Protecting Our Water Environment

Metropolitan Water Reclamation District of Greater Chicago

RESEARCH AND DEVELOPMENT DEPARTMENT

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USE OF BIOSOLIDS FOR ESTABLISHING VEGETATION AT THE USX STEEL MILL SLAG BROWNFIELD IN CHICAGO: A RESEARCH AND DEMONSTRATION PROJECT

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USE OF BIOSOLIDS FOR ESTABLISHING VEGETATION ON A STEEL MILL SLAG BROWNFIELD IN CHICAGO AT THE USX SITE: A RESEARCH AND DEMONSTRATION PROJECT

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TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

LIST OF TABLES

LIST OF TABLES (CONTINUED)

LIST OF TABLES (CONTINUED)

LIST OF TABLES (CONTINUED)

LIST OF TABLES (CONTINUED)

LIST OF TABLES (CONTINUED)

LIST OF TABLES (CONTINUED)

LIST OF TABLES (CONTINUED)

LIST OF TABLES (CONTINUED)

LIST OF TABLES (CONTINUED)

LIST OF TABLES (CONTINUED)

LIST OF TABLES (CONTINUED)

LIST OF TABLES (CONTINUED)

LIST OF TABLES (CONTINUED)

LIST OF FIGURES

LIST OF FIGURES (CONTINUED)

LIST OF FIGURES (CONTINUED)

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DISCLAIMER

Mention of proprietary equipment and chemicals in this report does not constitute endorsement by the Metropolitan Water Reclamation District of Greater Chicago.

COOPERATING AGENCIES

The USX research and demonstration project was conducted as a collaborative effort between the following entities:

- The Metropolitan Water Reclamation District of Greater Chicago (District) Departments of Research and Development and Maintenance and Operations;
- The City of Chicago Departments of Planning and Development, Streets and Sanitation, and Environment;
- The Chicago Park District; and
- The Illinois Environmental Protection Agency.

SUMMARY AND CONCLUSIONS

The USX site, a 570-acre brownfield located on Chicago's southern lakefront, consists mostly of a deep heterogeneous fill of steel mill slag materials resulting from the former U. S. Steel Southworks (USSS) iron and steel operations. The City of Chicago (City) is planning to reclaim the site and develop it into parks, residential, commercial, and industrial areas. The slag materials at the USX site are very hard and porous and thus are unsuitable for establishing vegetation. One of the most feasible options for establishing vegetation at the site is to cap the slag with topsoil or topsoil-like materials, using biosolids as an amendment. The District conducted a research and demonstration project in collaboration with the City and the Chicago Park District (CPD) to evaluate the suitability of using mixtures of biosolids and other soil-like materials for capping the slag materials and establishing vegetation at the USX site. Dredged sediments from a pond at a CPD site were chosen by the CPD to blend with biosolids. The specific objectives of the project were to evaluate the suitability of mixtures of biosolids and sediment for capping the slag for establishing turfgrass and trees, and to determine the effect of these mixtures on concentrations of nutrients and trace metals in Lake Michigan and subsurface water at the USX site. In addition, the effectiveness of a 6-inch thick silty clay loam layer placed between the amendments and the slag in reducing loss of nutrients from the amendments through leaching was evaluated.

The research and demonstration project was started in June 2000 on a 1-acre parcel at the USX site. The amendments consisted of mixtures of Class A biosolids and dredged sediments containing 0, 25, 75, and 100 percent biosolids by volume. For each of the amendments, two sets of plots (east and west) were established. A 6-inch layer of silty clay loam soil was placed as a liner on top of the slag before placing the amendments in the east side plots, but no liner was included in the plots on the west side. The amendments were placed at 1-ft depths for planting turfgrass in

the east and west plots, but on the eastern side of the west plots and the western side of the east plots the amendments were placed at a 4-ft depth for planting trees. In the 1-ft depth portion of each of the eight main plots, four turfgrass blends that are commonly used in parks in the Chicago area were seeded and the subplots were separated by a 3-ft wide sod buffer. Six species of shade trees and five species of ornamental trees that are commonly grown in parks in the Chicago area were planted in the 4-ft depth portion of the amendments. Two lysimeters, at 5-ft and 10-ft depths, and one well at 20-ft depth were installed in each main plot and at a remote location about 200 ft from the southern end of the plots for monitoring subsurface water quality. Three sampling locations were designated in Lake Michigan at about 50-ft off shore, corresponding to north of the plots, the middle of the plots, and south of the research and demonstration plots. The devices were sampled monthly for analysis of inorganic constituents and quarterly for analysis of organic priority pollutants. The amendments were sampled at the 0- to 6-inch and 6- to 10-inch depths immediately after application and every spring and fall during 2001 to 2003 for analysis. Also, during 2001 to 2003, samples of turfgrass tissues were collected every spring and fall and tree leaf tissues were collected every fall for analysis. The performance of the turfgrasses was evaluated visually and the tree growth was evaluated by monitoring tree height and trunk diameter.

Concentrations of Constituents in Amendments

Overall, the fertility of the amendments with respect to organic carbon (OC), the major plant nutrients, N and P, and some micronutrients was improved with increasing proportion of biosolids in the amendments. The salinity in the amendments increased with increasing the amount of biosolids but it diminished rapidly and by the end of the project the salinity levels in the root zone of all amendments were similar. The total concentrations of Zn, Cd, Cu, and Mo in the amendments increased with increasing proportion of biosolids in the amendments as expected, because the total concentrations of these trace metals are generally higher in the biosolids than in the sediment used in this project. The data on the concentration of constituents in the amendments showed that compared to using the sediment alone, the addition of biosolids in the sediment improved the topsoil characteristics with respect to essential plant nutrients and OC content.

Plant Growth and Performance

Vegetation was successfully established on all amendments. In the amendments containing biosolids, the turf performed better and it was much greener, robust, and healthier than in the plots amended with sediment alone. The growth rate of the shade and ornamental trees was much better in the amendments containing biosolids than in the sediment alone. The improvement in growth and performance of the turfgrass and trees in the amendments containing biosolids were due to the increase in essential plant nutrients and enhancements in the physical characteristics of amendment provided by the biosolids. Amendments consisting of sediment alone or biosolids-sediment mixtures may be used to establish vegetation on the slag, but the performance and growth rate of the vegetation in biosolids-sediment mixture amendments will be much better than in the sediment alone.

Concentrations of Constituents in Vegetation

The concentrations of the plant nutrients N, P, K, Cu, and Zn, and of Ni, which is a non-nutrient, increased in the turfgrass tissues with the amounts of biosolids in the amendments. Biosolids had no effect on the concentrations of all other non-nutrient trace metals including Cd, Cr, and Pb in the turfgrass tissues. The concentrations of all essential plant nutrients in the four turf blends were within or above the sufficiency range for all amendments tested.

The concentrations of N and P in the shade tree species, and N and Zn in the ornamental tree species evaluated increased with increasing amounts of biosolids in the amendments. The concentrations of most other trace metals in the shade and ornamental trees were not affected by biosolids amendments, except the concentrations of Cu and Pb, which were lower in the trees in amendments containing biosolids than in the amendment consisting of sediment alone. The concentrations of trace metals in the leaves of ornamental and shade trees were similar to the concentrations observed in tree leaves collected from public parks in the City.

Overall, the N concentration increased in turf tissue and tree leaves with increasing proportions of biosolids in the amendments, and the higher N uptake that occurred in amendments containing biosolids may have produced the higher plant growth rates that were observed in biosolids amendments than in the sediment alone. The concentrations of trace metals in the turfgrass and tree tissues were very low and within the ranges commonly found in plant tissues, which suggest that the turfgrass and leaf fall from the trees grown on biosolids-amended sites will not pose a risk of trace metal bioaccumulation in the herbivorous food chains.

Concentrations of Constituents in Subsurface and Lake Water

The concentrations of trace metals, fecal coliforms, and other water quality parameters in the lysimeters and wells in the amended plots and in the remote location were similar, and did not increase with increasing amounts of biosolids in the amendments. In addition, the research and demonstration project had no effect on the concentrations of constituents in Lake Michigan water. The study showed that trace metals did not migrate from the amendments into subsurface or Lake Michigan water.

The research and demonstration plots had no effect on the concentrations of nutrients in Lake Michigan. The concentrations of P in the wells and lysimeters in the remote location, the sediment amended plots, and the biosolids amended plots were all similar. However, the concentrations of N species (NH_3-N, NO_3-N, and TKN) varied widely during the project and in the 5-ft and 10-ft deep lysimeters, the highest levels were most frequently observed for the amendments containing biosolids.

Most of the highest concentrations of NO_3-N observed were at the 5-ft and 10-ft depth lysimeters in the 50 and 100 percent biosolids amendments. The highest concentrations occurred mostly during the first 12 months after the amendments were applied, then concentrations declined to less than 25 mg N/L for the remainder of the study. In the 20-ft depth wells in all the amendments, NO_3-N concentrations were mostly less than 1 mg N/L, except for a few occasional spikes, including the 0 percent biosolids amendments, ranging from 2 to 25 mg N/L. These data show that the leaching of NO_3-N out of the amendments occurred mostly just after the amendments were placed on the slag and that the leached NO_3-N remained primarily in the vadose zone, without causing large sustained increases in groundwater NO_3-N concentrations.

The NH_3-N concentrations were highest in the 100 percent biosolids amendment in the 5-ft depth lysimeters in the clay-lined plots, but were highest in 10-ft depth lysimeters in the nonlined plots. This relationship showed that in the 100 percent biosolids treatment, conversion of NH_3-N to NO_3-N was probably slower than in the other amendments and the clay loam layer helped to retard the vertical migration of NH_3-N. In the 20-ft depth wells, the concentrations of NH_3-N for all the amendments were less than 1 mg N/L, except a few occasional spikes, up to 2 mg N/L, which occurred in the 100 percent biosolids amendment.

The amendments had no effect on fecal coliform counts and the concentrations of organic priority pollutants in the subsurface water. Fecal coliforms were detected in only a few well samples at concentrations ranging from 6 to 9 counts/100 mL. This is consistent with the fact that fecal coliforms were found in all Lake Michigan water samples taken off shore of the plots and from north and south of the plots. Of the 111 priority pollutants monitored, 12 were detected in only a few of the samples, and the frequency at which they were detected and their concentrations did not correlate with amounts of biosolids in the amendments.

The study showed that P did not migrate from the amendments, including those containing biosolids, into the subsurface of the slag or into Lake Michigan. However, in amendments containing biosolids, there were periodic increases in the pore water concentrations of NH_3-N and NO_3-N down to the 10-ft depth of the slag. The data also showed that placing a clay layer on top of the slag before placing amendments containing biosolids might help in minimizing the vertical movement of soluble N.

Conclusions

The project demonstrated that Class A air-dried biosolids can be used as amendments for establishing turfgrass and trees at the USX site at rates up to 100 percent biosolids. Among the four rates of biosolids used in the amendments in this study, the 25 percent biosolids amendment appears to be the most suitable for establishing turfgrass and trees on the slag at the USX site, both in terms of agronomic performance and environmental impacts. Amendments containing 25 percent biosolids by volume will provide a long-term supply of plant nutrients, enhance the physical and moisture holding properties of the amendment, and provide rapid growth and good performance of turfgrasses and trees. Except for a few spikes in NO_3-N concentrations in the slag subsurface pore water, the 25 percent biosolids amendments did not have significant impact on groundwater or Lake water quality with respect to nutrients, trace metals, organic priority pollutants, and pathogens. The concentrations of trace metals in turf and tree leaves from the 25 percent biosolids amendments were very similar to those in the 0 percent biosolids plots, and to those in tree leaves collected from the public parks in Chicago. This indicates that use of 25 percent biosolids amendments will be effective and environmentally safe to cap the slag and establish a vegetative cover at the USX site.

Biosolids may also be used at rates higher than 25 percent by volume but more careful consideration will need to be given to management of excess nutrients during the first several years following applications at sites where groundwater can be impacted. The use of heavy textured soils to simulate a B soil horizon beneath the biosolids amendment layer at porous slag sites has merits, but it needs to be studied further to improve design parameters.

PUBLIC OUTREACH

The research and demonstration project was showcased in two field day events conducted in May 2001 and July 2003. The attendees at the field days included the District's General Superintendent, officers, and members of the Board of Commissioners, local landscapers, staff members of the CPD and the Chicago Departments of Environment (DOE) and Planning and Development (DPD), environmental interest groups, staff members of USDA Forest Service, and researchers from Southern Illinois University at Carbondale. The field days provided a good perspective on the use and benefits of biosolids as a soil amendment and some of the attendees became interested in using biosolids in their projects.

Based on the successful demonstration at the USX site, the CPD – one of the largest holders of parks and recreational areas in the City, became interested in using biosolids for developing recreational sites. Unfortunately, the DOE has raised some concerns regarding the use of biosolids on city projects. This has delayed further developmental work with the CPD.

The District is continuing to work with the City to address the DOE's concerns so that the biosolids can be used as an amendment at the USX site and for other parks and recreational areas in Chicago.

BACKGROUND

Site History and Description

The USX site is a 570-acre brownfield located near 86th Street and South Shore Drive in Chicago. The former USSS operated one of the biggest steel mills in the U.S. at this site. The steel mill ceased operation approximately 20 years ago and all buildings and other facilities have since been demolished. Most of the site was created by progressively filling the Lake Michigan shoreline with slag (a by-product of steel and iron manufacture) and demolition rubble.

A geotechnical review of the USX site conducted by Harza Environmental Services (Harza Environmental Services, 1998) showed that the subsurface stratigraphy of the slag materials consists of the following:

- Heterogeneous Fill: This is a surface mantle ranging from 4- to 40-ft deep, and it consists of slag interspersed with cinders, silty sand and gravel, concrete rubble, ore, bricks and metal pieces. The typical surface features and a cross section of the fill material are shown in Figure 1. The slag particles range in size from silt to coarse gravel, making the fill very porous with very low water holding capacity.

- Sand: A layer of fine to medium-grained sand originating from lake deposits underlies the upper slag fill. The sand layer ranges from 6- to 10-ft thick on the eastern side of the site and it is over 40-ft thick on the western side.

- Silty Clay, Clayey Silt: The sand layer is underlain by a layer of stiff to hard silty clay (till) and includes some sand, gravel, and boulders. It appears that

FIGURE 1: SURFACE FEATURES (A) AND CROSS-SECTIONAL VIEW (B) OF THE SLAG MATERIALS AT THE USX SITE

this layer exists mostly in the southeastern portion of the site, where it is about 20-ft thick and does not exist in the northern portion of the site.

- Bedrock: The till is underlain by limestone bedrock. The depth of the slag materials to the top of the bedrock ranges from less than 15 ft in the northeast to up to 50 ft for the remainder of the site.

- Groundwater: The depth to groundwater at the site is expected to range from about 10 to 15 ft, and depends mostly on the site stratigraphy, water level in Lake Michigan, and seasonal variations. Previous investigations at the slip located in the northern portion of the site reported high levels of sulfite, sulfate, chloride, and other salts in the subsoil and groundwater.

The previous investigations showed that there are numerous shallow and deep foundations buried in many areas of the site. These investigations also revealed that during demolition of structures, debris was pushed into the basements and only about a 1-ft portion of the foundations below grade were removed leaving the lower portions of the foundations intact. This contributed tremendous heterogeneity to the slag and fill materials on the site.

Future Plans for the Site

The City is considering redeveloping the site for commercial and industrial uses with some open park spaces. The CPD is planning to create a 120-acre park on the parcel to extend the lakefront recreational system. In 2003, the eastern extreme of 87th Street was extended through the USX site to approach the lakefront, and trees and turfgrass were planted along the roadside.

Rationale for the Research and Demonstration Project

In the late winter of 1999, the City of Chicago DPD contacted the District seeking technical assistance in demonstrating that park-like vegetation could be grown at the USX site. The slag material at the site is extremely porous with low water holding capacity and it lacks most of the essential plant nutrients. The site is almost barren, because these conditions are unsuitable for supporting vegetation. It was decided that the most viable reclamation option for constructing a good rooting zone needed for establishing vegetation at the site is to cap the slag materials with topsoil. However, the costs associated with reclaiming the site with topsoil will be very high due to the scarcity of good quality topsoil in the Chicago metropolitan area.

Abundant urban waste soils (largely subsoil generated from excavation associated with building construction) are usually poorly suited for use in establishing vegetation, primarily due to their poor physical characteristics and low nutrient and organic content. However, blending these poor quality soils with nutrient-rich high organic matter materials such as biosolids will greatly increase the economic feasibility of capping the slag. A pilot-scale research and demonstration project was initiated for evaluating the potential of using biosolids as a soil amendment for capping the slag to support turf and woody ornamentals. The impact on soil, groundwater and the Lake is also important in evaluating the suitability of biosolids for reclaiming the USX site, because the USX site is very close to Lake Michigan and the slag at the site is very porous.

OBJECTIVES

The research and demonstration project was conducted to:

1. Evaluate the suitability of four amendments consisting of mixtures of Class A air-dried biosolids and sediment dredged from a golf course pond for establishing turfgrasses and trees that are commonly used in landscaping, parks, and recreational areas in Chicago.

2. Evaluate the effects of these amendments on the concentrations of constituents in soil, subsurface water, and Lake Michigan water.

3. Evaluate the effect of a clay liner, simulating the B-horizon (layer) found in most natural soil profiles, in reducing leaching of constituents from the amendments.

MATERIALS AND METHODS

Amendments and Plot Layout

The research and demonstration project was designed to compare the effectiveness of four amendments of biosolids and dredged sediment mixtures containing 0, 25, 50, and 100 percent biosolids by volume. The project was established on an approximately 1-acre parcel on the slag at the USX site. Each of the four amendments was established on two sections of study area, one on the east and one on the west. On the east section, a 6-inch thick layer of silty clay loam soil was placed on the slag to simulate the heavy textured B-horizon found in most natural soil profiles, before placing the amendments (clay-lined plots). On the west section, the amendments were placed directly on the slag (nonlined plots).

In June of 2000, Class A air-dried biosolids from the District's Calumet Water Reclamation Plant and the pond sediment were brought to the USX site for *in situ* blending. The chemical analysis of the biosolids, sediment, and the slag are presented in Table 1. The amendments were blended using end loaders and bulldozers (Figure 2). The same equipment was used to spread the amendments on each of the eight plots to an approximate depth of 1 ft, where turfgrass was to be established and to an approximate depth of 4 ft, where trees were to be established. The portion of the main plot that received the 1-ft layer of amendments was divided into four subplots for testing four different turfgrass blends (Figure 3). A 9-ft wide, 1-ft high earthen berm was constructed around the entire plot area to control surface runoff from leaving the plots and a 3-ft wide sod buffer was placed between the subplots to minimize runoff between the subplots.

TABLE 1: CHEMICAL CHARACTERISTICS OF BIOSOLIDS, SEDIMENT, AND SLAG AT THE USX RESEARCH AND DEMONSTRATION PROJECT, AND SLAG MATERIALS AT THE USX SITE

Parameter	Unit	Biosolids	Sediment	Slag
Total Solids	%	69	NA	NA
pH[1]		6.3	6.6	7.6
Organic Carbon	%	16.4	2.1	ND
EC[1]	dS/m	2.9	0.4	0.6
Total Kjeldahl N	mg/dry kg	15,845	1,734	674
NH_3-N[1]	"	125	0.3	0.03
$NO_2 + NO_3$-N[1]	"	288	5.0	8.86
Total P	"	23,658	668	500
SO_4-S[1]		3,309	282	2.5
Ca	"	54,645	ND	83,700
Mg	"	16,985	ND	5,100
K	"	1,593	ND	1,050
Na	"	559	ND	660
Fe	"	24,463	19,400	61,300
Mn	"	390	504	6,600
Zn	"	1,347	83	811
Cu	"	303	27	375
Cr	"	148	30	220
Cd	"	10	<0.18	10
Mo	"	9.3	<0.3	18.9
Ni	"	32	24	72
Pb	"	132	21	370
Sb	"	3.6	<2.4	3.4
Se	"	12.5	ND	<0.12
As	"	9.0	ND	9.3
Hg	"	0.98	ND	1.0

[1]Determined in 1:2 (solid:water) ratio.
NA = Not applicable.
ND = Not determined.

