



# **Analytical Results for Municipal Biosolids Samples from a Monitoring Program Near Deer Trail, Colorado (USA), 1999 through 2006**

By J. G. Crock, D. B. Smith, T. J. B. Yager, Z. A. Brown, and M.G. Adams

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## **Abstract**

Since late 1993, Metro Wastewater Reclamation District of Denver (Metro District), a large wastewater treatment plant in Denver, Colorado, has applied Grade I, Class B biosolids to about 52,000 acres of non-irrigated farmland and rangeland near Deer Trail, Colorado. In cooperation with the Metro District in 1993, the U.S. Geological Survey (USGS) began monitoring ground water at part of this site (Yager and Arnold, 2003). In 1999, the USGS began a more comprehensive monitoring study of the entire site to address stakeholder concerns about the potential chemical effects of biosolids applications. This more comprehensive monitoring program has recently been extended through 2010. Monitoring components of the more comprehensive study include biosolids collected at the wastewater treatment plant, soil, crops, dust, alluvial and bedrock ground water, and stream bed sediment. Streams at the site are dry most of the year, so samples of stream bed sediment deposited after rain were used to indicate surface-water effects. This report will present only analytical results for the biosolids samples collected at the Metro District wastewater treatment plant in Denver and analyzed during 1999 through 2006. More information about the other monitoring components is presented elsewhere in the literature (e.g., Yager and others, 2004a, 2004b, 2004c, 2004d). Priority parameters for biosolids identified by the stakeholders and also regulated by Colorado when used as an agricultural soil amendment include the total concentrations of nine trace elements (arsenic, cadmium, copper, lead, mercury, molybdenum, nickel, selenium, and zinc), plutonium isotopes, and gross alpha and beta activity. Nitrogen and chromium also were priority parameters for ground water and sediment components.

In general, the objective of each component of the study was to determine whether concentrations of priority parameters (1) were higher than regulatory limits, (2) were increasing with time, or (3) were significantly higher in biosolids-applied areas than in a similar farmed area where biosolids were not applied.

Analytical results indicate that the elemental composition of the biosolids from the Denver plant was consistent during 1999-2006, and total concentrations of regulated trace elements were consistently lower than the regulatory limits. Plutonium isotopes were not detected in any of the biosolids samples for the entire sampling period. Analytical results for gross alpha and beta activity were highly imprecise and erratic. As a result of the cancellation of regulation requiring their monitoring in biosolids, the determination of both was discontinued mid-study.

Data from this study were used to compile an inorganic-chemical biosolids signature that can be contrasted with the geochemical signature for this site. The biosolids signature and an understanding of the geology and hydrology of the site can be used to separate biosolids effects from natural geochemical effects. Elements of particular interest for a biosolids signature include bismuth, copper, silver, mercury, and phosphorus.

## **Introduction**

Since 1993, the Metro Wastewater Reclamation District of Denver (Metro District) has been applying biosolids from the Denver metropolitan area to their property near Deer Trail, Colorado, (fig.1), as an agricultural soil amendment. The biosolids are applied to non-irrigated farmland according to agronomic loading rates. More information about the sewage-treatment process that results in the Metro District biosolids can be found at <http://www.metrowastewater.com>. The biosolids-application areas, dates of application, and application rates provided by the Metro District for their properties near Deer Trail for 1999 through 2003 are detailed in Stevens and others (2003), and Yager and others (2004a, 2004b, 2004c). As more information becomes available, it will be posted at the USGS project web page at <http://co.water.usgs.gov/projects/CO406/CO406.html>.

In 1999, the Metro District property, known as the METROGRO Farm, encompassed about 81 mi<sup>2</sup> (52,000 acres) of farmland in Arapahoe and Elbert Counties, Colorado. The Metro District property and surrounding private property are herein referred to as “the study area.”

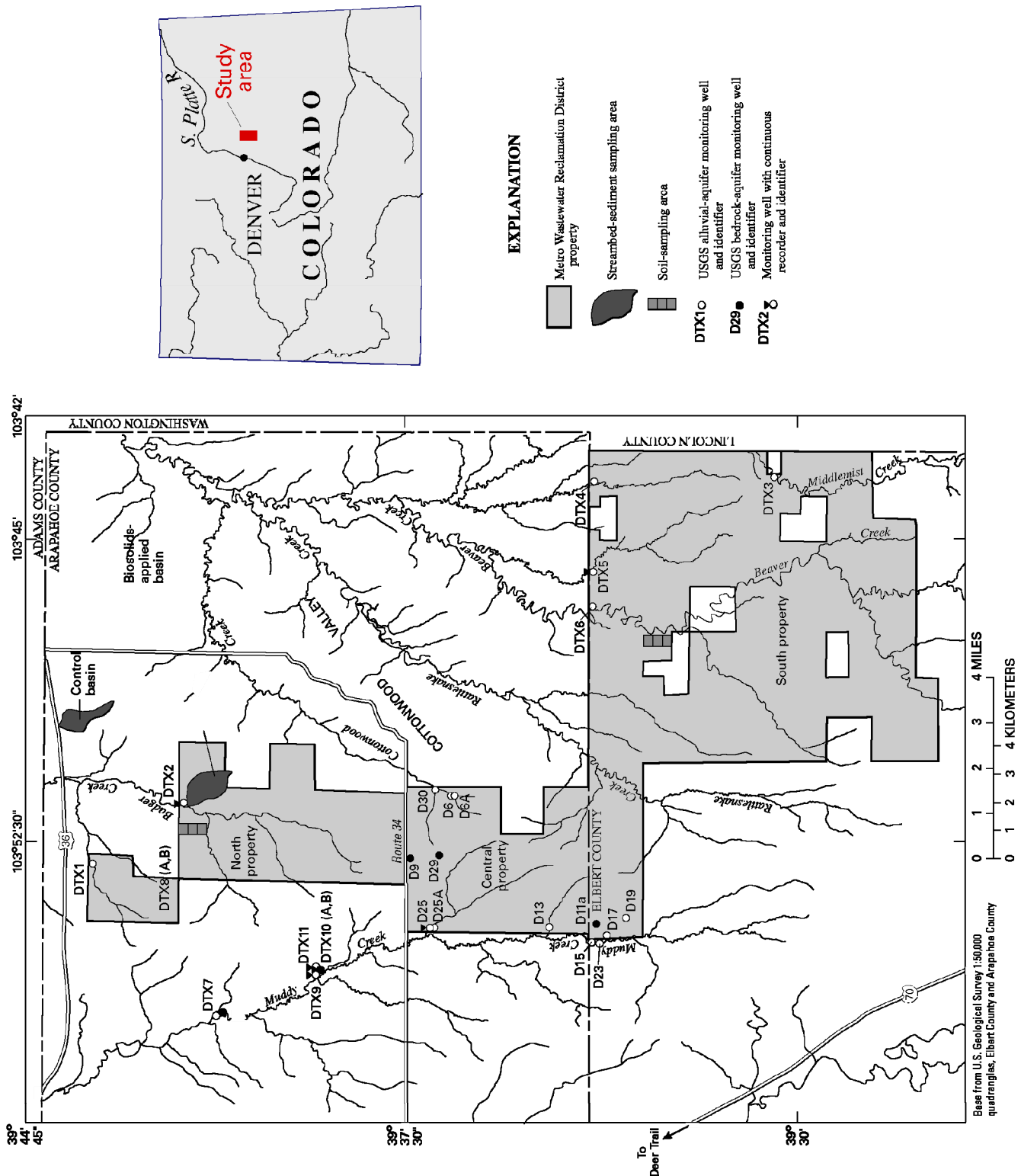


Figure 1. Metro Wastewater Reclamation District of Denver (Metro District) biosolids application farm and study area location.

Soils in the study area generally are sandy or loamy on flood plains and stream terraces, clayey to loamy on gently sloping to rolling uplands, and sandy and shaley on steeper uplands. About one-half of the Metro District property is farmed; the remaining is rangeland with some pasture. Land use within the rest of the study area during 1993 through 2006 mostly was rangeland or pasture with some cropland. Farmland in the study area was not irrigated. Biosolids were applied to the land surface of the Metro District property as an agricultural soil amendment, and the primary crop was wheat. Figure 2 shows a typical example of what fresh biosolids look like on the landscape after a single broadcast application.



Figure 2. Biosolids as typically seen after broadcast application to agricultural land.

Public concern about applications of biosolids to farmland increased after the Metro District agreed to accept treated ground water from the Lowry Landfill Superfund site in Denver. The U.S. Geological Survey (USGS), in cooperation with the Metro District and (in 1999) the North Kiowa Bijou Groundwater Management District, studied natural geochemical conditions and the effects of biosolids applications to the Metro District properties near Deer Trail, Colorado, during 1999 through 2006. The study addressed the concerns about biosolids applications and other farming-related effects on the environment. The objectives of this USGS study were to: (1) evaluate the combined effects of biosolids applications, land use, and natural processes on soil, crops, the bedrock aquifer, alluvial aquifers, and stream bed sediments by comparing chemical data to regulatory standards, data from a site where biosolids are not applied (a control site), or earlier data from the same site (trends); (2) monitor biosolids for trace elements and radioactivity and compare trace-element concentrations and radioactivity with regulatory standards; and (3) characterize the hydrology of the study area. This report provides the 1999-2006 analytical data for biosolids only.



A complete discussion of findings (up to the end of 2003) for all matrices and the other study area objectives is detailed in Yager and others (2004d).

## Methodology

Biosolids are solid organic matter recovered from a sewage-treatment process that meets State and Federal regulatory criteria for beneficial use, such as for a soil amendment. Figure 3 shows freshly collected biosolids from the Metro plant spread out in a plastic-lined box to dry. Biosolids are moist (usually ranging 75 – 85% moisture) and have a firm, pudding-like texture. The regulations state that land-applied biosolids must meet or exceed Table 1 Ceiling Concentration Limits and Class B pathogen criteria (Grade II, Class B criteria in the Colorado regulations until 2003) (Colorado Department of Public Health and Environment, 1998; U.S. Environmental Protection Agency, 1993). Table 3 and Grade I requirements are stricter than Table 1 and Grade II requirements. The Metro District applies Table 3 (Grade I) Class B biosolids to their properties near Deer Trail. The regulatory references for biosolids can be found at the following websites.

<http://www.cdphe.state.co.us/wq/PermitsUnit/biosolids/index.html>

<http://www.epa.gov/owm/mtb/biosolids/503pe/index.htm>

<http://www.epa.gov/owm/mtb/biosolids/index.htm#awards>

The biosolids-application areas, dates of application, and application rates provided by the Metro District for their properties near Deer Trail are detailed in Stevens and others (2003), and Yager and others (2004a, 2004b, 2004c).

Priority parameters identified by stakeholders for biosolids (arsenic, cadmium, copper, lead, mercury, molybdenum, nickel, selenium, and zinc; gross alpha and gross beta radioactivity, and plutonium isotopes; and later in the study, total sulfur), included the nine trace elements regulated by Colorado for biosolids. Consult Table 1 for a complete list of the priority elements determined by the various analytical methods. Additional elements were determined by the multi-element inductively coupled plasma – mass spectrometry (ICP-MS) method (Briggs and Meier, 1999; Taggart, 2002).



Figure 3. Biosolids sample, as received, prior to drying in the laboratory.

Table 1. Priority parameters and analytical methods for biosolids samples.

ELEMENT	TECHNIQUE	REFERENCE
Arsenic	HG-AAS <sup>1</sup>	Hageman and Welch (1996); Taggart (2002)
Cadmium	ICP-MS <sup>2</sup>	Briggs and Meier (1999); Taggart (2002)
Copper	ICP-MS <sup>2</sup>	Briggs and Meier (1999); Taggart (2002)
Lead	ICP-MS <sup>2</sup>	Briggs and Meier (1999); Taggart (2002)
Mercury	CV-AAS <sup>3</sup>	O'Leary and others (1996); Taggart (2002)
Molybdenum	ICP-MS <sup>2</sup>	Briggs and Meier (1999); Taggart (2002)
Nickel	ICP-MS <sup>2</sup>	Briggs and Meier (1999); Taggart (2002)
Selenium	HG-AAS <sup>1</sup>	Hageman and Welch (1996); Taggart (2002)
Zinc	ICP-MS <sup>2</sup>	Briggs and Meier (1999); Taggart (2002)
Gross Alpha, Total	Radiochemistry	Greenberg (1992)
Gross Beta, Total	Radiochemistry	Greenberg (1992)
Plutonium-238, 239+240, Total	Radiochemistry	Whittaker and Grothaus (1979); Lyon (1980)
Total Sulfur	Combustion, IR detection <sup>4</sup>	Brown and Curry (2002)

<sup>1</sup>Hydride Generation – Atomic Absorption Spectrometry

<sup>2</sup>Inductively Coupled Plasma – Mass Spectrometry

<sup>3</sup>Continuous Flow – Cold Vapor – Atomic Absorption Spectrometry

<sup>4</sup>Automated combustion in oxygen, measured by a solid state infrared detector

From January 1999 through August 2000, biosolids samples were collected quarterly. From October 2000 through 2006, biosolids samples were collected monthly. Biosolids samples were collected directly from the Metro District facility's processing line in Denver, rather than from individual trucks or fields near Deer Trail, to ensure a more representative sample. Each biosolids sample was a 24-hour composite of 12 subsamples collected about every 2 hours by Metro District personnel at the Metro District facility. The subsamples were collected from the conveyor belt that transfers the biosolids into the transport trucks. The samples were prepared and analyzed at the chemical laboratories of the USGS, Geologic Discipline, Denver, Colorado. The biosolids material was air dried under forced air and an infrared lamp (surface temperature ~40° C) and then ground in an agate-lined shatter box to less than 150 µm prior to chemical analysis. Complete details of the analytical methods and the quality-assurance protocols used are described by Stevens and others (2003), Taggart (2002), and Yager and others (2004a, 2004b, 2004c). For quality control and quality assurance control, the National Institute of Standards and Technology (NIST) standard reference material (SRM) 2781, domestic sludge, was analyzed with each batch of biosolids samples.

## Discussion and Results

Biosolids exceeding the standards for trace elements could adversely affect the quality of soil on which the biosolids are applied and could alter Metro District plans for the application of biosolids in Arapahoe and Elbert Counties. The composition of biosolids was monitored to provide an independently determined data set against which the Metro District chemical analyses and the regulatory standards for biosolids can be compared. The data will also constitute a chemical baseline against which any future change in the concentration of constituents analyzed for in this study may be recognized, measured, and compared. The data set will also establish a “geochemical signature” for biosolids that will potentially enable scientists to recognize when biosolids have impacted soils or stream sediments.

All data for the 1999 – 2006 biosolids samples are presented in tables 2 – 9 on a yearly basis. Table 10 lists the plutonium isotopes and the gross *a* and *b* results for the entire time frame. The concentration of all nine trace elements remained consistent throughout the study and below the Grade 1 biosolids requirements. Reference material NIST SRM 2781 results are also presented in tables 2 – 9. The certificate of analysis for NIST SRM 2781 can be found at: <https://srmors.nist.gov/certificates/2781.pdf?CFID=14170104&CFTOKEN=d06e643b27500f42-A419A2E6-D5FA-93A1-CD37130CDA7B75FF&jsessionid=b43051d8258c3f293473> or [https://srmors.nist.gov/certificates/view\\_cert2gif.cfm?certificate=2781](https://srmors.nist.gov/certificates/view_cert2gif.cfm?certificate=2781). Figures 4 -13 show the temporal variation of the priority parameters and total sulfur. Arsenic (fig. 4) showed the most variability with its high and low concentration differing by a factor of 6. The other eight elements varied by a factor of 3 or less. All trace-element concentrations were less than the maximum allowable concentrations established for Table 3 (Grade I) biosolids. (Note that molybdenum does not have a maximum allowable concentration established for Table 3 biosolids. The value used is that for Table 1 biosolids.)

