kg
Antimony	14	5.44	0.02
Arsenic	99.5	6.42	0.003
Beryllium	94	8.38	0.03
Cadmium	83	5.24	0.006
Chromium	68	7.02	0.7
Copper	76	5.47	0.6
Lead	92	3.04	1.2
Manganese	114.5	3.52	0.6
Mercury	65	9.48	0.01
Nickel	98.5	3.62	1.2
Selenium	83	33.57	0.01
Silver	43	16.09	0.01
Thallium	96	17.16	0.06
Vanadium	81	9.84	0.3
Zinc	89.5	7.49	0.24

[1] Rates of recovery for metals will vary with the metal, its source, and the nature of the analytical matrix. Recoveries of metals would likely be greater from spiked matrices than from metals present in the mineral matrix.

[2] MDL = Minimum Detection Limit

= $S(t_{0.99})$, where S = standard deviation in concentration units; $t_{0.99}$ = Student's one-tailed t value for the 99% confidence level and a standard deviation estimate with n-1 degrees of freedom.

Table 3 ***Quality Assurance Results for Polychlorinated Biphenyls***

PCB Aroclor	Sensitivity (mg/kg)
Aroclor 1016	0.054
Aroclor 1242	0.043
Aroclor 1248	0.042
Aroclor 1254	0.030
Aroclor 1260	0.021

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Table 4 ***Quality Assurance Results for Chlorinated Pesticides***

	Average % Recovery	Coefficient of Variation of % Recovery	MDL ug/kg
alpha-BHC	98.9	11.3	3.19
gamma-BHC	99.8	17.1	0.66
beta-BHC	87.6	20.1	1.10
Heptachlor	80.0	15.7	0.54
Aldrin	98.4	9.9	0.58
Heptachor Epoxide	107.7	12.3	0.67
alpha-Endosulfan	91.6	24.5	0.61
beta-Endosulfan[1]	-	-	2.35
o,p'-DDE	87.9	19.7	1.30
Dieldrin	96.8	14.1	1.37
Endrin	95.8	13.3	2.31
o,p'-DDT	90.3	13.1	3.54
p,p'-DDD	93.1	24.7	3.39
p,p'-DDT	92.1	38.6	4.45
Endosulfan Sulfate	-	-	32.8
Chlordane	-	-	1.93
Mirex	95.0	17.7	1.76
Methoxychlor	37.6	69.1	6.03
Toxaphene	-	-	-

[1] Recoveries were not provided by the laboratory for beta-endosulfan, endosulfan sulfate, chlordane and toxaphene.

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Table 5 ***Quality Assurance Results for Polycyclic Aromatic Hydrocarbons***

	Average % Recovery	CV of % Recovery	MDL mg/kg	Sensitivity mg/kg
Napthalene	90.5	10.6	9.2	0.20
Acenaphthylene	93.6	10.5	9.4	0.17
Acenaphthene	97.9	8.2	10.1	0.16
Fluorene	101.6	4.9	9.2	0.17
Phenanthrene	98.7	6.6	9.7	0.18
Anthracene	90.7	12.7	9.0	0.18
Fluoranthene	75.6	16.8	11.9	0.20
Pyrene	64.8	33.3	12.6	0.20
Chrysene	45.2	56.4	14.6	0.30
Benzo(a)anthracene	32.9	64.4	14.5	0.38
Benzo(b)fluoranthene	20.9	62.6	10.9	1.14
Benzo(k)fluoranthene	-	-	7.5	0.95
Benzo(a)pyrene	-	-	6.6	2.07
Indeno(1,2,3-cd)pyrene[1]	-	-	-	-
Dibenzo(a,h)anthacene[1]	-	-	-	-
Benzo(ghi)perylene[1]	-	-	-	-

[1] Indeno(1,2,3-cd)pyrene, dibenzo(a,h)anthracene and benzo(g,h,i)perylene had recoveries too low to be detectable by this procedure. Benzo(a)pyrene and benzo(k)fluoranthrene were only marginally detectable.

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Table 6 ***Quality Assurance Results for Organophosphate Pesticides and Chlorinated Herbicides***

	Average % Recovery	Coefficient of Variation of Recovery %	MDL mg/kg
Organophosphate Pesticides			
Phosdrin + Thimet	106.6	13.2	0.11
Diazinon	117.3	17.4	0.04
Disulfoton	119.8	24.0	0.05
Merphos	102.2	24.9	0.06
Dimethoate	73.0	39.5	0.04
Malathion + DEF	97.8	32.3	0.08
Parathion	110.3	15.4	0.02
Trithion	81.4	44.7	0.03
Ethion	108.3	12.0	0.02
Chlorinated Herbicides			
2,4-Dichlorophenoxy acetic acid (2,4-D)	85.3	14.0	0.0099
2-(2,4,5-Trichlorophenoxy) propanoic acid (silvex)	84.6	20.0	0.0013
2,4,5-Trichlorophenoxy propanoic acid (2,4,5-T)	84.1	15.7	0.0024

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RESULTS and DISCUSSION

A. Definition of Background

The term "background", which is used frequently throughout this report, often means different things to different people. Therefore, a definition and discussion of the term "background" as used in this report is necessary. There are three potential sources of the chemical parameters that were analyzed in this survey: natural soil constituents, non-point sources, and local point sources.

Soil "background" may be viewed as a continuum of values in which a concentration gradient of anthropogenic pollution is superimposed onto the preexisting distribution of concentrations found in nature. This concentration gradient ranges from diffuse anthropogenic pollution (DAP), to local, identifiable point sources. DAP is here defined as broadly distributed contaminants, often arising from multiple sources, which were generated by human activities. It generally arises from atmospheric deposition, but may also contain some contribution from random, non-attributable, non-point sources. As measured concentrations increase, the DAP contribution will tend to yield to sources which are less diffuse, more concentrated, and more localized. At some point along the continuum, the resulting "background" may then be seen as a "regional" or even "local" measurement which is strongly indicative of neighboring land use, e.g. industrial areas, transportation corridors.

In the context of this report, background soils are those which display a range of constituents and contaminants likely to be found in New Jersey soils, that have not been impacted by a local-point source, but may contain some contribution from DAP.

Measurements of inorganic elements, as well as polycyclic aromatic hydrocarbons, may thus reflect natural and/or anthropogenic concentrations, which may arise from atmospheric deposition (DAP) and/or local point sources. Synthetic organic compounds, which are fundamentally anthropogenic, would be present in soils only as the result of DAP or current or historical local application. The results for the different chemical classes are discussed in further detail below.

B. General Soil Analyses

A broad range of soil types were included in this study as indicated by the general soil characteristics data. The data for the general soil analyses, including range, mean, and median, are found in Appendix I and are summarized in Table 7.

One sample (# 010) was a very fine-grained black muck collected from a cedar bog in the Pine Barrens. As expected, the analysis of this sample produced the maximum measurement for loss on ignition (81.4%), and the lowest pH value (3.6) of all the samples analyzed. Even though the muck sample had very different soil characteristics from the other soils collected during this survey, it was included with the rural sample tabulations because it was collected from an undisturbed rural setting. A number of metals have been shown to complex with soil organic matter to varying degrees (Friedland et.al., 1984). A Spearman Rank correlation was conducted to determine if a significant correlation existed between metal concentrations and loss on ignition of the soils collected during this study. No definitive statistical correlation was observed.

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Table 7 ***Summary of General Soil Analysis Data***

	Range	Mean	Median
Loss on Ignition %	0.50 - 81.4	5.7	4.1
pH	3.6 - 8.3	5.6	5.3
Sand Content %	14 - 98	57	56
Silt Content %	1 - 68	30	30
Clay Content %	0 - 34	14	12

A Spearman Rank correlation was also conducted to determine the correlation between the sand, silt and clay content of the samples and metal concentrations. A significant negative correlation was determined for most metals and sand content (Table 8).