FIGURE 2: CONSTRUCTION OF PLOTS (A) AND INSTALLATION OF LYSIMETERS AND WELLS (B) FOR THE USX RESEARCH AND DEMONSTRATION PROJECT

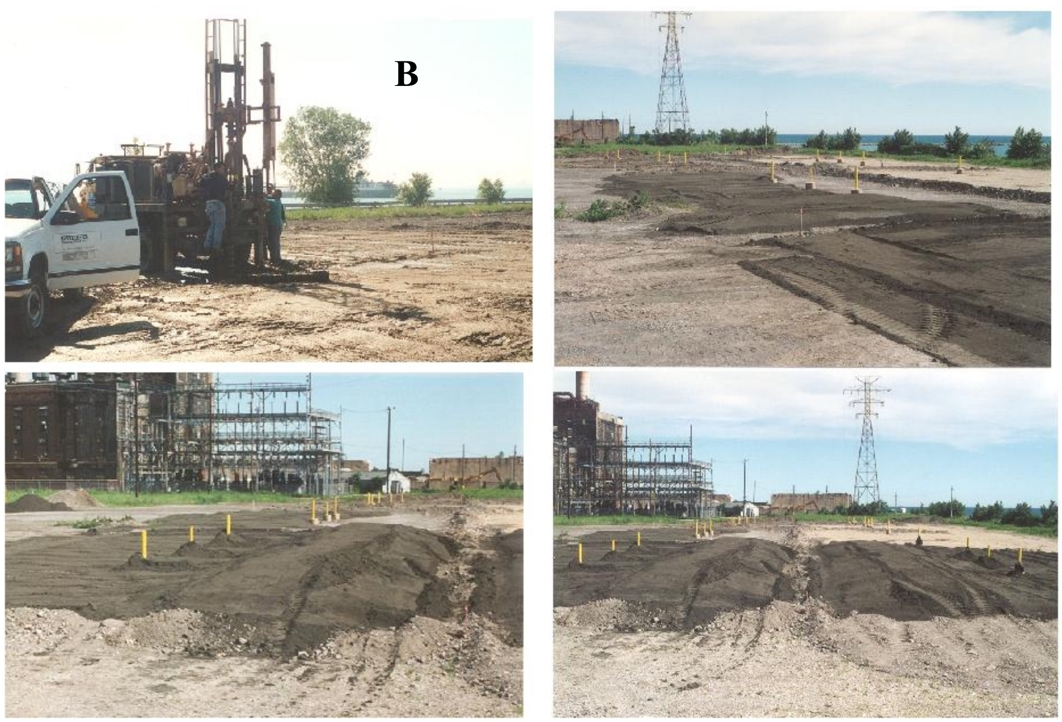
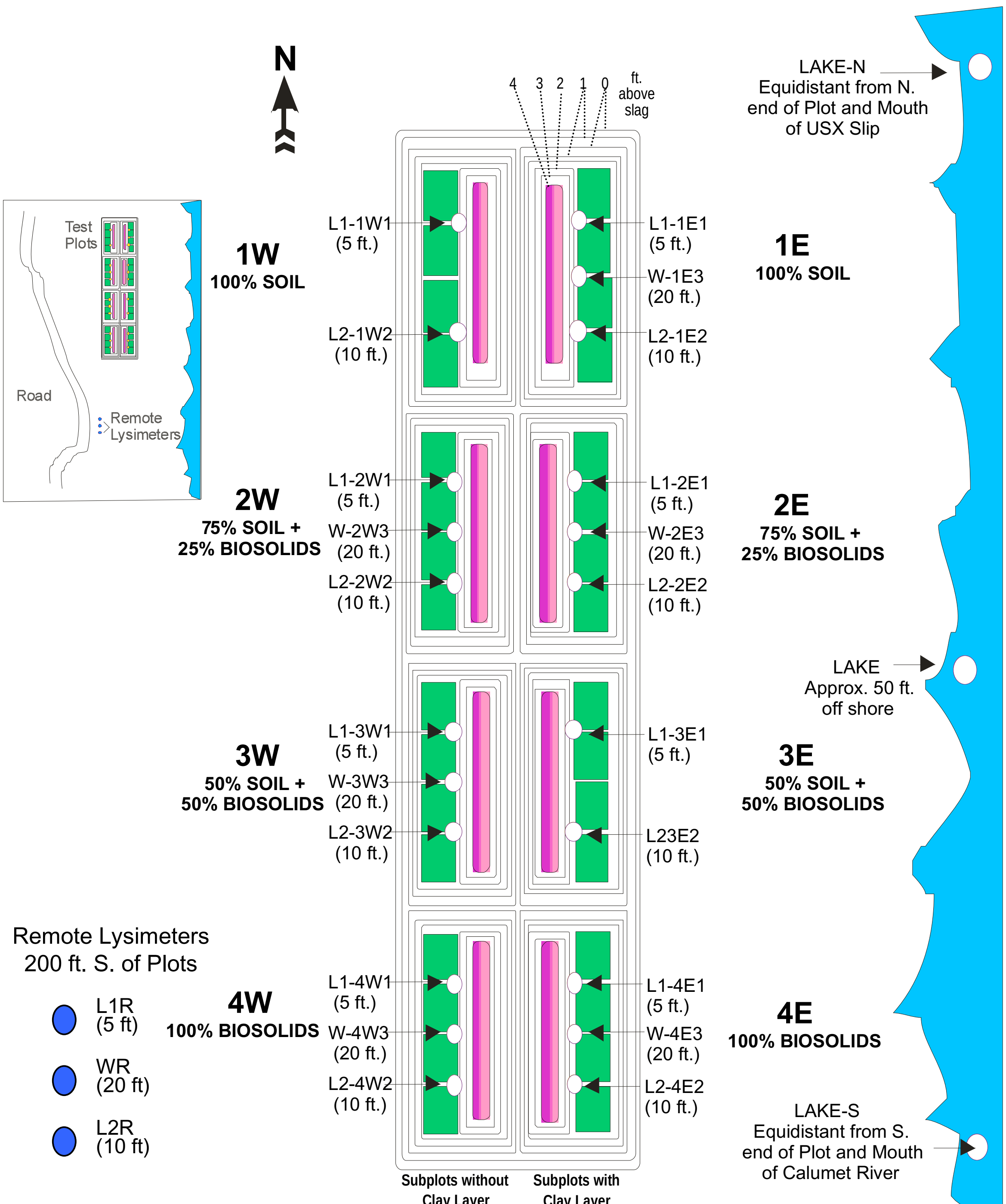


FIGURE 3: SCHEMATIC OF RESEARCH AND DEMONSTRATION PLOTS AT THE USX SITE



Letters L and W in groundwater sampling device designations represent lysimeters and observation wells.

Subsurface and Lake Water Quality Monitoring Devices

Prior to spreading the amendments, two lysimeters (5- and 10-ft deep) and one well (20- to 25-ft deep) were installed in each plot and at a remote location (approximately 200 ft south of the plots) for the purpose of monitoring the quality of subsurface water and groundwater at the site (Figure 3). The 20- to 25-ft depth below the slag surface is the static water level of Lake Michigan. Due to frequent obstructions encountered during drilling, wells could not be installed in the 0 percent biosolids nonlined plot and in the 50 percent biosolids clay-lined plot. Additionally, three sampling locations were designated in Lake Michigan at points approximately 50 ft off shore, as illustrated in Figure 3.

Vegetation Establishment

Four turfgrass blends, six shade trees, and five ornamental trees that are commonly used in the city and public parks were planted. Detailed descriptions of the turfgrass blends tested are presented in Table 2. In fall 2000, the four turfgrass blends were seeded as four separate subplots in each of the eight main plots.

The shade and ornamental trees were obtained from a local nursery by the CPD. A description of the tree species evaluated is presented in Table 2. The planting of trees was started in August 2000 and was completed during the fall of 2000. At the time of planting, the shade trees ranged in size from 1- to 2-inch caliper and the ornamental trees ranged in size from 4- to 6-ft clump. During the period of the study, weed control in the plots was done periodically by chemical, mechanical, and manual methods.

TABLE 2: TURFGRASS SEED MIXTURES AND ORNAMENTAL AND SHADE TREES USED AT THE USX RESEARCH AND DEMONSTRATION SITE

Turfgrass Seed Mixtures

Name	Acronym	Composition
Metropolitan Water Reclamation District of Greater Chicago	MWRDGC	70% Tall Fescue 30% Kentucky Bluegrass
Standard Chicago Park District Turf Blend	SCPD	70% Kentucky Bluegrass 15% Creeping Red Fescue 10% Perennial Rye 5% Redtop
Illinois Department of Transportation	IDOT 1B	75% Tall Fescue 15% Perennial Rye 10% Creeping Red Fescue
Variation of Illinois Department of Transportation Lawn Mixture	VIDOT1	50% Perennial Rye 30% Kentucky Bluegrass 20% Creeping Red Fescue

Ornamental and Shade Trees

Botanical Name	Common Name	Size	Classification
Acer ginnala	Amur Maple	6’ clump	Ornamental Tree
Acer x *freemanii* “Marmo”	Marmo Hybrid Maple	2” cal	Shade Tree
Amelanchier x *grandiflora*	Apple Serviceberry	4’-5’ clump	Ornamental Tree
Crataegus crusgalli inermis	Thornless Cockspur Hawthorn	1 3/4” cal	Ornamental Tree
Fraxinus americana “Autumn Purple”	Autumn Purple Ash	2” cal	Shade Tree
Gleditsia triacanthos inermis “Skyline”	Skyline Honey Locust	2” cal	Shade Tree
Malus “Donald Wyman”	Donald Wyman Crabapple	4’-5’ clump	Ornamental Tree
Malus zumi calocarpa	Zumi Crabapple	4’-5’ clump	Ornamental Tree
Populus deltoides “Siouxland”	Siouxland Cottonless Cottonwood	2” cal	Shade Tree
Quercus rubra	Red Oak	1 1/2” cal	Shade Tree
Ulmus x “Homestead”	Homestead Hybrid Elm	2” cal	Shade Tree

Vegetation Performance Evaluation

Turfgrass Performance. The turfgrass performance was evaluated using scores that were determined based on turf density and quality. Turf density was measured visually and scores ranging from 0 to 100 were assigned based on the thickness of the turfgrass, occurrence of bare spots, and the density of weeds. The higher the numbers of bare spots and the density of weeds, the lower the scores that were assigned. The highest scores were assigned to the plots with dense turf, no bare spots, and no weeds.

The turf quality was determined based on the color and overall appearance of the turfgrass. The turf color was measured by using the Munsell Color Chart for plant tissues, which defines colors by assigning a code for the hue (the predominant basic color) and a ratio of two numbers (for example 7/8) to represent the value (lightness or darkness) and chroma (color intensity). Turfgrass color ranged from light green, i.e., 7.5 GY (7/8 to 7/10) to dark green, i.e., 7.5 GY (5/4 to 5/8), and was assigned scores ranging from 0 to 100. The dark green color was assigned the highest score and the scoring decreased as the turfgrass color approached pale yellow.

The overall performance evaluation scores for turfgrass were calculated by using a weighted sum of the turf density and quality scores. Weighting factors of 0.75 and 0.25 were assigned to turf density and turf quality, respectively. Therefore, the overall performance scores were calculated as follows:

$$\text{Overall Performance Score} = \text{Density score} \times 0.75 + \text{Quality Score} \times 0.25$$

The turfgrass performance was rated based on the overall performance scores as follows:

Excellent – Greater than 70

Good – 55 to 70

Poor – 30 to 55

Very Poor – Less than 30

Tree Growth. Tree growth was determined by measuring tree height and trunk diameter. The trunk diameter was measured at breast height (approximately 4.5 feet). The overall performance of each tree species was evaluated by using a growth index which was calculated as:

Growth Index = height (ft) x trunk diameter (ft)

Sampling and Analysis of Amendments, Plant Tissue, and Water

Sampling and Analysis of Amendments. Immediately after placing the amendments on the plots in 2000 and in the spring and fall during 2001 to 2003, samples of the amendments were collected from the turfgrass plots. The samples were collected at the 0- to 6-inch and the 6- to 10-inch depths. A representative sample was obtained for each depth by collecting and compositing 10 cores from the entire plot. In spring, composite samples were collected from within each subplot of each of the four amendments for the clay-lined and for the nonlined plots. In the fall, a soil sample was collected that was a composite of all four subplots within each of the four amendments.

The samples of the amendments were air-dried, ground with a pestle and a mortar, passed through a 2-mm sieve, and stored in capped glass jars for chemical analyses. The samples were analyzed for the following parameters:

- 1:2 solid-to-water extract – pH, EC, NH_3-N, NO_3-N, and SO_4-S.

- 1:10 solid-to-1M KCl extract – NH_3-N and NO_3-N.

- Total Kjeldahl digests – Total Kjeldahl nitrogen (TKN) and total P.

- Bray P1 available P (1:7.5 solid-to-solution ratio; 5 min. shaking).

- 1M ammonium acetate exchangeable bases – K, Ca, Mg, and Na.

In addition, the 0- to 6-inch depth samples collected in the fall were analyzed for organic carbon (OC) (Walkley-Black wet oxidation) and total trace metals (concentrated nitric acid digestion).

Plant Tissue Sampling and Analysis. The turfgrass tissue samples were collected in spring and fall every year from 2001 through 2003 by clipping four, 1-ft^2 areas in each subplot to a height of one inch above the soil surface. Leaf tissue samples were collected from each tree in fall of every year from 2001 through 2003 by plucking some of the mature and healthy leaves.

All plant tissue samples were washed in distilled-deionized water and a mild phosphate-free detergent to remove adhering particulate matter, dried at 65°C, then ground in a Wiley mill to pass a 2-mm screen. The ground samples were stored in capped glass jars for chemical analyses. All plant tissue samples were analyzed as follows:

- N and P – Total Kjeldahl digestion

- Total trace metals – Concentrated nitric acid digestion

Subsurface and Lake Water Sampling and Analysis. Water samples from the lysimeters, wells, and three sampling locations from Lake Michigan were collected on a monthly basis starting in June 2000 through June 2003 and on a bimonthly basis from August through

December 2003. The legend for coding the groundwater monitoring and lake sampling locations is shown in Figure 3.

The water samples were analyzed for pH, EC, TSS, Cl, SO_4, TKN, NO_3-N, NH_3-N, Total P, alkalinity, hardness, nine trace metals (As, Cd, Cr, Cu, Hg, Ni, Pb, Sb, and Zn), and fecal coliform counts.

From August 2000 through November 2003, additional water samples were collected on a quarterly basis for analysis of 111 organic compounds designated as priority pollutants by the United States Environmental Protection Agency (USEPA). Due to the small sample volumes obtained from the lysimeters, the water samples were composited for the analysis of the organic compounds. For each lysimeter depth and the wells, samples from the plots and remote location were composited to produce a total of nine samples at each sampling event. The three composited samples for each depth consisted of samples from all 0 percent biosolids amendments and remote location, all 25, 50 and 100 percent biosolids amendments (Table 3). The list of the organic compounds analyzed is presented in Table 4. The MDLs for the organic compounds are also included in the table because the MDLs changed during the study period. The organic compounds analysis was conducted by the District's Organic Compounds Laboratory (formerly, the Toxic Substances Laboratory).

Statistical Analysis

All data collected were first tested for normality using the Kolmogorov-Smirnov test (SAS, 1995). For each parameter, if the Kolmogorov-Smirnov test indicated that the data was normally distributed, then Bartlett's test or F-test (Walpole and Meyers, 1989) was used to test the equality of variances. Standard analysis of variance (ANOVA) was performed if the data met the

TABLE 3: DESCRIPTION OF COMPOSITE SAMPLES FOR ANALYSIS OF ORGANICS IN WATER COLLECTED FROM LYSIMETERS AND WELLS AT THE USX SITE DURING 2000 THROUGH 2003

Composite ID	Composite Description
L11E1WR	5-ft lysimeters in clay-lined and nonlined 0% biosolids plots and at the remote location
L12E2W	5-ft lysimeters in clay-lined and nonlined 25% biosolids plots
L13E3W4E4W	5-ft lysimeters in clay-lined and nonlined 50% and 100% biosolids plots
L21E1WR	10-ft lysimeters in clay-lined and nonlined 0% biosolids plots and at the remote location
L22E2W	10-ft lysimeters in clay-lined and nonlined 25% biosolids plots
L23E3W4E4W	10-ft lysimeters in clay-lined and nonlined 50% and 100% biosolids plots
W1ER	Wells in clay-lined 0% biosolids plots and at the remote location
W2E2W	Wells in clay-lined and nonlined 25% biosolids plots
W3W4E4W	Wells in nonlined 50% biosolids plot and clay-lined and nonlined 100% biosolids plots

TABLE 4: LIST AND REPORTING LIMITS OF ORGANIC PRIORITY POLLUTANTS ANALYZED IN COMPOSITE WATER SAMPLES COLLECTED QUARTERLY FROM LYSIMETERS AND WELLS AT THE USX RESEARCH AND DEMONSTRATION SITE DURING 2000 THROUGH 2003

Compound	ReportingLimit, µg/L (ppb)			
	2000	2001	2002	2003
Volatile Organic Compounds				
Acrolein	33	33	33	33
Acrylonitrile	2	2	2	2
Benzene	2	2	2	2
Bromoform	2	2	2	2
Carbon tetrachloride	2	2	2	2
Chlorobenzene	2	2	2	2
Chlorodibromomethane	2	2	2	2
Chloroethane	4	4	4	4
2-Chloroethylvinyl ether	2	2	2	2
Chloroform	2	2	2	2
Dichlorobromomethane	1	1	2	2
1,1-Dichloroethane	2	2	2	2
1,2-Dichloroethane	2	2	2	2
1,1-Dichloroethylene	1	1	3	3
1,2-Dichloropropane	2	2	2	2
1,3-Dichloropropene	1	1	2	2
Ethyl benzene	2	2	2	2
Methyl bromide	8	8	3	3
Methyl chloride	3	3	3	3
Methylene chloride	2	2	2	2
1,1,2,2 Tetrachloroethane	3	3	3	3
Tetrachloroethylene	2	2	2	2
Toluene	2	2	2	2
1,2-trans Dichloroethylene	1	1	2	2
1,1,1-Trichloroethane	1	1	2	2
1,1,2-Trichloroethane	2	2	2	2
Trichloroethylene	2	2	2	2
Vinyl chloride	3	3	3	3
Trichlorofluoromethane	4	4	4	4

TABLE 4 (CONTINUED): LIST AND REPORTING LIMITS OF ORGANIC PRIORITY POLLUTANTS ANALYZED IN COMPOSITE WATER SAMPLES COLLECTED QUARTERLY FROM LYSIMETERS AND WELLS AT THE USX RESEARCH AND DEMONSTRATION SITE DURING 2000 THROUGH 2003

Compound	ReportingLimit, µg/L (ppb)			
	2000	2001	2002	2003
Acid Extractable Compounds				
2-Chlorophenol	3	3	7	7
2,4-Dichlorophenol	3	3	4	4
2,4-Dimethylphenol	4	4	3	3
4,6-Dinitro-o-cresol	17	17	29	29
2,4-Dinitrophenol	20	20	28	28
2-Nitrophenol	2	2	4	4
4-Nitrophenol	12	12	22	22
Parachlorometacresol	3	3	4	4
Pentachlorophenol	13	13	15	15
Phenol	1	1	4	4
2,4,6-Trichlorophenol	3	3	6	6
Base/Neutral Extractable Compounds				
Acenaphthene	2	2	4	4
Acenaphthylene	2	2	5	5
Anthracene	1	1	3	3
Benzidine	12	12	26	26
Benzo(a)anthracene	3	3	3	3
Benzo(a)pyrene	2	2	2	2
3,4-Benzofluoranthene	2	2	2	2
Benzo(ghi)perylene	2	2	2	2
Benzo(k)fluoranthene	2	2	2	2
Bis(2-chloroethoxy)methane	6	6	6	6
Bis(2-chloroethyl)ether	6	6	6	6
Bis(2-chloroisopropyl)ether	6	6	6	6
Bis(2-ethylhexyl)phthalate	50	50	50	50
4-Bromophenyl phenyl ether	4	4	4	4
Butylbenzyl phthalate	4	4	4	4
2-Chloronaphthalene	4	4	4	4
4-Chlorophenyl phenyl ether	4	4	4	4
Chrysene	2	2	2	2
Dibenzo(a,h)anthracene	2	2	2	2
1,2-Dichlorobenzene	4	4	4	4

TABLE 4 (CONTINUED): LIST AND REPORTING LIMITS OF ORGANIC PRIORITY POLLUTANTS ANALYZED IN COMPOSITE WATER SAMPLES COLLECTED QUARTERLY FROM LYSIMETERS AND WELLS AT THE USX RESEARCH AND DEMONSTRATION SITE DURING 2000 THROUGH 2003

Compound	ReportingLimit, µg/L (ppb)			
	2000	2001	2002	2003
1,3-Dichlorobenzene	4	4	4	4
1,4-Dichlorobenzene	4	4	4	4
3,3'-Dichlorobenzidine	11	11	11	11
Diethyl phthalate	6	6	6	6
Dimethyl phthalate	4	4	4	4
Di-n-butyl phthalate	5	5	5	5
2,4-Dinitrotoluene	4	4	4	4
2,6-Dinitrotoluene	4	4	4	4
Di-n-octyl phthalate	6	6	6	6
1,2-Diphenylhydrazine	4	4	4	4
Fluoranthene	2	2	2	2
Fluorene	4	4	4	4
Hexachlorobenzene	4	4	4	4
Hexachlorobutadiene	5	5	5	5
Hexachlorocyclopentadiene	50	50	50	50
Hexachloroethane	4	4	4	4
Indeno(1,2,3-cd)pyrene	2	2	2	2
Isophorone	6	6	6	6
Naphthalene	5	5	5	5
Nitrobenzene	8	8	8	8
N-Nitrosodimethylamine	5	5	5	5
N-Nitrosodi-n-propylamine	6	6	6	6
N-Nitrosodiphenylamine	4	4	4	4
Phenanthrene	2	2	2	2
Pyrene	2	2	2	2
1,2,4-Trichlorobenzene	4	4	4	4
<u>Pesticides & PCBs</u>				
Aldrin	0.06	0.06	0.03	0.03
a-BHC-alpha	0.06	0.06	0.03	0.03
b-BHC-beta	0.07	0.07	0.03	0.03
BHC-gamma	0.06	0.06	0.03	0.03
BHC-delta	0.06	0.06	0.03	0.03
Chlordane	0.3	0.3	0.3	0.3
4,4'-DDT	0.09	0.09	0.03	0.03

TABLE 4 (CONTINUED): LIST AND REPORTING LIMITS OF ORGANIC PRIORITY POLLUTANTS ANALYZED IN COMPOSITE WATER SAMPLES COLLECTED QUARTERLY FROM LYSIMETERS AND WELLS AT THE USX RESEARCH AND DEMONSTRATION SITE DURING 2000 THROUGH 2003

Compound	ReportingLimit, µg/L (ppb)			
	2000	2001	2002	2003
4,4'-DDE	0.06	0.06	0.03	0.03
4,4'-DDD	0.08	0.08	0.03	0.03
Dieldrin	0.06	0.06	0.03	0.03
a-Endosulfan-alpha	0.06	0.06	0.03	0.03
b-Endosulfan-beta	0.06	0.06	0.03	0.03
Endosulfan sulfate	0.06	0.06	0.03	0.03
Endrin	0.06	0.06	0.06	0.06
Endrin aldehyde	0.09	0.09	0.03	0.03
Heptachlor	0.09	0.09	0.03	0.03
Heptachlor epoxide	0.06	0.06	0.03	0.03
PCB-1242	0.3	0.3	0.3	0.3
PCB-1254	0.3	0.3	0.3	0.3
PCB-1221	0.6	0.6	0.6	0.6
PCB-1232	0.4	0.4	0.4	0.4
PCB-1248	0.3	0.3	0.3	0.3
PCB-1260	0.3	0.3	0.3	0.3
PCB-1016	0.3	0.3	0.3	0.3
Total PCB	0.3	0.3	0.3	0.3
Toxaphene	1.0	1.0	1.0	1.0

assumptions of normality and equal variances across the treatment levels. Otherwise, the ANOVA was performed on the ranked data. If the ANOVA indicated that there were significant differences in means among the treatment levels, the Scheffe's F statistic was used for pair-wise comparison of treatment means. All statistical tests were performed at the 5 percent level of significance.