Measurements for plutonium isotopes and gross *a* and *b* exhibit a relatively high uncertainty as shown by the “error bars” or “+/- standard deviation/range” associated with each analysis. There is no regulatory value established for gross *b* radioactivity. Until 2003, there was a Colorado regulatory limit for gross *a* radioactivity. However, this regulation was revised, effective June 30,

2003, to delete the previous regulation that generally restricted land application of biosolids that exceeded a gross  $\alpha$  activity of 40 pCi/g (Colorado Department of Public Health and Environment, 1998). The samples collected before July 2002 have an average gross  $\alpha$  activity of 37 pCi/g, whereas the samples collected from July 2002 through 2003 have an average of 18 pCi/g. The uncertainty is also different, with the samples collected prior to July 2002 having an average uncertainty of +/- 34% while the samples collected from July 2002 through 2003 have an average uncertainty of +/- 12%. The samples collected from July 2002 and later were analyzed in a different laboratory from the samples collected prior to July 2002 (Yager and others, 2004a, 2004b, 2004c). The USGS has no basis for determining which laboratory provided the most accurate values. A few of the gross  $\alpha$  activity values may have exceeded the old regulatory limit of 40 pCi/g, but with the uncertainty in the analyses, it is difficult to draw any conclusion from this data set.

There are no published regulatory values for plutonium isotopes in biosolids. All isotopic measurements were below the limit of determination (0.06 pCi/g). The radioactivity data for biosolids were reported in previous annual reports (Stevens and others, 2003; Yager and others, 2004a, 2004b, 2004c) as the uncensored data as received from the laboratory rather than censored by either the contract or calculated minimum detectable concentration (MDC). Relative to the censored form (data reported as less than the MDC), the uncensored form provides more information about the uncertainty, the very small concentrations of plutonium, and the gross alpha and gross beta activity.

In conclusion, chemical data for biosolids samples collected from the Metro District plant over an eight-year period (1999–2006) show that all nine of the trace elements for which regulatory limits are established maintained relatively uniform concentrations and never exceeded the maximum allowable levels for Table 3 (Grade I) biosolids. Measurements of gross  $\alpha$  radioactivity carry a high degree of uncertainty, but generally are below the now-outdated limit of 40 pCi/g. No regulatory limits have been established for plutonium, but all values are below the minimum detectable level.

In addition to the nine trace elements that have regulatory standards established, USGS analyzed the samples for many other elements. Of the regulated elements, mercury and copper had the highest concentrations in biosolids compared to concentrations in soil. Of the non-regulated elements, silver, phosphorous, and bismuth have the highest concentrations in biosolids compared to soils (Yager and others, 2004a, 2004b, 2004c). For this reason, these five elements would be the most likely “geochemical signature” to indicate that soils or stream sediments may have been impacted by biosolids.

## **Acknowledgements**

This study was done in cooperation with and funding from the Metro Wastewater Reclamation District and the North Kiowa-Bijou Groundwater Management District. The authors also wish to thank Paul Lamothe, Paul Wigton, and Murray Beasley, all with the analytical chemistry laboratories of the USGS, Denver, for their efforts in the preparation and analyses of the samples for this study and Richard O’Leary and Philip Hageman for their very helpful review of the manuscript.

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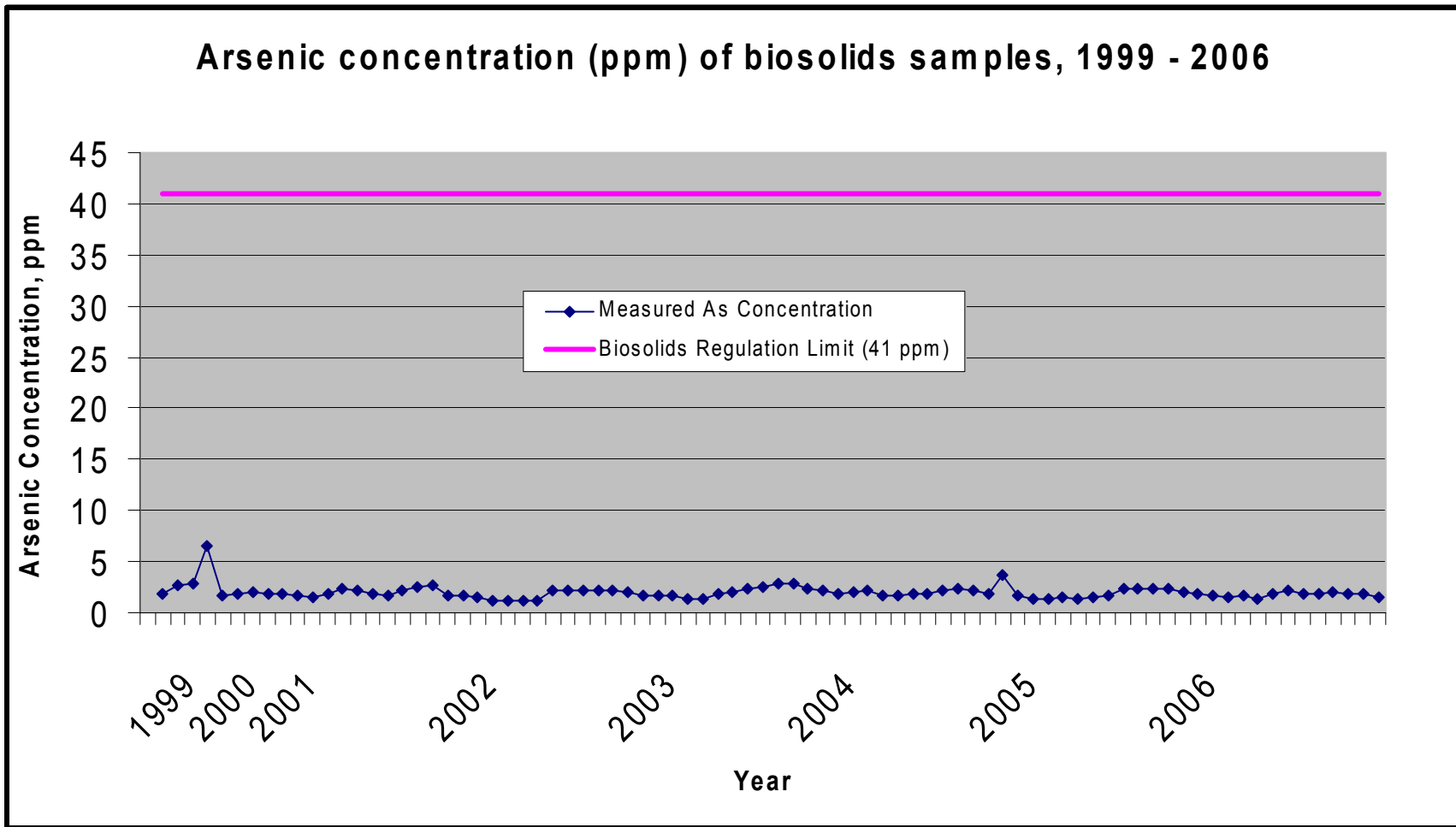


Figure 4. Arsenic concentrations of biosolids samples, 1999 – 2006.

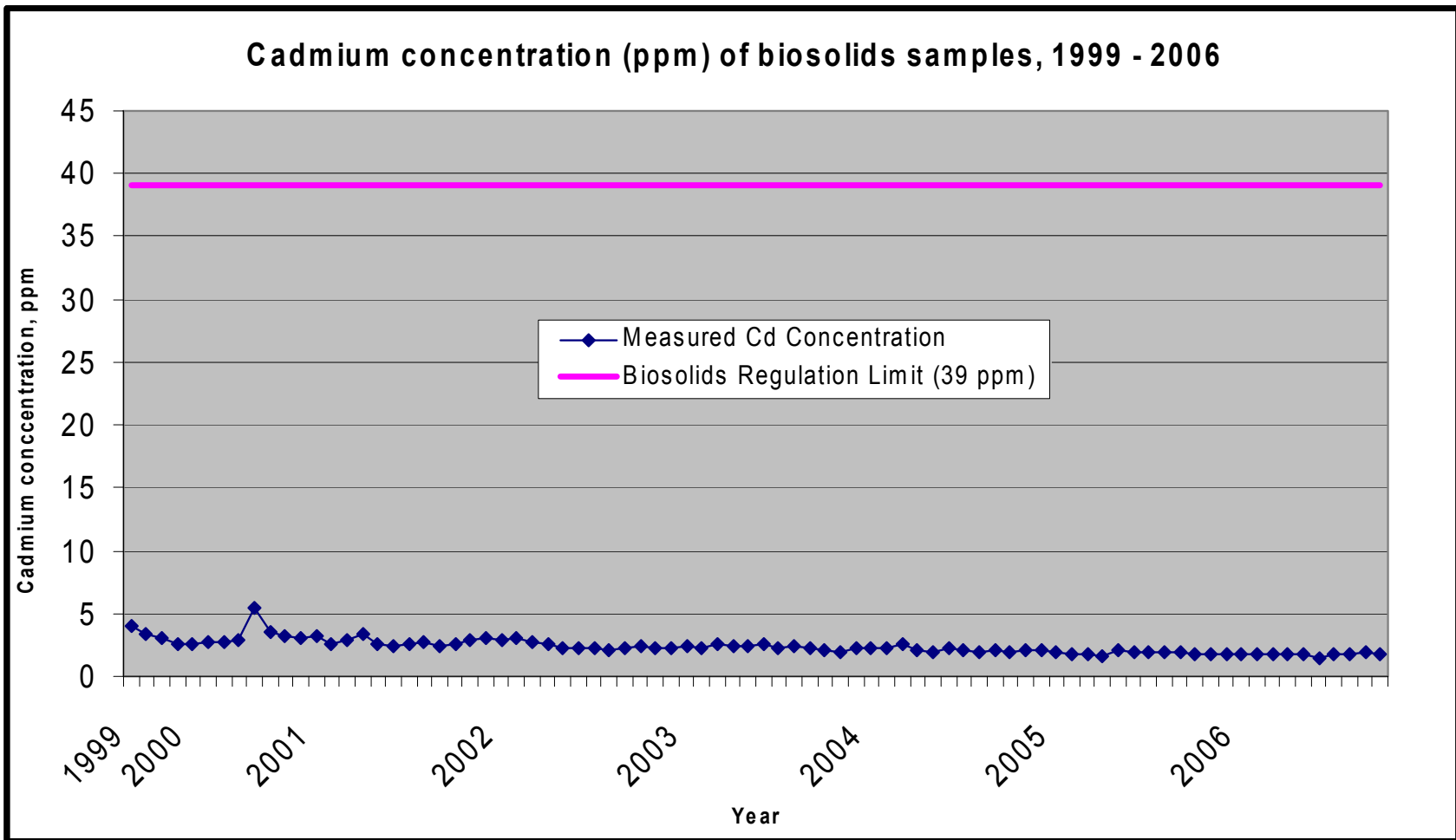


Figure 5. Cadmium concentrations of biosolids samples, 1999 – 2006.



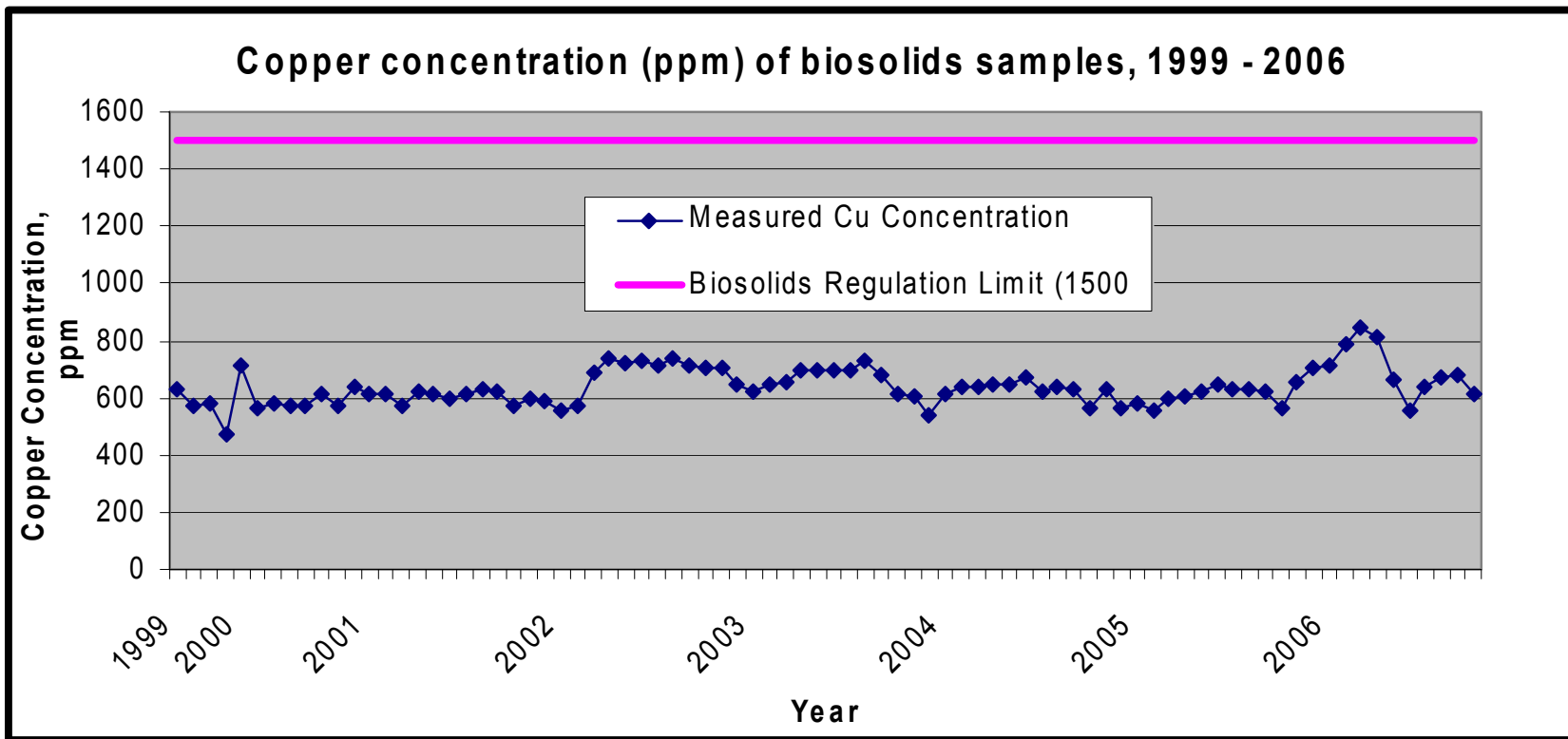


Figure 6. Copper concentrations of biosolids samples, 1999 – 2006.

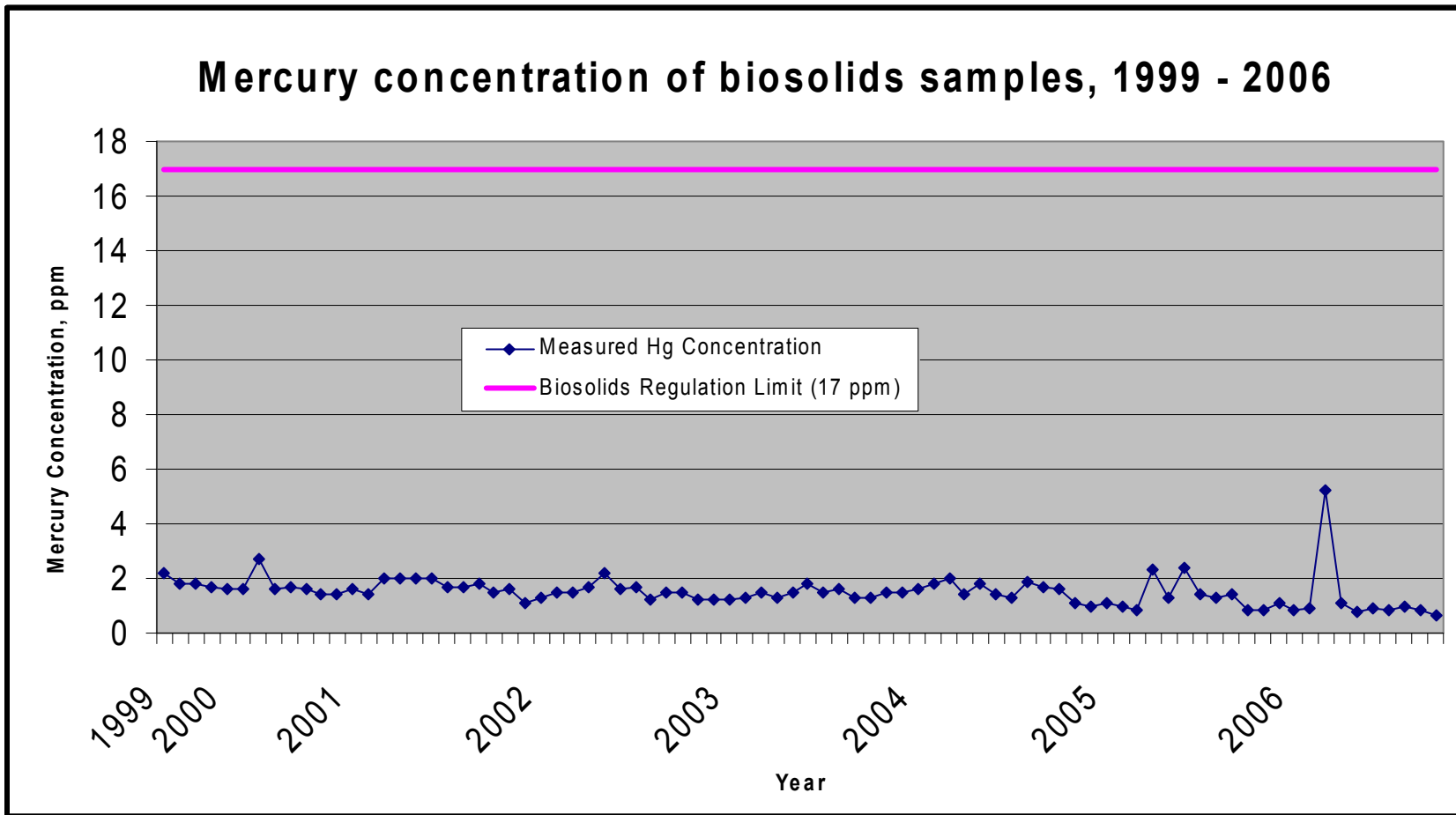


Figure 7. Mercury concentrations of biosolids samples, 1999 – 2006.