Table 8 ***Spearman Rank Correlation of Metals with Sand Content***

Metal	Rank Correlation	P-Value (2 sided)
Antimony	NSC[1]	-
Arsenic	-0.31	0.006
Beryllium	-0.79	0.000
Cadmium	-0.32	0.005
Chromium	-0.46	0.000
Copper	-0.51	0.000
Lead	-0.35	0.002
Manganese	-0.63	0.000
Mercury	NSC	-
Nickel	-0.70	0.000
Selenium	-0.40	0.001
Silver	-0.42	0.000
Thallium	-0.36	0.002
Vanadium	-0.67	0.000
Zinc	-0.56	0.000

[1] NSC = No Significant Correlation

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This correlation would be expected for the following reasons. In uncontaminated soils, most metals are present as trace constituents in minerals inherited from the parent material. These native metals, which are found primarily in the silt and clay ranges, are rather insoluble. In addition, sand is made up largely of quartz or silicon dioxide, containing relatively small amounts of trace metals. Therefore, sand will serve as a diluent of the higher metal content silt and clay. While contaminated soils will more likely contain metals in a more soluble form, these will tend to bind to silt and clay particles due to the greater available surface area of these particles. Both of these factors will generally result in lower metal concentrations in soils with higher sand content.

Significant negative correlations were not demonstrated for antimony and mercury. This is possibly due to the relatively low frequency of detection of these metals in the samples (Appendix III). This explanation cannot account for the demonstrated correlation of thallium, which displays an even lower frequency of detection. This anomalous behavior, with respect to detection frequency can potentially be accounted for by differences in geochemical characteristics of these elements.

C. Metals

1. Potential Sources of Metals in Soils

Metal concentrations in soils under natural conditions result from in situ weathering of parent geological material. There are, however, a wide variety of sources both direct and indirect, of anthropogenic metal additions to soils. The major sources include atmospheric deposition from industrial emissions such as smelting and refining, and automotive emissions. Direct sources of metals include the intentional application of wastes, fertilizers, pesticides, etc. (Thornton, 1985). The metal concentrations measured in the urban, suburban and rural land use categories collected during this study reflect natural conditions, plus amounts resulting from atmospheric deposition and, therefore, are functionally indicative of contemporary background conditions. Even though the sample size is small, golf green samples present higher concentrations of certain metals and other compounds that directly relate to soil and turf amendment. They are representative of natural conditions amended by the direct application of fertilizers, herbicides and pesticides (Sax, 1984). Raw data for the metal analyses are in Appendix II.

2. Elements Included in Survey

Soil samples were analyzed for the EPA Priority Pollutant metals plus manganese and vanadium. All of these elements are on the EPA Target Analyte List (TAL), which is used in the EPA Contract Laboratory Program (CLP) for the evaluation of Superfund sites. The Priority Pollutant metals are among the most commonly measured inorganic pollutants and are often detected in elevated concentrations at hazardous waste and industrial sites. Manganese is a highly variable minor soil constituent. Though not generally considered hazardous, under certain environmental conditions manganese could constitute a problem. Vanadium was included because it is sometimes used as a tracer for oil combustion in air pollution studies and has been detected in elevated concentrations at a number of hazardous waste sites in New Jersey.

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3. Concentrations of Inorganics Observed by Land Use Category

Statistical summaries for the metals by land use category are provided in Table 9. This summary table includes the geometric and arithmetic means, the minimum, median, 90th percentile, and the maximum concentrations by land use category. One half the minimum detection limit (MDL) was used to determine the geometric and arithmetic mean concentrations for the metals reported to contain less than the MDL in any sample. One half of the MDL was used because these inorganic elements are naturally occurring constituents, and theoretically would be measured if the detection limit were low enough. Most of the metals were routinely detected in most soils. Only 5 of the 15 metals analyzed were detected at a frequency less than 95%. Nondetectable concentrations, as represented by reduced detection frequencies, occurred more frequently for antimony (33%), mercury (58%), nickel (85%), selenium (60%) and thallium (32%), out of 80 samples.

To determine the relationship of metal concentrations in the urban, suburban, and rural land use categories, the data were evaluated utilizing the Kruskal-Wallis nonparametric statistical test. Median metal concentrations were significantly higher ($P < 0.05$) in the urban samples for cadmium, copper, lead, mercury, nickel, zinc and thallium, than both the suburban and rural land use categories. Five metals, arsenic, manganese, silver, vanadium and antimony, showed significant differences between the urban and rural data sets, but not between the urban and suburban samples. Beryllium, chromium and selenium did not show significant differences between land use categories as indicated by the nonparametric multiple comparison procedure.

Due to the small sample number of samples in each category, farm and golf course samples were not formally evaluated. However, cursory inspection of the data revealed elevated concentrations of certain inorganic constituents in the golf course soils, which are known to be impacted by human activities. For example, elevated levels of inorganics detected in soils collected on the greens, were consistent with the application of fungicides (cadmium and mercury salts), commonly utilized on turf grass (Sax, 1984). No statistical analysis was conducted utilizing the farm or golf course samples due to the small sample size.

This trend of maximum concentrations in the urban data is likely to have been due to atmospheric deposition. This interpretation is consistent with a 1987 Division of Science and Research-sponsored study of inhalable particulate matter conducted in New Jersey, in which higher levels of lead, vanadium, zinc and arsenic were consistently found in outdoor ambient air at urban sites (Newark, Camden, and Elizabeth) than the rural "background" site (Ringwood) (Lioy and Daisey, 1987.) Correspondingly, in the present study all four of these were significantly elevated in urban, relative to rural soils.

Additional statistical evaluations of the metals data set are presented in Appendix III. This Appendix includes: geometric standard deviation, the 95% confidence interval, and the proportion detected above the minimum detection limit.

4. Samples Containing Fill Material

Samples #26 and #66 were disturbed soils and contained fill material of unknown origin. These disturbed soil samples were designated as fill due to the presence of cinders and debris. Data from

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these samples were included in the urban land use category data set. The majority of the metal concentrations measured in these samples were close to the geometric mean and median metal concentrations of the soils in the urban category, with the exception of the lead and zinc values (Table 9). Sample #26 was collected in a residential area that had been owned by a utility company and was previously used as a substation. Sample #66 was collected in an open field by abandoned railroad tracks near the Delaware River in Phillipsburg, Warren County. The measured lead concentrations for samples #26 and #66 were 285 mg/kg and 428 mg/kg respectively. These concentrations are somewhat greater than the geometric mean and median concentrations (123 and 97 mg/kg) for lead in the urban land use category. The concentrations of zinc in samples #26 (789 mg/kg) and #66 (163 mg/kg) are greater than the geometric mean and median concentrations (104 and 85.9 mg/kg) for that element in the urban samples. These samples also contained quantities of chlorinated pesticides and PAHs.

5. Comparison of Survey Data with Other Data Sets

Comparison of the present data set with other existing soils data for New Jersey, the rest of the country, and samples collected from various locations around the world, provides useful insights. Only inorganics are compared here because similar data for the other parameters that were analyzed during this survey were not readily available. These comparative data are summarized in Table 10. Arithmetic means of the various data sets are presented for comparative purposes because this form of statistical summary for soils data has been most commonly, if not exclusively, used.

The DEPE data set is provided as both inclusive (n = 80), and with the samples of potentially amended soils (farms and golf courses) removed (n=72). The data from Rutgers University were accumulated over many years by Professor H.L. Motto, Department of Environmental Sciences. The Rutgers data set represents a wide assortment of New Jersey surface soil data culled from various studies and theses. The USGS data were compiled over a number of years by Shacklette and Boerngen (1984); it is presented for both the conterminous United States (USGS-C) (i.e., the lower 48 states) and the eastern US (USGS-E). Sampling for this study was generally conducted at sites that were altered very little from their natural condition, at distances greater than 100 meters from roads. World data is from Vinogradov (1959), as cited in Shacklette and Boerngen (1984).