RESULTS AND DISCUSSION

Concentrations of Chemical Constituents in the Amendments

The amendments were sampled at the 0- to 6-inch and 6- to 10-inch depths immediately after amendments were applied in July 2000 and then in April (spring) and October (fall) during 2001 to 2003. For each treatment (main plot), samples were collected from each of the four turfgrass subplots in the spring sampling and as composites for each main plot in the fall sampling. Appendix AI contains nutrients and trace metals data for both depths for all the sampling events during 2000 through 2003. Statistical analysis of the data showed no significant difference for any parameter between the clay-lined and nonlined plots, indicating that the 6-inch clay loam layer that was placed beneath the amendments did not have any impact on any of the parameters evaluated. Therefore, the clay-lined and nonlined plots were used as treatment replicates for any further statistical analysis. The lack of significant impact of the 6-inch clay layer on the majority of the parameters measured is most likely due to the fact that the clay loam layer was not as thick or clayey as was originally intended. This can also be due to uneven spreading of the clay loam layer, which was closer to 3 inches than 6 inches in depth after compaction.

Fertility. The mean concentrations of nutrients and other soil fertility parameters in the 0- to 6-inch and 6- to 10-inch depths of the four amendments from 2000 to 2003 are presented in Table 5. Plant-available P, OC, and exchangeable bases were measured only in the 0- to 6-inch depth of the amendments. The results of the statistical pair-wise comparison showed that for almost all parameters, the treatment means were significantly different from each other.

pH. The mean pH at both depths was not statistically different ($p>0.05$) among the amendments, except that it was significantly lower ($p<0.05$) in the 100 percent biosolids amendment (Table 5).

TABLE 5: MEAN[1] CONCENTRATIONS OF NUTRIENTS AND SOIL FERTILITY PARAMETERS AT TWO DEPTHS IN FOUR AMENDMENTS OF SEDIMENT AND BIOSOLIDS MIXTURES IN THE USX RESEARCH AND DEMONSTRATION PLOTS DURING 2000 THROUGH 2003

Depth	Amendment	pH[2]	EC[2]	OC	Available P[3]	TKN[4]	NH_3-N[5]	NO_3-N[5]	SO_4-S[2]	Exchangeable Bases[6] Ca	Mg	K	Na
Inch	% Biosolids		dS/m	%	mg/kg								
0–6	0	7.4	0.28	2.3	23	1,574	2.7	2.5	207	3,339	621	328	113
	25	7.1	0.64	6.2	248	4,783	6.6	41.8	497	5,331	819	481	215
	50	7.3	0.83	8.1	247	6,769	9.8	53.9	535	6,389	820	601	243
	100	6.4	1.98	15.7	519	13,347	26.4	200.8	1,260	6,274	1,069	933	384
6–10	0	7.5	0.63	NA	NA	2,191	4.4	8.1	178	NA	NA	NA	NA
	25	7.3	0.97	NA	NA	4,806	5.0	31.9	302	NA	NA	NA	NA
	50	7.4	1.05	NA	NA	6,311	8.4	50.5	311	NA	NA	NA	NA
	100	6.5	2.79	NA	NA	13,356	55.6	192.4	661	NA	NA	NA	NA

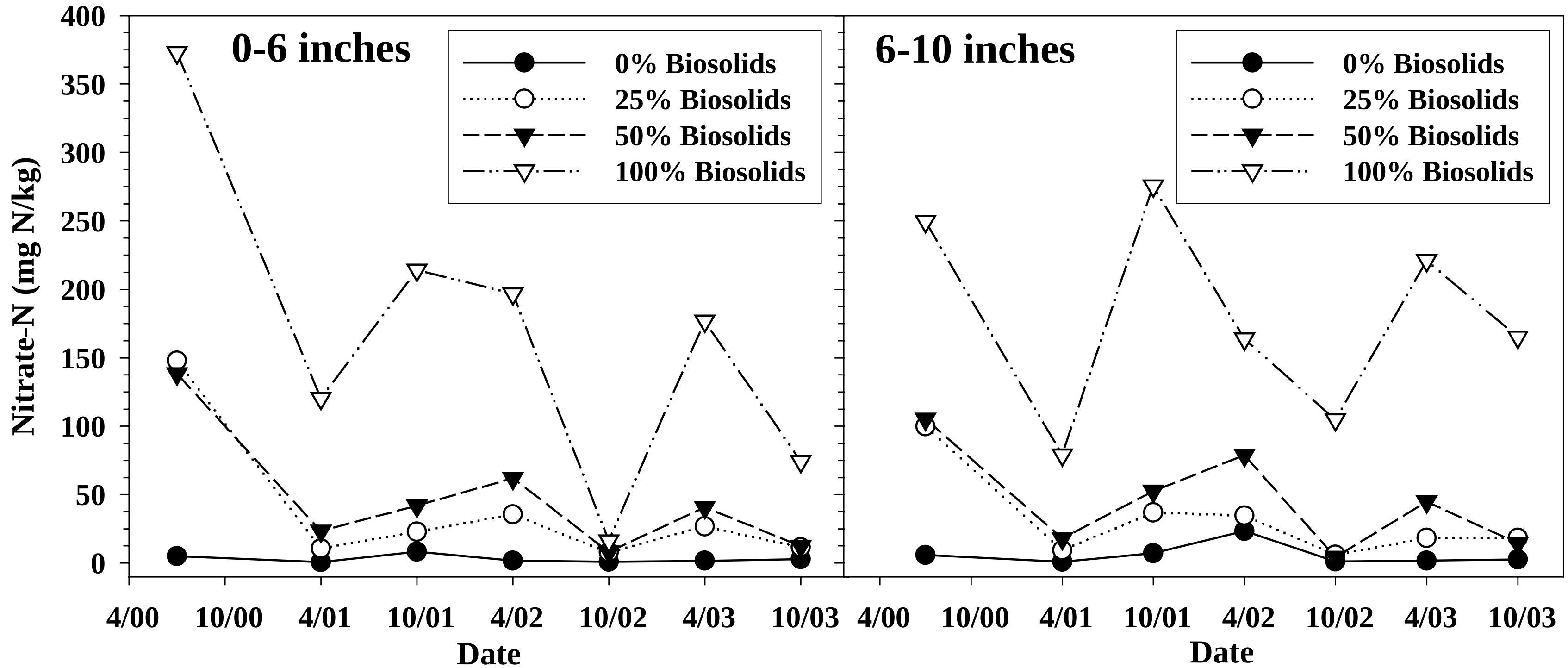
[1]Values are means of annual means of two replicate samples taken from clay-lined and nonlined plots for spring and fall samplings of 2000 through 2003.
[2]1:2 (soil:water) ratio.
[3]Bray P1 method.
[4]Total Kjeldahl nitrogen.
[5]1 M KCl extract, 1:10 (soil:solution) extract.
[6]1 M ammonium acetate, 1:10 (soil:solution) extract.
NA = No analysis.

The lower pH in the 100 percent biosolids amendment is most likely due to acidification associated with the higher amount of nitrification and organic matter mineralization in this amendment. In all the amendments, the pH values observed during the study were within the optimum range for plant growth (Soil and Plant Analysis Council, 1999).

Nitrogen. The mean concentrations of TKN, and KCl-extractable NH_3-N and NO_3-N at both depths in the amendments increased with the amount of biosolids in the amendment (Table 5). The mean concentrations in the 0- to 6-inch and 6- to 10-inch depths were similar, except that in the 100 percent biosolids amendment the mean concentration of NH_3-N in the 0- to 6-inch depth was lower than in the 6- to 10-inch depth. The statistical analysis showed that all amendments were significantly different ($p<0.05$), except that TKN and extractable NO_3-N concentrations in the 25 and 50 percent biosolids amendments, which were not significantly different. The high TKN levels in the biosolids-amended plots show that the addition of biosolids in amendments will provide a long-term supply of plant-available N as organic matter mineralizes over time.

Throughout the study, the water-extractable NO_3-N and the 1M KCl-extractable NO_3-N levels were similar and are equally useful for evaluating plant availability and the potential for NO_3-N mobility in the amendments. The concentrations of water-extractable NO_3-N over time are presented in Figure 4. In the amendments containing biosolids, especially in the 100 percent biosolids amendment, water-extractable NO_3-N concentrations were higher than in the 0 percent biosolids amendment. In the amendments containing biosolids, soluble NO_3-N concentrations decreased sharply after the initial sampling, then fluctuated afterwards, with the increases observed mostly in the spring sampling. The fluctuations are primarily due to seasonal variations affecting mineralization of organic matter and subsequent nitrification, plant N uptake, and

FIGURE 4: MEAN CONCENTRATIONS (CLAY-LINED AND NONLINED PLOTS) OF WATER-EXTRACTABLE NITRATE-N AT TWO DEPTHS IN FOUR AMENDMENTS OF SEDIMENT AND BIOSOLIDS MIXTURES IN THE USX RESEARCH AND DEMONSTRATION PLOTS DURING 2000 THROUGH 2003



leaching. In the 100 percent biosolids amendment, the concentrations of water-extractable NO_3-N, the predominant form of plant-available N under aerobic soil conditions, were high enough to meet the N nutritional needs of the turfgrass and trees for a long time. The concentrations of soluble NO_3-N (less than 5 mg N/kg) in the 0 percent biosolids amendments are too low to meet the N nutritional needs of the turfgrass and trees.

The concentrations of water-extractable NH_3-N are more reliable than 1M KCl-extractable NH_3-N for evaluating the potential for NH_3-N mobility in the amendments because the KCl-extractable NH_3-N consists of both water-extractable NH_3-N and NH_3-N held on soil exchange sites which cannot be easily leached. The water-extractable NH_3-N concentrations are presented in Figure 5. The concentrations of water-extractable NH_3-N were generally more than ten times lower than the water-extractable NO_3-N concentrations. Throughout the study, water-extractable NH_3-N at both depths in the 25 and 50 percent biosolids amendments remained below 5 mg N/kg. In the 100 percent biosolids amendment, water-extractable NH_3-N concentrations were higher in the 0- to 6-inch depth, and in the 6- to 10-inch depth there were very large seasonal fluctuations in the concentrations of NH_3-N.

Water-Extractable Sulfate and Electrical Conductivity. The mean concentrations of water-extractable SO_4-S over time are presented in Figure 6. The SO_4-S concentrations in the amendments containing biosolids were highest in the initial sampling in July 2000, then decreased and reached their lowest levels by spring 2001. The SO_4-S concentrations were always highest in the 100 percent biosolids treatment. The decrease in SO_4-S concentrations over time is due to leaching with percolating water.

FIGURE 5: MEAN CONCENTRATIONS (CLAY-LINED AND NONLINED PLOTS) OF WATER-EXTRACTABLE AMMONIA-N AT TWO DEPTHS IN FOUR AMENDMENTS OF SEDIMENT AND BIOSOLIDS MIXTURES IN THE USX RESEARCH AND DEMONSTRATION PLOTS DURING 2000 THROUGH 2003

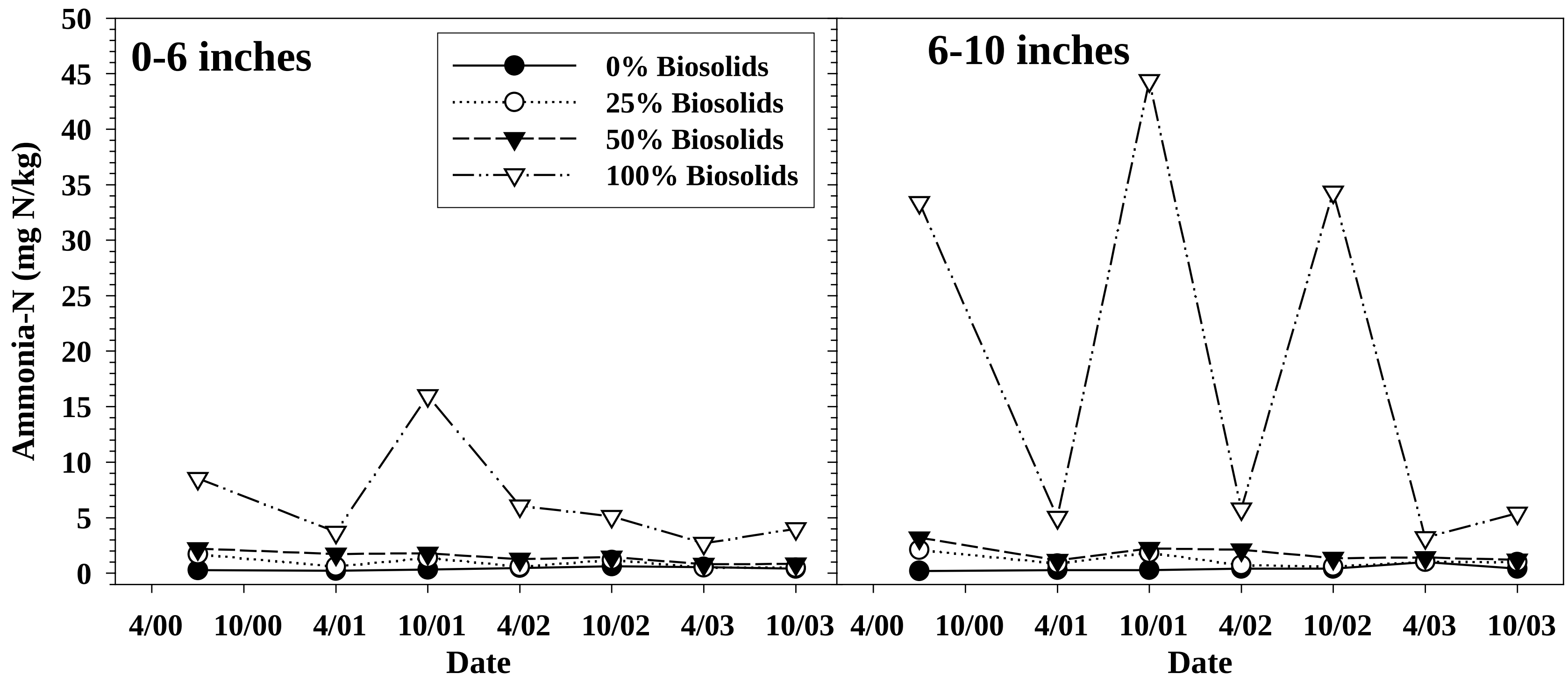
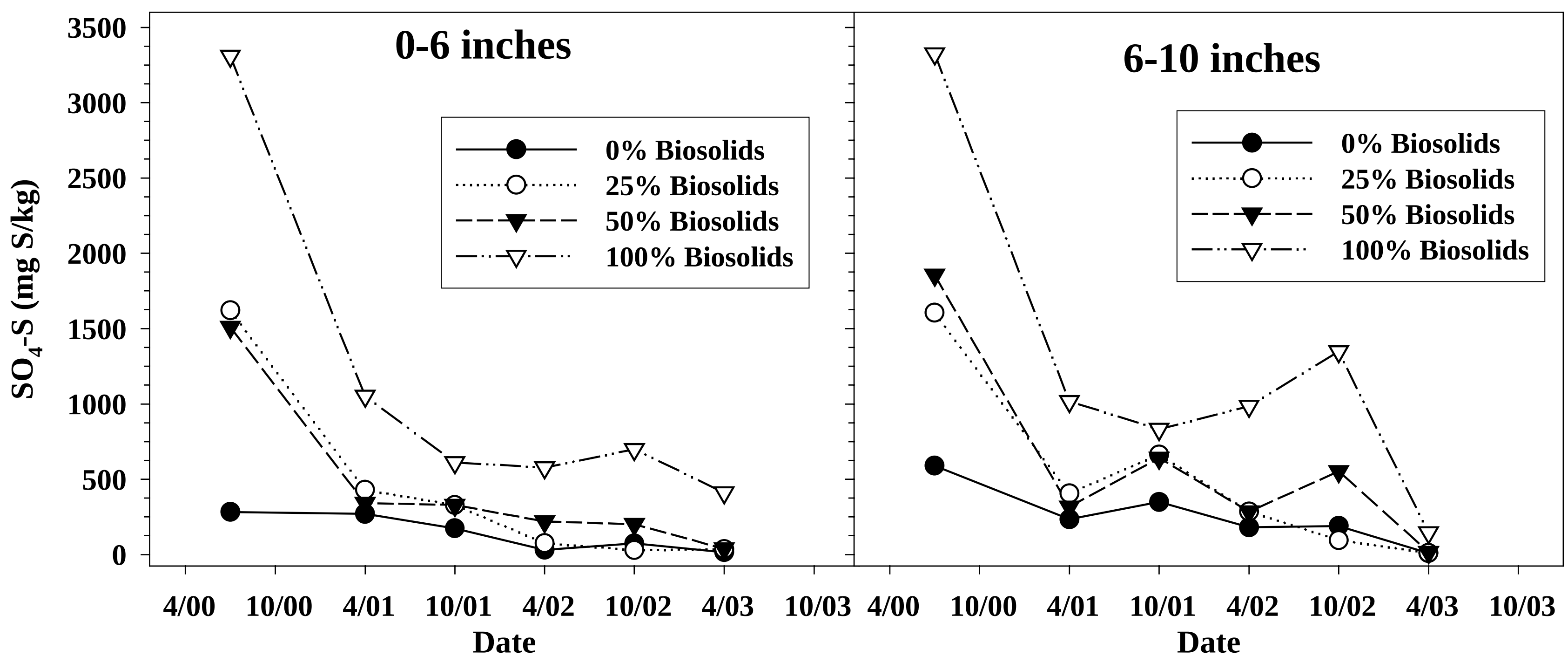


FIGURE 6: MEAN CONCENTRATIONS (CLAY-LINED AND NONLINED PLOTS) OF SULFATE-S (SO_4-S) AT TWO DEPTHS IN FOUR AMENDMENTS OF SEDIMENT AND BIOSOLIDS MIXTURES IN THE USX RESEARCH AND DEMONSTRATION PLOTS DURING 2000 THROUGH 2003

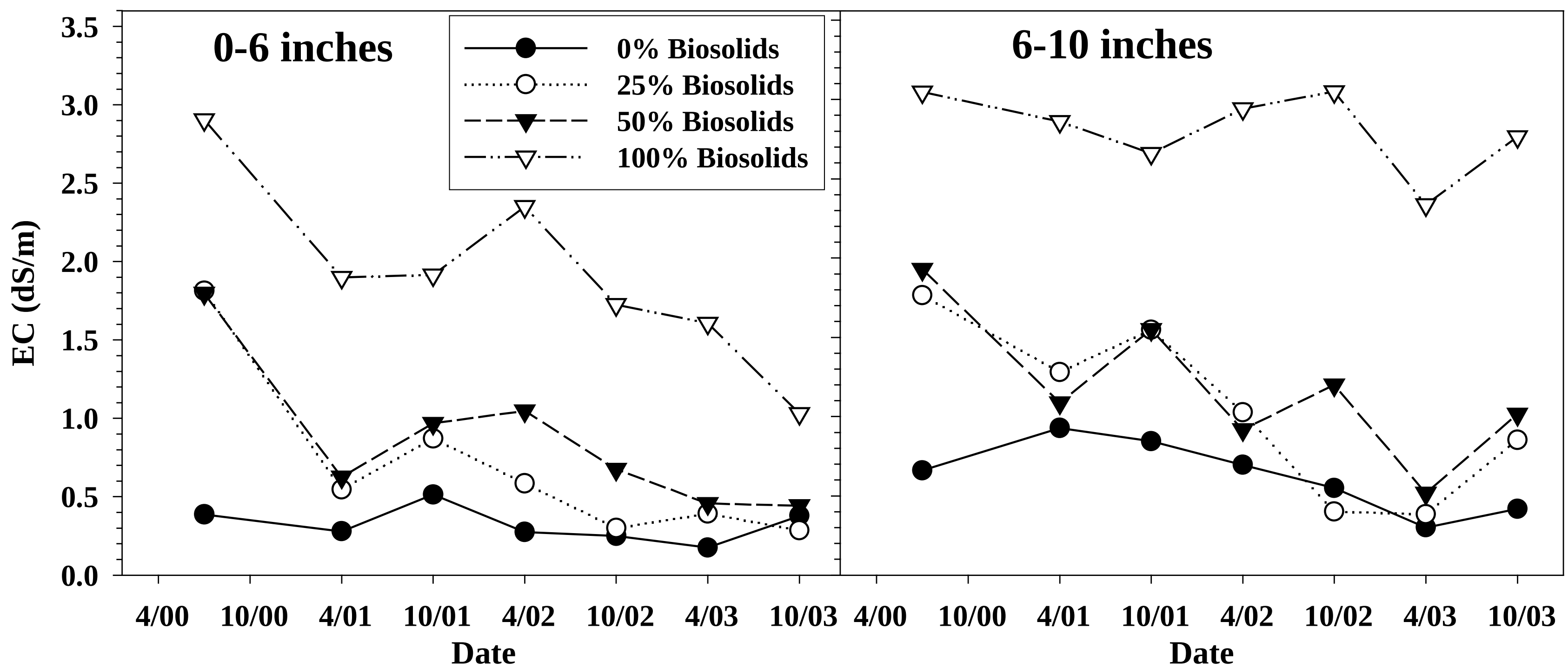


Throughout the study, EC in all amendments was higher at the 6- to 10-inch depth than in the 0- to 6-inch depth (Figure 7). This trend is consistent with leaching of soluble salts from the upper to the lower depths, but it does not correlate well with the concentrations of soluble NO_3-N (Figure 4), NH_3-N (Figure 5), and SO_4-S (Figure 6). At both soil depths, EC levels in all the amendments containing biosolids decreased with time. By the end of the study, the EC in the 0- to 6-inch depth of the 25 and 50 percent biosolids amendments were very similar to the EC in the 0 percent biosolids amendment. This shows that in the 25 and 50 percent biosolids amendments, the effect of biosolids on EC in the root zone is only temporary, because soluble salts leach down rapidly with percolating water. In the 100 percent biosolids amendment, the mineralization rate of organic matter is sufficiently high to result in NH_3-N and NO_3-N accumulation in excess of the amounts removed by plant uptake and leaching.