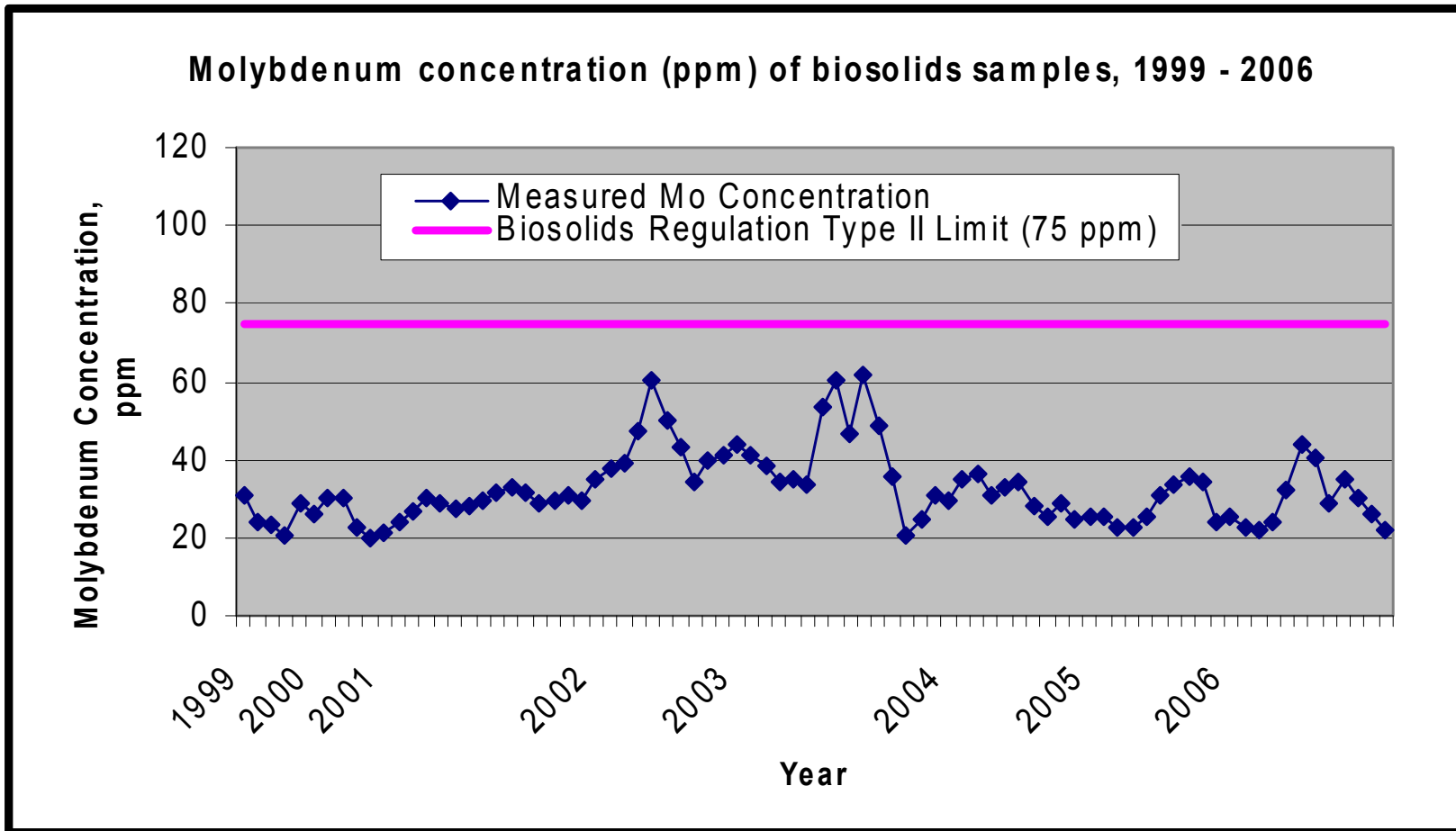


Figure 8. Molybdenum concentrations of biosolids samples, 1999 – 2006.

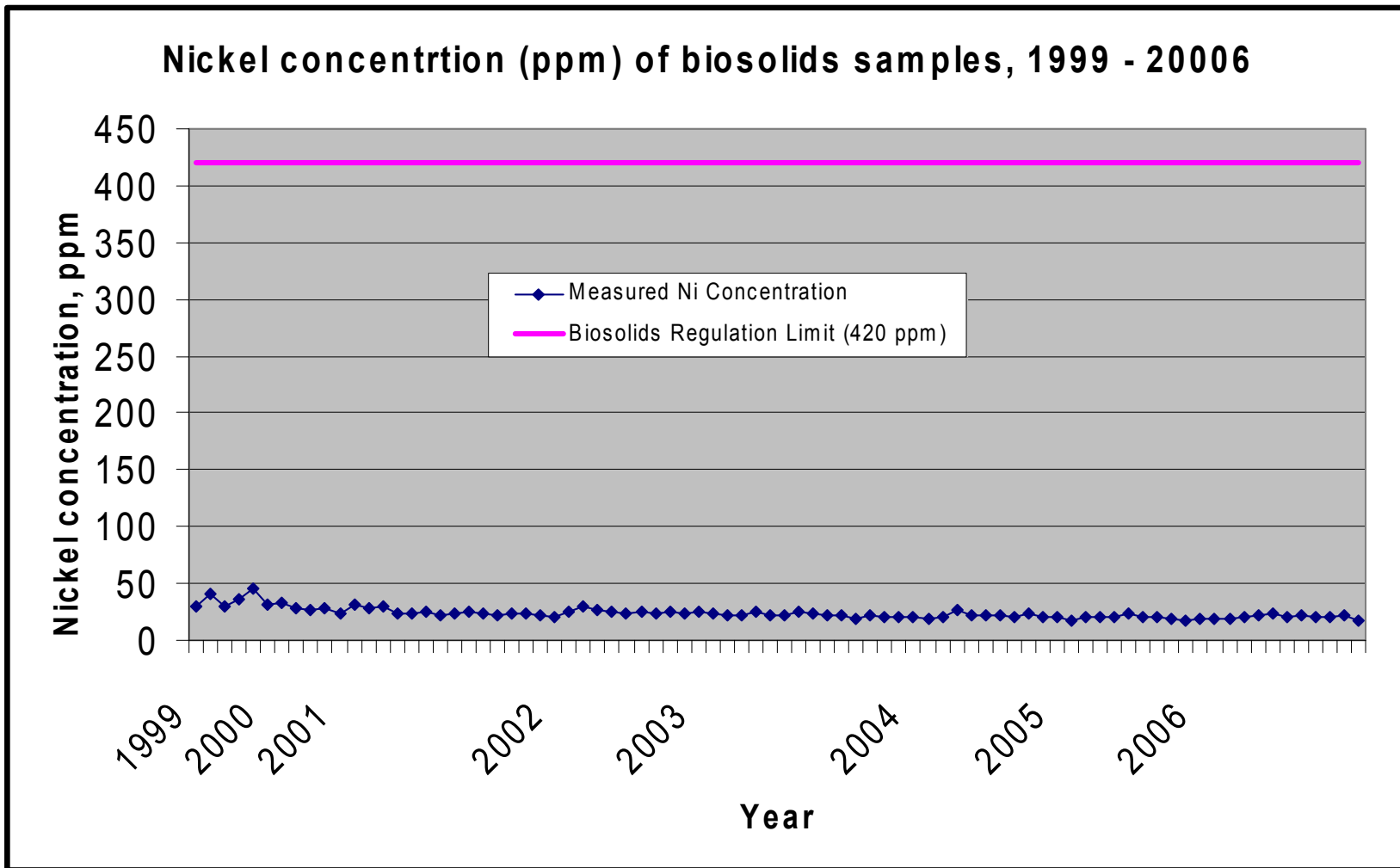


Figure 9. Nickel concentrations of biosolids samples, 1999 – 2006.

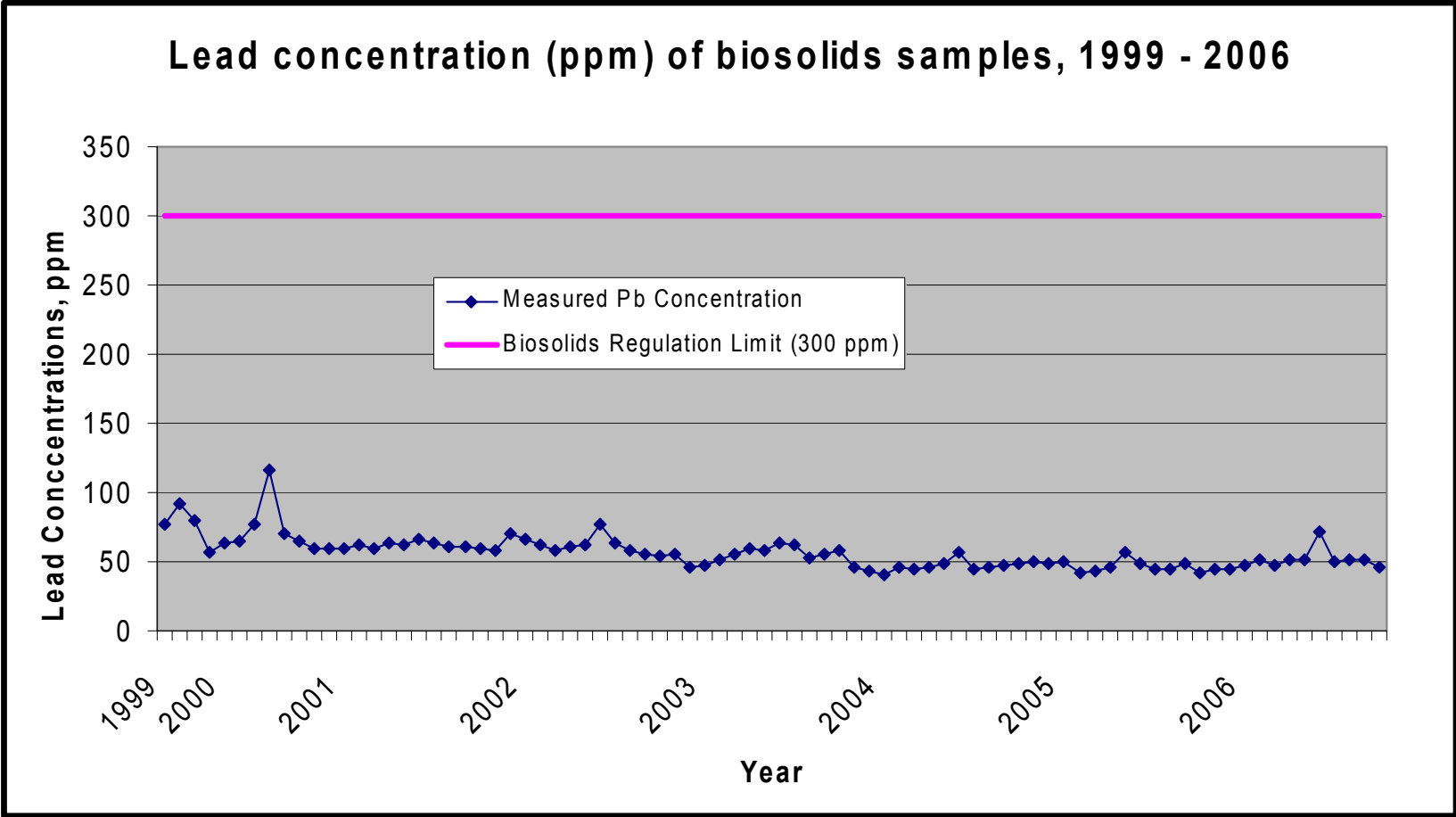


Figure 10. Lead concentrations of biosolids samples, 1999 – 2006.

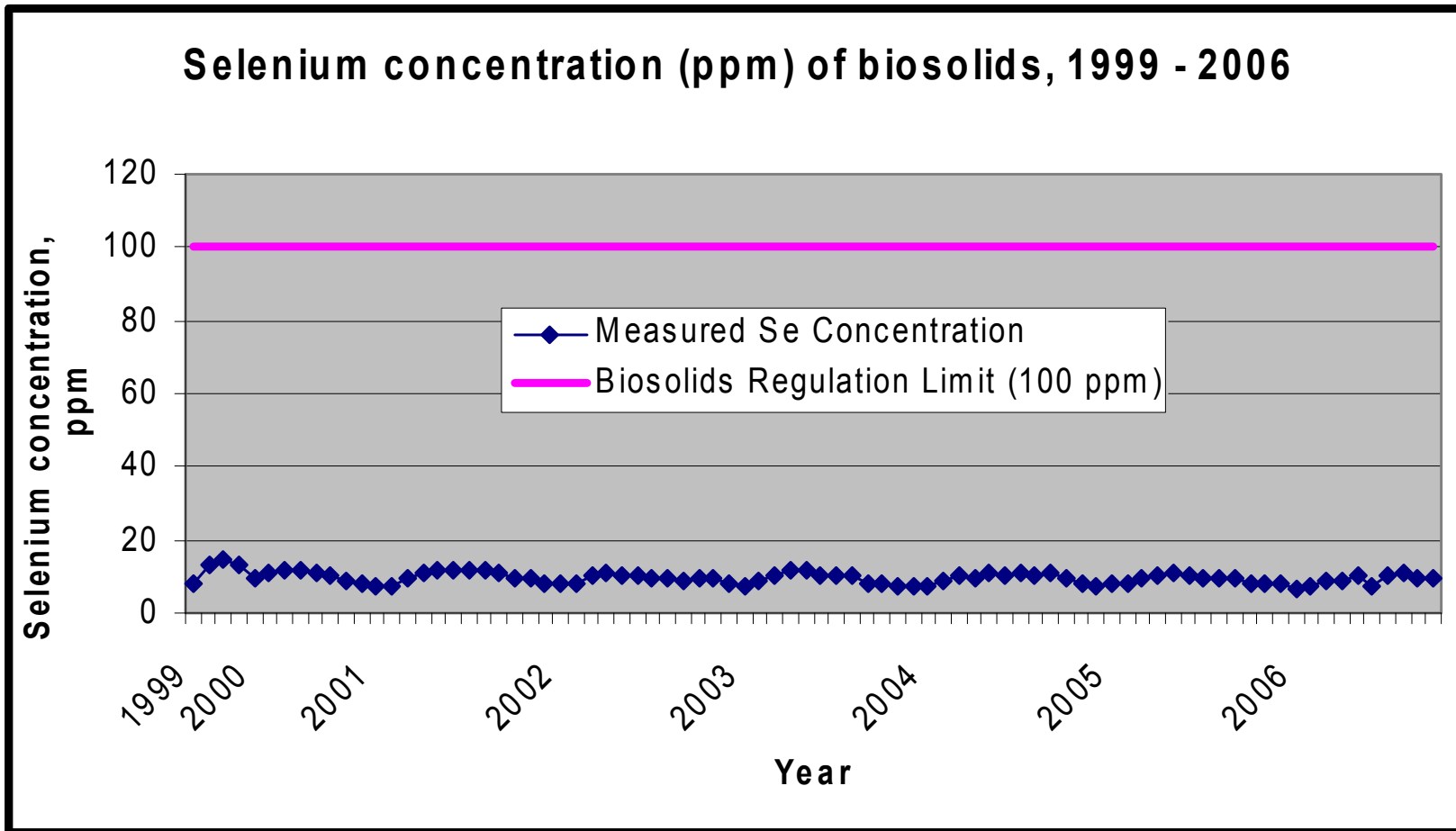


Figure 11. Selenium concentrations of biosolids samples, 1999 – 2006.