Within the DEPE data, only cadmium and mercury display any substantial differences in their means with the farms and golf greens removed. Inspection of Table 9 reveals this effect to emanate chiefly from the golf green samples. While cadmium concentrations in the farm samples appear to be slightly elevated, the small sample size precludes distinguishing between natural soil variation and soil amendment.

The DEPE data is most directly comparable to the Rutgers data, which is also exclusively made up of New Jersey soils. The two data sets in general display an acceptable degree of correspondance. Cadmium, copper, and zinc are nearly identical in the two sets. Manganese, nickel, vanadium, and to a lesser extent chromium, appear to be lower in the DEPE than in the Rutgers data. A potential contributing factor to this apparent tendency is a possible variation in the distributions of the samples throughout the state in the two data bases. The DEPE samples, as indicated previously, were selected to provide coverage of every county in the state. The

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Table 9 ***Summary Statistics for Metals by Land Use Category*** ***(mg/kg)***

Metal Land Use[1]	Geo Mean	Arith Mean	Min	Med	90th Percentile	Max
Antimony[2]						
Urban	0.03	0.07	<0.02	0.03	0.10	0.69
Suburban	0.02	0.02	<0.02	<0.02	0.05	0.07
Rural	<0.02	0.02	<0.02	<0.02	0.03	0.10
Golf	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Farm	<0.02	<0.02	<0.02	<0.02	0.02	0.02
Arsenic						
Urban	5.49	8.26	0.34	5.65	10.90	48.90
Suburban	2.06	4.72	0.02	3.72	10.70	22.70
Rural	1.21	2.40	0.04	2.21	3.83	17.10
Golf	2.85	3.23	1.06	3.37	5.00	5.00
Farm	4.73	4.78	3.97	4.79	5.57	5.57
Beryllium						
Urban	0.86	1.07	0.16	0.88	2.55	4.09
Suburban	0.35	0.59	0.02	0.65	1.16	2.00
Rural	0.44	1.04	0.02	0.84	1.63	10.30
Golf	0.68	0.68	0.54	0.71	0.79	0.79
Farm	1.29	1.31	1.10	1.17	1.66	1.66
Cadmium						
Urban	0.50	0.65	0.16	0.47	1.61	2.36
Suburban	0.08	0.16	<0.01	0.14	0.32	0.59
Rural	0.04	0.07	<0.01	0.07	0.15	0.24
Golf	1.87	2.26	0.90	1.64	5.16	5.16
Farm	0.23	0.24	0.18	0.23	0.30	0.30
Chromium						
Urban	11.2	12.1	4.9	10.8	18.7	24.6
Suburban	8.1	10.1	2.2	9.1	18.7	21.4
Rural	6.8	10.9	0.7	7.5	16.5	101.0
Golf	28.0	32.4	16.3	24.9	72.7	72.7
Farm	9.7	9.7	9.6	9.7	9.9	9.9
Copper						
Urban	32.8	42.2	8.8	31.5	102.0	143.0
Suburban	6.3	11.3	0.8	6.7	28.4	41.7
Rural	4.8	8.0	0.3	5.8	12.8	55.9
Golf	9.8	10.9	4.6	9.9	19.7	19.7
Farm	11.3	11.4	9.4	11.7	13.0	13.0

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Table 9 -- (continued) ***Summary Statistics for Metals by Land Use Category (mg/kg)***

Metal Land Use[1]	Geo Mean	Arith Mean	Min	Med	90th Percentile	Max
Lead[2]						
Urban	112.9	177.7	25.8	97.8	446.0	617.0
Suburban	19.0	36.0	<1.2	22.3	100.0	150.0
Rural	11.1	15.1	<1.2	17.2	22.0	46.0
Golf	8.0	12.3	<1.2	13.9	16.8	16.8
Farm	19.6	20.0	16.4	18.4	24.8	24.8
Manganese						
Urban	283	335	30	333	515	952
Suburban	75	201	3	79	846	959
Rural	45	186	1	40	561	1313
Golf	384	392	307	348	495	495
Farm	752	817	414	913	1125	1125
Mercury						
Urban	0.20	0.50	<0.01	0.31	1.58	2.71
Suburban	0.02	0.07	<0.01	0.06	0.14	0.19
Rural	0.02	0.06	<0.01	<0.01	0.16	0.26
Golf	3.88	4.74	1.40	5.00	7.70	7.70
Farm	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nickel						
Urban	14.1	16.6	5.5	13.3	28.7	53.8
Suburban	3.2	6.3	<1.2	4.4	14.9	19.2
Rural	4.6	8.8	<1.2	6.4	18.7	42.2
Golf	10.1	10.3	8.3	9.4	13.1	13.1
Farm	12.1	12.2	10.2	11.8	14.6	14.6
Selenium						
Urban	0.04	0.06	<0.01	0.05	0.13	0.15
Suburban	0.02	0.07	<0.01	0.05	0.17	0.34
Rural	0.04	0.08	<0.01	0.06	0.15	0.80
Golf	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Farm	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Silver						
Urban	0.16	0.24	0.04	0.19	0.34	1.53
Suburban	0.07	0.12	0.01	0.10	0.26	0.42
Rural	0.06	0.09	<0.01	0.08	0.19	0.30
Golf	0.08	0.09	0.03	0.09	0.15	0.15
Farm	0.10	0.10	0.08	0.09	0.13	0.13

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Table 9 -- (continued) ***Summary Statistics for Metals by Land Use Category (mg/kg)***

Metal Land Use[1]	Geo Mean	Arith Mean	Min	Med	90th Percentile	Max
Thallium						
Urban	0.07	0.10	<0.06	0.06	0.24	0.46
Suburban	0.04	0.05	<0.06	<0.06	0.19	0.23
Rural	0.04	0.06	<0.06	<0.06	0.13	0.28
Golf	0.04	0.04	<0.06	<0.06	0.10	0.10
Farm	0.10	0.13	<0.06	0.14	0.23	0.23
Vanadium						
Urban	18.5	22.6	1.0	21.1	39.9	46.1
Suburban	8.1	14.1	0.5	14.0	34.4	41.4
Rural	6.5	17.3	<0.3	7.6	34.8	165.0
Golf	8.3	11.4	1.3	10.6	20.1	20.1
Farm	20.7	20.7	20.3	20.3	21.5	21.5
Zinc[3]						
Urban	116.1	162.3	40.4	88.9	317.0	789.0
Suburban	25.0	38.5	2.1	31.5	82.6	121.0
Rural	19.5	34.0	<0.2	32.8	65.9	95.8
Golf	75.8	142.6	37.6	48.1	524.0	524.0
Farm	64.0	64.8	51.5	67.1	75.7	75.7

[1] Sample Size
- Urban = 19
- Suburban = 18
- Rural = 35
- Golf Green = 5
- Farm = 3

[2] The samples were reanalyzed for antimony due to problems with the initial sample extraction procedure. Only seventy-three of the 80 samples were reanalyzed due to insufficient amount of soil in the archived samples.

[3] Lead and zinc values for samples #26 and #66 were removed from the database before the summary statistics were calculated to avoid skewing the data. Samples #26 and #66 contained fill material of unknown origin (see text), and thus are not representative of background as defined in this report.