Plant-Available Phosphorus. Plant-available P was measured only in the 0- to 6-inch depth of the amendments. The mean concentrations of Bray P1 plant-available P in the amendments containing biosolids were much higher than the 0 percent biosolids amendment (Table 5). The levels in the 25 and 50 percent biosolids amendments were not statistically different. The mean concentration of 23 mg P/kg plant-available P in the 0 percent biosolids treatment is in the lower part of the range considered sufficient to meet P nutritional needs of plants. In the amendments containing biosolids, the high available P levels indicate that those amendments can sustain plant P nutrition for an extended period of time without additional P fertilization.

Organic Carbon. The OC content of the amendments increased consistently with the amount of biosolids in the amendment (Table 5). The OC content was significantly higher in all the amendments containing biosolids than in the 0 percent biosolids amendment. The higher OC

FIGURE 7: MEAN VALUES (CLAY-LINED AND NONLINED PLOTS) OF ELECTRICAL CONDUCTIVITY (EC) AT TWO DEPTHS IN FOUR AMENDMENTS OF SEDIMENT AND BIOSOLIDS MIXTURES IN THE USX RESEARCH AND DEMONSTRATION PLOTS DURING 2000 THROUGH 2003



content associated with the addition of biosolids in the amendments will increase retention and supply of nutrients and water in the root zone.

Exchangeable Bases. The mean concentrations of exchangeable bases tended to increase with the amount of biosolids in the amendment (Table 5). Except for exchangeable Ca, the mean concentrations of exchangeable bases among the amendments were statistically different ($p<0.05$). The mean concentration of exchangeable K in the 0 percent biosolids amendments is barely within the sufficiency range for plant K nutrition. Although the biosolids have relatively low fertilizer values for K, Ca, and Mg, at rates of 25 and 50 percent biosolids in the amendments, the loading rates are high enough to ensure the long-term supply of these nutrients.

Total Concentrations of Trace Metals. The mean total concentrations of trace metals in the 0- to 6-inch depth of the amendments during 2000 to 2003 are presented in Table 6. Statistical analysis of the data showed that the total concentrations of Zn, Cd, Cu, Pb and Mo increased significantly ($p<0.05$) with the proportion of biosolids in the amendments (Table 6). This is expected because the total concentrations of these trace metals are generally higher in the biosolids than in the sediment used in the amendments (Table 1). The results of pair-wise comparisons showed also that for these metals the amendments were statistically different from each other (data not shown). There was no consistent trend for Mn and Fe. The concentration of total Mn in the slag is much higher than the concentrations in the sediment or in the biosolids (Table 1) and might have affected the Mn concentration in some of the samples.

Generally, the total concentrations of metals did not change with time (data not shown), indicating that most of the metals remained in the amendments and very little was removed by uptake in the turfgrass or lost by leaching. Trace metal total concentration is generally not an indicator of

TABLE 6: MEAN[1] TOTAL CONCENTRATIONS OF TRACE METALS IN THE 0- TO 6-INCH DEPTH OF FOUR AMENDMENTS OF SEDIMENT AND BIOSOLIDS MIXTURES IN THE USX RESEARCH AND DEMONSTRATION PLOTS DURING 2000 THROUGH 2003

Amendment	Zn	Cd	Cu	Cr	Ni	Pb	Mn	Fe	Mo
% Biosolids	mg/kg								
0	88	1.1	27	43	24	28	574	15,097	0.7
25	472	4.1	121	135	32	61	987	17,969	3.4
50	647	5.7	201	244	35	76	1,850	19,711	5.6
100	1,255	10.7	332	187	36	136	659	19,348	10.1

[1]Values are the mean of values for two replicate samples taken from four subplots of the clay-lined and nonlined plots each year.

plant availability or potential for leaching losses because most of the metals are tightly bound to the inorganic phases of the amendments.

Vegetation Performance

Turfgrass Performance. Overall performance scores and ratings for the four turfgrass mixes evaluated are presented in Table 7. The turf performance data show that all amendments were effective in establishing turfgrass on slag (Figure 8). Annual performance scores and ratings for all turfgrass mixes are presented in Appendix AII. However, evaluation of the overall turf performance scores shows that all the four turfgrass mixes performed poorly in the plots amended with the sediment alone (0 percent biosolids) but the performance was excellent in the plots amended with mixtures of biosolids and sediment. The turf was healthier, greener, and more robust in the amendments containing biosolids. This is shown in an aerial photograph (Figure 9) taken on April 10, 2002 (available at http://terraserver.microsoft.com). The improved turfgrass performance in the amendments containing biosolids could be attributed primarily to the improved fertility (Table 5), water holding capacity and other physical properties in the root zone.

For all four amendments, all the turfgrass mixtures (except SCPD in the 25 percent plot) performed better in the clay-lined plots than in the nonlined plots. The better performance in the clay-lined plots could be attributed to the clay loam liner that must have improved moisture retention in the root zone by slowing water percolation, which is essential for establishing and sustaining turf during dry periods.

Tree Growth. The growth of the trees in the clay-lined and nonlined plots were similar (data not shown), indicating that the clay liner had no impact on the tree performance. The growth index values (aggregate for clay-lined and nonlined plots) for the five ornamental and six shade tree

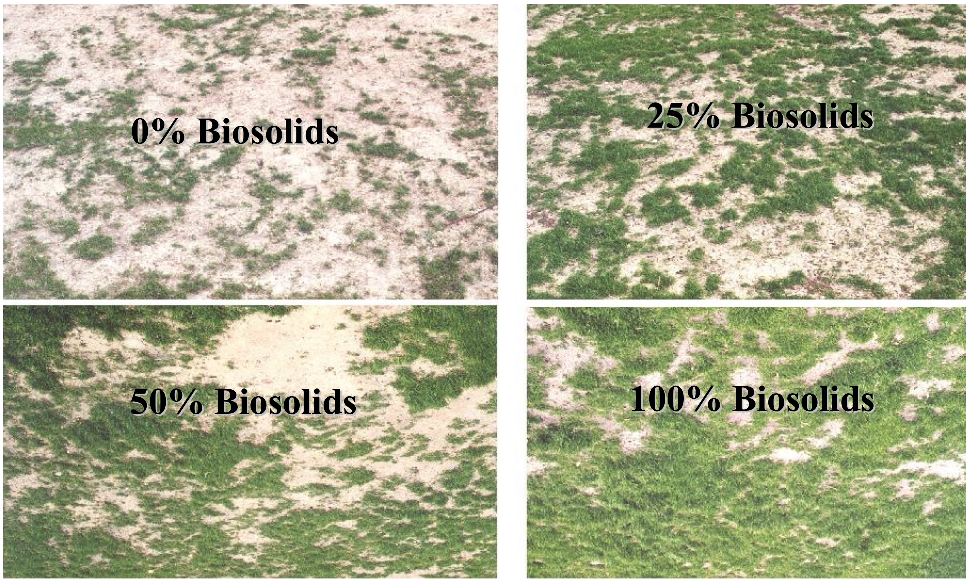
TABLE 7: OVERALL PERFORMANCE SCORES[1] AND RATING FOR THE FOUR TURFGRASS MIXES EVALUATED IN THE USX RESEARCH AND DEMONSTRATION PLOTS DURING 2001 THROUGH 2003

Amendment	Turfgrass Mix							
	MWRDGC[2]		SCPD[3]		IDOT[4]		VIDOT 1B[5]	
(% Biosolids)	Score	Rating	Score	Rating	Score	Rating	Score	Rating
Clay-Lined Plots								
0	42	Poor	44	Poor	48	Poor	51	Poor
25	75	Excellent	69	Good	70	Good	72	Excellent
50	75	Excellent	73	Excellent	74	Excellent	73	Excellent
100	76	Excellent	76	Excellent	77	Excellent	74	Excellent
Nonlined Plots								
0	53	Poor	52	Poor	49	Poor	51	Poor
25	73	Excellent	72	Excellent	60	Good	64	Good
50	61	Good	68	Good	56	Good	63	Good
100	65	Good	65	Good	69	Good	68	Good

[1]Overall Performance Score = Turf Density Score x 0.75 + Turf Color Quality Score x 0.25.
[2]MWRDGC = Metropolitan Water Reclamation District of Greater Chicago: 70% tall fescue, 30% Kentucky bluegrass.
[3]SCPD = Standard Chicago Park District turf mix: 70% tall fescue, 15% creeping red fescue, 10% Kentucky bluegrass, 5% redtop.
[4]IDOT 1B = Illinois Department of Transportation low maintenance turf mix: 75% tall fescue, 15% perennial rye, 10% creeping red fescue.
[5]VIDOT1 = Variation of Illinois Department of Transportation low maintenance lawn mix: 50% perennial rye, 30% Kentucky bluegrass, 20% creeping red fescue.

FIGURE 8: TURFGRASS PERFORMANCE IN FOUR AMENDMENTS OF SEDIMENT AND BIOSOLIDS MIXTURES IN THE USX RESEARCH AND DEMONSTRATION PLOTS

One month after seeding in summer 2000



Summer 2002

Late summer 2003

FIGURE 9: AERIAL PHOTOGRAPH OF THE USX RESEARCH AND DEMONSTRATION PROJECT SITE TAKEN ON APRIL 10, 2002 (http://terraserver.microsoft.com/cmap.aspx, accessed February 24, 2005)

species are presented in Table 8. The tree growth data show that all amendments were effective in establishing ornamental and shade trees on the slag materials (Figure 10). However, evaluation of the overall growth index values shows that all tree species performed relatively better in the plots amended with biosolids. The improved tree performance in the plots receiving biosolids could be attributed to improved fertility of the amendments with the addition of biosolids (Table 5).

All tree species grew rapidly during the evaluation period. Annual growth index values, trunk diameter, and height measurements for all trees are presented in Appendix AII. The data in Figures 11 and 12 show the increase in trunk diameter and height, respectively, of three ornamental trees from 2001 to 2003. During the two years, the trunk diameter and height of amur maple increased from 1.1 to 4.0 inch and from 5.4 to 7.8 ft, respectively. The rapid growth of three shade tree species is shown similarly in Figures 13 and 14. For example, the trunk diameter of cottonless cottonwood increased from 1.2 to 4.8 inch and the height increased from 9.9 to 25.0 ft during the two-year period.

Nutrients and Trace Metals in Turfgrass

Tissue samples of all four turfgrass blends were collected from all plots in the spring and fall during 2001 to 2003 for analysis of nutrients and trace metals. Appendix AIII contains nutrients and trace metals data for all turfgrass tissue samples collected during 2001 through 2003. For most of the parameters, except K and Cr, the ANOVA showed that there were no significant differences ($p>0.05$) between the clay-lined and nonlined plots throughout the study, indicating that the clay liner had no impact on the concentrations of these elements in the turfgrass tissues. Although, K and Cr concentrations were significantly different, there were no consistent trends in

TABLE 8: OVERALL GROWTH INDEX[1] VALUES FOR FIVE ORNAMENTAL AND SIX SHADE TREE SPECIES EVALUATED IN THE USX RESEARCH AND DEMONSTRATION PLOTS DURING 2001 THROUGH 2003

Tree Type	Amendment			
	0% Biosolids	25% Biosolids	50% Biosolids	100% Biosolids
Ornamental Trees				
Amur Maple	0.7	1.2	1.6	1.4
Apple Serviceberry[2]	0.4	0.6	1.0	0.7
Thornless Cockspur	1.1	1.0	1.4	1.8
Donald Wyman Crabapple	1.2	0.7	1.5	1.5
Zumi Crabapple	0.9	0.6	1.5	1.5
Shade Trees				
Hybrid Maple	1.3	1.8	2.0	1.8
Purple Ash	1.3	1.3	1.5	1.5
Honey Locust	1.8	1.8	2.5	2.3
Cottonless Cottonwood	3.7	5.3	4.8	5.1
Red Oak[3]	0.9	1.3	1.4	1.2
Hybrid Elm[2]	1.9	2.3	2.7	2.6

[1]Growth Index = Tree trunk diameter (ft) x tree height (ft). Values are mean of Growth Index values for 2001 through 2003.

[2]Growth Index values for the 50 and 100 percent biosolids amendments are based on two years data, because most of the apple serviceberry trees were severely damaged by wildlife in the winter 2002.

[3]Growth Index values for the 50 and 100 percent biosolids amendments are based on one year data, because most of the red oak trees were damaged by wildlife in the winter 2001.

FIGURE 10: APPEARANCE OF SHADE AND ORNAMENTAL TREES IN FOUR AMENDMENTS OF SEDIMENT AND BIOSOLIDS MIXTURES IN THE USX RESEARCH AND DEMONSTRATION PLOTS IN 2000 AND 2003

Shade and ornamental trees at the time of planting in summer 2000

Shade and ornamental trees in late summer 2003

FIGURE 11: CHANGE IN TRUNK DIAMETER OF THREE SPECIES OF ORNAMENTAL TREES IN FOUR AMENDMENTS OF SEDIMENT AND BIOSOLIDS MIXTURES IN THE USX RESEARCH AND DEMONSTRATION PLOTS FROM 2001 THROUGH 2003

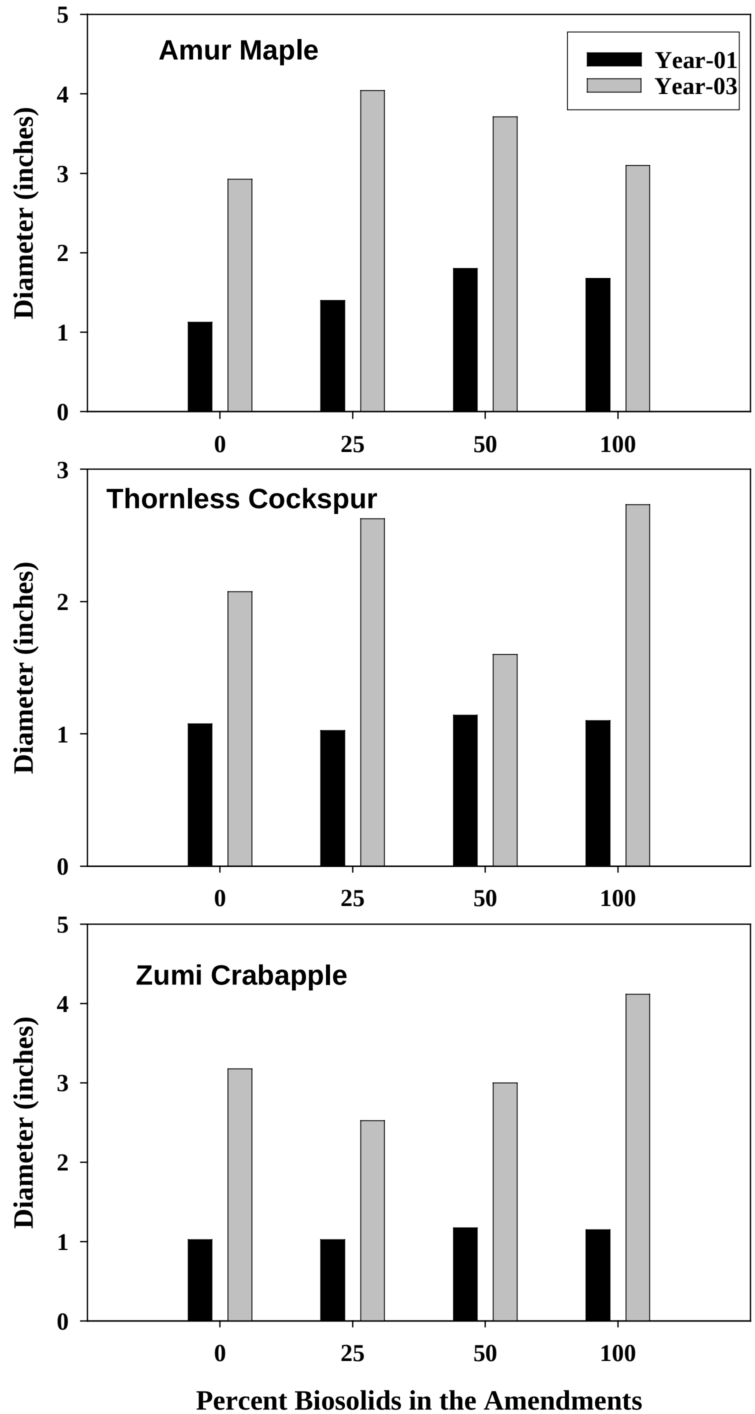


FIGURE 12: CHANGE IN HEIGHT OF THREE SPECIES OF ORNAMENTAL TREES IN FOUR AMENDMENTS OF SEDIMENT AND BIOSOLIDS MIXTURES IN THE USX RESEARCH AND DEMONSTRATION PLOTS FROM 2001 THROUGH 2003

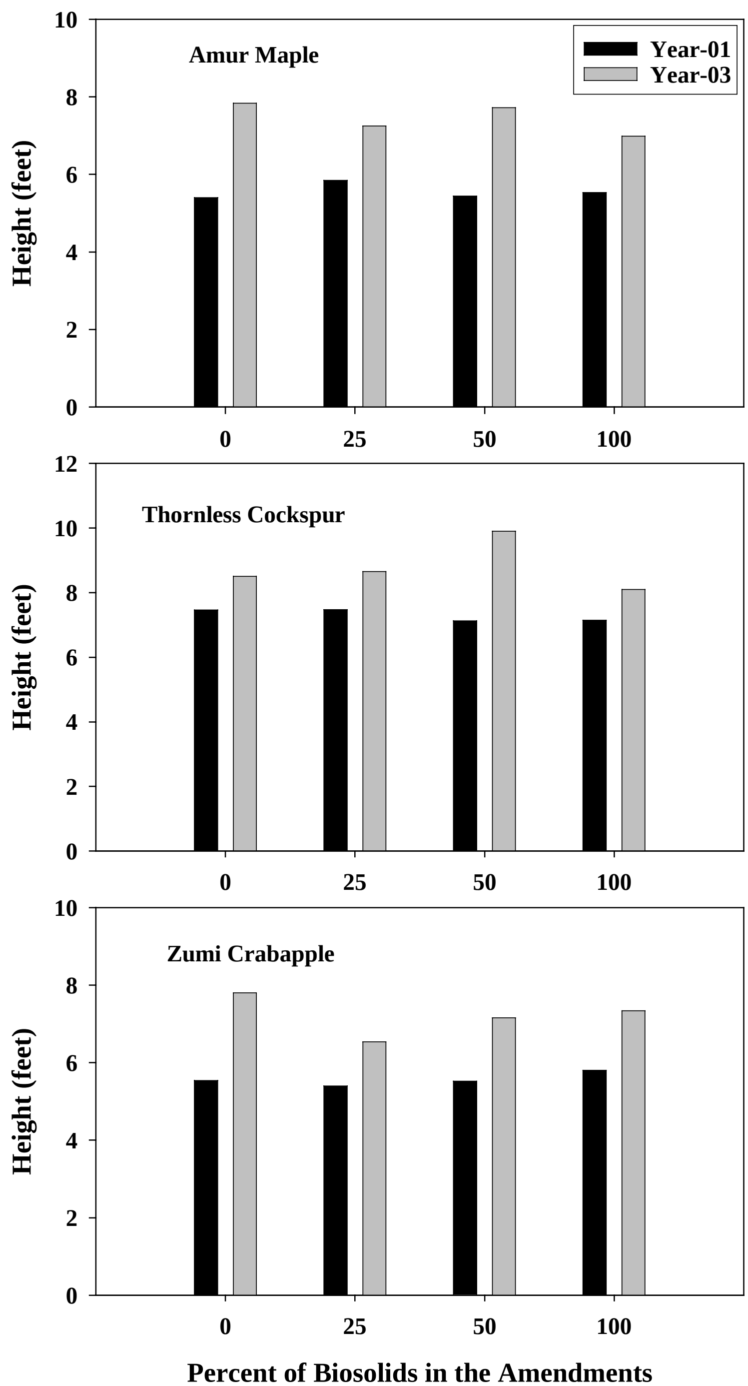


FIGURE 13: CHANGE IN TRUNK DIAMETER OF THREE SPECIES OF SHADE TREES IN FOUR AMENDMENTS OF SEDIMENT AND BIOSOLIDS MIXTURES IN THE USX RESEARCH AND DEMONSTRATION PLOTS FROM 2001 THROUGH 2003