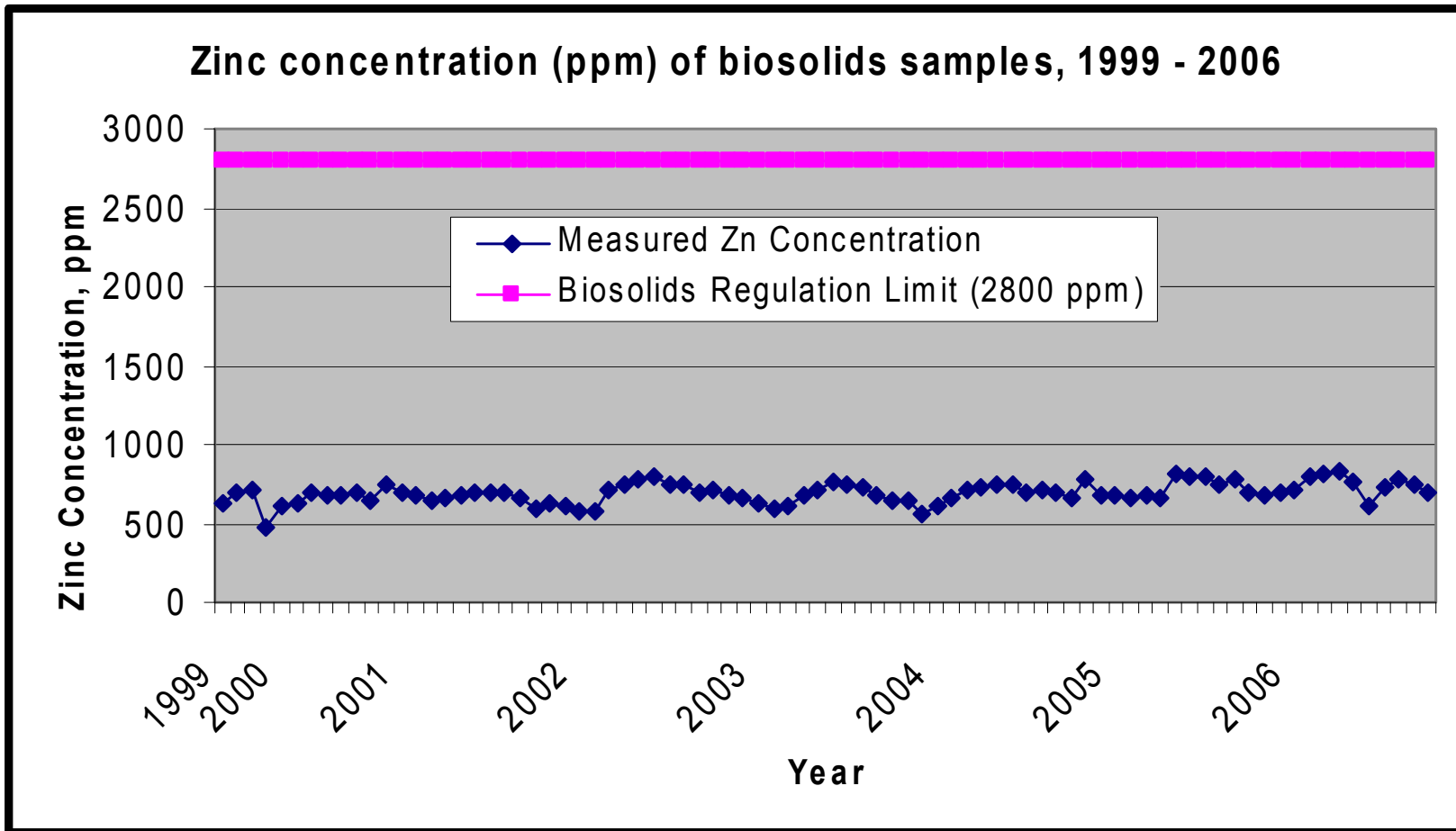


Figure 12. Zinc concentrations of biosolids samples, 1999 – 2006.

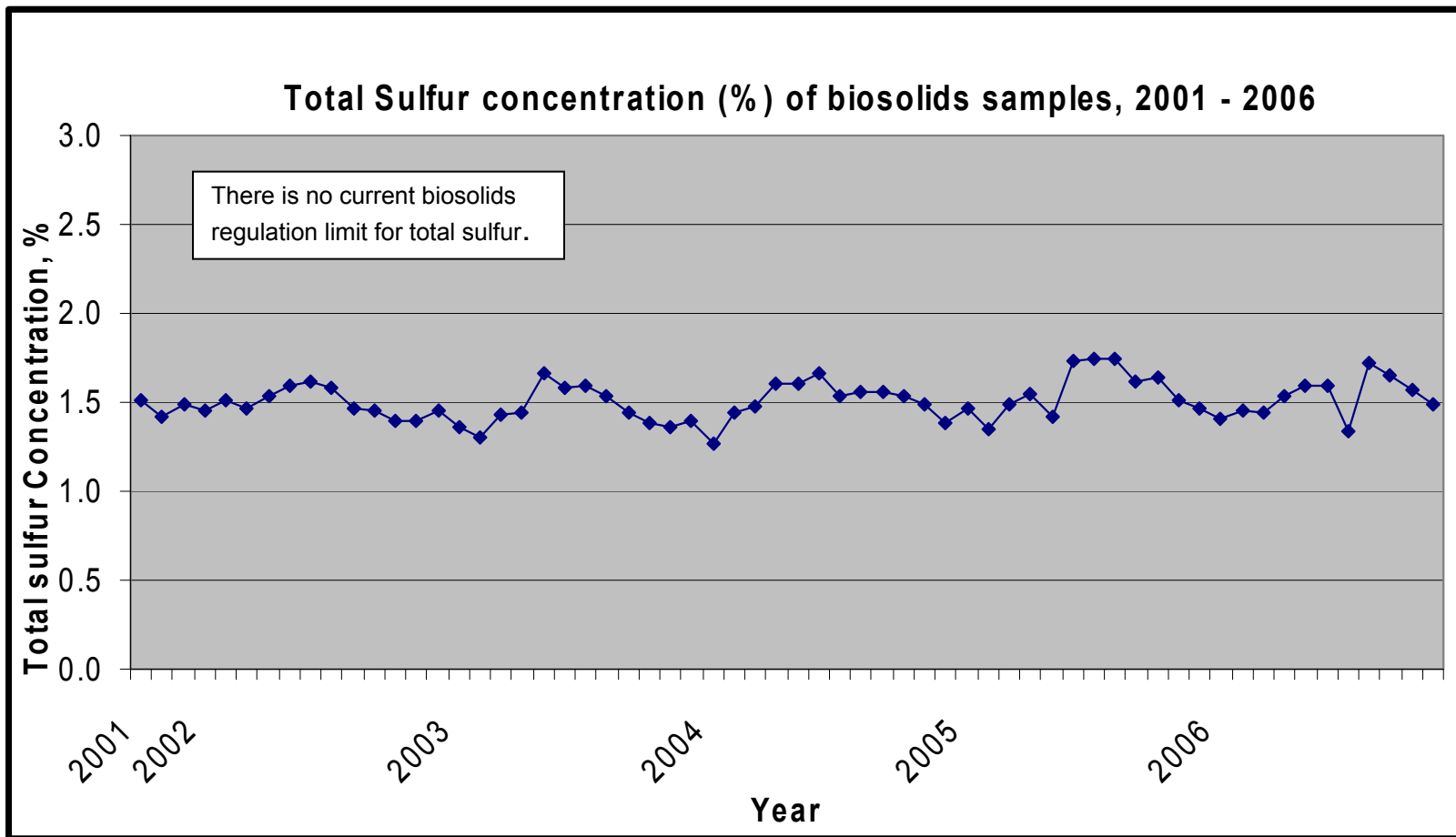


Figure 13. Total sulfur concentration of biosolids samples, 2001 – 2006.



Table 2. Analytical results for biosolids samples, 1999.

<b>Sample ID</b>	<b>ICPMS Al, %</b>	<b>HG-AAS As, ppm</b>	<b>ICPMS As, ppm</b>	<b>ICPMS Ba, ppm</b>	<b>ICPMS Be, ppm</b>	<b>ICPMS Bi, ppm</b>	<b>ICPMS Ca, %</b>	<b>ICPMS Cd, ppm</b>	<b>ICPMS Ce, ppm</b>	<b>ICPMS Co, ppm</b>
Bios 03/99	2.4	1.9	2.2	520	0.30	31.0	3.1	4.0	30	4
Bios 06/99	2.2	2.6	4.2	451	0.01	33.5	3.5	3.3	30	4
Bios 09/99	2.2	2.9	4.9	468	0.02	33.9	2.9	3.1	32	4
Bios 12/99	2.31	6.6	2.3	400	0.16	25.9	3.32	2.6	25	4.2

Table 2. Analytical results for biosolids samples, 1999.

<b>Sample ID</b>	<b>ICPMS Cr, ppm</b>	<b>ICPMS Cs, ppm</b>	<b>ICPMS Cu, ppm</b>	<b>ICPMS Dy, ppm</b>	<b>ICPMS Er, ppm</b>	<b>ICPMS Eu, ppm</b>	<b>ICPMS Fe, %</b>	<b>ICPMS Ga, ppm</b>	<b>ICPMS Gd, ppm</b>	<b>CV-AAS Hg, ppm</b>
Bios 03/99	44	0.50	630	0.7	0.4	0.2	2.4	4	1.1	2.2
Bios 06/99	44	0.44	570	1.3	0.88	0.34	2.7	4	1.9	1.8
Bios 09/99	43	0.60	580	1.4	1.1	0.4	3.1	4	2.2	1.8
Bios 12/99	42	0.47	474	0.70	0.36	0.24	3.14	3.3	1.2	1.7

Table 2. Analytical results for biosolids samples, 1999.

<b>Sample ID</b>	<b>ICPMS Ho, ppm</b>	<b>ICPMS K, %</b>	<b>ICPMS La, ppm</b>	<b>ICPMS Li, ppm</b>	<b>ICPMS Mg, %</b>	<b>ICPMS Mn, ppm</b>	<b>ICPMS Mo, ppm</b>	<b>ICPMS Na, %</b>	<b>ICPMS Nd, ppm</b>	<b>ICPMS Ni, ppm</b>
Bios 03/99	0.10	0.3	14	5	0.41	240	31	0.11	10	30
Bios 06/99	0.24	4	20	5	0.45	260	24	0.2	12	40
Bios 09/99	0.26	4	21	6	0.45	260	23	0.2	13	30
Bios 12/99	0.13	3.2	14	3.7	0.632	209	20	0.15	8	36

Table 2. Analytical results for biosolids samples, 1999.

<b>Sample ID</b>	<b>ICPMS P, %</b>	<b>ICPMS Pb, ppm</b>	<b>ICPMS Pr, ppm</b>	<b>ICPMS Rb, ppm</b>	<b>ICPMS Sb, ppm</b>	<b>ICPMS Sc, ppm</b>	<b>HG-AAS Se, ppm</b>	<b>ICPMS Sm, ppm</b>	<b>ICPMS Sr, ppm</b>	<b>ICPMS Tb, ppm</b>
Bios 03/99	4.4	77	2.6	7	1.9	1	7.7	1.3	370	0.1
Bios 06/99	3.8	92	3.9	9	1.5	3	13	1.8	330	0.24
Bios 09/99	3.8	80	4.4	10	1.8	3	15	2.1	320	0.3
Bios 12/99	3.02	56	2.7	5.5	2.4	1	13	1.2	299	0.16

Table 2. Analytical results for biosolids samples, 1999.

<b>Sample ID</b>	<b>ICPMS Th, ppm</b>	<b>ICPMS Tm, ppm</b>	<b>ICPMS U, ppm</b>	<b>ICPMS V, ppm</b>	<b>ICPMS Y, ppm</b>	<b>ICPMS Zn, ppm</b>
Bios 03/99	1.6	<0.1	42.0	29	4	630
Bios 06/99	1.9	0.12	60.5	46	6	700
Bios 09/99	2.0	0.13	66.1	49	6	710
Bios 12/99	1.1	0.04	32.3	40	3	481

Table 3. Analytical results for biosolids samples, 2000.

Sample ID	ICPMS Ag, ppm	ICPMS Al, %	HG-AAS As, ppm	ICPMS As, ppm	ICPMS Ba, ppm	ICPMS Be, ppm	ICPMS Bi, ppm	ICPMS Ca, %	ICPMS Cd, ppm
Bios 03/00	--	3.28	1.7	2.93	412	0.202	27.6	4.77	2.58
Bios 06/00	52.6	1.44	1.8	2.6	472	0.35	27.9	2.15	2.7
Bios 08/00	61.1	1.6	2	3	506	0.37	30	2.06	2.7
Bios 10/00	55	1.67	1.8	3.4	488	0.41	28.1	2.23	2.9
Bios 11/00	55.2	1.52	1.8	2.6	468	0.37	28.8	2.25	5.4
Bios 12/00	59	2	1.7	2	430	0.4	28	2.9	3.6
NIST 2781	100	1.6	--	6.5	640	0.5	28	3.9	12
NIST 2781	93.9	1.32	4.9	7.8	611	0.45	26.6	3.5	11.9
NIST 2781 Recommended/ Certified Value*	98 +/- 8	1.6 +/- 0.1	7.82 +/- 0.28	7.82 +/- 0.28				3.9 +/-0.1	12.78 +/-0.72

--, not determined; \*NIST Certificate

Table 3. Analytical results for biosolids samples, 2000.

Sample ID	ICPMS Ce, ppm	ICPMS Co, ppm	ICPMS Cr, ppm	ICPMS Cs, ppm	ICPMS Cu, ppm	ICPMS Fe, %	ICPMS Ga, ppm	CV-AAS Hg, ppm	ICPMS K, %
Bios 03/00	29.6	5.62	57.9	0.393	715	4.2	5.77	1.6	0.432
Bios 06/00	41.1	3.8	35.2	0.47	565	2.92	3.8	1.6	0.283
Bios 08/00	39	3.7	43.3	0.66	583	2.81	4.4	2.7	0.314
Bios 10/00	41.8	3.5	39.7	0.62	568	2.2	4.3	1.6	0.324
Bios 11/00	32.1	3.5	38.4	0.56	573	1.96	4.1	1.7	0.285
Bios 12/00	30	3.8	43	0.6	610	2.3	4.2	1.6	0.38
NIST 2781	75	6.1	170	0.8	590	2.9	6.4	--	0.47
NIST 2781	76	5.6	156	0.79	556	2.57	6.2	3.4	0.416
NIST 2781 Recommended/ Certified Value*			202 +/- 9		627.4 +/- 13.5	2.8 +/- 0.1		3.64 +/- 0.25	0.49 +/- 0.03

Table 3. Analytical results for biosolids samples, 2000.

Sample ID	ICPMS La, ppm	ICPMS Li, ppm	ICPMS Mg, %	ICPMS Mn, ppm	ICPMS Mo, ppm	ICPMS Na, %	ICPMS Nb, ppm	ICPMS Ni, ppm	ICPMS P, %
Bios 03/00	16	4.02	0.449	306	28.9	0.111	0.299	46	4.23
Bios 06/00	20.9	3	0.32	188	26.1	0.112	5.1	31	2.25
Bios 08/00	19.9	3.7	0.34	222	30.5	0.12	5.3	33	2.22
Bios 10/00	21.7	3.9	0.369	244	30.5	0.125	5.3	29	2.16
Bios 11/00	16.6	3.4	0.33	180	22.7	0.114	4.6	27	2.01
Bios 12/00	16	5	0.53	190	20	0.17	2.8	28	2.7
NIST 2781	24	6.2	0.59	820	40	0.2	61	72	2.4
NIST 2781	21.8	5.5	0.519	724	39.2	0.176	120	68	2.18
NIST 2781 Recommended/ Certified Value*			0.59 +/- 0.04		46.7 +/- 3.2	0.21 +/- 0.02		80.2 +/- 2.3	2.42 +/- 0.09



Table 3. Analytical results for biosolids samples, 2000.