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Table 10 ***Arithmetic Means of Inorganic Soil Constituents from Various Data Sets (mg/kg)***

	DEPE[1]		RUTGERS[2]	USGS-C[3]	USGS-E[4]	WORLD[5]
	N=80	N=72				
Sb[6]	0.03	0.03	--[7]	--	--	--
As	4.46	4.53	--	7.2	7.4	5
Be	0.93	0.94	--	0.92	0.85	6
Cd	0.37	0.25	0.24	--	--	--
Cu	17.2	17.9	15.6	54	22	20
Cr	12.3	11.0	19.9	25	22	200
Pb[8]	58.4	63.2	28.6	19	17	--
Mn	261	229	553	550	640	850
Hg	0.46	0.18	--	0.089	0.12	--
Ni	10.3	10.2	20.9	19	18	40
Se	0.07	0.07	--	0.39	0.45	0.001
Ag	0.14	0.14	--	--	--	--
Tl	0.07	0.07	--	--	--	--
V	17.6	17.9	48.7	80	66	100
Zn[8]	73.4	69.0	71.3	60	52	50

[1] NJDEPE data collected during this survey; 80 samples constitute the complete data set, and 72 samples represent the data with the potentially amended soils, golf course (5) and farm (3) samples removed.

[2] Rutgers data represent a compilation of research and thesis data compiled over many years by Dr. H.L. Motto, Department of Environmental Sciences. Sample size unknown.

[3] USGS-C data includes soils collected from the conterminous United States. N ranges from 1248 to 1319 with the exception of Sb, where N = 354.

[4] USGS-E data are from soils collected from the eastern portion of the United States. Values of N are approximately 50% of these given in 3 above.

[5] World data was compiled from various locations around the world by Vinogradov (1959). Sample size unknown.

[6] 73 samples were reanalyzed for antimony due to poor recoveries during first analysis. Seven samples were not reanalyzed due to insufficient sample size.

[7] Dashed lines (--) indicate that no data were available for the element in the data set indicated.

[8] NJDEPE Pb and Zn data were calculated for N=78 and N=70, two samples containing fill material were deleted.

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Rutgers data however tends to be based on samples from New Jersey agricultural soils. This sampling bias would tend to exclude the soil series of the state which included higher concentrations of sand. As previously noted, sand content corellates inversely with these metal concentrations.

Taken together, the two New Jersey data sets (DEPE and RU) show beryllium, chromium, manganese, and nickel to be comparable to both the eastern and conterminous US data sets. Copper appears to be lower in New Jersey than the US as a whole, but approximates the values of the eastern US. Vanadium appears to be somewhat lower in New Jersey than in the USGS data, while selenium appears to be substantially lower in New Jersey. Arsenic appears to be somewhat lower in the present study than in the USGS data. This is possibly due to the relatively high sand content of the soils in the present study. Analytical method bias might also contribute to this apparent discrepancy.

An additional potential contributing factor to discrepancies between data sets arises from variations in the methods of analysis. The nitric acid digestion used in the present method was designed for digestion of waste materials. While it also suffices for soil digestion, it is not as vigorous as other digestion methods for the total metals such as the perchloric acid digestion predominately used in the Rutgers data set. It might also be expected to display a downward bias relative to the X-ray fluorescence method used in the USGS data set for selenium. Use of the nitric acid digestion in the present data is desirable in that it affords a direct comparability to environmental data routinely gathered in hazardous waste site investigations, which is predominantly derived from the nitric acid digestion methodology outlined in USEPA SW-846 (EPA, 1986).

Of the remaining elements for which comparisons are possible, lead and mercury, the trend is toward higher values in New Jersey. Zinc also exhibits a slight elevation in the New Jersey data over the USGS data. Of these elements the most distinct is lead, which, counter to the predominant trend observed above, is notably elevated in New Jersey relative to the USGS samples.

The higher New Jersey mean lead value (58.4 mg/kg) reflects the bias in the sampling of this survey when the land use categories are combined into the whole data set. The sampling design intentionally included samples from urban and suburban locations which were expected to contain higher surficial lead values than the rural soils. The increase of lead concentration with increasing population density and human activity has previously been discussed and can be observed in Table 9. Removal of the amended (farm and golf green) samples from the data base has no substantive effect on the mean lead values (63.2 mg/kg).

Relative to the worldwide data, New Jersey values of arsenic and copper are comparable, beryllium, chromium, manganese, nickel and vanadium tend to be lower, and selenium and zinc somewhat higher. These differences may be due in part to inconsistencies in the analytical techniques and methodologies employed over the many years that these samples were collected and analyzed. This may be particularly true for chromium, and selenium.

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D. Chlorinated Pesticides

The samples were analyzed for 19 chlorinated pesticides. These compounds are listed with summary statistics in Table 11. The pesticides data have been summarized in two ways, both the arithmetic and geometric means for each compound are provided for the entire sample set (n = 80). This data set contains a large number of values that are below the minimum limit of laboratory detection. The arithmetic means were calculated using zero for samples below the MDLs. The use of zeros in the MDL calculation is consistent with the fact that these compounds are synthetic and, unlike inorganics, their natural background concentration should be zero. The geometric mean values were calculated using one-half the minimum detection limit because zeros cannot be used in the calculation. The detectable concentrations for all the samples collected ranged from 2 to 10,560 ug/kg. The raw pesticide data are provided in Appendix IV.

Toxaphene, beta-endosulfan and methoxychlor were not detected in any of the samples. As noted in the QA section, recoveries were not determined for toxaphene and beta-endosulfan. No confidence may therefore be assigned to this apparently negative conclusion. Recoveries were also not reported for endosulfan sulfate and chlordane. However, these compounds were detected in one and seven of the samples, respectively. While these compounds were apparently present, without recovery data, quantitative estimates are potentially suspect.

Indicative of a number of relatively high pesticide concentrations that were observed in some of the samples, only three of the pesticides (alpha-BHC, gamma-BHC and heptachlor) had arithmetic mean values less than the MDL. While detectable concentrations are generally in the parts per billion range, a number of pesticides (dieldrin, DDT-related compounds, endosulfan sulfate and chlordane) were detected in the parts per million range. The highest concentration, 10.6 mg/kg chlordane, was detected in one fill sample. The second fill sample, however, contained only ug/kg concentrations of beta-BHC (298 ug/kg), alpha-endosulfan (18 ug/kg), p,p'-DDE (47 ug/kg), and dieldrin (2 ug/kg). Overall, the calculated means are quite low due to the high incidence of non-detectable levels. As with certain inorganics, golf green concentrations tend to be substantially elevated. No overall trend of increasing concentrations from rural to urban land is seen, however, certain compounds do display an apparent variation with land use.

Due to the low detection frequency, possible associations between occurrence and land use categories were not formally tested. However, certain trends in occurrence were observed. Fifty-one percent of the samples contained detectable levels of the chlorinated pesticides. Frequency of pesticide detection apparently varies by land use category. An average of 3.9 pesticides were observed in the urban land use category, which was higher than 2.7 in the suburban or 2.1 in the rural land use categories. Not surprisingly, the occurrence of pesticides in the samples increases substantially on lands where applications of pesticides would be anticipated. The five golf course soil samples had a total of 41 pesticide occurrences resulting in an average of 8.2 pesticides per sample.