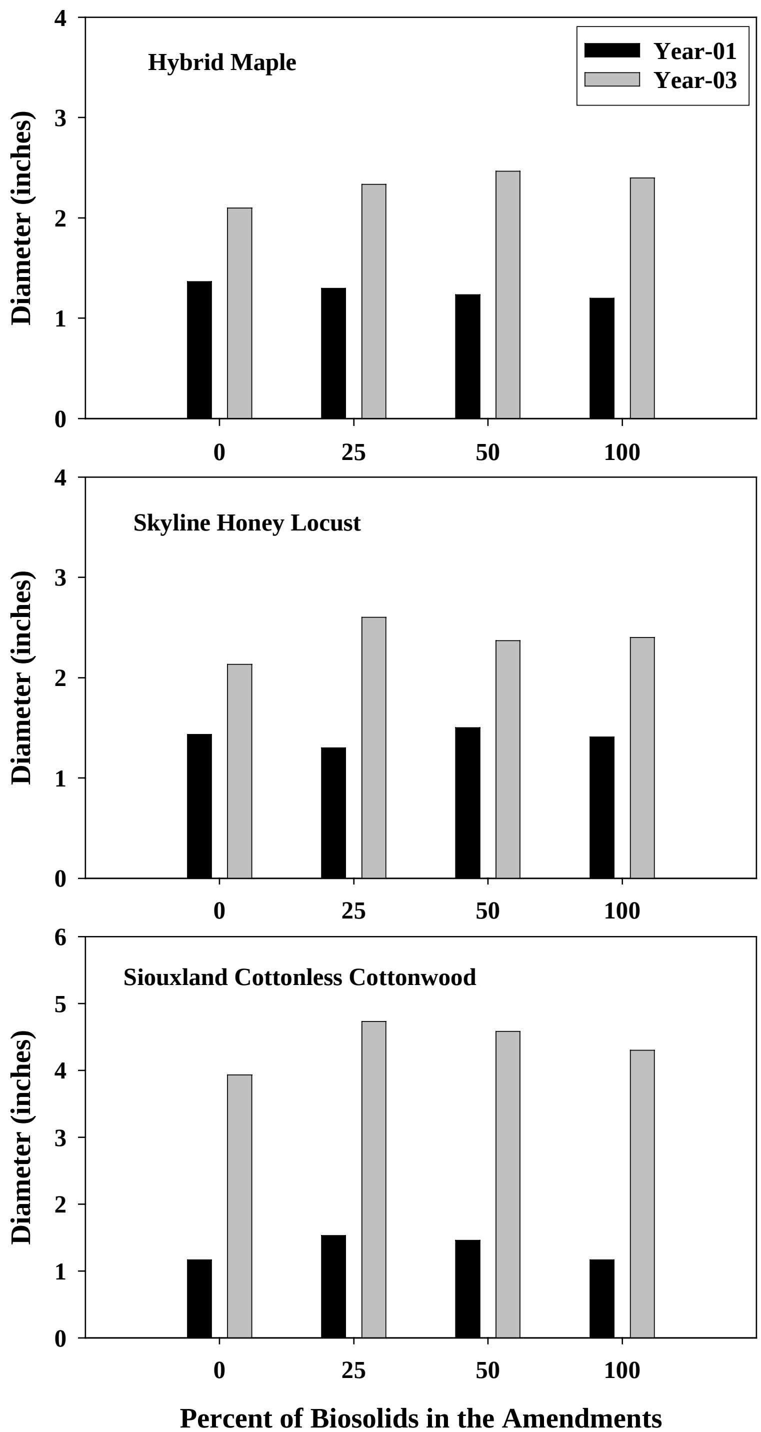
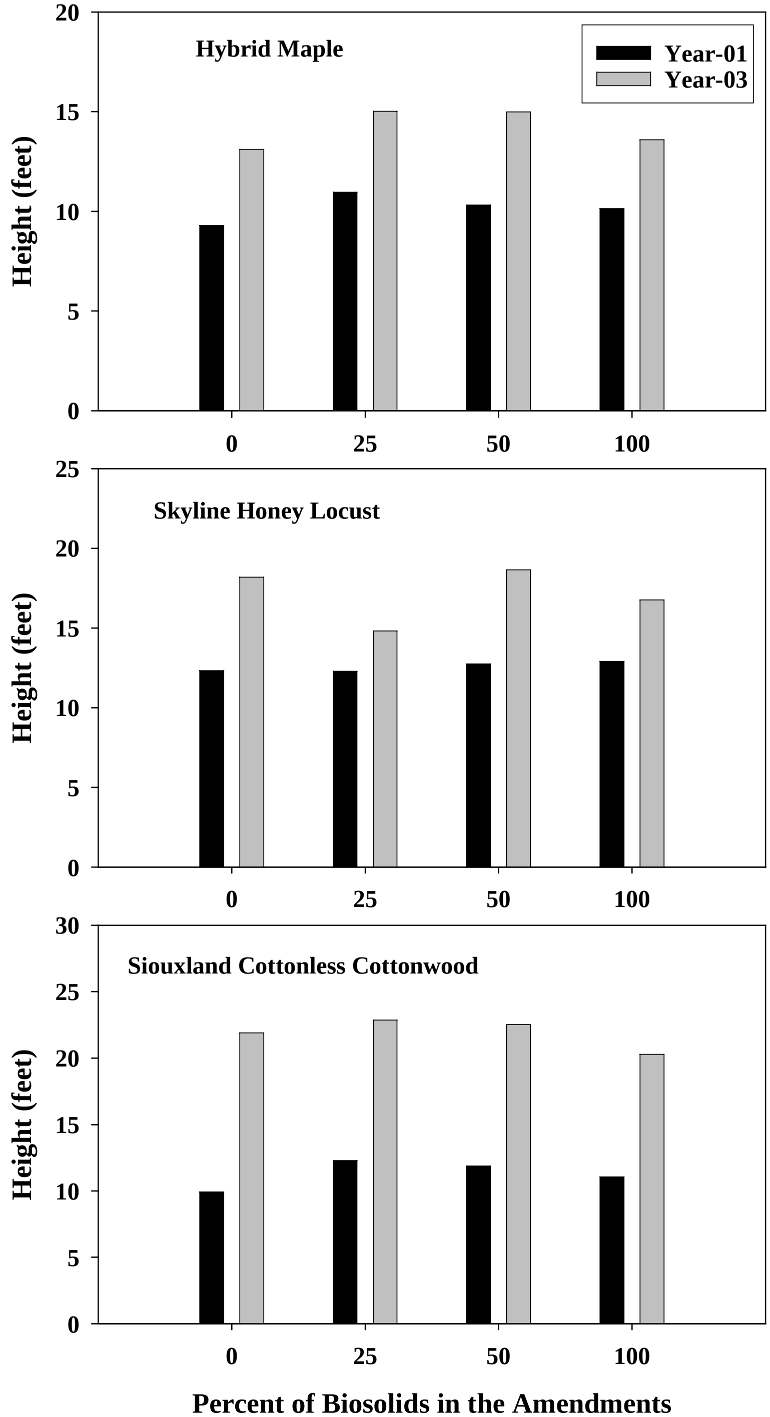


FIGURE 14: CHANGE IN HEIGHT OF THREE SPECIES OF SHADE TREES IN FOUR AMENDMENTS OF SEDIMENT AND BIOSOLIDS MIXTURES IN THE USX RESEARCH AND DEMONSTRATION PLOTS FROM 2001 THROUGH 2003



concentrations among the clay-lined and nonlined plots. Also, the concentrations did not change significantly with time. Therefore, the concentrations of nutrients and trace metals for each of the amendments were computed as the mean for all sampling events and for the clay-lined and non-lined plots.

Concentrations of Nutrients in Turfgrass Tissues. The concentrations of nutrient and trace metals in tissue samples of turfgrass mixes and the general nutrient sufficiency range for turfgrass (Cockerham and Miner, 2001; Plank, 2002) are presented in Table 9. The mean tissue N concentrations in the amendments containing biosolids (25, 50, and 100 percent) were similar and were higher than the concentrations in the 0 percent biosolids amendment, in which mean N concentration was 24,070 mg N/kg. The mean N concentrations in the turfgrass tissues for the amendments containing biosolids are above the general sufficiency range for turfgrass, but in the 0 percent biosolids amendment the mean N concentration was barely within the sufficiency range.

The mean tissue concentrations of all other nutrients for all amendments were either within or above the general sufficiency range for turfgrass (Table 9). The mean concentrations of P, K, S, and Na in the turfgrass tissues sampled from amendments containing biosolids were similar and somewhat higher than concentrations found in tissues from the 0 percent biosolids amendment. The higher concentrations of these nutrients in the turfgrass in the amendments containing bio-solids are most likely due to the higher amounts of these nutrients in the amendments containing biosolids compared to the 0 percent biosolids amendment (Table 5). These data show that N is most likely the primary nutrient responsible for better performance of turfgrass in the amend-ments containing biosolids.

TABLE 9: MEAN[1] CONCENTRATIONS OF NUTRIENTS AND TRACE METALS IN LEAF TISSUE OF FOUR TURFGRASS MIXES COLLECTED FROM THE USX RESEARCH AND DEMONSTRATION PLOTS DURING 2001 THROUGH 2003

Parameter	Amendment				Optimum	Toxicity
	0% Biosolids	25% Biosolids	50% Biosolids	100% Biosolids	Range[2]	Range[3]
	mg/kg					
N	24,135b[4]	42,480a	41,909a	44,632a	22,000 - 40,000	---
P	4,532a	4,603a	4,517a	4,857a	3,000 - 7,000	---
K	21,962c	28,129b	28,562b	32,312a	15,000 - 30,000	---
Ca	6,358a	4,984b	5,225b	4,913b	---	---
Mg	3,401a	3,470a	3,642a	3,828a	1,500 - 6,000	---
S	8,702b	9,409b	9,134b	10,395a	2,000 - 4,000	---
Na	57b	168a	156a	157a	---	---
Fe	141a	95b	106b	133a	30 - 200	---
Mn	94b	49c	54c	133a	20 - 300	---
Zn	35c	62b	69b	111a	15 - 70	100 - 400
Cu	7.6c	14.0b	14.7b	19.0a	5 - 20	20 - 100
Mo	8.6a	6.6b	6.1b	7.6b	0.2 - 5.05	10 - 50
Cd	0.12c	0.18bc	0.25b	0.47a	0.05 - 0.25	5 - 30
Cr	0.96a	0.56b	0.68b	0.69b	0.1 - 0.55	5 - 30
Ni	1.7d	2.1c	2.8b	6.9a	0.1 - 55	10 - 100
Pb	1.1a	0.55b	0.45b	0.54b	5 - 10	30 - 300

[1]Values are the mean of composite tissue samples of four turf blends taken in 2001 through 2003 from clay-lined and nonlined plots.
[2]Data from Kabata-Pendias, 2001.
[3]Data from Cockerham and Miner, 2001; Plank, 2002.
[4]Values of each parameter followed by the same letter are not significantly different at the 0.05 level of probability.
---Value not available.

Concentrations of Trace Metals in Turfgrass Tissues. The mean concentrations of trace metals in the turfgrass tissues are presented in Table 9. The ranges of trace metal concentrations in plant vegetative tissues generally considered normal and concentrations considered potentially phytotoxic (Kabata-Pendias, 2001) are also included in Table 9 as a reference. The mean concentrations of Cd, Cu, Ni, and Zn in the turfgrass increased with increasing amounts of biosolids in the amendments (Table 9). There were no trends in the mean concentrations of Mo or Pb, but the concentrations in the 0 percent biosolids amendment tended to be higher than the concentrations found in the amendments containing biosolids. These relationships indicate that although the concentrations of Mo and Pb were higher in the biosolids than in the sediments (Table 1), this did not result in increased concentrations of these metals in the turfgrass grown in the amendments containing biosolids. The Zn and Cu concentrations in the turfgrass tissues from all amendments were within or above the normal range (Table 9).

Nutrients and Trace Metals in Trees

The shade tree species grown in the amendments included marmo hybrid maple (*Acer x freemanii*), autumn purple ash (*Fraxinus americana*), skyline honey locust (*Gleditsia triacanthos inermis*), Siouxland cottonless cottonwood (*Populus deltoides*), red oak (*Quercus rubra*), and Homestead hybrid elm (*Ulmus x* “Homestead”). The ornamental tree species were amur maple (*Acer ginnala*), apple serviceberry (*Amelanchier x grandiflora*), thornless cockspur hawthorn (*Crataegus crusgalli inermis*), Donald Wyman crabapple (*Malus*), and zumi crabapple (*Malus zumi calocarpa*). Composite leaf tissue samples of each tree species were collected every fall during 2001 to 2003 and analyzed for nutrient and trace metal contents. Appendix AIII contains nutrients and trace metals data for all tree tissue samples collected during 2001 to 2003. The mean concentrations of nutrients and trace metals in the leaves of the shade and ornamental trees are presented in Table 10. The mean tissue concentrations of nutrients and trace metals in samples of some shade and ornamental trees collected from parks in the City are also included in Table 10 for reference. Statistical analysis of the data showed that the chemical composition of both shade and ornamental tree species were similar ($p>0.05$) for the clay-lined and nonlined plots. Therefore, the mean concentrations were computed by combining the data from both the clay-lined and nonlined plots.

Concentrations of Nutrients. Generally, the mean leaf tissue concentrations of major plant nutrients such as N and P in the shade tree species tended to increase with the amount of biosolids in the amendments (Table 10). The mean concentrations of K, Ca, S and Zn were highest in the leaves of shade tree species grown in the 100 percent biosolids amendment but the concentrations were similar in the leaves collected from the other amendments. The mean concentrations of Na increased with the amount of biosolids in the amendments. The results show that concentrations of N and P in the shade tree species responded to the N and P addition associated with the biosolids amendments. Except for Mg, which was unusually low in all the samples collected from parks in Chicago, the concentrations of most of the nutrients analyzed were similar to the concentrations observed in the trees grown in the research and demonstration plots.

In the ornamental tree species, mean tissue N concentrations increased slightly with the amount of biosolids in the amendment, and P and S concentrations increased with the amount of biosolids from the 25 to 100 percent biosolids amendments. There was no trend in ornamental tree tissue concentrations of K, Na, Ca, and Mg among the amendments. However, the tissue concentrations of S were significantly higher for the 50 and 100 percent biosolids amendments. Overall, the concentrations of N, P, K, and Zn in the leaves of ornamental tree species were

TABLE 10: MEAN[1] CONCENTRATIONS OF NUTRIENTS AND TRACE METALS IN LEAF TISSUE OF SHADE AND ORNAMENTAL TREE SPECIES COLLECTED FROM THE USX RESEARCH AND DEMONSTRATION PLOTS DURING 2001 THROUGH 2003

	Shade Tree Species[2]					Ornamental Tree Species[3]				
	Percent Biosolids					Percent Biosolids				
Parameter	0%	25%	50%	100%	City Parks[4]	0%	25%	50%	100%	City Parks[4]
	mg/kg									
N	23,405b[5]	26,833a	26,923a	29,296a	29,771	19,418b	21,900a	20,884ab	22,220a	22,593
P	2,232b	2,181b	2,660b	3,909a	2,171	2,543a	1,786b	1,934b	2,765a	1,644
K	10,117a	10,610a	11,696a	12,620a	12,461	8,944a	9,372a	8,401a	8,875a	8,251
Ca	16,895a	17,511a	17,366a	17,378a	28,035	19,283a	18,285a	18,218a	16,815a	17,186
Mg	3,911a	3,784a	3,827a	3,814a	155	3,520a	3,580a	4,442a	4,132a	101
S	8,366b	7,793ab	5,978b	11,482a	ND	4,789b	4,720b	7,398a	9,127ab	ND
Na	43a	48a	55a	58a	88	45a	42a	26b	39a	21
Fe	171a	172a	127b	90c	173	140a	138a	110ab	111b	118
Mn	82b	101b	158a	182a	50	45d	69c	130b	206a	27
Zn	83a	81a	77a	99a	208	26b	29ab	31ab	36a	31
Cu	9.6a	5.8b	6.3b	6.7b	10.5	7.8a	4.7b	5.4bc	6.3ac	8.9
Mo	0.94b	1.47ab	1.74a	1.42ab	0.90	0.68b	1.09a	1.41a	1.64a	0.90
Cd	0.83a	0.85a	0.84a	1.25a	5.83	0.03c	0.09ab	0.09b	0.19a	0.07
Cr	0.69a	0.71a	0.73a	0.60a	0.72	0.74a	0.83a	0.81a	0.78a	0.55
Ni	1.24a	0.78a	0.92a	0.84a	0.91	0.95b	0.78b	1.20b	1.49a	1.61
Pb	2.15a	1.67a	0.92b	0.98b	1.10	1.06a	1.19a	1.05a	0.82a	0.20

[1]Values are the mean of composite tissue samples taken in 2001 through 2003 from clay-lined and nonlined plots.
[2]Species included hybrid maple, autumn purple ash, skyline honey locust, Siouxland cottonless cottonwood, red oak, and hybrid elm.
[3]Species included amur maple, apple serviceberry, thornless cockspur, Donald Wyman crabapple, and Zumi crabapple.
[4]Leaf tissue samples of shade and ornamental trees were collected from the city parks in the Chicago area.
[5]Values of each parameter within a tree group followed by the same letter are not significantly different at the 0.05 level of probability.
ND = Not determined.

lower than the concentrations found in the leaves of the shade tree species. The concentrations of most of the nutrients evaluated were similar to concentrations observed in the tissues of ornamental trees collected from parks in the City.

Concentrations of Trace Metals. In the shade trees, the mean leaf tissue concentrations of trace metals were similar among all amendments (Table 10). Tissue concentrations of Mo in the shade trees in the amendments containing biosolids were almost identical but the concentration was slightly higher for the 0 percent biosolids amendment. Also, the concentrations of Cu and Pb were significantly higher in the 0 percent biosolids amendment. The concentrations of Cr and Ni in the leaves of shade trees decreased slightly with increasing amount of biosolids in the amendment. These results suggest that the biosolids probably reduced the bioavailability of some metals to the shade tree species evaluated in the project. Except for Zn, Cu, and Cd concentrations, which were higher in trees from parks in the City, the tissue concentrations of most of the trace metals evaluated in the shade trees in the research and demonstration plots were similar to concentrations observed in the Park District shade trees.

In the ornamental trees, the mean leaf tissue concentrations of Cd, Mo, and Zn increased slightly with the amount of biosolids in the amendment. However, the concentrations of Cu, Cr, Ni, and Pb tended to decrease with increasing amount of biosolids in the amendment. The concentrations of most of the trace metals evaluated were similar to concentrations observed in the ornamental trees from the City parks, except that Pb concentrations in the ornamentals in the research and demonstration plots were higher.

Overall, the low tissue concentrations of trace metals observed in the tree leaves are probably within the range typical of trees in the Chicago area and the potential for bioaccumulation of metals in the herbivorous food chains in biosolids amended soil is minimal. These results also demonstrate that the leaf fall from the trees grown on biosolids-amended sites does not pose any risk of attractive nuisance.

Concentrations of Constituents in Subsurface and Lake Water

Water samples from the lysimeters (5- and 10-ft depths), wells (20-ft depth), and three locations in Lake Michigan were collected monthly starting in June 2000 through June 2003 and bi-monthly from August through December 2003. Appendix AIV contains annual mean concentrations of constituents in all water samples collected during 2000 to 2003. In the 5-ft lysimeter in the 0 percent biosolids nonlined plot, the sample yield during the study was very small and the pH and EC analysis was allocated the highest priority among the analytes. As a result, for the entire period of the study, only two samples were available for analysis of nutrients (N species and P) and other water quality parameters, and only one sample was available for metals analysis.

Nutrients and Other Water Quality Parameters.