Sample ID	ICPMS Pb, ppm	ICPMS Rb, ppm	ICPMS Sb, ppm	ICPMS Sc, ppm	HG-AAS Se, ppm	ICPMS Sr, ppm	ICPMS Th, ppm	ICPMS Ti, %	ICPMS Tl, ppm	
Bios 03/00	64	7.44	1.95	1.63	9.8	370	1.38	0.017	0.0653	
Bios 06/00	66	10.5	3.4	1	11	297	1.66	0.174	0.02	
Bios 08/00	78	13.5	3.2	1.3	12	288	2.13	0.163	0.03	
Bios 10/00	116	13	6.9	1.4	12	287	2.43	0.244	0.16	
Bios 11/00	70	11.6	2.8	1.1	11	296	2.02	0.169	0.03	
Bios 12/00	65	11	1.4	1	10	300	1.5	0.3	0.1	
NIST 2781	190	18	5.7	71	--	230	5.6	0.3	0.2	
NIST 2781	184	16.9	5.6	65.8	15	226	5.44	0.243	0.26	
NIST 2781										
Recommended/ Certified Value*	202.1 +/- 6.5				16.0 +/- 1.6		0.32 +/- 0.03			

Table 3. Analytical results for biosolids samples, 2000.

<b>Sample ID</b>	<b>ICPMS U, ppm</b>	<b>ICPMS V, ppm</b>	<b>ICPMS Y, ppm</b>	<b>ICPMS Zn, ppm</b>
Bios 03/00	34.4	63300	4.05	611
Bios 06/00	59.4	44.6	5.5	632
Bios 08/00	61.4	47.1	6.2	695
Bios 10/00	51.3	37.4	6.8	672
Bios 11/00	47	32.4	5.4	685
Bios 12/00	35	25	6.1	700
NIST 2781	36	72	36	1200
NIST 2781	41.9	82.6	28.2	1100
NIST 2781 Recommended/ Certified Value*				1273 +/- 53

Table 4. Analytical results for biosolids samples, 2001.

Sample ID	ICPMS Ag, ppm	ICPMS Al, %	HG-AAS As, ppm	ICPMS As, ppm	ICPMS Au, ppm	ICPMS Ba, ppm	ICPMS Be, ppm	ICPMS Bi, ppm	ICPMS Ca, %	ICPMS Cd, ppm
Bios 01/01	51	1.9	1.5	2	0.75	430	0.4	30	2.7	3.2
Bios 02/01	13	1.7	1.8	1	0.2	420	0.2	31	3.0	3.1
Bios 03/01	12	1.7	2.3	1	0.1	400	0.3	27	3.0	3.2
Bios 04/01	25	1.6	2.1	1	0.1	380	0.2	29	2.9	2.6
Bios 05/01	47.8	1.95	1.8	2.8	--	446	0.37	27.1	2.86	2.86
Bios 06/01	52.7	1.74	1.7	2.9	--	440	0.32	28.8	2.77	3.32
Bios 07/01	26.3	2.03	2.1	3.2	--	451	0.46	26.9	2.69	2.61
Bios 08/01	32.8	1.82	2.5	3.6	--	448	0.45	30.7	2.58	2.47
Bios 09/01	33.3	1.6	2.6	4.8	--	437	0.33	30.6	2.58	2.52
Bios 10/01	23.6	1.6	1.7	3.0	--	447	0.32	31.7	2.61	2.67
Bios 11/01	49	1.67	1.7	2.5	0.50	421	0.21	32.1	2.57	2.45
Bios 12/01	43.7	1.37	1.5	2	0.64	403	0.29	35.1	2.29	2.64
NIST 2781	9.9	1.3	4.4	5.4	0.20	560	0.40	31	4.2	11
NIST 2781	34	1.28	5.1	8.0	--	598	0.61	29.6	3.56	11.7
NIST 2781	32.2	1.23	6.3	7.4	--	608	0.54	29.8	3.53	12
NIST 2781	91.2	1.11	4.7	6.8	0.44	657	0.41	35.6	3.52	13.7
NIST 2781 Recommended/ Certified Value*	98 +/- 8	1.6 +/- 0.1	7.82 +/- 0.28	7.82 +/- 0.28					3.9 +/-0.1	12.78 +/-0.72

--, not determined; \*NIST Certificate

Table 4. Analytical results for biosolids samples, 2001.

Sample ID	ICPMS Ce, ppm	ICPMS Co, ppm	ICPMS Cr, ppm	ICPMS Cs, ppm	ICPMS Cu, ppm	ICPMS Dy, ppm	ICPMS Er, ppm	ICPMS Eu, ppm	ICPMS Fe, %	ICPMS Ga, ppm
Bios 01/01	29	3.4	41	0.5	570	0.94	0.49	0.22	2.1	4.0
Bios 02/01	27	3.7	37	0.5	640	1	0.55	0.23	1.8	3.6
Bios 03/01	26	3.6	33	0.5	610	0.9	0.49	0.23	1.8	3.6
Bios 04/01	23	3.7	36	0.5	610	0.86	0.48	0.22	1.8	3.6
Bios 05/01	23.5	4.2	44	0.69	571	--	--	--	2.07	4.4
Bios 06/01	20.2	4.2	47	0.55	620	--	--	--	2.28	4.0
Bios 07/01	23.7	4.1	43	0.89	612	--	--	--	2.51	5.0
Bios 08/01	23.4	3.8	44	0.78	599	--	--	--	2.47	4.6
Bios 09/01	20.9	3.4	42	0.60	610	--	--	--	2.12	4.1
Bios 10/01	17.5	3.6	43	0.51	631	--	--	--	2.0	3.9
Bios 11/01	17.7	3.6	44	0.46	618	0.53	0.27	0.15	2.07	3.5
Bios 12/01	17.4	3.8	39	0.42	569	0.54	0.27	0.14	1.73	3.2
NIST 2781	76	6.1	140	0.80	650	5	3.4	0.39	2.6	5.6
NIST 2781	76	5.7	158	0.79	570	--	--	--	2.63	6.4
NIST 2781	76.8	5.7	158	0.79	573	--	--	--	2.6	6.6
NIST 2781	82.3	6.1	159	0.90	603	3.99	2.37	0.354	2.72	6.3
NIST 2781 Recommended/ Certified Value*			202 +/- 9		627.4 +/- 13.5				2.8 +/- 0.1	

Table 4. Analytical results for biosolids samples, 2001.

Sample ID	ICPMS Gd, ppm	ICPMS Ge, ppm	CV-AAS Hg, ppm	ICPMS Ho, ppm	ICPMS In, ppm	ICPMS K, %	ICPMS La, ppm	ICPMS Li, ppm	ICPMS Mg, %	ICPMS Mn, ppm
Bios 01/01	1.1	< 0.1	1.4	0.19	< 0.1	0.36	16	4	0.50	190
Bios 02/01	1.2	< 0.1	1.4	0.21	4.7	0.41	14	4	0.39	160
Bios 03/01	1.2	< 0.1	1.6	0.20	4.2	0.44	13	4	0.40	160
Bios 04/01	1	< 0.1	1.4	0.18	12	0.44	12	3	0.42	160
Bios 05/01	--	--	2.0	--	--	0.41	12.7	5.2	0.419	192
Bios 06/01	--	--	2.0	--	--	0.36	11.4	4.5	0.373	204
Bios 07/01	--	--	2.0	--	--	0.43	13.9	5.5	0.403	299
Bios 08/01	--	--	2.0	--	--	0.37	13.9	5.2	0.372	377
Bios 09/01	--	--	1.7	--	--	0.30	12.3	4.2	0.367	696
Bios 10/01	--	--	1.7	--	--	0.29	10.4	3.7	0.35	395
Bios 11/01	0.76	0.28	1.8	0.10	0.09	0.29	10.2	3.7	0.396	289
Bios 12/01	0.82	0.16	1.5	0.09	0.11	0.26	9.7	3.4	0.33	211
NIST 2781	3.8	< 0.1	3.8	1.20	16	0.48	23	5.2	0.48	700
NIST 2781	--	--	3.9	--	--	0.41	21.8	5.9	0.494	742
NIST 2781	--	--	3.5	--	--	0.40	21.9	5.7	0.432	744
NIST 2781	3.38	0.36	3.9	0.74	0.29	0.37	24	4.7	0.414	773
NIST 2781 Recommended/ Certified Value*			3.64 +/- 0.25			0.49 +/- 0.03			0.59 +/- 0.04	

Table 4. Analytical results for biosolids samples, 2001.

Sample ID	ICPMS Mo, ppm	ICPMS Na, %	ICPMS Nb, ppm	ICPMS Nd, ppm	ICPMS Ni, ppm	ICPMS P, %	ICPMS Pb, ppm	ICPMS Pr, ppm	ICPMS Rb, ppm	Total S, IR S, %
Bios 01/01	21	0.16	2.7	8.4	24	2.5	59	2.8	11	--
Bios 02/01	24	0.15	2.7	8.9	31	2.4	60	2.6	11	--
Bios 03/01	27	0.15	3.1	7.9	29	2.4	60	2.5	12	--
Bios 04/01	30	0.15	2.8	6.8	30	2.4	62	2.2	12	--
Bios 05/01	28.8	0.18	3.7	--	24	2.73	59	--	14.1	--
Bios 06/01	27.6	0.162	3.2	--	24	2.58	64	--	11.9	--
Bios 07/01	27.9	0.169	4.5	--	25	2.43	63	--	17.6	--
Bios 08/01	29.4	0.142	4.0	--	23	2.35	66	--	15.5	--
Bios 09/01	31.4	0.129	2.8	--	23	2.42	64	--	11.9	--
Bios 10/01	33.1	0.123	2.7	--	24	2.44	61	--	11	--
Bios 11/01	31.8	0.14	4.5	5.6	24	3.04	60	1.9	9.8	1.51
Bios 12/01	29.1	0.113	3.7	5.4	22	2.54	60	1.8	9.3	1.42
NIST 2781	41	0.17	70	17	82	2.1	200	3.8	17	1.48
NIST 2781	39.7	0.17	103	--	69	2.28	189	--	17.1	--
NIST 2781	41	0.156	103	--	69	2.22	194	--	17.2	--
NIST 2781	46.1	0.146	78	17.8	76	2.31	237	4.2	18.4	--
NIST 2781										
Recommended/ Certified Value*	46.7 +/- 3.2	0.21 +/- 0.02			80.2 +/- 2.3	2.42 +/- 0.09	202.1 +/- 6.5			

Table 4. Analytical results for biosolids samples, 2001.

Sample ID	ICPMS Sb, ppm	ICPMS Sc, ppm	HG-AAS Se, ppm	ICPMS Sm, ppm	ICPMS Sr, ppm	ICPMS Tb, ppm	ICPMS Th, ppm	ICPMS Ti, %	ICPMS Tl, ppm	ICPMS Tm, ppm
Bios 01/01	2.7	1	8.8	1.3	290	0.15	1.9	0.2	<0.1	0.08
Bios 02/01	2.9	2	7.8	1.3	280	0.17	2.1	0.2	0.1	0.08
Bios 03/01	3.3	2	7.0	1.2	260	0.18	2.0	0.2	0.2	0.08
Bios 04/01	2.6	2	7.0	1.1	250	0.16	1.8	0.2	0.1	0.07
Bios 05/01	2.7	1.9	9.4	--	302	--	2.4	0.253	0.2	--
Bios 06/01	2.8	1.7	11	--	298	--	1.8	0.277	0.1	--
Bios 07/01	2.6	2.4	12	--	308	--	2.5	0.193	0.2	--
Bios 08/01	2.4	2.2	12	--	300	--	2.7	0.273	0.2	--
Bios 09/01	2.7	1.7	12	--	299	--	2.4	0.239	0.1	--
Bios 10/01	2.8	1.6	12	--	296	--	1.8	0.278	0.1	--
Bios 11/01	3.6	1.1	11	0.80	254	0.10	1.3	0.198	0.3	0.05
Bios 12/01	3.8	0.9	9.6	0.83	234	0.10	1.6	0.191	0.1	0.04
NIST 2781	5.7	77	14	3.3	230	0.74	6.1	0.3	0.2	0.55
NIST 2781	5.8	70	14	--	230	--	5.9	0.292	0.3	--
NIST 2781	5.9	69	14	--	234	--	6.0	0.299	0.3	--
NIST 2781	7.4	61	14	3.36	238	0.57	5.9	0.207	0.3	0.36
NIST 2781										
Recommended/ Certified Value*										
			16.0 +/- 1.6				0.32 +/- 0.03			

Table 4. Analytical results for biosolids samples, 2001.

<b>Sample ID</b>	<b>ICPMS U, ppm</b>	<b>ICPMS V, ppm</b>	<b>ICPMS Y, ppm</b>	<b>ICPMS Yb, ppm</b>	<b>ICPMS Zn, ppm</b>
Bios 01/01	33	20	5.8	0.50	640
Bios 02/01	34	18	6.4	0.50	740
Bios 03/01	34	16	5.9	0.52	690
Bios 04/01	37	14	5.6	0.50	670
Bios 05/01	57	18	5.2	--	642
Bios 06/01	62.5	18	4.7	--	660
Bios 07/01	63.8	24	6.3	--	680
Bios 08/01	63.7	23	6.3	--	687
Bios 09/01	59.9	19	5.3	--	689
Bios 10/01	56.8	17	4.9	--	700
Bios 11/01	48.4	13	3.3	0.26	653
Bios 12/01	43.1	11	3.2	0.24	600
NIST 2781	42	76	39.0	3.70	1200
NIST 2781	41.4	84	29.3	--	1120
NIST 2781	41.6	85	30.2	--	1130
NIST 2781	47.1	75	30.2	2.56	1180
NIST 2781 Recommended/ Certified Value*					1273 +/- 53



Table 5. Analytical results for biosolids samples, 2002.

Sample ID	ICPMS Ag, ppm	ICPMS Al, %	HG-AAS As, ppm	ICPMS As, ppm	ICPMS Au, ppm	ICPMS Ba, ppm	ICPMS Be, ppm	ICPMS Bi, ppm	ICPMS Ca, %
Bios 01/02	40.8	1.36	1.1	2.0	0.63	427	0.19	40.0	2.33
Bios 02/02	40.0	1.20	1.1	1.4	0.39	481	0.28	39.3	2.26
Bios 03/02	36.0	1.09	1.1	1.4	0.30	441	0.20	34.7	2.15
Bios 04/02	35.4	1.08	1.2	1.3	0.32	436	0.16	34.2	2.01
Bios 05/02	21.6	2.05	2.2	3.0	0.18	471	0.32	32.2	2.7
Bios 06/02	22.9	2.18	2.2	2.5	0.11	474	0.39	30.8	2.9
Bios 07/02	22.0	2.13	2.2	2.8	0.11	461	0.27	31.2	2.8
Bios 08/02	24.5	2.13	2.1	3.1	0.32	497	0.43	31.0	2.7
Bios 09/02	22.2	2.08	2.2	3.0	0.15	484	0.31	29.6	2.5
Bios 10/02	24.4	2.12	2.0	2.9	0.10	501	0.48	30.9	2.7
Bios 11/02	22.8	2.04	1.7	2.2	0.12	460	0.36	30.9	2.7
Bios 12/02	23.7	1.97	1.6	2.8	0.10	456	0.23	33.2	2.7
NIST 2781	91.8	0.91	4.7	6.3	0.23	592	0.33	33.5	3.13
NIST 2781	56.2	1.60	6.2	7.5	0.05	640	0.60	30.2	3.9
NIST 2781 Recommended/ Certified Value*	98 +/- 8	1.6 +/- 0.1	7.82 +/- 0.28	7.82 +/- 0.28					3.9 +/-0.1

--, not determined; \*NIST Certificate

Table 5. Analytical results for biosolids samples, 2002.