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Table 11 ***Summary Statistics for Chlorinated Pesticides***

Pesticides	MDL ug/kg	Number Detected	Range of Detected Values ug/kg	Geometric Mean ug/kg	Arithmetic Mean ug/kg
alpha-BHC	4	2	4 - 9	2.1	0.16
gamma-BHC	1	3	2 - 4	0.5	0.13
beta-BHC	1	29	3 - 713	3.0	27.8
Heptachlor	1	4	5 - 15	0.6	0.4
Aldrin	1	1	17	0.5	--
Heptachlor Epoxide	1	11	2 - 780	0.9	16.1
alpha-Endosulfan	1	9	2 - 80	0.7	1.7
beta-Endosulfan	3	0	--	--	--
p,p'-DDE	2	28	2 - 1770	4.2	65.8
Dieldrin	2	13	2 - 1237	1.9	33.3
Endrin	3	2	229 - 260	1.7	6.1
o,p'-DDT	4	13	10 - 2632	3.8	63.2
p,p'-DDD	4	14	4 - 490	3.6	22.7
p,p'-DDT	5	18	5 - 4610	5.4	78.9
Endosulfan Sulfate	33	1	2108	17.5	--
Chlordane	2	7	13 - 10560	1.6	223
Mirex	2	1	8	1.0	--
Methoxychlor	6	0	--	--	--
Toxaphene	nd	0	--	--	--

MDL = Minimum Detection Limit
nd = MDL was not determined by laboratory for this compound
[1] Sample total = 80

Beta-BHC and p,p'-DDE were detected in the largest number of samples, 36% and 35%, respectively. Alpha and beta BHC, heptachlor, p,p'-DDE, o,p'-DDT, p,p'-DDD and p,p'-DDT tended to occur more frequently in the urban and golf green land use categories than the suburban, rural or agricultural land use categories. Dieldrin and chlordane occurred more frequently in the golf course samples than the other land use data sets.

E. Polycyclic Aromatic Hydrocarbons

Analyses were performed for sixteen polycyclic aromatic hydrocarbons (PAH) listed in Table 5. Ten of the eighty samples (13%) contained detectable levels of fluoranthrene, chrysene, phenanthrene, and pyrene. Fluoranthrene was detected more frequently than chrysene and phenanthrene, and pyrene was detected in only one sample. These data are summarized below in Table 12. Of the ten samples containing PAHs, six were collected in urban areas, two in suburban areas and two in rural areas. Nearly 1 in 3 (32%) of the urban samples contained detectable PAHs, though two of these samples were from fill material of unknown origin. PAHs were also detected in 11% of suburban

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and 6% of rural samples. This increased incidence of detection parallels the previously noted trend of increased impact in urban areas.

As noted in the Quality Assurance section, recoveries were negligible for the heavier PAHs (benzo(k)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, dibenzo(a,h)anthracene, benzo(g,h,i)perylene). Therefore, no conclusion can be drawn in this study regarding the environmental concentration of these compounds.

Table 12 ***Summary of PAH Data For All Land Use Categories***

	No. of Detects	Max. Conc. ug/g	Min. Conc. ug/g
Fluoranthrene	5	4.27	0.22
Chrysene	4	3.93	1.21
Phenanthrene	4	3.63	0.49
Pyrene	1	1.43	1.43

F. PCBs, Chlorinated Herbicides, and Organophosphate Pesticides

There were no detectable quantities of any compounds of the remaining chemical groups in the soils analyzed during this study. These groups include PCBs, chlorinated herbicides and organophosphate pesticides.

The PCB analyses included the Aroclors 1016, 1242, 1248, 1254 and 1260. Sensitivities for the various PCB mixtures varied from 0.021 to 0.054 mg/kg. As noted in the QA section, recoveries were not determined. The apparent conclusion resulting from this study must thus be qualified.

In a similar study conducted in Great Britain, total PCB (including Aroclors 1242, 1254 and 1260) concentrations were measured in soils from 100 background sites (Creaser and Fernandes, 1986). The British study reported PCB background concentrations at a mean value of 0.022 mg/kg with a median of 0.007 mg/kg. These values are less than the sensitivities determined for the present study (Table 3).

The soil samples were also analyzed for three chlorophenoxy herbicides, 2,4-D, 2,4,5-T and Silvex. None were detected at any sites during this study. The MDLs for these compounds were calculated to be 10 ug/kg for 2,4-D, 2 ug/kg for 2,4,5-T and 1 ug/kg for Silvex. Since only 2,4-D can be considered reasonably degradable this would seem to indicate that contamination with these herbicides had probably not occurred.

In addition, eleven organophosphate pesticides were analyzed. These pesticides are listed below in Table 13.

No organophosphate pesticides were detected in any sample, nor were unknown peaks recorded by the Thermionic Nitrogen/Phosphorus detector. This is not unreasonable since these compounds tend

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to photooxidize and hydrolyze and thus, in contrast to the organochlorine pesticides, have relatively short environmental half-lives and are not considered to be persistent in the environment.

Table 13 ***Organophosphate Pesticides***

MDL = 0.02 ug/kg

Phosorin	Merphos
Thimet	Dimethoate
Diazinon	Malathion
Disulfonton	DEF
Parathion	Ethion
Trithion	

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CONCLUSIONS

1. Elevated levels of anthropogenic pollutants, primarily metals, result from increased human activity in New Jersey. Urban park soils contained elevated levels of most metals relative to suburban and/or rural soils as determined by nonparametic statistics. The exceptions to this were beryllium, chromium, and selenium which showed no significant variation with land use category. It is assumed that the higher levels observed in the urban areas are due primarily to the diffuse regional deposition of air pollutants originating from both mobile (vehicular) and stationary emission sources.

2. Golf course soils (greens) have been the obvious recipients of compounds containing cadmium, chromium, and mercury, as well as organic pesticides. No firm conclusions may be offered regarding agricultural land due to the small sample size.

3. For the most part, the data collected during this survey were consistent with other background studies in the literature for the state, the country and worldwide data.

4. The data contained in this report can be used to establish a statewide range for inorganics such that a threshold value may be determined, which indicates human impact to the soil. Measured values in excess of such a number would thus have a high probability of being of local anthropogenic origin rather than natural origin. Environmental concentrations that were less than this threshold value would, therefore, likely be of either natural or diffuse anthropogenic origin.

5. While background PCB levels appear to be low, less than 0.054 mg/kg, this conclusion should be interpreted with caution as no matrix spike recovery data was reported by the laboratory.

6. Chlorinated pesticides were detected at low concentrations in a majority (51%) of samples, with BHC and DDT-related compounds generally being the most common. The large number of non-detectable samples precluded formal statistical evaluation, thus no significant overall relationships were demonstrated between concentration and land use categories. Chlorinated pesticides appear to be detected more frequently in urban than suburban or rural soils. Golf greens also tended to show elevated frequencies and concentrations of certain compounds.

7. Background concentrations of polycyclic aromatic hydrocarbons (PAH) were only measured below the MDL, at or below the low part per million level. No data was reported for the heavier members of this group due to negligible matrix spike recoveries. PAHs continue the general trend of increasing prevalence in urban relative to suburban and rural land.

8. No organophosphate pesticides were detected in this study. This is consistent with the relative degradability of this class of compounds.

9. No chlorinated herbicides were detected in this study. As these compounds are relatively persistent in the environment, the data indicates that this class of compounds is not a significant component of diffuse anthropogenic pollution.

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APPENDIX I *General Soil Parameters*

Sample Number	Percent[1] Loss of Ignition	Soil pH	Sand %	Silt %	Clay %
001	3.9	4.8	14	60	26
002	4.1	5.2	14	62	24
003	4.3	5.2	42	34	24
004	4.3	4.6	46	36	18
005	5.5	4.7	42	34	24
006	5.6	5.0	42	40	18
007	8.8	5.1	38	44	18
008	4.0	5.1	44	44	12
009	5.0	5.4	34	48	18
010[2]	80.1	3.6	NS[3]	NS[3]	NS[3]
011	2.9	4.5	80	14	6
012	2.1	4.3	98	1	1
013	2.7	3.8	90	4	6
014	7.9	5.8	36	44	20
015	5.4	5.3	47	36	17
016	4.5	4.7	58	29	13
017	5.3	4.9	42	38	20
018	6.5	5.3	43	39	18
019	2.8	5.5	77	16	7
020[2]	4.3	4.6	24	52	24
021	4.8	4.5	54	34	12
022	7.1	4.3	65	21	14
023	6.3	5.0	NS	NS	NS
024	6.3	5.0	24	52	24
025	4.0	4.9	22	46	32
026	4.9	8.3	63	20	17
027	4.0	6.5	40	42	18
028	5.5	6.9	30	38	32
029	0.5	5.9	90	4	6
030[2]	1.0	4.5	92	4	4
031	15.6	4.1	84	10	6
032	4.0	6.4	82	12	6
033	5.8	4.6	73	19	8
034	3.2	4.0	74	18	8
035	2.8	5.9	82	12	6
036	4.5	5.7	62	26	12
037	3.8	6.6	54	32	14
038	7.7	5.1	44	36	24
039	5.1	6.4	58	30	12
040[2]	3.7	6.3	54	36	10
041	4.4	5.4	44	44	12
042	3.4	6.9	56	30	14
043	9.3	5.3	62	30	8