Nitrogen. The mean concentrations of inorganic N species (NH_3-N, NO_2-N, NO_3-N) and TKN in water samples collected from Lake Michigan, lysimeters, and wells during the study are presented in Table 11. The mean concentrations of the N species were similar for the three sampling locations in the lake and were much lower than the concentrations in the wells and lysimeters, including the remote location and control plot, indicating that the amendments applied to the plots had no impact on concentration of N species in the lake water. The mean concentrations of N species were variable between the clay-lined and nonlined plots. Generally, the mean

TABLE 11: MEAN[1] CONCENTRATIONS OF FECAL COLIFORM, GENERAL WATER CHEMISTRY PARAMETERS, AND NUTRIENTS IN WATER SAMPLES COLLECTED FROM LAKE MICHIGAN AND LYSIMETERS AND WELLS IN THE USX RESEARCH AND DEMONSTRATION PLOTS DURING 2000 THROUGH 2003

Location/Plot	Fecal Coliform #/100 mL	pH	EC dS/m	Alkalinity	TDS	Hardness	$SO_4^{=}$	Cl^-	NH_3-N	NO_2-N	NO_3-N	TKN	Total P
				mg/L									
Lake (North)		7.6	0.073	123	243	141	26	19	0.04	0.01	0.40	0.20	0.07
Lake (Middle)		7.6	0.077	111	199	140	26	17	0.04	0.01	0.43	0.24	0.07
Lake (South)		8.0	0.077	106	221	142	26	15	0.01	<0.002	0.07	0.24	0.07
Lysimeter Depth = 5 ft													
Remote[2]	<1	7.6	0.120	25	1,347	503	337	11	0.22	0.17	1.01	1.81	0.14
Lysimeter Depth = 10 ft													
Remote[2]	<1	7.7	0.152	680	1,681	940	647	34	0.26	0.12	1.90	0.81	0.13
Well Depth = 20 ft[3]													
Remote[2]	<3	7.5	0.129	351	1,032	624	356	37	0.34	0.02	0.14	0.53	0.09
Clay-Lined Plots (% Biosolids)													
Lysimeter Depth = 5 ft													
0	1	7.7	0.156	490	1,491	819	414	20	0.15	0.15	4.21	1.35	0.14
25	<1	8.0	0.148	363	1,695	961	445	18	0.26	0.37	25.19	3.56	0.34
50	1	7.9	0.176	295	1,840	1,076	622	25	0.39	1.90	35.01	4.64	0.13
100	<1	9.0	0.130	366	1,418	147	157	121	26.86	5.09	2.87	43.22	0.31

TABLE 11 (CONTINUED): MEAN CONCENTRATIONS OF FECAL COLIFORM, GENERAL WATER CHEMISTRY PARAMETERS, AND NUTRIENTS IN WATER SAMPLES TAKEN FROM LAKE MICHIGAN AND LYSIMETERS AND WELLS IN THE USX RESEARCH AND DEMONSTRATION PLOTS DURING 2000 THROUGH 2003

Location/Plot	Fecal Coliform #/100 mL	pH	EC dS/m	Alkalinity	TDS	Hardness	$SO_4^{=}$	Cl^-	NH_3-N	NO_2-N	NO_3-N	TKN	Total P
				mg/L									
	Lysimeter Depth = 10 ft												
0	2	7.7	0.158	379	1,854	1,086	199	18	0.31	0.46	4.84	1.22	0.13
25	1	7.7	0.204	426	2,206	1,287	811	21	0.17	0.31	16.07	2.09	0.12
50	<1	7.7	0.189	314	1,928	1,152	852	49	1.07	4.61	15.67	3.97	0.14
100	<1	7.8	0.225	395	2,562	1,404	1,127	33	0.71	0.45	13.36	2.58	0.13
	Well Depth = 20 ft[3]												
0	6	7.5	0.144	430	1,212	727	398	35	0.18	0.02	0.43	0.49	0.07
25	8	7.5	0.153	395	1,133	564	310	110	0.27	0.02	0.43	0.57	0.07
100	9	7.6	0.154	112	1,295	586	623	73	0.87	0.02	0.99	1.27	0.06
Nonlined Plots (% Biosolids)													
	Lysimeter Depth = 5 ft												
0	<1	7.9	0.189	412	3,152	1,816	ND[4]	22	0.13	0.01	11.98	3.14	0.12
25	<1	7.7	0.166	513	1,683	805	425	13	0.20	0.10	16.01	2.69	0.15
50	1	7.8	0.175	331	1,681	955	635	22	0.78	0.29	40.57	3.93	0.15
100	1	8.0	0.220	325	1,991	1,686	1,286	26	3.11	1.07	50.42	12.61	0.46

TABLE 11 (CONTINUED): MEAN CONCENTRATIONS OF FECAL COLIFORM, GENERAL WATER CHEMISTRY PARAMETERS, AND NUTRIENTS IN WATER SAMPLES TAKEN FROM LAKE MICHIGAN AND LYSIMETERS AND WELLS IN THE USX RESEARCH AND DEMONSTRATION PLOTS DURING 2000 THROUGH 2003

Location/Plot	Fecal Coliform #/100 mL	pH	EC dS/m	Alkalinity	TDS	Hardness	$SO_4^=$	Cl^-	NH_3-N	NO_2-N	NO_3-N	TKN	Total P
				mg/L									
	Lysimeter Depth = 10 ft												
0	1	7.5	0.255	354	2,797	1,625	1,421	19	0.17	0.36	18.23	1.56	0.14
25	1	7.9	0.206	715	2,382	1,519	664	18	0.22	0.23	7.34	3.05	0.14
50	1	7.7	0.254	197	2,907	1,452	1,428	44	0.24	0.37	8.28	2.07	0.11
100	1	7.7	0.177	119	1,810	892	863	64	14.24	8.41	12.98	20.98	0.16
	Well Depth = 20 ft[3]												
25	7	7.6	0.138	367	994	450	268	80	0.29	0.02	0.40	0.56	0.07
50	7	7.6	0.143	337	1,074	561	346	70	0.31	0.02	0.25	0.54	0.07
100	9	7.5	0.172	305	1,294	728	506	56	0.71	0.03	0.25	1.05	0.07

[1]MDL was used in calculating the mean if a value was less than the MDL. If all the values were less than the MDL, the mean is reported as less than MDL.
[2]Remote lysimeters and wells were installed at approximately 200 ft south of the amended plots.
[3]Due to difficult drilling conditions, wells could not be installed in the 50% biosolids clay-lined plots and in the 0% biosolids nonlined plots.
[4]ND = No data.

concentrations of N species increased in response to the amount of biosolids in the amendments, especially in the 5-ft and 10-ft depth lysimeters.

The concentration of NO_3-N in the wells and lysimeters for the clay-lined and nonlined plots are presented in Figures 15 and 16, respectively. In the clay-lined plots, the highest concentrations of NO_3-N were observed in the lysimeters in the 25 and 50 percent biosolids amendments during the initial period of the study but the concentrations declined rapidly to the lowest levels (generally less than 25 mg N/L) by fall of 2001. The NO_3-N concentrations increased for a short period starting in late 2002 in the 5-ft depth lysimeter of the 25 and 50 percent biosolids amendments and in early 2003 in the 10-ft lysimeters in all amendments containing biosolids.

In the nonlined plots, the trends were similar to the clay-lined plots, except that the highest NO_3-N concentrations were observed in the 100 percent biosolids amendment and occurred as a single spike in the 5-ft (approximately 380 mg N/L) and 10-ft depth lysimeters during 2003. In the 5-ft depth lysimeter in the 50 percent biosolids plot, NO_3-N increased up to approximately 160 mg N/L in October 2000 and April 2003, but then decreased to near minimum levels by the end of the study. For both nonlined and clay-lined plots, NO_3-N concentrations in the 20-ft depth wells in all amendments were less than 1 mg N/L during most of the study, except a few occasional spikes as shown in Figures 15 and 16. Variability in the concentrations of NO_3-N in the lysimeters and wells among the amendments and over time can be attributed to variations in permeability of the slag and rate of recharge from the surface (Muchovej and Rechcigl, 1995).

The concentrations of NH_3-N in the clay-lined and nonlined plots are presented in Figures 17 and 18, respectively. Except in the 5-ft depth lysimeter in 100 percent biosolids clay-lined plots, the NH_3-N concentrations were much lower than the NO_3-N concentrations (Figures 15 and 16). In

FIGURE 15: CONCENTRATIONS OF NITRATE-N IN LYSIMETERS AND WELLS IN CLAY-LINED PLOTS OF FOUR AMENDMENTS OF SEDIMENT AND BIOSOLIDS MIXTURES IN THE USX RESEARCH AND DEMONSTRATION PLOTS. INSERT SHOWS AN EXPANDED SCALE OF THE WELL DATA

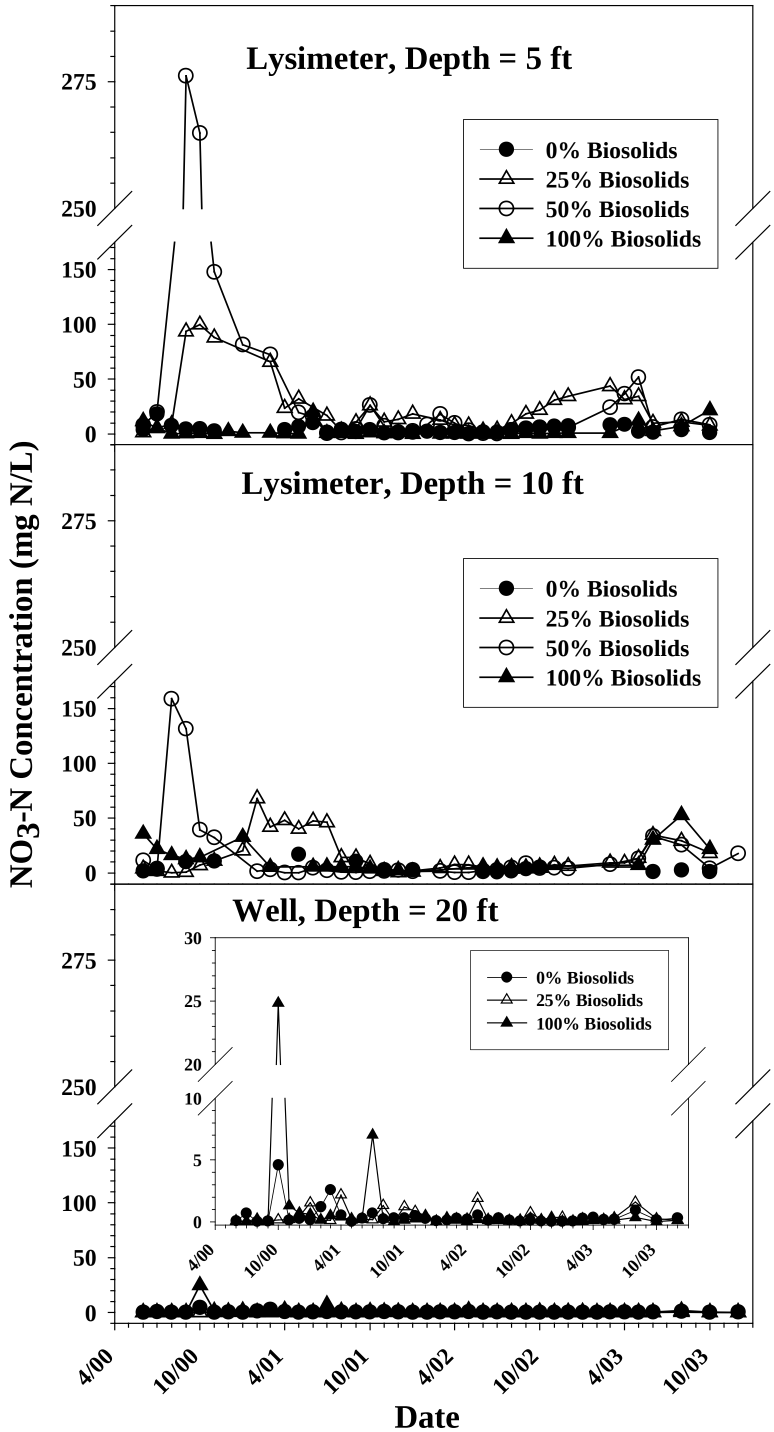


FIGURE 16: CONCENTRATIONS OF NITRATE-N IN LYSIMETERS AND WELLS IN NONLINED PLOTS OF FOUR AMENDMENTS OF SEDIMENT AND BIOSOLIDS MIXTURES IN THE USX RESEARCH AND DEMONSTRATION PLOTS. INSERT SHOWS AN EXPANDED SCALE OF THE WELL DATA

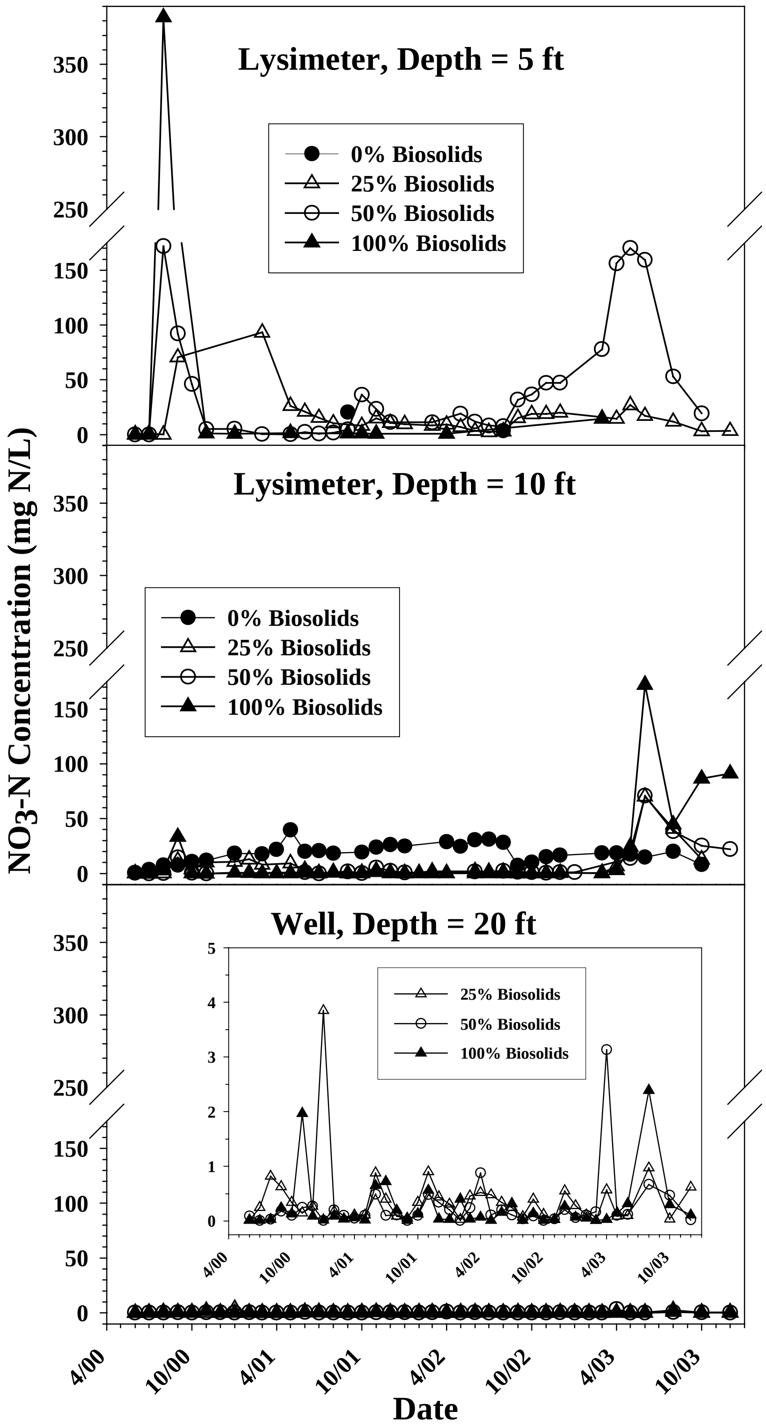


FIGURE 17: CONCENTRATIONS OF AMMONIA-N IN LYSIMETERS AND WELLS IN CLAY-LINED PLOTS OF FOUR AMENDMENTS OF SEDIMENT AND BIOSOLIDS MIXTURES IN THE USX RESEARCH AND DEMONSTRATION PLOTS

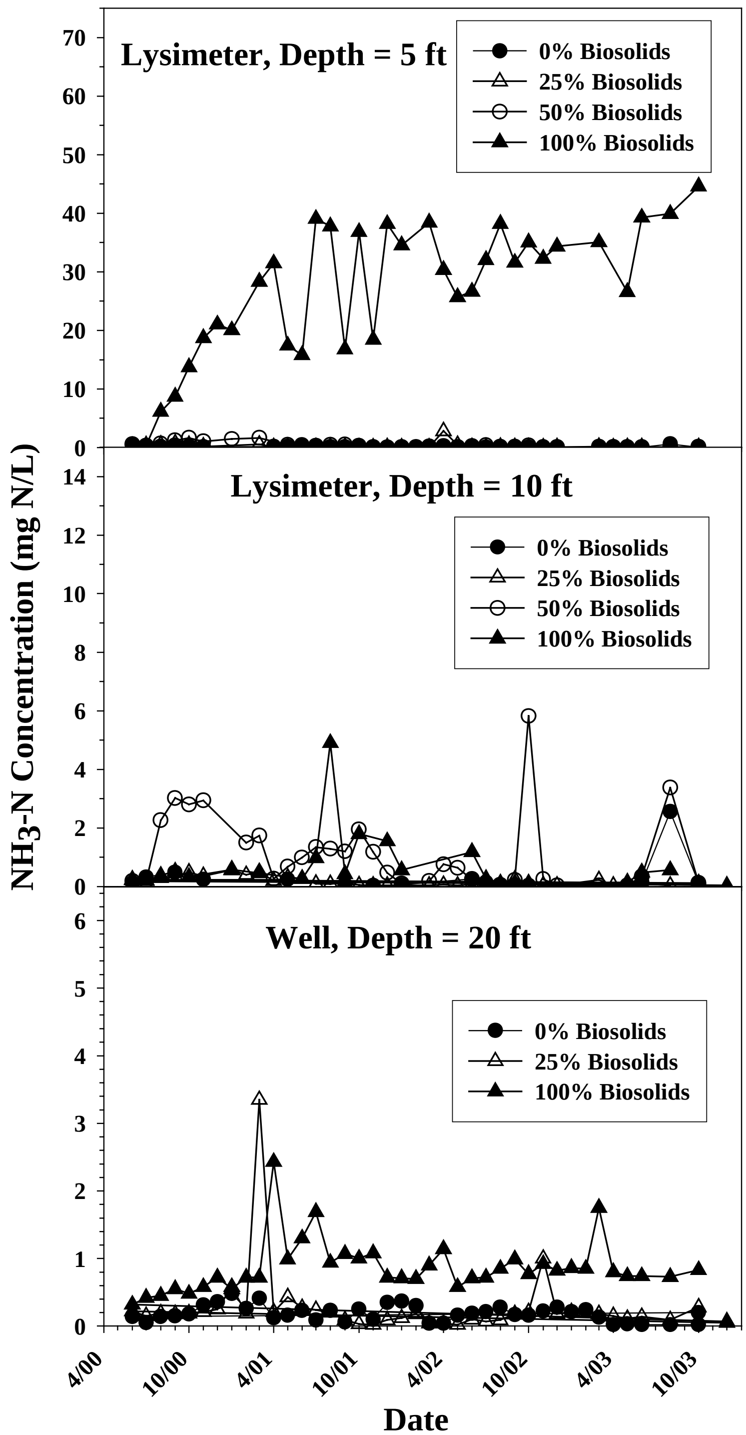
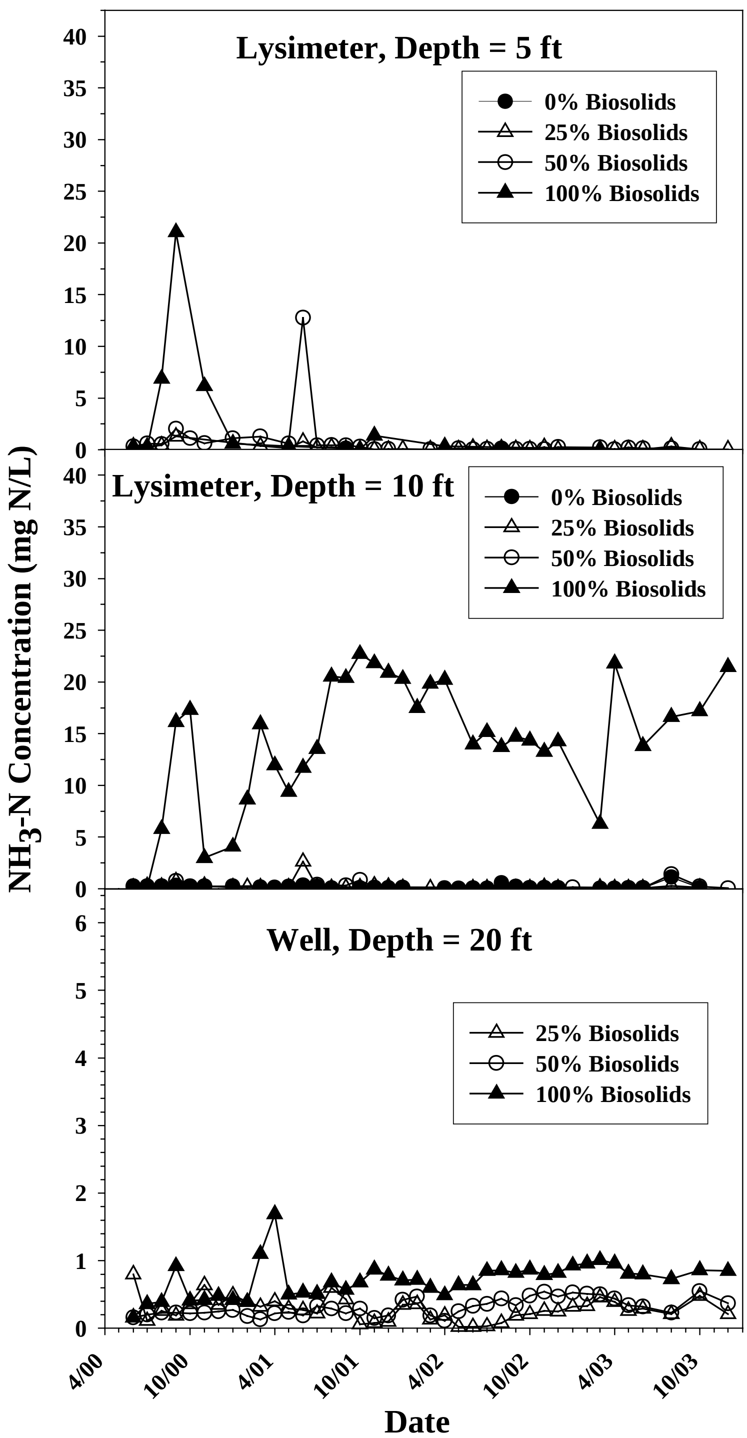


FIGURE 18: CONCENTRATIONS OF AMMONIA-N IN LYSIMETERS AND WELLS IN NONLINED PLOTS OF FOUR AMENDMENTS OF SEDIMENT AND BIOSOLIDS MIXTURES IN THE USX RESEARCH AND DEMONSTRATION PLOTS



the clay-lined plots, the NH_3-N concentrations in the 5-ft depth lysimeter in the 100 percent biosolids amendment were much higher than in all other lysimeters and wells. The concentrations of NH_3-N increased steadily until spring 2001 but then fluctuated up to a maximum level of approximately 48 mg N/L afterwards. Generally, the NH_3-N concentrations observed in all other lysimeters and wells were less than 5 mg N/L and the highest concentrations were observed in the amendments containing biosolids.

In the 5-ft depth lysimeters in the nonlined plots, the NH_3-N concentrations were generally lower than in the clay-lined plots, especially in the 100 percent biosolids amendment. The NH_3-N concentrations in the 10-ft depth lysimeters were also generally lower in the nonlined than in the clay-lined plots, except in the 100 percent biosolids. The NH_3-N concentrations in the 10-ft lysimeter in the nonlined 100 percent amendment followed a similar trend to the NH_3-N concentrations in the 5-ft depth lysimeter in the clay-lined 100 percent amendment, but the concentrations were much lower. These relationships might be due to the clay layer and differences in the subsurface characteristics that affect nitrification rates, NH_4^+ retention on cation exchange sites, and the rate of NH_3-N leaching. However, a similar trend was not observed for NO_3-N (Figures 15 and 16), which was probably due to the fact that NO_3-N is much more mobile than NH_3-N. The higher concentration of NH_3-N in the 5-ft depth lysimeter in the clay-lined 100 percent biosolids amendment is probably due to more anaerobic conditions, which reduces nitrification rates compared to the nonlined plots. The concentrations of NH_3-N for most of the lysimeters and wells were generally less than 5 mg N/L, with only a few instances of higher concentrations observed in the plots amended with biosolids.