Sample ID	ICPMS Cd, ppm	ICPMS Ce, ppm	ICPMS Co, ppm	ICPMS Cr, ppm	ICPMS Cs, ppm	ICPMS Cu, ppm	ICPMS Dy, ppm	ICPMS Er, ppm	ICPMS Eu, ppm
Bios 01/02	2.9	18.3	3.3	39	0.43	600	0.54	0.27	0.15
Bios 02/02	3.0	17.6	3.5	38	0.50	592	0.65	0.34	0.18
Bios 03/02	2.9	20.1	3.4	37	0.46	555	0.62	0.34	0.17
Bios 04/02	3.0	18.4	3.4	37	0.46	574	0.60	0.30	0.16
Bios 05/02	2.7	23.3	3.9	45	0.59	689	0.93	0.53	0.19
Bios 06/02	2.6	24.2	4.1	47	0.67	735	0.96	0.56	0.20
Bios 07/02	2.2	20.6	3.9	46	0.63	722	0.95	0.54	0.18
Bios 08/02	2.3	20.6	4.4	46	0.63	731	0.97	0.57	0.18
Bios 09/02	2.2	20.4	4.0	43	0.63	709	0.97	0.57	0.19
Bios 10/02	2.2	21.0	4.1	45	0.53	736	0.89	0.48	0.18
Bios 11/02	2.2	22.3	3.7	41	0.48	710	0.80	0.45	0.15
Bios 12/02	2.4	19.0	3.7	45	0.41	705	0.80	0.44	0.14
NIST 2781	12.9	72.9	5.7	137	0.81	566	3.67	2.12	0.33
NIST 2781	12.0	79.7	6.3	180	0.89	626	5.19	3.47	0.37
NIST 2781									
Recommended/ Certified Value*	12.78 +/-0.72			202 +/- 9		627.4 +/- 13.5			

Table 5. Analytical results for biosolids samples, 2002.

Sample ID	ICPMS Fe, %	ICPMS Ga, ppm	ICPMS Gd, ppm	ICPMS Ge, ppm	CV-AAS Hg, ppm	ICPMS Ho, ppm	ICPMS In, ppm	ICPMS K, %	ICPMS La, ppm
Bios 01/02	1.99	3.4	0.83	0.20	1.6	0.09	0.06	0.26	10.1
Bios 02/02	1.94	6.9	0.89	0.18	1.1	0.11	0.10	0.29	9.9
Bios 03/02	1.84	7.1	0.91	0.18	1.3	0.11	0.10	0.28	11.2
Bios 04/02	1.80	6.7	0.82	0.22	1.5	0.10	0.13	0.27	10.2
Bios 05/02	2.24	6.6	1.14	0.04	1.5	0.20	0.19	0.42	14.0
Bios 06/02	2.45	7.0	1.14	0.04	1.7	0.20	0.13	0.43	15.3
Bios 07/02	2.40	7.5	1.08	0.04	2.2	0.20	0.15	0.39	13.2
Bios 08/02	2.29	6.9	1.14	0.04	1.6	0.20	0.12	0.40	12.6
Bios 09/02	2.23	6.2	1.13	0.03	1.7	0.20	0.10	0.45	11.9
Bios 10/02	2.00	6.3	1.09	0.04	1.2	0.19	0.12	0.41	12.1
Bios 11/02	1.96	7.0	0.99	0.03	1.5	0.17	0.12	0.40	13.5
Bios 12/02	2.24	8.1	0.97	0.03	1.5	0.17	0.12	0.36	11.2
NIST 2781	2.57	6.0	3.15	0.39	3.5	0.66	0.28	0.33	21.3
NIST 2781	2.88	6.5	3.69	0.05	3.5	1.15	0.28	0.48	24.3
NIST 2781 Recommended/ Certified Value*	2.8 +/- 0.1				3.64 +/- 0.25			0.49 +/- 0.03	

Table 5. Analytical results for biosolids samples, 2002.

Sample ID	ICPMS Li, ppm	ICPMS Mg, %	ICPMS Mn, ppm	ICPMS Mo, ppm	ICPMS Na, %	ICPMS Nb, ppm	ICPMS Nd, ppm	ICPMS Ni, ppm	ICPMS P, %
Bios 01/02	2.3	0.314	207	29.6	0.110	3	6.0	23	2.60
Bios 02/02	1.6	0.278	245	30.6	0.105	55	5.8	23	2.34
Bios 03/02	1.2	0.266	236	29.5	0.100	56	6.8	22	2.18
Bios 04/02	1.0	0.238	252	34.8	0.097	51	6.0	21	2.09
Bios 05/02	5.1	0.532	263	37.7	0.196	56	7.5	25	2.98
Bios 06/02	5.1	0.527	345	39.4	0.203	62	7.3	30	3.06
Bios 07/02	4.8	0.503	402	47.6	0.182	70	6.8	26	2.95
Bios 08/02	5.2	0.626	818	60.6	0.177	55	6.7	25	3.20
Bios 09/02	5.1	0.695	531	50.3	0.193	52	6.8	23	3.29
Bios 10/02	4.7	0.594	360	43.0	0.191	69	6.7	25	3.27
Bios 11/02	4.4	0.556	307	34.2	0.196	61	6.2	23	3.12
Bios 12/02	4.6	0.504	334	40.0	0.179	92	5.9	26	3.18
NIST 2781	2.8	0.342	725	44.0	0.116	73	15.7	72	1.98
NIST 2781	7.0	0.676	815	42.6	0.216	92	18.0	77	2.80
NIST 2781 Recommended/ Certified Value*		0.59 +/- 0.04		46.7 +/- 3.2	0.21 +/- 0.02			80.2 +/- 2.3	2.42 +/- 0.09

Table 5. Analytical results for biosolids samples, 2002.

Sample ID	ICPMS Pb, ppm	ICPMS Pr, ppm	ICPMS Rb, ppm	Total S, IR S, %	ICPMS Sb, ppm	ICPMS Sc, ppm	HG-AAS Se, ppm	ICPMS Sm, ppm	ICPMS Sr, ppm	
Bios 01/02	58	1.9	9.6	1.49	4.3	0.8	9.4	0.90	254	
Bios 02/02	71	1.9	11.8	1.45	3.7	1.5	8.3	0.87	274	
Bios 03/02	67	2.2	11.6	1.51	3.2	1.4	8.3	1.01	256	
Bios 04/02	63	2.0	11.2	1.47	3.2	1.3	8.3	0.90	235	
Bios 05/02	58	2.6	12.4	1.54	2.3	1.9	9.9	1.16	262	
Bios 06/02	61	2.6	13.4	1.59	2.4	2.0	11	1.18	288	
Bios 07/02	63	2.2	12.1	1.62	2.0	1.9	10	1.11	269	
Bios 08/02	78	2.2	12.0	1.58	2.0	1.8	10	1.12	262	
Bios 09/02	64	2.2	12.6	1.46	2.1	1.8	9.7	1.12	262	
Bios 10/02	58	2.2	11.1	1.45	2.1	1.6	9.8	1.11	285	
Bios 11/02	56	2.4	10.8	1.39	2.6	1.7	9.1	1.00	277	
Bios 12/02	54	2.0	9.0	1.40	2.0	1.8	9.5	0.94	266	
NIST 2781	222	3.7	17.1	1.51	10.1	55	15	2.97	222	
NIST 2781	196	4.2	17.0	1.46	5.1	72	15	3.50	237	
NIST 2781										
Recommended/ Certified Value*	202.1 +/- 6.5						16.0 +/- 1.6			

Table 5. Analytical results for biosolids samples, 2002.

Sample ID	ICPMS Tb, ppm	ICPMS Th, ppm	ICPMS Ti, %	ICPMS Tl, ppm	ICPMS Tm, ppm	ICPMS U, ppm	ICPMS V, ppm	ICPMS Y, ppm	ICPMS Yb, ppm
Bios 01/02	0.09	1.7	0.20	0.1	0.04	45.1	11	3.3	0.28
Bios 02/02	0.11	2.1	0.15	0.1	0.05	46.2	48	4.0	0.34
Bios 03/02	0.12	2.1	0.18	0.1	0.06	43.7	52	4.0	0.31
Bios 04/02	0.11	1.8	0.18	0.1	0.05	41.5	51	3.7	0.31
Bios 05/02	0.16	2.1	0.31	0.2	0.08	40.3	76	5.4	0.48
Bios 06/02	0.16	1.9	0.23	0.2	0.09	45.9	83	5.7	0.46
Bios 07/02	0.22	1.7	0.27	0.1	0.08	40.9	77	5.6	0.47
Bios 08/02	0.16	1.7	0.28	0.1	0.09	34.9	69	5.8	0.49
Bios 09/02	0.15	1.8	0.25	0.1	0.09	31.4	69	5.6	0.50
Bios 10/02	0.15	1.8	0.24	0.1	0.08	32.9	69	5.1	0.46
Bios 11/02	0.13	1.7	0.21	0.1	0.07	31.3	84	4.6	0.40
Bios 12/02	0.12	1.6	0.29	0.1	0.07	31.0	118	4.4	0.42
NIST 2781	0.53	5.2	0.20	0.3	0.34	43.4	67	28	2.4
NIST 2781	0.73	5.3	0.27	0.3	0.56	39.6	87	34	3.3
NIST 2781 Recommended/ Certified Value*			0.32 +/- 0.03						

Table 5. Analytical results for biosolids samples, 2002.

<b>Sample ID</b>	<b>ICPMS Zn, ppm</b>
Bios 01/02	630
Bios 02/02	614
Bios 03/02	579
Bios 04/02	578
Bios 05/02	717
Bios 06/02	754
Bios 07/02	778
Bios 08/02	796
Bios 09/02	747
Bios 10/02	749
Bios 11/02	702
Bios 12/02	705
NIST 2781	1100
NIST 2781	1230
NIST 2781	
Recommended/ Certified Value*	1273 +/- 53

Table 6. Analytical results for biosolids samples, 2003.

Sample ID	ICPMS Ag, ppm	ICPMS Al, %	HG-AAS As, ppm	ICPMS Au, ppm	ICPMS Ba, ppm	ICPMS Be, ppm	ICPMS Bi, ppm	ICPMS Ca, %	ICPMS Cd, ppm
Bios 01/03	21.2	1.95	1.6	0.14	463	0.24	34.7	2.70	2.3
Bios 02/03	18.1	1.80	1.4	0.11	466	0.36	31.7	2.60	2.2
Bios 03/03	15.5	1.82	1.3	0.14	449	0.34	29.6	2.70	2.4
Bios 04/03	33.6	1.79	1.9	--	449	0.36	28.6	2.85	2.3
Bios 05/03	35.2	1.68	2.0	--	445	0.31	28.0	2.76	2.5
Bios 06/03	37.4	1.66	2.4	--	450	0.32	30.1	2.63	2.4
Bios 07/03	37.5	1.70	2.5	--	442	0.36	30.4	2.41	2.4
Bios 08/03	39.9	1.69	2.8	--	467	0.44	30.2	2.44	2.5
Bios 09/03	37.5	1.73	2.8	--	467	0.37	30.9	2.43	2.3
Bios 10/03	36.9	1.54	2.4	--	469	0.33	33.4	2.50	2.4
Bios 11/03	34.0	1.46	2.1	--	435	0.25	33.1	2.54	2.2
Bios 12/03	29.9	1.31	1.9	--	413	0.24	31.7	2.51	2.1
NIST 2781	97.6	1.25	6.4	--	617	0.57	29.4	3.56	12.4
NIST 2781									
Recommended/ Certified Value*	98 +/- 8	1.6 +/- 0.1	7.82 +/- 0.28					3.9 +/-0.1	12.78 +/-0.72

--, not determined; \*NIST Certificate



Table 6. Analytical results for biosolids samples, 2003.

Sample ID	ICPMS Ce, ppm	ICPMS Co, ppm	ICPMS Cr, ppm	ICPMS Cs, ppm	ICPMS Cu, ppm	ICPMS Dy, ppm	ICPMS Er, ppm	ICPMS Eu, ppm	ICPMS Fe, %
Bios 01/03	23.3	3.5	42	0.43	701	0.90	0.51	0.17	2.05
Bios 02/03	19.5	3.2	46	0.38	648	0.72	0.42	0.12	2.34
Bios 03/03	19.8	3.5	44	0.48	619	0.81	0.47	0.16	2.18
Bios 04/03	21.8	3.5	38	0.50	650	--	--	--	1.90
Bios 05/03	22.2	3.5	38	0.53	654	--	--	--	2.20
Bios 06/03	20.2	3.7	47	0.51	700	--	--	--	2.50
Bios 07/03	20.5	3.5	37	0.60	694	--	--	--	2.40
Bios 08/03	23.2	3.5	36	0.64	694	--	--	--	2.60
Bios 09/03	25.7	3.7	39	0.64	696	--	--	--	3.10
Bios 10/03	23.1	3.3	36	0.49	731	--	--	--	2.00
Bios 11/03	22.6	3.2	34	0.41	676	--	--	--	2.00
Bios 12/03	20.0	2.8	33	0.33	613	--	--	--	2.00
NIST 2781	77.2	5.6	153	0.82	594	--	--	--	2.60
NIST 2781									
Recommended/ Certified Value*			202 +/- 9			627.4 +/- 13.5			2.8 +/- 0.1

Table 6. Analytical results for biosolids samples, 2003.

Sample ID	ICPMS Ga, ppm	ICPMS Gd, ppm	ICPMS Ge, ppm	CV-AAS Hg, ppm	ICPMS Ho, ppm	ICPMS In, ppm	ICPMS K, %	ICPMS La, ppm	ICPMS Li, ppm
Bios 01/03	7.2	1.06	0.03	1.2	0.19	0.19	0.39	14.1	4.1
Bios 02/03	8.28	0.85	0.04	1.2	0.15	0.10	0.36	11.9	4.0
Bios 03/03	9.44	0.93	0.03	1.2	0.17	0.18	0.38	12.4	4.9
Bios 04/03	8.4	--	--	1.3	--	--	0.37	12.8	3.7
Bios 05/03	8.7	--	--	1.5	--	--	0.35	12.9	3.9
Bios 06/03	8.7	--	--	1.3	--	--	0.33	11.8	3.9
Bios 07/03	8.6	--	--	1.5	--	--	0.33	11.5	4.0
Bios 08/03	8.5	--	--	1.8	--	--	0.34	13.2	4.1
Bios 09/03	10	--	--	1.5	--	--	0.37	14.4	4.4
Bios 10/03	6.3	--	--	1.6	--	--	0.30	13.0	3.6
Bios 11/03	6.3	--	--	1.3	--	--	0.29	12.2	3.4
Bios 12/03	6.7	--	--	1.3	--	--	0.27	10.6	3.0
NIST 2781	6.9	--	--	3.2	--	--	0.41	21.8	6.0
NIST 2781									
Recommended/ Certified Value*				3.64 +/- 0.25			0.49 +/- 0.03		

Table 6. Analytical results for biosolids samples, 2003.

Sample ID	ICPMS Mg, %	ICPMS Mn, ppm	ICPMS Mo, ppm	ICPMS Na, %	ICPMS Nb, ppm	ICPMS Nd, ppm	ICPMS Ni, ppm	ICPMS P, %	ICPMS Pb, ppm
Bios 01/03	0.546	296	41.3	0.183	81	7.4	24	3.20	55
Bios 02/03	0.474	280	43.7	0.176	112	5.1	25	3.12	46
Bios 03/03	0.474	247	40.9	0.181	92	5.9	23	2.91	47
Bios 04/03	0.436	250	38.1	0.172	70	--	22	2.60	51
Bios 05/03	0.403	296	34.0	0.162	91	--	22	2.50	56
Bios 06/03	0.381	358	34.9	0.154	110	--	25	2.50	60
Bios 07/03	0.369	346	33.6	0.137	69	--	22	2.40	58
Bios 08/03	0.387	407	53.7	0.131	67	--	21	2.40	63
Bios 09/03	0.428	597	60.2	0.133	110	--	25	2.60	62
Bios 10/03	0.350	469	46.3	0.113	50	--	23	2.40	53
Bios 11/03	0.394	294	61.8	0.104	63	--	21	2.50	55
Bios 12/03	0.359	256	48.6	0.103	78	--	22	2.40	58
NIST 2781	0.474	757	48.8	0.157	62	--	70	2.10	184
NIST 2781 Recommended/ Certified Value*	0.59 +/- 0.04		46.7 +/- 3.2	0.21 +/- 0.02			80.2 +/- 2.3	2.42 +/- 0.09	202.1 +/- 6.5

Table 6. Analytical results for biosolids samples, 2003.