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APPENDIX I – (continued) ***General Soil Parameters***

Sample Number	Percent[1] Loss of Ignition	Soil pH	Sand %	Silt %	Clay %
044	4.3	5.8	50	40	10
045	4.6	7.5	64	26	10
046	4.7	6.7	42	40	18
047	6.0	7.5	56	34	10
048	3.9	5.5	82	12	6
049	6.3	5.0	60	26	14
050[2]	2.9	6.3	90	8	2
051	2.2	4.8	90	6	4
052	2.9	4.7	56	34	10
053	3.5	4.6	26	58	16
054	2.9	5.2	82	16	2
055	1.8	5.8	82	8	10
056	6.3	5.5	76	16	8
057	1.3	5.6	90	4	6
058	3.6	4.6	60	30	10
059	1.9	4.5	90	6	4
060[2]	1.1	4.5	96	4	0
061	1.9	4.7	88	6	6
062	2.4	6.3	84	8	8
063	1.4	5.4	86	6	8
064	8.8	6.1	34	40	26
065	3.9	5.3	34	48	18
066	7.6	7.3	72	18	10
067	16.6	6.1	NS	NS	NS
068	11.4	7.3	60	30	10
069	4.6	6.3	36	34	30
070[2]	5.4	7.2	32	50	18
071	3.1	6.6	26	68	6
072	5.0	6.0	24	42	34
073	4.6	7.0	16	60	24
074	2.9	6.5	62	24	14
075	4.0	5.2	28	64	8
076	4.0	6.6	42	40	18
077	4.5	6.7	70	22	8
078	3.4	6.9	70	20	10
079	5.3	6.8	52	32	16
080[2]	4.6	6.4	60	24	16

[1] "Total, Fixed and Volatile Solid and Semisolid Samples." Standard Methods for the examination of Wastewater, 16th Ed.; APHA, WPCF, 1985.

[2] Average values were reported for duplicate analyses. Duplicate analyses were conducted on every tenth sample.

[3] NS = Not Enough Sample

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APPENDIX II *Metal Analysis (mg/kg)*

Sample	Sb	As	Be	Cd	Cr	Cu	Pb	Mn	Hg	Ni	Se	Ag	Tl	V	Zn
1[1]	ND	3.62	0.80	0.073	11.1	9.47	16.0	344	0.13	9.8	0.06	0.05	0.27	41.1	47.7
2	ND	2.55	1.48	0.14	16.5	10.0	17.3	270	0.18	15.0	0.15	0.06	0.28	34.8	53.1
3	ND	1.00	1.33	0.089	12.5	9.61	17.4	423	0.11	25.0	0.04	0.08	ND	20.4	57.8
4	ND	0.61	1.50	0.085	13.5	12.8	21.5	692	0.12	34.0	0.06	0.15	0.12	14.6	95.8
5	ND	2.70	0.96	0.081	11.5	11.4	17.6	133	ND	17.3	0.16	0.19	ND	1.4	69.1
6	ND	1.79	1.05	0.077	11.8	6.21	18.4	52	ND	8.7	0.19	0.12	ND	29.7	32.8
7	ND	4.53	0.91	0.201	17.4	28.4	62.4	959	0.13	11.5	0.34	0.15	0.19	41.4	66.3
8	0.05	2.13	0.61	0.193	17.1	24.9	34.4	226	0.14	12.9	0.16	0.10	ND	34.4	58.5
9	0.10	2.38	10.3	0.182	7.5	7.47	21.9	100	ND	9.0	0.09	0.08	ND	17.9	55.3
10	ND	4.78	1.63	0.146	9.7	10.4	46.0	7	0.11	6.6	0.80	0.03	ND	5.3	27.0
11[1]	ND	0.14	0.08	0.014	2.5	1.34	6.1	4	ND	ND	ND	0.02	0.13	3.2	4.9
12	ND	0.04	0.11	0.007	0.8	0.63	4.4	1	ND	ND	ND	0.01	ND	0.8	2.7
13	ND	0.23	0.02	0.011	3.7	1.31	7.4	3	ND	ND	ND	0.01	ND	0.9	5.5
14	ND	3.74	1.74	0.244	9.8	14.7	22.0	561	0.1	9.2	0.15	0.06	0.11	23.2	65.9
15	NA	3.52	1.83	0.135	8.3	11.1	14.8	660	0.15	10.8	0.10	0.06	ND	19.8	54.2
16	0.03	3.83	1.08	0.146	5.7	11.0	19.7	273	0.1	6.2	0.12	0.14	ND	1.4	38.8
17	ND	3.07	1.14	0.098	10.0	12.5	17.2	375	ND	17.4	0.05	0.13	ND	15.4	69.0
18	ND	2.31	1.28	0.138	10.2	11.9	19.5	537	0.1	18.7	0.06	0.12	ND	18.3	63.5
19	NA	17.1	0.76	0.079	20.7	5.57	44.3	28	0.17	7.6	0.10	0.11	ND	23.5	25.5
20	NA	2.85	1.07	0.03	18.9	5.25	18.5	27	ND	6.4	0.11	0.10	ND	23.6	35.1
21[1]	ND	2.21	0.46	0.069	5.4	5.64	15.3	13	ND	3.2	0.07	0.14	ND	1.3	19.1
22	ND	1.69	0.19	0.08	5.8	4.38	17.9	6	ND	2.2	0.09	0.04	ND	1.0	27.9
23	ND	1.32	1.07	0.159	14.4	5.84	17.9	40	0.11	9.1	0.13	0.05	0.08	27.1	53.0
24	ND	2.42	1.16	0.045	14.0	13.9	22.6	73	0.14	12.0	0.05	0.20	ND	29.6	41.6
25	NA	2.38	0.91	0.073	15.4	10.1	21.6	31	0.16	11.1	0.08	0.19	ND	38.0	52.0
26	NA	10.3	1.15	0.471	15.0	31.5	285	252	1.06	19.2	0.07	0.04	0.07	36.8	789
27	ND	4.00	1.16	0.314	12.8	20.5	59.3	459	0.19	19.2	0.09	0.24	0.07	25.3	121
28	ND	9.68	4.09	0.303	10.6	27.6	39.9	515	0.18	28.2	0.15	0.20	0.46	39.9	132
29	ND	0.02	ND	0.011	2.2	0.82	2.2	4	ND	ND	ND	0.01	ND	3.1	2.1
30	0.04	0.14	ND	0.007	1.0	0.78	5.0	4	ND	ND	ND	0.01	ND	1.0	3.4
31[1]	0.08	0.54	0.06	0.026	4.3	1.48	3.7	6	ND	ND	ND	ND	ND	0.8	4.0
32	ND	2.27	0.16	0.256	12.0	13.7	97.8	30	0.13	5.5	0.10	0.04	ND	18.5	40.4
33	NA	0.55	0.03	0.01	4.5	1.74	11.6	40	ND	1.4	0.06	0.30	0.10	1.2	4.9
34	ND	0.06	0.22	0.016	4.2	1.77	8.0	17	0.1	2.1	0.05	0.19	ND	0.7	9.5
35	ND	4.56	0.09	0.116	10.4	6.05	25.9	59	ND	3.2	0.11	0.21	ND	1.3	44.6
36	ND	10.7	0.88	0.135	14.0	7.27	15.1	120	ND	8.3	0.17	0.26	ND	14.0	28.1
37	0.02	8.41	0.70	0.164	14.3	41.7	58.9	86	0.14	8.5	0.05	0.42	ND	19.4	40.6
38	0.04	6.60	2.55	0.632	15.3	17.0	65.7	333	ND	28.7	0.12	0.22	0.10	26.3	88.9
39	ND	2.72	0.70	0.586	21.3	21.1	150	289	0.11	11.1	0.06	0.18	ND	21.8	82.6
40	0.07	22.7	0.55	0.32	8.2	10.7	100	240	0.13	9.9	0.08	0.12	ND	14.2	35.3