The trends in TKN concentration (Figures 19 and 20) were similar to those of NH_3-N (Figures 17 and 18), but the TKN concentrations were much higher than NH_3-N. The higher concentrations of TKN compared to NH_3-N indicate that a major fraction of the total N found in the lysimeters and wells existed in the form of soluble organic N.

Total Phosphorus. The highest mean concentration of total P observed in the wells and lysimeters was 0.34 mg P/L, which occurred in the 5-ft depth lysimeter in the 25 percent biosolids clay-lined plot (Table 11). There was no consistent trend in total P concentrations among the treatments. Phosphorus is generally immobile in soils and is not expected to migrate from the amendments with percolating water.

Other Water Quality Parameters. A summary of the other water quality parameters monitored in the lysimeters and wells is presented in Table 11. The ANOVA results indicated that the amount of biosolids in the amendments significantly affected the annual mean concentrations of these parameters. However, the differences observed were mostly fluctuations with no consistent trend. Fecal coliform counts in the lysimeters were either below or close to the detection limit and in the wells counts ranging from only 6 to 9 per 100 mL were observed. There was no consistent trend in the concentration of general chemistry parameters such as pH and concentration of dissolved salts in lysimeters and wells between the remote location and the amended plots. The general chemistry of the subsurface water is more likely to be controlled by the properties of the slag than by the amendments used in the plots.

Organic Priority Pollutants. Due to low sample volumes, the lysimeter and well samples collected during the study were composited based on a scheme to best evaluate the effect of the amendments on the concentration of organic priority pollutants. Three composite samples were

FIGURE 19: CONCENTRATIONS OF TKN IN LYSIMETERS AND WELLS IN CLAY-LINED PLOTS OF FOUR AMENDMENTS OF SEDIMENT AND BIOSOLIDS MIXTURES IN THE USX RESEARCH AND DEMONSTRATION PLOTS

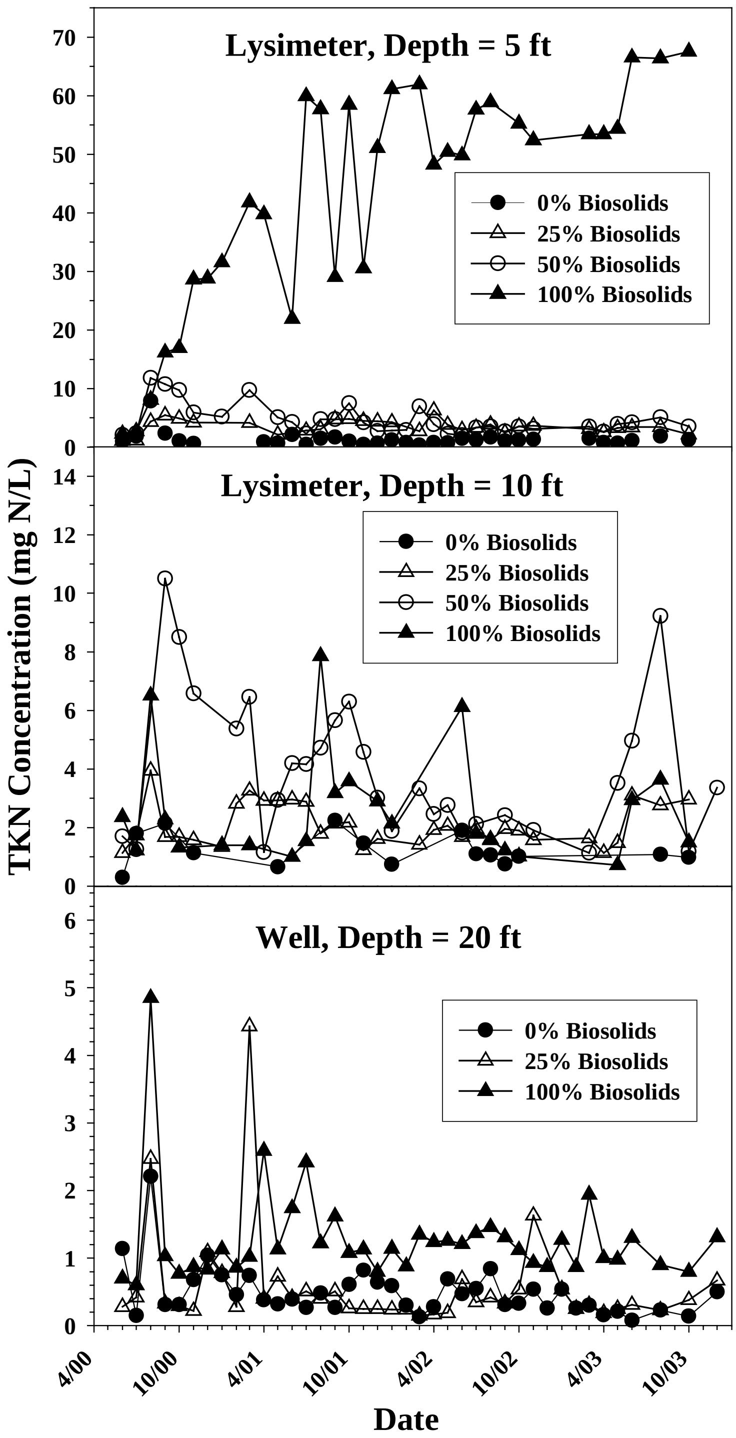
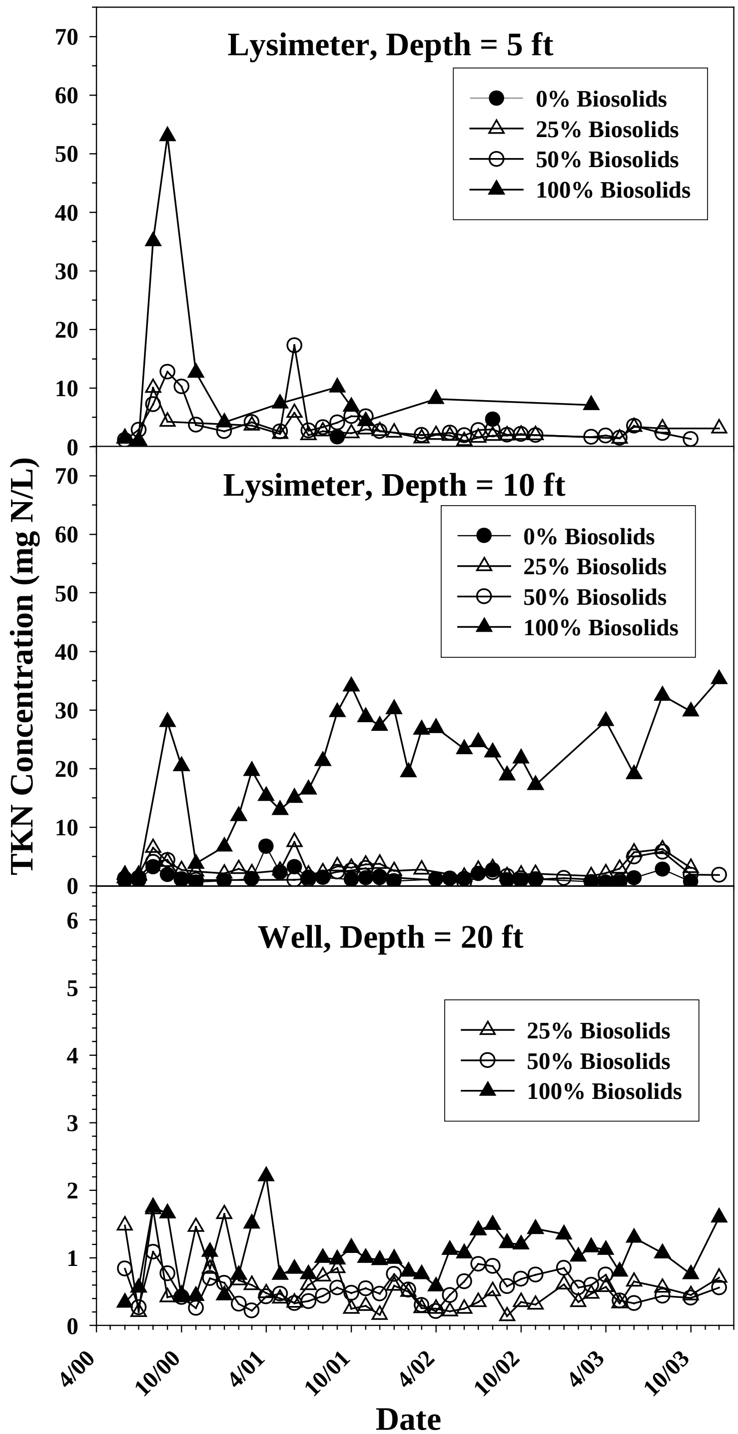


FIGURE 20: CONCENTRATIONS OF TKN IN LYSIMETERS AND WELLS IN NONLINED PLOTS OF FOUR AMENDMENTS OF SEDIMENT AND BIOSOLIDS MIXTURES IN THE USX RESEARCH AND DEMONSTRATION PLOTS



produced for each lysimeter depth and well. These consisted of a no biosolids composite (includes 0 percent amendment plots and a remote location), a 25 percent biosolids composite, and a high rate biosolids composite (50 and 100 percent amendment plots). During the study, only 12 out of the 111 compounds analyzed were detected and only in some of the samples (Table 12). None of the organic compounds were detected in all sampling events during the study, and 1,1,1-trichloroethane, phenol, and heptachlor were detected mostly just after the study began in 2000, and in 2001. The frequency at which the organic compounds were detected and the concentrations found did not correlate with the amount of biosolids in the amendments. The data show that the use of biosolids at the USX site had no impact on concentration of the organic priority pollutants in the subsurface water.

Metals. The mean concentrations observed for most of the trace metals in the lysimeters and wells were very low and close to the detection limits (Table 13). There were no trends among the treatments, and the few statistical differences observed are most likely due to expected fluctuations in concentrations among the sampling events, and are therefore of very little practical or environmental significance. For some of the metals, the method detection limits (MDL) changed during the study period. For making comparisons between mean concentrations, the minimum MDLs for the study period are included in Table 13.

The ANOVA results showed that all mean trace metal concentrations, except Cr, Hg, and Sb, in the lysimeters and wells were not significantly different among the amendments (data not shown). The mean concentrations of Cr and Sb in the 100 percent biosolids amendment plots were either lower or comparable to the mean concentrations found in the 0 percent amendment plots and at the remote location (Table 13). The mean concentrations of Hg were noticeably

TABLE 12: MAXIMUM CONCENTRATIONS OF ORGANIC PRIORITY POLLUTANTS IN COMPOSITE WATER SAMPLES COLLECTED QUARTERLY FROM LYSIMETERS AND WELLS IN THE USX RESEARCH AND DEMONSTRATION PLOTS DURING 2000 THROUGH 2003

	Concentration (µg/L)				
Compound	2000	2001	2002	2003	Composite ID[2]
Dichlorobromomethane	1 (1)[1]	ND	ND	ND	L23E3W4E4W
Methyl chloride	ND	6 (2)	ND	ND	W1ER
Methylene chloride	4 (1)	ND	ND	ND	L13E3W4E4W
1,1,1-Trichloroethane	ND	ND	2 (1)	ND	L13E3W4E4W
Phenol	ND	129 (2)	79 (2)	167 (3)	L13E3W4E4W
Anthracene	ND	14 (1)	ND	ND	W3W4E4W
Bis (2-ethylhexyl)phthalate	380 (2)	6,133 (1)	ND	ND	L13E3W4E4W L23E3W4E4W
Fluoranthene	ND	27 (2)	ND	ND	W3W4E4W
Phenanthrene	10 (1)	50 (2)	ND	ND	W3W4E4W
Pyrene	ND	22 (1)	ND	ND	W1ER
Endrin	0.06 (1)	ND	ND	ND	L13E3W4E4W
Heptachlor	ND	ND	0.03 (1)	ND	W3W4E4W

[1]Value in parentheses indicates the number of times the compound was detected during year.
[2]L23E3W4E4W = samples of the 10-ft lysimeters in clay-lined and nonlined 50% and 100% biosolids plots; W1ER = samples of the wells in clay-lined 0% biosolids plot and at the remote location; L13E3W4E4W = samples of the 5-ft lysimeters in clay-lined and nonlined 50% and 100% biosolids plots; W3W4E4W = samples of the wells in nonlined 50% biosolids plot and clay-lined and nonlined 100% biosolids plots.
ND = Not detected.

TABLE 13: MEAN[1] CONCENTRATIONS OF TRACE METALS IN WATER SAMPLES COLLECTED FROM LAKE MICHIGAN AND FROM LYSIMETERS AND WELLS IN THE USX RESEARCH AND DEMONSTRATION PLOTS DURING 2000 THROUGH 2003

Location/Plot	As	Cd	Cr	Cu	Hg	Ni	Pb	Sb	Zn
	(mg/L)				(µg/L)	(mg/L)			
Lake (North)	<0.045	<0.004	0.005	0.008	0.056	0.019	<0.04	<0.045	0.010
Lake (Middle)	<0.045	<0.004	0.005	0.006	0.021	0.019	0.087	<0.045	0.012
Lake (South)	0.045	<0.004	0.005	0.006	0.054	0.017	<0.04	<0.045	0.010
	Lysimeter Depth = 5 ft								
Remote[2]	0.107	0.009	0.016	0.202	0.088	0.314	0.087	0.111	0.279
	Lysimeter Depth = 10 ft								
Remote[2]	0.104	<0.008	0.018	0.018	0.092	0.151	0.077	0.102	0.116
	Well Depth = 20 ft[3]								
Remote[2]	0.050	<0.004	0.008	0.012	0.057	0.023	0.085	0.052	0.052
Clay-Lined Plots (% Biosolids)									
	Lysimeter Depth = 5 ft								
0	0.084	0.008	0.029	0.052	0.152	0.048	0.061	0.079	0.113
25	0.087	0.007	0.020	0.070	0.148	0.060	0.064	0.085	0.054
50	0.096	0.007	0.018	0.067	0.101	0.058	0.074	0.100	0.052
100	0.088	0.007	0.010	0.032	0.476	0.052	0.061	0.075	0.017

TABLE 13 (CONTINUED): MEAN[1] CONCENTRATIONS OF TRACE METALS IN WATER SAMPLES TAKEN FROM LAKE MICHIGAN AND FROM LYSIMETERS AND WELLS IN THE USX RESEARCH AND DEMONSTRATION PLOTS DURING 2000 THROUGH 2003

Location/Plot	As	Cd	Cr	Cu	Hg	Ni	Pb	Sb	Zn
	(mg/L)				(µg/L)	(mg/L)			
	Lysimeter Depth = 10 ft								
0	0.117	0.007	0.032	0.038	0.113	0.069	0.062	0.136	0.033
25	0.094	0.007	0.018	0.036	0.102	0.048	0.066	0.090	0.052
50	0.091	0.007	0.017	0.056	0.099	0.060	0.069	0.089	0.052
100	0.077	0.006	0.019	0.046	0.109	0.053	0.053	0.090	0.045
	Well Depth = 20 ft[3]								
0	0.052	0.004	0.010	0.011	0.074	0.029	0.037	0.051	0.043
25	0.049	0.004	0.009	0.010	0.058	0.027	0.035	0.048	0.054
100	0.049	0.004	0.010	0.010	0.066	0.049	0.035	0.052	0.097
Nonlined Plots (% Biosolids)									
	Lysimeter Depth = 5 ft								
0	<0.160	<0.014	0.058	0.228	0.080	0.024	0.160	0.220	0.080
25	0.098	0.008	0.018	0.055	0.094	0.052	0.075	0.104	0.100
50	0.104	0.008	0.018	0.060	0.101	0.050	0.073	0.099	0.075
100	0.141	0.007	0.027	0.077	0.090	0.100	0.073	0.133	0.048

TABLE 13 (CONTINUED): MEAN[1] CONCENTRATIONS OF TRACE METALS IN WATER SAMPLES TAKEN FROM LAKE MICHIGAN AND FROM LYSIMETERS AND WELLS IN THE USX RESEARCH AND DEMONSTRATION PLOTS DURING 2000 THROUGH 2003

Location/Plot	As	Cd	Cr	Cu	Hg	Ni	Pb	Sb	Zn
	(mg/L)				(µg/L)	(mg/L)			
	Lysimeter Depth = 10 ft								
0	0.101	0.008	0.021	0.066	0.138	0.063	0.078	0.108	0.294
25	0.135	0.008	0.026	0.046	0.111	0.062	0.085	0.153	0.075
50	0.088	0.006	0.023	0.062	0.092	0.046	0.078	0.094	0.057
100	0.086	0.008	0.013	0.121	0.175	0.053	0.069	0.077	0.106
	Well Depth = 20 ft[3]								
25	0.048	0.004	0.007	0.009	0.055	0.023	0.034	0.048	0.040
50	0.051	0.004	0.008	0.009	0.061	0.025	0.035	0.046	0.053
100	0.058	0.004	0.010	0.024	0.060	0.046	0.037	0.055	0.162
MDL[4]	0.002	0.004	0.003	0.003	0.050	0.002	0.001	0.045	0.002

[1]MDL was used in calculating the mean if a value was less than the MDL. If all the values were less than the MDL, the mean is reported as less than MDL.
[2]Remote lysimeters and wells were installed approximately 200 ft south of the amended plots.
[3]Due to difficult drilling conditions, wells could not be installed in the 50% biosolids clay-lined plots and in the 0% biosolids nonlined plots.
[4]The MDLs for some metals varied during the study. The given values represent minimum MDLs encountered during the duration of the study.

higher (0.476 μg/L) in the 5-ft depth lysimeter in the clay-lined 100 percent biosolids amendment. The major contribution to this higher mean concentration of Hg was from random spikes in Hg levels ranging from 1.32 to 2.84 μg/L, which occurred in only four out of the 32 sampling events during the study (data not shown). It is unlikely that these spikes in Hg concentration are associated with the biosolids amendment because Hg concentrations in the 5-ft depth lysimeters for all the nonlined plots, including the 100 percent biosolids amendment, and in the remote location were identical. It is noteworthy to mention here that the Hg concentrations in the USX slag materials were higher than the Hg concentrations in the biosolids (Table 1). Thus, the data show that the biosolids amendments had no impact on the subsurface water and Lake water Hg concentrations.

Data in Table 13 show that the concentrations of trace metals for the three locations sampled in Lake Michigan were very similar, indicating that the amendments in the research and demonstration plots had no impact on trace metal concentrations in Lake Michigan. The data also show that the trace metal concentrations in the lysimeters and wells at the remote location, including the 100 percent biosolids amendments, were either slightly higher or similar to the concentrations found in the nonlined plots, indicating that the amendments had no impact on trace metal concentrations in the subsurface water.

In general, the amount of biosolids had no impact on the concentrations of trace metals in the subsurface and Lake water. For the trace metals monitored, the concentrations in the biosolids were either lower or similar to the concentration in the slag at the USX site (Table 1). Therefore, the slag materials probably have the greatest potential for controlling the concentration of trace metals in the subsurface and the Lake Michigan water. In addition, since there were no consistent trends between trace metal concentrations found in the lysimeters and wells in the amended plots and the remote location, it appears that leaching from the amendments was minimal.

REFERENCES

1. Cockerham, S. T., and D. D. Miner, "Turfgrass Nutrition and Fertilizers," in D. E. Aldous, ed., *International Turf Management Handbook*, CRC Press, New York, NY, 2001.

2. Harza Environmental Services, "Review of Geotechnical Conditions at the USX Site," 1998.

3. Kabata-Pendias, A., *Trace* Elements *in Soils and Plants*, 3rd ed., CRC Press, Boca Raton, FL, 2001.

4. Muchovej, R. M. C., and J. E. Rechcigl, "Nitrogen Fertilizers," in J. E. Rechcigl, ed., *Soil Amendments and Environmental Quality*, CRC Press, Boca Raton, FL, 1995.

5. Plank, C. O., "Plant Analysis Handbook for Georgia," The Cooperative Extension Service, The University of Georgia, 2002.

6. SAS Institute, "SAS Procedures Guide," Vol. I-II, Cary, NC, 1995.

7. Soil and Plant Analysis Council, *Soil Analysis Handbook of Reference Methods*, CRC Press, Boca Raton, FL, 1999.

8. Walpole, R. E., and R. H. Meyers, *Probability and Statistics for Engineers and Scientists*, 4th ed., Macmillan Publishing Company, New York, NY, 1989.