Sample ID	ICPMS Pr, ppm	ICPMS Rb, ppm	Total S, IR S, %	ICPMS Sb, ppm	ICPMS Sc, ppm	HG-AAS Se, ppm	ICPMS Sm, ppm	ICPMS Sr, ppm	ICPMS Tb, ppm	
Bios 01/03	2.6	9.6	1.45	2.1	1.6	9.2	1.20	272	0.15	
Bios 02/03	2.1	8.9	1.36	1.9	1.8	7.7	0.86	263	0.12	
Bios 03/03	2.2	10.2	1.30	2.1	1.9	7.4	0.98	261	0.13	
Bios 04/03	--	11.0	1.43	2.0	1.8	8.7	--	299	--	
Bios 05/03	--	11.1	1.44	2.0	2.0	10	--	301	--	
Bios 06/03	--	11.0	1.66	1.6	1.8	12	--	305	--	
Bios 07/03	--	12.2	1.58	1.4	1.7	12	--	275	--	
Bios 08/03	--	12.6	1.59	1.6	1.8	10	--	268	--	
Bios 09/03	--	13.8	1.54	1.3	2.1	10	--	264	--	
Bios 10/03	--	9.9	1.44	1.7	1.4	10	--	269	--	
Bios 11/03	--	8.9	1.38	1.6	1.4	8.3	--	257	--	
Bios 12/03	--	7.4	1.36	1.7	1.4	8.2	--	258	--	
NIST 2781	--	17	1.48	3.8	64	14	--	237	--	
NIST 2781 Recommended/ Certified Value*						16.0 +/- 1.6				

Table 6. Analytical results for biosolids samples, 2003.

Sample ID	ICPMS Th, ppm	ICPMS Ti, %	ICPMS Tl, ppm	ICPMS Tm, ppm	ICPMS U, ppm	ICPMS V, ppm	ICPMS Y, ppm	ICPMS Yb, ppm	ICPMS Zn, ppm
Bios 01/03	1.9	0.27	0.1	0.08	32.6	98	4.9	0.45	675
Bios 02/03	1.4	0.27	0.1	0.07	28.3	128	4.3	0.40	657
Bios 03/03	1.5	0.32	0.1	0.07	27.3	114	5.2	0.43	627
Bios 04/03	2.0	0.32	0.1	--	43.8	85	4.4	--	599
Bios 05/03	2.1	0.32	0.1	--	47.3	97	4.4	--	615
Bios 06/03	2.1	0.31	0.1	--	54.7	109	4.4	--	686
Bios 07/03	2.2	0.26	0.1	--	51.4	83	4.6	--	709
Bios 08/03	2.1	0.27	0.1	--	41.6	79	4.7	--	755
Bios 09/03	2.6	0.30	0.2	--	40.0	107	4.9	--	738
Bios 10/03	1.7	0.26	0.1	--	39.2	57	4.1	--	726
Bios 11/03	1.8	0.31	0.1	--	35.5	70	3.8	--	682
Bios 12/03	1.7	0.32	0.1	--	31.6	80	3.3	--	650
NIST 2781	4.9	0.24	0.3	--	38.4	82	27.6	--	1170
NIST 2781									
Recommended/ Certified Value*		0.32 +/- 0.03							1273 +/- 53

Table 7. Analytical results for biosolids samples, 2004.

Sample ID	ICPMS Ag, ppm	ICPMS As, ppm	HG-AAS As, ppm	ICPMS Ba, ppm	ICPMS Be, ppm	ICPMS Bi, ppm	ICPMS Ca, %	ICPMS Cd, ppm	ICPMS Ce, ppm
Bios 01/04	28.1	2.0	2	412	0.23	33.7	2.55	2.0	17.4
Bios 02/04	21.8	2.1	3	393	0.35	26.0	2.30	2.2	17.2
Bios 03/04	25.5	1.7	2	410	0.28	28.2	2.52	2.3	16.3
Bios 04/04	21.8	1.7	2	405	0.28	28.9	2.60	2.2	16.4
Bios 05/04	22.4	1.8	2	406	0.30	26.4	2.58	2.5	14.8
Bios 06/04	24.3	1.9	2	410	0.26	27.6	2.46	2.1	16.1
Bios 07/04	24.7	2.1	2	403	0.32	27.9	2.50	2.0	20.1
Bios 08/04	24.6	2.3	3	423	0.43	28.9	2.48	2.3	19.0
Bios 09/04	24.6	2.1	3	387	0.33	27.4	2.42	2.1	14.8
Bios 10/04	25.0	1.9	2	387	0.33	29.1	2.45	2.0	13.0
Bios 11/04	27.4	3.7	2	396	0.34	29.4	2.53	2.1	13.9
Bios 12/04	27.6	1.7	2	392	0.25	29.4	2.42	2.0	13.2
NIST 2781	29.3	6.7	7.8	572	0.57	26.4	3.32	11.7	56.8
NIST 2781									
Recommended/ Certified Value*	98 +/- 8	7.82 +/- 0.28	7.82 +/- 0.28				3.9 +/-0.1	12.78 +/-0.72	

--, not determined; \*NIST Certificate

Table 7. Analytical results for biosolids samples, 2004.

Sample ID	ICPMS Co, ppm	ICPMS Cr, ppm	ICPMS Cs, ppm	ICPMS Cu, ppm	ICPMS Fe, %	ICPMS Ga, ppm	CV-AAS Hg, ppm	ICPMS K, %	ICPMS La, ppm
Bios 01/04	2.7	30	0.32	607	2.1	4.3	1.5	0.27	9.5
Bios 02/04	3.7	32	0.53	542	4.0	3.7	1.5	0.37	10.6
Bios 03/04	3.4	27	0.43	615	2.1	3.2	1.6	0.29	10.6
Bios 04/04	3.2	27	0.37	641	2.2	3.3	1.8	0.27	10.9
Bios 05/04	3.7	27	0.43	640	2.4	3.4	2.0	0.29	9.6
Bios 06/04	3.4	25	0.45	648	2.6	3.2	1.4	0.25	10.8
Bios 07/04	3.4	28	0.53	644	2.1	3.5	1.8	0.27	14.1
Bios 08/04	5.1	33	0.75	668	2.5	4.3	1.4	0.34	13.8
Bios 09/04	6.6	25	0.46	625	2.7	3.2	1.3	0.27	10.4
Bios 10/04	6	25	0.43	642	2.4	3.1	1.9	0.26	9.0
Bios 11/04	7.1	25	0.38	632	1.8	3.1	1.7	0.26	9.2
Bios 12/04	10.3	27	0.36	565	2.6	2.9	1.6	0.27	8.6
NIST 2781	6	133	0.79	593	2.7	6.5	4.1	0.39	19.6
NIST 2781 Recommended/ Certified Value*		202 +/- 9		627.4 +/- 13.5	2.8 +/- 0.1		3.64 +/- 0.25	0.49 +/- 0.03	

Table 7. Analytical results for biosolids samples, 2004.

Sample ID	ICPMS Li, ppm	ICPMS Mg, %	ICPMS Mn, ppm	ICPMS Mo, ppm	ICPMS Na, %	ICPMS Nb, ppm	ICPMS Ni, ppm	ICPMS P, %	ICPMS Pb, ppm
Bios 01/04	3.2	0.376	210	35.8	0.099	27	19	2.5	46
Bios 02/04	3.8	0.256	221	20.4	0.157	8	22	4.5	44
Bios 03/04	2.0	0.233	213	24.7	0.125	5	20	4.2	41
Bios 04/04	1.6	0.234	202	30.9	0.116	28	20	4.1	46
Bios 05/04	1.5	0.225	228	29.8	0.126	9	20	4.0	45
Bios 06/04	0.9	0.203	235	35.3	0.113	4	19	3.8	47
Bios 07/04	1.4	0.209	249	36.5	0.118	3	20	3.5	48
Bios 08/04	2.6	0.222	429	31.1	0.124	4	26	3.5	56
Bios 09/04	0.9	0.211	573	32.8	0.104	3	21	3.7	45
Bios 10/04	0.4	0.197	395	34.4	0.108	3	22	3.5	46
Bios 11/04	0.5	0.201	284	28.1	0.112	2	21	3.4	48
Bios 12/04	0.7	0.198	222	25.4	0.118	3	20	3.6	49
NIST 2781	2.9	0.273	758	37.3	0.148	71	72	3.3	222
NIST 2781 Recommended/ Certified Value*		0.59 +/- 0.04		46.7 +/- 3.2	0.21 +/- 0.02		80.2 +/- 2.3	2.42 +/- 0.09	202.1 +/- 6.5



Table 7. Analytical results for biosolids samples, 2004.

Sample ID	ICPMS Rb, ppm	Total S, IR S, %	ICPMS Sb, ppm	ICPMS Sc, ppm	HG-AAS Se, ppm	ICPMS Sr, ppm	ICPMS Th, ppm	ICPMS Ti, %	ICPMS Tl, ppm	
Bios 01/04	7.8	1.39	1.6	1.0	7.4	274	1.3	0.18	0.09	
Bios 02/04	10.0	1.27	3.1	1.5	7.5	240	1.9	0.10	0.1	
Bios 03/04	7.8	1.44	2.8	1.2	7.6	277	1.5	0.12	0.1	
Bios 04/04	6.8	1.48	2.6	1.2	8.9	268	1.4	0.12	0.1	
Bios 05/04	8.3	1.60	2.5	1.2	10	287	1.4	0.12	0.1	
Bios 06/04	7.6	1.60	2.8	1.3	9.7	269	1.4	0.12	0.1	
Bios 07/04	9.0	1.66	2.6	1.4	11	267	1.5	0.12	0.1	
Bios 08/04	12.2	1.53	2.8	2.0	10	276	2.2	--	0.2	
Bios 09/04	8.0	1.56	3.3	1.3	11	252	1.6	--	0.1	
Bios 10/04	7.7	1.56	2.4	1.2	10	262	1.3	--	0.1	
Bios 11/04	7.5	1.54	2.7	1.2	11	268	1.2	--	0.1	
Bios 12/04	7.3	1.49	2.8	1.1	9.3	270	1.3	--	0.1	
NIST 2781	13.6	1.47	6.0	64.3	14	224	5.1	0.12	0.3	
NIST 2781										
Recommended/ Certified Value*					16.0 +/- 1.6		0.32 +/- 0.03			

Table 7. Analytical results for biosolids samples, 2004.

<b>Sample ID</b>	<b>ICPMS U, ppm</b>	<b>ICPMS V, ppm</b>	<b>ICPMS Y, ppm</b>	<b>ICPMS Zn, ppm</b>
Bios 01/04	32.3	30	3.1	636
Bios 02/04	27.4	16	4.2	565
Bios 03/04	29.9	12	3.5	604
Bios 04/04	31.4	15	3.5	659
Bios 05/04	39.8	13	3.7	707
Bios 06/04	37.8	13	3.7	728
Bios 07/04	38.2	16	4.4	742
Bios 08/04	39.3	20	5.4	747
Bios 09/04	38.5	14	4.2	692
Bios 10/04	39.9	14	3.8	708
Bios 11/04	41.6	12	3.6	688
Bios 12/04	36.6	12	3.5	666
NIST 2781	35.1	80	27	1150
NIST 2781 Recommended/ Certified Value*				1273 +/- 53

Table 8. Analytical results for biosolids samples, 2005.

Sample ID	ICPMS Ag, ppm	ICPMS Al, %	ICPMS As, ppm	HG-AAS As, ppm	ICPMS Ba, ppm	ICPMS Be, ppm	ICPMS Bi, ppm	ICPMS Ca, %	ICPMS Cd, ppm
Bios 01/05	34.2	1.63	2	1.4	457	0.27	37.9	3.28	2.1
Bios 02/05	27.4	1.54	2	1.4	430	0.30	32.5	2.97	2.1
Bios 03/05	25.6	1.42	2	1.5	417	0.26	33.4	2.81	2.0
Bios 04/05	20.6	1.30	2	1.4	388	0.24	29.2	2.93	1.7
Bios 05/05	20.4	1.26	2	1.5	398	0.22	28.2	2.97	1.7
Bios 06/05	21.3	1.59	2	1.6	393	0.30	29.4	2.83	1.6
Bios 07/05	26.6	1.49	2.7	2.4	405	0.32	35.4	2.78	2.1
Bios 08/05	20.1	1.44	2.5	2.4	410	0.33	35.5	2.83	2.0
Bios 09/05	19.4	1.31	2.5	2.4	390	0.30	34.5	2.81	2.0
Bios 10/05	19.3	1.15	2	2.3	364	0.28	34.6	2.43	2.0
Bios 11/05	19.9	1.18	2.4	2.0	365	0.30	35.7	2.62	2.0
Bios 12/05	18.5	1.05	2.1	1.9	333	0.24	33.6	2.40	1.8
NIST 2781	88.7	1.51	7.7	4.6	619	0.50	29.4	4.14	11.0
NIST 2781	42.8	1.28	8.1	8.7	565	0.58	34.1	3.57	12.3
NIST 2781 Recommended/ Certified Value*	98 +/- 8	1.6 +/- 0.1	7.82 +/- 0.28	7.82 +/- 0.28				3.9 +/-0.1	12.78 +/-0.72

--, not determined; \*NIST Certificate

Table 8. Analytical results for biosolids samples, 2005.

Sample ID	ICPMS Ce, ppm	ICPMS Co, ppm	ICPMS Cr, ppm	ICPMS Cs, ppm	ICPMS Cu, ppm	ICPMS Fe, %	ICPMS Ga, ppm	CV-AAS Hg, ppm	ICPMS K, %
Bios 01/05	16.6	9.6	37	0.40	633	3.4	2.8	1.1	0.33
Bios 02/05	16.5	9.2	33	0.39	563	2.6	2.7	1.0	0.32
Bios 03/05	15.9	6.7	32	0.36	577	2.3	2.6	1.1	0.32
Bios 04/05	15.4	5.8	29	0.37	553	3.2	2.5	1.0	0.31
Bios 05/05	14.2	7.8	29	0.36	600	2.8	2.4	0.85	0.29
Bios 06/05	20.3	9.7	30	0.62	606	2.3	3.1	2.3	0.40
Bios 07/05	23.0	9.6	34	0.53	622	2.7	5.3	1.3	0.32
Bios 08/05	22.2	9.7	33	0.55	643	2.4	3.5	2.4	0.31
Bios 09/05	18.3	9.1	33	0.42	633	2.9	6.8	1.4	0.27
Bios 10/05	17.4	8.7	32	0.37	632	2.4	6.4	1.3	0.28
Bios 11/05	19.4	9.2	30	0.34	621	2.2	5.0	1.4	0.29
Bios 12/05	16.9	10.2	29	0.29	566	1.9	5.9	0.87	0.26
NIST 2781	75	6.2	150	0.83	617	2.8	5.9	3.1	0.49
NIST 2781	69	6.3	153	0.73	560	2.6	6.5	3.8	0.42
NIST 2781 Recommended/ Certified Value*			202 +/- 9		627.4 +/- 13.5	2.8 +/- 0.1		3.64 +/- 0.25	0.49 +/- 0.03

Table 8. Analytical results for biosolids samples, 2005.

Sample ID	ICPMS La, ppm	ICPMS Li, ppm	ICPMS Mg, %	ICPMS Mn, ppm	ICPMS Mo, ppm	ICPMS Na, %	ICPMS Nb, ppm	ICPMS Ni, ppm	ICPMS P, %
Bios 01/05	9.6	< 0.2	0.422	284	28.6	0.140	< 2	24	3.00
Bios 02/05	9.5	1.2	0.398	227	24.8	0.137	< 2	20	2.80
Bios 03/05	9.5	0.4	0.451	200	25.2	0.128	< 2	21	2.70
Bios 04/05	9.3	< 0.2	0.385	185	25.4	0.130	< 2	18	2.70
Bios 05/05	9.5	< 0.2	0.433	244	22.4	0.133	< 2	20	2.70
Bios 06/05	12.8	< 0.2	0.499	241	22.4	0.139	6	20	2.50
Bios 07/05	14.0	4.3	0.470	298	25.4	0.148	45	21	3.42
Bios 08/05	14.4	4.4	0.406	443	31.1	0.139	12	23	3.17
Bios 09/05	12.4	2.9	0.490	696	33.6	0.124	75	20	3.49
Bios 10/05	11.9	1.8	0.496	298	35.7	0.117	73	20	3.25
Bios 11/05	12.3	2.0	0.378	244	34.0	0.126	55	19	3.10
Bios 12/05	10.8	1.5	0.338	229	24.3	0.116	68	17	2.72
NIST 2781	22.0	0.4	0.560	808	41.9	0.180	99	76	2.40
NIST 2781	21.2	3.0	0.508	750	38.3	0.176	77	70	2.67
NIST 2781 Recommended/ Certified Value*			0.59 +/- 0.04		46.7 +/- 3.2	0.21 +/- 0.02		80.2 +/- 2.3	2.42 +/- 0.09

Table 8. Analytical results for biosolids samples, 2005.