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APPENDIX II -- (continued) ***Metal Analysis (mg/kg)***

Sample	Sb	As	Be	Cd	Cr	Cu	Pb	Mn	Hg	Ni	Se	Ag	Tl	V	Zn
41[1]	0.02	4.16	0.88	0.160	11.1	15.2	67.8	251	0.15	13.3	0.10	0.19	ND	23.0	56.1
42	0.04	8.22	0.89	0.873	18.7	102	271	371	0.33	21.1	0.05	0.34	ND	29.2	246
43	0.69	48.9	0.45	2.36	18.3	143	617	240	1.58	53.8	0.05	1.53	0.04	46.1	210
44	0.05	3.68	0.69	0.347	15.9	21.2	83.4	260	2.71	10.9	0.07	0.16	0.07	21.1	76.6
45	0.04	8.03	0.90	0.444	9.6	31.3	53.6	354	0.14	15.4	ND	0.32	ND	14.4	73.0
46	0.05	4.62	0.78	0.601	10.8	48.3	446	388	0.46	15.1	0.05	0.24	0.06	19.5	129
47	0.10	10.9	0.83	0.517	24.6	47.9	189	239	0.48	16.9	0.09	0.30	0.11	32.5	112
48	0.03	0.34	0.67	0.223	4.9	18.4	48.5	121	0.39	6.0	ND	0.09	0.07	1.0	63.1
49	0.03	2.62	0.71	0.10	9.3	9.89	16.1	48	0.12	5.6	0.06	0.10	ND	25.0	29.8
50	0.03	0.02	0.07	0.22	2.5	1.73	12.2	71	ND	1.4	ND	0.02	ND	1.0	18.1
51[1]	ND	0.19	0.06	0.026	1.6	1.40	5.2	15	ND	ND	ND	0.06	ND	4.9	0.9
52	ND	0.31	0.56	0.011	3.7	2.62	8.7	31	ND	4.0	ND	0.05	ND	9.1	16.8
53	ND	0.19	0.84	0.024	5.7	3.89	7.8	5	ND	5.8	ND	0.04	ND	4.8	23.3
54	ND	0.99	0.47	0.011	5.5	3.04	10.0	94	0.11	2.5	ND	0.15	ND	4.3	16.0
55	ND	0.29	0.47	0.028	6.8	1.22	4.7	28	ND	ND	ND	0.02	ND	0.5	11.2
56	0.03	10.9	0.65	0.914	13.8	64.3	165	210	0.31	7.8	0.13	0.07	0.24	18.6	81.8
57	0.03	3.63	0.21	0.014	2.9	3.62	18.6	25	ND	ND	ND	0.02	ND	6.3	8.9
58	ND	3.52	0.43	0.006	4.8	2.59	4.2	23	ND	2.3	ND	0.04	ND	6.0	13.0
59	0.03	3.81	0.04	ND	3.6	2.35	44.2	3	ND	ND	ND	0.02	ND	4.9	4.6
60	ND	2.08	ND	0.008	0.7	ND	ND	2	ND	ND	ND	ND	ND	0.2	ND
61[1]	ND	3.10	0.68	0.059	8.9	1.79	4.9	47	ND	0.6	ND	0.01	ND	4.7	15.8
62	ND	4.42	0.73	0.132	18.7	5.40	11.6	104	0.14	2.6	ND	0.09	ND	10.8	33.2
63	ND	1.35	0.12	0.007	3.2	1.95	ND	11	0.11	ND	ND	0.10	ND	4.5	9.6
64	ND	6.02	0.81	0.04	101	55.9	17.2	1313	0.26	42.2	0.11	0.19	ND	165	56.0
65	ND	4.35	0.96	0.185	8.1	8.84	25.8	285	0.15	8.8	0.05	0.07	0.06	15.7	42.5
66	ND	5.65	0.85	0.505	8.7	36.0	428	385	0.47	12.8	0.04	0.07	0.06	13.0	162
67	NA	6.41	0.91	1.04	9.3	35.9	109	354	0.68	10.5	0.05	0.16	ND	16.8	317
68	0.03	5.12	1.50	1.61	7.0	39.4	27.0	358	0.28	11.9	0.09	0.26	0.14	26.5	316
69	ND	4.40	0.36	0.421	8.2	22.3	39.1	458	ND	18.7	ND	0.09	0.19	24.9	74.6
70	ND	2.32	1.11	0.437	7.2	77.9	318	952	ND	10.1	ND	0.26	ND	7.0	73.6
71[1]	0.03	6.15	2.00	0.27	8.8	14.3	27.0	846	ND	14.9	0.05	0.15	0.23	20.5	82.2
72	ND	5.57	1.10	0.308	9.9	13.0	18.4	913	ND	11.8	ND	0.13	0.23	20.3	67.1
73	0.02	4.79	1.66	0.176	9.6	11.7	24.8	1125	ND	14.6	ND	0.09	0.14	21.5	75.7
74	ND	3.23	0.86	0.169	5.5	11.3	ND	315	ND	5.3	ND	0.08	0.18	16.9	43.8
75	ND	3.97	1.17	0.234	9.7	9.37	16.4	414	ND	10.2	ND	0.08	ND	20.3	51.5
76	ND	4.23	0.71	2.28	72.7	19.7	13.9	495	7.4	12.3	ND	0.12	0.10	20.1	524
77	ND	5.00	0.79	1.64	16.3	9.11	13.7	330	7.7	8.3	ND	0.09	ND	9.8	37.6
78	ND	1.06	0.56	5.16	22.6	4.58	ND	307	5.0	8.5	ND	0.03	ND	1.3	47.0
79	ND	2.49	0.79	0.90	24.9	11.3	16.8	480	1.4	13.1	ND	0.15	ND	15.0	56.3
80	ND	3.37	0.54	1.32	25.6	9.86	16.5	348	2.2	9.4	ND	0.05	ND	10.6	48.1

[1] Average values were reported for duplicate analyses which were run on every tenth sample.