Sample ID	ICPMS Pb, ppm	ICPMS Rb, ppm	Total S, IR S, %	ICPMS Sb, ppm	ICPMS Sc, ppm	HG-AAS Se, ppm	ICPMS Sr, ppm	ICPMS Th, ppm	ICPMS Ti, %
Bios 01/05	50	9.7	1.38	3.9	1.5	8.2	332	1.5	0.24
Bios 02/05	48	9.2	1.46	3.3	1.1	7.6	289	1.3	0.25
Bios 03/05	50	9.1	1.35	3.1	1.1	8.2	271	1.3	0.23
Bios 04/05	42	8.7	1.49	2.6	1.0	8.2	283	1.4	0.20
Bios 05/05	43	8.3	1.55	2.7	1.0	9.4	285	1.2	0.19
Bios 06/05	46	13.6	1.42	2.6	1.6	10	267	1.9	0.24
Bios 07/05	56	10.8	1.73	2.8	1.8	11	260	2.9	0.22
Bios 08/05	49	11.2	1.74	2.8	1.5	10	255	2.5	0.19
Bios 09/05	44	8.8	1.74	2.3	1.6	9.5	247	1.8	0.21
Bios 10/05	44	8.1	1.62	2.0	1.6	9.6	232	2.0	0.19
Bios 11/05	48	8.5	1.64	2.0	1.5	9.4	242	1.8	0.19
Bios 12/05	41	7.6	1.51	1.9	1.4	7.9	228	1.5	0.15
NIST 2781	199	18.5	1.46	8.0	70	14	246	5.5	0.30
NIST 2781	168	17.2	1.51	7.6	68	14	235	5.6	0.24
NIST 2781									
Recommended/ Certified Value*	202.1 +/- 6.5					16.0 +/- 1.6			0.32 +/- 0.03

Table 8. Analytical results for biosolids samples, 2005.

Sample ID	ICPMS Ti, ppm	ICPMS U, ppm	ICPMS V, ppm	ICPMS Y, ppm	ICPMS Zn, ppm
Bios 01/05	0.1	40.1	13	5.3	772
Bios 02/05	0.1	36.1	12	4.2	675
Bios 03/05	0.1	33.6	11	4.4	673
Bios 04/05	0.1	35.4	12	3.9	656
Bios 05/05	0.1	45.1	11	4.2	679
Bios 06/05	0.1	46.8	17	5.7	664
Bios 07/05	0.2	50.8	58	5.0	811
Bios 08/05	0.1	46.9	22	4.9	794
Bios 09/05	0.1	41.2	69	4.1	803
Bios 10/05	0.1	41.3	68	3.8	750
Bios 11/05	0.1	43.5	50	4.1	772
Bios 12/05	0.1	36.2	59	3.7	702
NIST 2781	0.2	37.3	84	32.7	1190
NIST 2781	0.3	40.0	82	28.6	1230
NIST 2781 Recommended/ Certified Value*					1273 +/- 53

Table 9. Analytical results for biosolids samples, 2006.

Sample ID	ICPMS Ag, ppm	ICPMS Al, %	ICPMS As, ppm	HG-AAS As, ppm	ICPMS Ba, ppm	ICPMS Be, ppm	ICPMS Bi, ppm	ICPMS Ca, %	ICPMS Cd, ppm
Bios 01/06	19.3	1.18	1.6	1.6	355	0.29	33.4	3.03	1.7
Bios 02/06	19.0	1.10	1.8	1.5	349	0.27	34.4	3.00	1.8
Bios 03/06	17.6	1.14	2.0	1.7	366	0.28	31.3	2.91	1.8
Bios 04/06	19.5	1.12	1.7	1.4	383	0.26	32.7	3.10	1.8
Bios 05/06	16.7	1.14	1.9	1.9	379	0.28	32.0	3.34	1.8
Bios 06/06	17.7	1.05	2.2	2.1	387	0.31	29.0	3.48	1.7
Bios 07/06	15.5	1.35	2.6	1.9	379	0.33	30.6	2.72	1.8
Bios 08/06	15.1	1.91	2.0	1.8	399	0.51	21.6	2.43	1.4
Bios 09/06	16.6	1.29	2.5	2.0	371	0.34	30.0	2.42	1.8
Bios 10/06	16.7	1.28	2.5	1.9	370	0.37	32.6	2.62	1.8
Bios 11/05	17.2	1.32	2.5	1.9	375	0.35	33.1	2.55	1.9
Bios 12/06	15.3	1.11	1.9	1.5	348	0.32	34.5	2.78	1.7
NIST 2781	83.8	1.41	7.8	7.1	601	0.51	29.4	5.20	11.1
NIST 2781	27.0	1.37	7.3	6.5	534	0.59	28.4	3.53	10.8
NIST 2781 Recommended/ Certified Value*	98 +/- 8	1.6 +/- 0.1	7.82 +/- 0.28	7.82 +/- 0.28				3.9 +/- 0.1	12.78 +/- 0.72

--, not determined; \*NIST Certificate



Table 9. Analytical results for biosolids samples, 2006.

Sample ID	ICPMS Ce, ppm	ICPMS Co, ppm	ICPMS Cr, ppm	ICPMS Cs, ppm	ICPMS Cu, ppm	ICPMS Fe, %	ICPMS Ga, ppm	CV-AAS Hg, ppm	ICPMS K, %
Bios 01/06	18.3	10.7	35	0.30	653	2.06	6.0	0.81	0.30
Bios 02/06	20.9	7.6	35	0.29	708	2.11	8.1	1.1	0.28
Bios 03/06	17.6	6.9	36	0.31	709	2.28	9.0	0.81	0.30
Bios 04/06	18.7	5.2	47	0.33	784	2.47	10.6	0.90	0.30
Bios 05/06	20.6	5.2	54	0.36	845	2.66	9.9	5.2	0.35
Bios 06/06	27.3	6.8	56	0.40	815	3.15	6.6	1.1	0.38
Bios 07/06	21.7	5.4	44	0.55	661	2.38	5.7	0.79	0.29
Bios 08/06	39.9	4.6	37	0.65	554	2.21	6.0	0.91	0.69
Bios 09/06	21.0	5.1	33	0.46	641	2.07	5.5	0.83	0.30
Bios 10/06	18.8	4.8	36	0.44	670	2.00	5.6	0.96	0.27
Bios 11/05	18.4	5.1	34	0.44	681	2.06	5.8	0.81	0.32
Bios 12/06	18.3	4.2	31	0.34	617	1.78	4.6	0.66	0.26
NIST 2781	69.8	7.2	218	0.80	685	3.24	7.2	3.8	0.59
NIST 2781	69.1	5.9	150	0.73	600	2.63	6.3	2.4	0.43
NIST 2781									
Recommended/ Certified Value*			202 +/- 9		627.4 +/- 13.5	2.8 +/- 0.1		3.64 +/- 0.25	0.49 +/- 0.03

Table 9. Analytical results for biosolids samples, 2006.

Sample ID	ICPMS La, ppm	ICPMS Li, ppm	ICPMS Mg, %	ICPMS Mn, ppm	ICPMS Mo, ppm	ICPMS Na, %	ICPMS Nb, ppm	ICPMS Ni, ppm	ICPMS P, %
Bios 01/06	11.6	2.6	0.410	260	25.4	0.130	72	19	2.73
Bios 02/06	13.3	1.6	0.502	279	22.7	0.108	78	19	2.84
Bios 03/06	11.1	1.1	0.346	291	21.9	0.111	94	19	2.59
Bios 04/06	12.1	1.9	0.316	288	23.9	0.114	120	20	2.62
Bios 05/06	13.0	1.6	0.343	329	32.2	0.128	110	22	2.71
Bios 06/06	18.8	1.6	0.443	419	44.1	0.117	60	23	2.92
Bios 07/06	17.1	4.4	0.468	331	40.7	0.123	48	21	2.66
Bios 08/06	24.5	4.9	1.51	407	28.6	0.277	39	21	3.67
Bios 09/06	17.5	3.8	0.392	453	35.1	0.133	54	20	2.46
Bios 10/06	16.0	3.7	0.435	338	30.0	0.125	53	21	2.57
Bios 11/05	15.1	4.0	0.416	260	26.4	0.149	74	22	2.67
Bios 12/06	14.5	2.9	0.349	185	22.1	0.123	66	17	2.42
NIST 2781	20.1	4.6	0.485	976	40.6	0.178	78	87	3.06
NIST 2781	19.4	5.9	0.499	742	37.3	0.183	75	71	2.53
NIST 2781									
Recommended/ Certified Value*			0.59 +/- 0.04		46.7 +/- 3.2	0.21 +/- 0.02		80.2 +/- 2.3	2.42 +/- 0.09

Table 9. Analytical results for biosolids samples, 2006.

Sample ID	ICPMS Pb, ppm	ICPMS Rb, ppm	Total S, IR S, %	ICPMS Sb, ppm	ICPMS Sc, ppm	HG-AAS Se, ppm	ICPMS Sr, ppm	ICPMS Th, ppm	ICPMS Ti, %	
Bios 01/06	45	7.4	1.47	2.4	1.6	8.0	231	1.6	0.26	
Bios 02/06	44	6.8	1.41	2.1	1.8	8.2	238	1.5	0.29	
Bios 03/06	47	7.5	1.45	2.2	2.1	6.9	255	1.6	0.30	
Bios 04/06	52	8.1	1.44	2.5	2.4	7.4	265	1.7	0.35	
Bios 05/06	47	9.0	1.54	2.0	2.4	8.8	266	1.7	0.28	
Bios 06/06	52	9.8	1.59	1.9	2.2	9.1	243	2.0	0.29	
Bios 07/06	52	10.5	1.59	2.5	1.8	10	213	1.8	0.24	
Bios 08/06	72	25.1	1.34	1.8	2.0	7.4	206	11.4	0.18	
Bios 09/06	51	9.9	1.72	1.9	1.6	10	221	2.1	0.22	
Bios 10/06	51	8.8	1.65	2.0	1.6	11	228	1.8	0.22	
Bios 11/05	52	10.2	1.57	1.9	1.7	9.6	244	1.9	0.22	
Bios 12/06	46	7.6	1.49	2.3	1.6	9.4	248	1.8	0.22	
NIST 2781	188	17.4	1.44	5.5	97.6	14	248	5.3	0.35	
NIST 2781	185	15.6	1.48	5.2	66.4	15	213	4.9	0.20	
NIST 2781										
Recommended/ Certified Value*	202.1 +/- 6.5					16.0 +/- 1.6			0.32 +/- 0.03	

Table 9. Analytical results for biosolids samples, 2006.

<b>Sample ID</b>	<b>ICPMS Ti, ppm</b>	<b>ICPMS U, ppm</b>	<b>ICPMS V, ppm</b>	<b>ICPMS Y, ppm</b>	<b>ICPMS Zn, ppm</b>
Bios 01/06	0.1	32.1	66	3.6	684
Bios 02/06	0.1	33.0	81	3.8	696
Bios 03/06	0.1	32.0	97	3.7	716
Bios 04/06	0.1	33.5	122	3.9	794
Bios 05/06	0.1	35.6	125	4.4	819
Bios 06/06	0.1	35.8	77	4.5	831
Bios 07/06	0.1	38.7	50	4.5	769
Bios 08/06	0.2	26.6	42	8.5	609
Bios 09/06	0.1	38.2	47	4.0	728
Bios 10/06	0.1	39.8	53	4.2	787
Bios 11/05	0.1	42.2	63	4.2	750
Bios 12/06	0.1	38.0	50	3.8	690
NIST 2781	0.3	35.2	116	30	1320
NIST 2781	0.3	37.8	83	25	1120
NIST 2781 Recommended/ Certified Value*					1273 +/- 53

Table 10. Gross Alpha and Beta and plutonium isotopes analytical results for biosolids samples, 1999 - 2006.

Measurement	Maximum Allowable for Grade I	Bios 03/99	Bios 06/99	Bios 09/99	Bios 12/99	Bios 03/00	Bios 06/00	Bios 08/00	Bios 09/00	Bios 10/00	Bios 11/00
Gross Alpha, pCi/g	40	19+/-7	37+/-11	32+/-22	27+/-12	23+/-14	44+/-11	36+/-12	45+/-12	43+/-11	44+/-11
sd/value*		0.37	0.3	0.69	0.44	0.61	0.25	0.33	0.27	0.26	0.25
Gross Beta, pCi/g	No standard set	24+/-7	39+/-7	24+/-6	21+/-6	26+/-5	23+/-6	27+/-5	29+/-5	29+/-5	25+/-4
sd/value*		0.29	0.18	0.25	0.29	0.19	0.26	0.19	0.17	0.17	0.16
Plutonium 238, pCi/g	No standard set	-0.01+/-0.01	0.00+/-0.04	0.00+/-0.01	0.01+/-0.02	0.00+/-0.01	0.00+/-0.01	0.02+/-0.03	0.01+/-0.02	0.00+/-0.01	-0.01+/-0.01
Plutonium 239+240, pCi/g	No standard set	0.00+/-0.01	0.02+/-0.03	0.00+/-0.01	0.00+/-0.02	0.00+/-0.01	0.00+/-0.01	0.00+/-0.01	0.00+/-0.01	-0.01+/-0.01	0.00+/-0.01

\* = Standard Deviation

nd = not determined

Table 10. Gross Alpha and Beta and plutonium isotopes analytical results for biosolids samples, 1999 - 2006.

Measurement	Bios 12/00	Bios 01/01	Bios 04/01	Bios 07/01	Bios 10/01	Bios 01/02	Bios 04/02	Bios 07/02	Bios 10/02	Bios 01/03	Bios 04/03
Gross Alpha, pCi/g	36+/-11	30+/-10	34+/-12	54+/-12	49+/-11	37+/-9	40+/-11	18+/-2	16+/-2	19+/-2	23+/-3
sd/value*	0.31	0.33	0.35	0.22	0.22	0.24	0.28	0.11	0.12	0.11	0.13
Gross Beta, pCi/g	22+/-4	24+/-5	22+/-5	31.0+/-6.8	28.0+/-6.3	27+/-5	22+/-4	23+/-3	19+/-2	19+/-2	26+/-3
sd/value*	0.18	0.21	0.23	0.22	0.22	0.19	0.18	0.13	0.11	0.11	0.12
Plutonium 238, pCi/g	0.01+/- 0.02	-0.01+/- 0.01	0.00+/- 0.01	-0.004+/- 0.019	-0.004+/- 0.12	0.00+/- 0.02	0.00+/- 0.02	0.00+/- 0.00	0.00+/- 0.00	0.00+/- 0.00	0.00+/- 0.00
Plutonium 239+240, pCi/g	0.00+/- 0.01	0.01+/- 0.02	0.00+/- 0.01	0.009+/- 0.012	0.000+/- 0.012	0.00+/- 0.02	0.00+/- 0.02	0.00+/- 0.00	0.00+/- 0.00	0.00+/- 0.00	0.00+/- 0.00

\* = Standard Deviation

nd = not determined

Table 10. Gross Alpha and Beta and plutonium isotopes analytical results for biosolids samples, 1999 - 2006.

Measurement	Bios 07/03	Bios 02/04	Bios 08/04	Bios 02/05	Bios 01/06
Gross Alpha, pCi/g	14+/-2	nd	nd	nd	nd
sd/value*	0.14	nd	nd	nd	nd
Gross Beta, pCi/g	24+/-3	nd	nd	nd	nd
sd/value*	0.12	nd	nd	nd	nd
Plutonium 238, pCi/g	0.00+/- 0.00	0.017 +/- 0.017	0.004 +/- 0.014	0.004 +/- 0.012	0.016 +/- 0.012
Plutonium 239+240, pCi/g	0.00+/- 0.00	-0.004 +/- 0.0085	0.000 +/- 0.007	0.000 +/- 0.004	0.000 +/- 0.008

\* = Standard Deviation

nd = not determined