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APPENDIX III ***Additional Summary Statistics for Metals (mg/kg)***

Metal Land Use	N	Proportion >MDL	Geo Std Deviation	95% Confidence Interval[1]
Sb MDL = 0.02				
Urban	17	0.65	3.0	0.02 - 0.05
Suburban	18	0.44	1.9	0.01 - 0.02
Rural	30	0.13	1.8	0.01 - 0.02
Golf Greens	5	0.00	----	----
Farm	3	0.33	----	----
As MDL = 0.003				
Urban	19	1.00	2.60	3.46 - 8.71
Suburban	18	1.00	6.74	0.80 - 5.33
Rural	35	1.00	4.08	0.74 - 1.96
Golf Greens	5	1.00	----	----
Farm	3	1.00	----	----
Be MDL = 0.03				
Urban	19	1.00	1.97	0.62 - 1.18
Suburban	18	0.94	3.75	0.18 - 0.67
Rural	35	0.94	4.68	0.26 - 0.77
Golf Greens	5	1.00	----	----
Farm	3	1.00	----	----
Cd MDL = 0.006				
Urban	19	1.00	2.0	0.36 - 0.71
Suburban	18	0.94	4.4	0.04 - 0.17
Rural	35	1.00	3.1	0.03 - 0.07
Golf Greens	5	1.00	----	----
Farm	3	1.00	----	----
Cr MDL = 0.7				
Urban	19	1.00	1.5	9.2 - 13.6
Suburban	18	1.00	2.1	5.6 - 11.8
Rural	35	1.00	2.7	4.8 - 9.5
Golf Greens	5	1.00	----	----
Farm	3	1.00	----	----

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APPENDIX III -- (continued) ***Additional Summary Statistics for Metals (mg/kg)***

Metal Land Use	N	Proportion >MDL	Geo Std Deviation	95% Confidence Interval[1]
Cu MDL = 0.6				
Urban	19	1.00	2.0	23.2 - 46.3
Suburban	18	1.00	3.3	3.5 - 11.4
Rural	35	0.97	3.0	3.3 - 7.0
Golf Greens	5	1.00	——	——
Farm	3	1.00	——	——
Pb MDL = 1.2				
Urban	19	1.00	2.7	69.7 -182.9
Suburban	18	0.94	4.0	9.3 - 37.2
Rural	35	0.94	2.6	8.0 - 15.5
Golf Greens	5	0.80	——	——
Farm	3	1.00	——	——
Mn MDL = 0.6				
Urban	19	1.00	2.0	203 -393
Suburban	18	1.00	5.2	33 -169
Rural	35	1.00	7.3	23 - 89
Golf Greens	5	1.00	——	——
Farm	3	1.00	——	——
Hg MDL = 0.01				
Urban	19	0.84	6.2	0.08 - 0.47
Suburban	18	0.50	5.4	0.01 - 0.06
Rural	35	0.46	5.2	0.01 - 0.04
Golf Greens	5	1.00	——	——
Farm	3	0.00	——	——
Ni MDL = 1.2				
Urban	19	1.00	1.8	10.8 - 18.5
Suburban	18	0.72	3.9	1.6 - 6.2
Rural	35	0.80	3.6	3.0 - 7.2
Golf Greens	5	1.00	——	——
Farm	3	1.00	——	——

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APPENDIX III -- (continued) ***Additional Summary Statistics for Metals (mg/kg)***

Metal Land Use	N	Proportion >MDL	Geo Std Deviation	95% Confidence Interval[1]
Se MDL = 0.01				
Urban	19	0.79	0.06	0.23 - 0.07
Suburban	18	0.55	0.06	0.01 - 0.05
Rural	35	0.66	0.08	0.02 - 0.06
Golf Greens	5	0.00	0.01	----
Farm	3	0.00	0.01	----
Ag MDL = 0.01				
Urban	19	1.00	0.24	0.11 - 0.24
Suburban	18	1.00	0.12	0.04 - 0.13
Rural	35	0.94	0.09	0.04 - 0.09
Golf Greens	5	1.00	0.09	----
Farm	3	1.00	0.10	----
Tl MDL = 0.06				
Urban	19	0.68	0.01	0.05 - 0.10
Suburban	18	0.16	0.06	0.03 - 0.06
Rural	35	0.23	0.06	0.03 - 0.05
Golf Greens	5	0.20	0.04	----
Farm	3	0.67	0.13	----
V MDL = 0.3				
Urban	19	1.00	22.67	12.43 - 27.68
Suburban	18	1.00	14.19	4.59 - 15.37
Rural	35	1.00	17.36	3.62 - 11.11
Golf Greens	5	1.00	11.36	----
Farm	3	1.00	20.70	----
Zn MDL = 0.24				
Urban	19	1.00	127.5	76.2 -143.0
Suburban	18	1.00	38.8	15.5 - 42.8
Rural	35	0.97	33.7	11.9 - 31.6
Golf Greens	5	1.00	142.6	----
Farm	3	1.00	64.8	----

[1] The 95% Confidence Interval about the geometric mean was based on geometric standard errors. It was not calculated for the farm and golf course samples due to the small sample size.

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APPENDIX IV *Chlorinated Pesticides Results[1] (ug/kg)*

Pesticide	Sample Number 19	26	31	32	34	35	36	38
alpha-BHC								
gamma-BHC								
beta-BHC								
Heptachlor								
Aldrin								
Heptachlor Epoxide								
alpha-Endosulfan				8	7	4		
p,p' - DDE	1770			39			2	5
Dieldrin								
Endrin								
o,p' - DDT	757			15				
p,p' - DDD	309							
p,p' - DDT	4610		19	51	19	5		34
Endosulfan Sulfate								
Chlordane		10560						
Mirex								

Pesticide	Sample Number 39	41	42	43	44	45	46
alpha-BHC						4	
gamma-BHC							
beta-BHC		5	132	37	39	26	21
Heptachlor							
Aldrin							
Heptachlor Epoxide	13		3	2	2		
alpha-Endosulfan						7	3
p,p' - DDE		55	537	177	154	27	
Dieldrin	39						
Endrin							
o,p' - DDT			73	30	27		
p,p' - DDD	17		195	13	10		
p,p' - DDT			312	243	219		
Endosulfan Sulfate							
Chlordane	30						
Mirex	8						

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APPENDIX IV -- (continued) ***Chlorinated Pesticides Results[1] (ug/kg)***

Pesticide	Sample Number 47	48	49	50[2]	51	52	54	57
alpha-BHC								
gamma-BHC								
beta-BHC	21	15		3	5	3		3
Heptachlor								
Aldrin								
Heptachlor Epoxide								
alpha-Endosulfan								
p,p' - DDE		174	151	12	128	51	10	44
Dieldrin		720		251				
Endrin								
o,p' - DDT			13		10			
p,p' - DDD		12	4					49
p,p' - DDT		51	40		26			118
Endosulfan Sulfate								
Chlordane								
Mirex								

Pesticide	Sample Number 59	62	64	65	66	67
alpha-BHC						
gamma-BHC						
beta-BHC		3	4	7	298	69
Heptachlor						
Aldrin						
Heptachlor Epoxide						
alpha-Endosulfan				2	18	9
p,p' - DDE	3	21		41	47	16
Dieldrin		19			2	4
Endrin						
o,p' - DDT						
p,p' - DDD						
p,p' - DDT				21		
Endosulfan Sulfate						
Chlordane						
Mirex						

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APPENDIX IV -- (continued) ***Chlorinated Pesticides Results[1] (ug/kg)***

Pesticide	Sample Number 68	69	70[2]	71	72	73	75	76
alpha-BHC	9							
gamma-BHC	2	4			4			
beta-BHC	210	10	17	11	3	8	16	713
Heptachlor		6			5			
Aldrin					17			
Heptachlor Epoxide	27					25		780
alpha-Endosulfan	80							
p,p' - DDE	260	6						511
Dieldrin	71	3			117	66		1237
Endrin								
o,p' - DDT	152							2632
p,p' - DDD	212							490
p,p' - DDT								
Endosulfan Sulfate	2108							
Chlordane								6434
Mirex								

Pesticide	Sample Number 77	78	79	80[2]
alpha-BHC				
gamma-BHC				
beta-BHC	258	240	22	22
Heptachlor			10	15
Aldrin				
Heptachlor Epoxide	140	224	25	47
alpha-Endosulfan				
p,p' - DDE	376	334	108	200
Dieldrin	41	97		
Endrin	229	260		
o,p' - DDT	239	802	87	217
p,p' - DDD	162	262	19	65
p,p' - DDT	142	178	28	192
Endosulfan Sulfate				
Chlordane	420	355	13	26
Mirex				

[1] While all samples were analyzed for pesticides, only samples with results greater than the MDLs have been included in this table.

[2] Average values were reported for duplicate analyses which were performed on every tenth sample.

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