APPENDIX AI

CONCENTRATIONS OF CHEMICAL CONSTITUENTS IN THE AMENDMENTS

TABLE AI-1: CONCENTRATIONS OF CHEMICAL CONSTITUENTS IN THE 0- TO 6-INCH DEPTH OF FOUR AMENDMENTS OF SEDIMENT AND BIOSOLIDS MIXTURES IN THE USX RESEARCH AND DEMONSTRATION PLOTS IN JUNE 2000[1]

		Amendment							
		0% Biosolids		25% Biosolids		50% Biosolids		100% Biosolids	
Parameter	Unit	East[2]	West[3]	East[2]	West[3]	East[2]	West[3]	East[2]	West[3]
pH[4]		6.6	6.6	6.8	6.8	6.6	7.1	6.0	6.1
EC[4]	dS/m	0.52	0.26	1.9	1.8	1.9	1.7	3.1	2.7
Total P	mg/kg	895	441	7,013	6,555	11,279	7,527	23,476	25,157
Avail. P	”	31	11	369	221	382	224	743	572
TKN[5]	”	1,827	1,641	7,250	6,538	12,791	6,933	15,671	11,965
KCl-NH_3[6]	”	1.7	2.0	26	31	34	41	69	72
KCl-NO_3[6]	”	4.3	3.8	171	147	192	88	377	444
H_2O-NH_3[4]	”	0.29	0.28	2.4	1.0	2.7	1.7	9.0	8.1
H_2O-NO_3[4]	”	5.1	4.8	156	140	185	92	364	382
SO_4-S	”	415	149	1,486	1,755	1,376	1,644	3,173	3,445
Org. Carbon	%	2.2	2.0	7.6	7.1	9.6	7.7	16	17
Exch. Ca	mg/kg	3,328	5,865	5,446	6,443	6,481	6,444	6,793	7,315
Exch. Mg	”	804	1,228	128	147	142	159	226	243
Exch. Na	”	102	140	1,222	1,276	1,408	1,406	1,877	1,975
Exch. K	”	96	343	225	224	308	274	702	718
Zn	”	75	91	525	482	765	535	1,116	1,396
Cd	”	0.18	0.33	3.2	2.8	4.2	3.1	7.6	9.9
Cu	”	25	30	118	108	166	121	254	311
Cr	”	31	30	72	118	169	186	140	157
Fe	”	20,051	18,748	19,995	20,422	24,352	20,351	26,279	22,647
Ni	”	23	24	28	30	31	32	29	35
Pb	”	21	21	61	52	85	53	114	136
Mn	”	543	466	348	849	1,033	1,027	520	442
Mo	”	0.41	0.41	3.3	1.8	5.6	3.5	8.5	9.1

[1]Values are the mean values for two replicate samples taken from four subplots.
[2]Six-inch thick layer of silty clay loam was placed beneath the amendments.
[3]Amendments were placed directly on the slag.
[4]Concentrations in 1:2 (soil:water) extract, NH_3 and NO_3 are expressed as N.
[5]Total Kjeldahl Nitrogen.
[6]Concentrations in 1:10 (soil:1M KCl) extract, NH_3 and NO_3 are expressed as N.

TABLE AI-2: CONCENTRATIONS OF CHEMICAL CONSTITUENTS IN THE 6- TO 10-INCH DEPTH OF FOUR AMENDMENTS OF SEDIMENT AND BIOSOLIDS MIXTURES IN THE USX RESEARCH AND DEMONSTRATION PLOTS IN JUNE 2000[1]

		Amendment							
		0% Biosolids		25% Biosolids		50% Biosolids		100% Biosolids	
Parameter	Unit	East[2]	West[3]	East[2]	West[3]	East[2]	West[3]	East[2]	West[3]
pH[4]		6.8	6.7	6.9	7.1	7.2	7.2	6.4	6.3
EC[4]	dS/m	0.91	0.41	1.9	1.7	2.1	1.7	3.3	2.8
TKN[5]	mg/kg	1,642	1,844	5,423	6,714	11,003	8,240	15,671	17,187
KCl-NH_3[6]	”	2.5	2.3	5.8	8.3	9.2	19	151	114
KCl-NO_3[6]	”	4.6	6.3	132	78	132	89	253	246
H_2O-NH_3[4]	”	0.27	0.14	1.7	2.4	2.3	4.0	48	19
H_2O-NO_3[4]	”	4.7	7.2	131	69	136	75	266	234
SO_4-S	”	927	251	1,602	1,608	1,730	1,981	3,192	3,457

[1]Values are the mean values for two replicate samples taken from four subplots.
[2]Six-inch thick layer of silty clay loam was placed beneath the amendments.
[3]Amendments were placed directly on the slag.
[4]Concentrations in 1:2 (soil:water) extract, NH_3 and NO_3 are expressed as N.
[5]Total Kjeldahl Nitrogen.
[6]Concentrations in 1:10 (soil:1M KCl) extract, NH_3 and NO_3 are expressed as N.

TABLE AI-3: CONCENTRATIONS OF CHEMICAL CONSTITUENTS IN THE 0- TO 6-INCH DEPTH OF FOUR AMENDMENTS OF SEDIMENT AND BIOSOLIDS MIXTURES IN THE USX RESEARCH AND DEMONSTRATION PLOTS IN SPRING 2001[1]

		Amendment							
		0% Biosolids		25% Biosolids		50% Biosolids		100% Biosolids	
Parameter	Unit	East[2]	West[3]	East[2]	West[3]	East[2]	West[3]	East[2]	West[3]
pH[4]		6.8	6.9	6.8	6.7	6.8	6.8	6.7	6.6
EC[4]	dS/m	0.69	0.34	0.78	0.97	0.88	1.1	2.5	1.3
Total P	mg/kg	511	348	6,343	5,602	10,164	8,446	24,609	24,286
Avail. P	”	25	9.5	284	203	231	215	544	617
TKN[5]	”	1,714	1,668	4,830	4,546	6,590	6,185	15,569	15,083
KCl-NH_3[6]	”	1.8	2.5	4.3	4.7	6.6	11	142	18
KCl-NO_3[6]	”	9.4	6.3	22	23	29	54	298	111
H_2O-NH_3[4]	”	0.39	0.28	1.4	1.4	1.5	2.1	28	3.6
H_2O-NO_3[4]	”	9.9	6.5	23	23	30	53	311	117
SO_4-S	”	122	226	395	261	356	302	441	781
Exch. Ca	”	3,523	3,781	5,271	6,273	6,874	6,755	7,273	6,653
Exch. Mg	”	754	915	1,150	1,212	1,044	1,283	1,422	1,502
Exch. Na	”	86	100	109	122	116	128	233	212
Exch. K	”	105	131	207	220	280	268	771	756

[1]Values are the mean values for two replicate samples taken from four subplots.
[2]Six-inch thick layer of silty clay loam was placed beneath the amendments.
[3]Amendments were placed directly on the slag.
[4]Concentrations in 1:2 (soil:water) extract, NH_3 and NO_3 are expressed as N.
[5]Total Kjeldahl Nitrogen.
[6]Concentrations in 1:10 (soil:1M KCl) extract, NH_3 and NO_3 are expressed as N.

TABLE AI-4: CONCENTRATIONS OF CHEMICAL CONSTITUENTS IN THE 6- TO 10-INCH DEPTH OF FOUR AMENDMENTS OF SEDIMENT AND BIOSOLIDS MIXTURES IN THE USX RESEARCH AND DEMONSTRATION PLOTS IN SPRING 2001[1]

		Amendment							
		0% Biosolids		25% Biosolids		50% Biosolids		100% Biosolids	
Parameter	Unit	East[2]	West[3]	East[2]	West[3]	East[2]	West[3]	East[2]	West[3]
pH[4]		7.0	7.2	7.0	6.9	6.9	6.9	6.7	6.9
EC[4]	dS/m	1.3	0.35	1.8	1.3	1.9	1.2	2.6	2.7
TKN[5]	mg/kg	1,681	1,963	2,073	4,959	2,603	6,254	15,934	11,279
KCl-NH_3[6]	"	2.4	2.1	6.1	9.5	12	15	193	207
KCl-NO_3[6]	"	9.5	7.0	14	59	27	72	353	267
H_2O-NH_3[4]	"	0.30	0.28	1.9	1.9	2.6	1.8	36	52
H_2O-NO_3[4]	"	10.0	4.3	14	60	30	74	303	248
SO_4-S	"	127	571	560	767	372	909	902	763

[1]Values are the mean values for two replicate samples taken from four subplots.
[2]Six-inch thick layer of silty clay loam was placed beneath the amendments.
[3]Amendments were placed directly on the slag.
[4]Concentrations in 1:2 (soil:water) extract, NH_3 and NO_3 are expressed as N.
[5]Total Kjeldahl Nitrogen.
[6]Concentrations in 1:10 (soil:1M KCl) extract, NH_3 and NO_3 are expressed as N.

TABLE AI-5: CONCENTRATIONS OF CHEMICAL CONSTITUENTS IN THE 0- TO 6-INCH DEPTH OF FOUR AMENDMENTS OF SEDIMENT AND BIOSOLIDS MIXTURES IN THE USX RESEARCH AND DEMONSTRATION PLOTS IN FALL 2001[1]

		Amendment							
		0% Biosolids		25% Biosolids		50% Biosolids		100% Biosolids	
Parameter	Unit	East[2]	West[3]	East[2]	West[3]	East[2]	West[3]	East[2]	West[3]
pH[4]		6.9	7.3	6.7	7.3	6.9	7.1	6.4	6.2
EC[4]	dS/m	0.30	0.26	0.67	0.42	0.86	0.39	1.9	1.9
Total P	mg/kg	522	535	5,412	5,719	7,904	10,466	16,359	21,129
Avail. P	”	18	10	237	175	238	279	456	529
TKN[5]	”	1,315	1,767	4,641	4,603	5,915	6,903	9,823	11,691
KCl-NH_3[6]	”	1.7	1.7	4.7	4.1	11	6.7	13	5.6
KCl-NO_3[6]	”	0.21	0.58	13	12	22	33	160	137
H_2O-NH_3[4]	”	0.27	0.17	0.65	0.54	1.3	2.2	5.8	1.6
H_2O-NO_3[4]	”	0.48	0.92	11	9.9	17	30	129	112
SO_4-S	”	419	122	540	316	508	175	947	1158
Org. Carbon	%	2.1	2.3	5.6	5.9	7.7	8.5	15	18
Exch. Ca	mg/kg	2,786	3,270	4,905	6,008	6,181	5,970	5,278	5,948
Exch. Mg	”	670	770	1,042	1,006	1,064	1,057	1,196	1,332
Exch. Na	”	35	16	51	27	62	28	100	115
Exch. K	”	84	90	159	173	191	405	392	521
Zn	”	67	75	457	429	610	594	1,109	1,204
Cd	”	1.3	1.5	4.7	4.6	6.4	6.1	10.0	11
Cu	”	21	19	123	107	167	446	288	311
Cr	”	24	26	70	148	228	197	136	148
Fe	”	11,840	11,754	12,002	13,770	13,919	13,440	12,003	12,854
Ni	”	21	22	31	32	35	33	32	33
Pb	”	28	32	60	63	75	78	120	137
Mn	”	470	517	448	1213	2349	1428	339	359
Mo	”	0.38	0.35	2.2	3.1	6.0	4.4	8.2	9.2

[1]Values are the mean values for two replicate samples taken from four subplots.
[2]Six-inch thick layer of silty clay loam was placed beneath the amendments.
[3]Amendments were placed directly on the slag.
[4]Concentrations in 1:2 (soil:water) extract, NH_3 and NO_3 are expressed as N.
[5]Total Kjeldahl Nitrogen.
[6]Concentrations in 1:10 (soil:1M KCl) extract, NH_3 and NO_3 are expressed as N.

TABLE AI-6: CONCENTRATIONS OF CHEMICAL CONSTITUENTS IN THE 6- TO 10-INCH DEPTH OF FOUR AMENDMENTS OF SEDIMENT AND BIOSOLIDS MIXTURES IN THE USX RESEARCH AND DEMONSTRATION PLOTS IN FALL 2001[1]

		Amendment							
		0% Biosolids		25% Biosolids		50% Biosolids		100% Biosolids	
Parameter	Unit	East[2]	West[3]	East[2]	West[3]	East[2]	West[3]	East[2]	West[3]
pH[4]		7.1	7.5	6.9	7.4	7.1	7.3	6.4	6.2
EC[4]	dS/m	1.3	0.61	1.5	1.0	1.5	0.71	2.7	3.0
TKN[5]	mg/kg	1,707	1,980	3,277	4,571	3,775	6,211	10,149	12,549
KCl-NH_3[6]	”	2.8	2.8	4.0	5.6	4.9	9.8	36	38
KCl-NO_3[6]	”	0.58	0.83	7.8	13	11	31	98	119
H_2O-NH_3[4]	”	0.44	0.15	1.00	0.76	1.2	1.1	7.8	2.2
H_2O-NO_3[4]	”	0.85	1.1	7.8	11	9.7	26	76	82
SO_4-S	”	389	79	538	272	475	158	943	1,089

[1]Values are the mean values for two replicate samples taken from four subplots.
[2]Six-inch thick layer of silty clay loam was placed beneath the amendments.
[3]Amendments were placed directly on the slag.
[4]Concentrations in 1:2 (soil:water) extract, NH_3 and NO_3 are expressed as N.
[5]Total Kjeldahl Nitrogen.
[6]Concentrations in 1:10 (soil:1M KCl) extract, NH_3 and NO_3 are expressed as N.

TABLE AI-7: CONCENTRATIONS OF CHEMICAL CONSTITUENTS IN THE 0- TO 6-INCH DEPTH OF FOUR AMENDMENTS OF SEDIMENT AND BIOSOLIDS MIXTURES IN THE USX RESEARCH AND DEMONSTRATION PLOTS IN SPRING 2002[1]

		Amendment							
		0% Biosolids		25% Biosolids		50% Biosolids		100% Biosolids	
Parameter	Unit	East[2]	West[3]	East[2]	West[3]	East[2]	West[3]	East[2]	West[3]
pH[4]		7.2	7.4	6.8	7.1	7.2	7.2	6.3	6.3
EC[4]	dS/m	0.40	0.10	0.30	0.30	1.1	0.30	1.7	1.8
Total P	mg/kg	510	497	7,551	6,214	6,928	10,175	26,235	26,277
Avail. P	”	16	24	297	224	194	265	452	494
TKN[5]	”	1,530	1,363	5,431	4,881	4,777	6,912	14,524	14,673
KCl-NH_3[6]	”	3.0	2.0	3.6	2.6	4.7	6.5	42	16
KCl-NO_3[6]	”	0.95	1.00	6.7	8.9	5.6	12	19	18
H_2O-NH_3[4]	”	0.65	0.60	1.5	0.95	1.7	1.3	7.8	2.5
H_2O-NO_3[4]	”	0.75	1.1	6.6	9.0	5.1	11	20	12
SO_4-S	”	112	36	31	28	360	42	646	751
Exch. Ca	”	3,211	4,648	5,088	4,897	7,106	6,001	5,758	6,271
Exch. Mg	”	718	778	1,002	948	894	979	1,216	1,231
Exch. Na	”	90	65	111	96	113	92	205	183
Exch. K	”	111	87	220	107	154	259	532	585

[1]Values are the mean values for two replicate samples taken from four subplots.
[2]Six-inch thick layer of silty clay loam was placed beneath the amendments.
[3]Amendments were placed directly on the slag.
[4]Concentrations in 1:2 (soil:water) extract, NH_3 and NO_3 are expressed as N.
[5]Total Kjeldahl Nitrogen.
[6]Concentrations in 1:10 (soil:1M KCl) extract, NH_3 and NO_3 are expressed as N.

TABLE AI-8: CONCENTRATIONS OF CHEMICAL CONSTITUENTS IN THE 6- TO 10-INCH DEPTH OF FOUR AMENDMENTS OF SEDIMENT AND BIOSOLIDS MIXTURES IN THE USX RESEARCH AND DEMONSTRATION PLOTS IN SPRING 2002[1]

		Amendment							
		0% Biosolids		25% Biosolids		50% Biosolids		100% Biosolids	
Parameter	Unit	East[2]	West[3]	East[2]	West[3]	East[2]	West[3]	East[2]	West[3]
pH[4]		7.3	7.7	7.0	7.4	7.4	7.3	6.6	6.3
EC[4]	dS/m	0.90	0.20	0.50	0.30	1.9	0.50	2.8	3.3
TKN[5]	mg/kg	1,348	1,444	4,977	5,204	719	6,084	9,780	15,280
KCl-NH_3[6]	”	2.8	2.8	3.9	4.7	4.8	9.7	59	166
KCl-NO_3[6]	”	0.85	1.1	4.7	7.1	1.3	6.5	32	178
H_2O-NH_3[4]	”	0.50	0.35	0.55	0.65	1.5	1.2	16	53
H_2O-NO_3[4]	”	0.95	1.4	4.9	7.1	1.5	7.1	25	184
SO_4-S	”	346	33	148	44	994	112	1,298	1,396
Exch. Ca	”	4,588	4,328	5,006	6,033	7,942	6,528	6,707	6,229
Exch. Mg	”	783	785	959	934	477	1,026	1,221	1,280
Exch. Na	”	68	92	95	106	68	113	198	238
Exch. K	”	86	106	107	155	70	192	462	676

[1]Values are the mean values for two replicate samples taken from four subplots.
[2]Six-inch thick layer of silty clay loam was placed beneath the amendments.
[3]Amendments were placed directly on the slag.
[4]Concentrations in 1:2 (soil:water) extract, NH_3 and NO_3 are expressed as N.
[5]Total Kjeldahl Nitrogen.
[6]Concentrations in 1:10 (soil:1M KCl) extract, NH_3 and NO_3 are expressed as N.

TABLE AI-9: CONCENTRATIONS OF CHEMICAL CONSTITUENTS IN THE 0- TO 6-INCH DEPTH OF FOUR AMENDMENTS OF SEDIMENT AND BIOSOLIDS MIXTURES IN THE USX RESEARCH AND DEMONSTRATION PLOTS IN FALL 2002[1]

		Amendment							
		0% Biosolids		25% Biosolids		50% Biosolids		100% Biosolids	
Parameter	Unit	East[2]	West[3]	East[2]	West[3]	East[2]	West[3]	East[2]	West[3]
pH[4]		7.3	7.8	6.9	7.4	8.4	6.9	6.5	6.4
EC[4]	dS/m	0.26	0.29	0.64	0.53	1.1	1.0	2.6	2.1
Total P	mg/kg	551	499	5,049	6,121	6,682	10,491	19,823	22,232
Avail. P	”	34	49	307	204	222	264	437	419
TKN[5]	”	1,129	958	4,128	4,512	4,654	6,326	12,128	10,918
KCl-NH_3[6]	”	2.9	2.8	3.5	4.4	5.1	7.3	18	14
KCl-NO_3[6]	”	2.8	2.7	34	39	42	85	193	207
H_2O-NH_3[4]	”	0.64	0.32	0.47	0.70	0.86	1.6	3.3	8.8
H_2O-NO_3[4]	”	1.9	1.6	34	37	41	83	190	203
SO_4-S	”	34	29	98	50	258	180	693	459
Org. Carbon	%	2.5	2.4	6.0	6.1	6.8	9.3	16	14
Exch. Ca	mg/kg	3,200	3,727	5,095	5,958	7,885	6,620	7,512	6,989
Exch. Mg	”	646	260	1,017	910	858	1,048	1,318	1,204
Exch. Na	”	93	489	119	114	119	137	204	181
Exch. K	”	123	132	168	192	235	325	585	617
Zn	”	77	82	440	458	505	721	1,393	1,333
Cd	”	1.1	1.1	4.2	4.3	5.2	6.6	12	12
Cu	”	24	25	117	118	392	197	380	369
Cr	”	33	53	85	180	399	242	274	295
Fe	”	14,893	11,921	14,893	17,340	19,380	16,737	21,001	17,423
Ni	”	24	26	32	36	40	38	46	44
Pb	”	30	32	60	67	64	89	152	153
Mn	”	485	603	526	1,783	3,796	1,847	1,068	1,603
Mo	”	0.90	0.93	2.8	3.8	7.0	6.1	12	11

[1]Values are the mean values for two replicate samples taken from four subplots.
[2]Six-inch thick layer of silty clay loam was placed beneath the amendments.
[3]Amendments were placed directly on the slag.
[4]Concentrations in 1:2 (soil:water) extract, NH_3 and NO_3 are expressed as N.
[5]Total Kjeldahl Nitrogen.
[6]Concentrations in 1:10 (soil:1M KCl) extract, NH_3 and NO_3 are expressed as N.

TABLE AI-10: CONCENTRATIONS OF CHEMICAL CONSTITUENTS IN THE 6- TO 10-INCH DEPTH OF FOUR AMENDMENTS OF SEDIMENT AND BIOSOLIDS MIXTURES IN THE USX RESEARCH AND DEMONSTRATION PLOTS IN FALL 2002[1]

		Amendment							
		0% Biosolids		25% Biosolids		50% Biosolids		100% Biosolids	
Parameter	Unit	East[2]	West[3]	East[2]	West[3]	East[2]	West[3]	East[2]	West[3]
pH[4]		8.3	7.4	7.7	7.4	8.0	7.3	6.6	6.6
EC[4]	dS/m	0.40	0.99	1.5	0.58	1.2	0.63	3.0	2.9
Total P	mg/kg	791	6,028	2,775	4,750	3,585	13,146	16,788	19,830
Avail. P	”	23	58	123	148	165	258	400	421
TKN[5]	”	1,988	4,313	3,519	5,547	4,089	8,411	9,746	11,988
KCl-NH_3[6]	”	3.2	4.6	4.1	4.6	5.3	12	14	13
KCl-NO_3[6]	”	3.8	42	22	49	44	109	194	161
H_2O-NH_3[4]	”	0.41	0.41	1.4	0.06	0.62	3.6	5.3	6.3
H_2O-NO_3[4]	”	3.6	43	22	48	43	115	190	137
SO_4-S	”	71	289	492	79	390	180	947	1024
Org. Carbon	%	2.6	4.9	3.8	5.8	5.9	9.9	11	13
Exch. Ca	mg/kg	5,017	5,023	6,795	5,946	7,569	6,539	7,521	6,927
Exch. Mg	”	710	888	881	905	846	1,029	1,473	1,377
Exch. Na	”	96	123	113	113	115	139	215	207
Exch. K	”	109	213	115	153	173	322	497	567
Zn	”	99	336	278	411	443	832	1,101	1,252
Cd	”	1.5	3.3	3.2	4.2	4.7	7.9	9.8	11
Cu	”	36	92	81	108	128	238	308	356
Cr	”	149	85	129	166	251	314	223	257
Fe	”	14,768	18,064	18,792	24,329	18,648	25,298	19,362	24,748
Ni	”	34	38	34	40	38	44	40	44
Pb	”	28	54	42	62	56	98	118	131
Mn	”	1,619	676	862	1,456	2,106	2,255	780	1,320
Mo	”	1.7	2.7	3.6	3.7	5.0	7.7	9.8	11

[1]Values are the mean values for two replicate samples taken from four subplots.
[2]Six-inch thick layer of silty clay loam was placed beneath the amendments.
[3]Amendments were placed directly on the slag.
[4]Concentrations in 1:2 (soil:water) extract, NH_3 and NO_3 are expressed as N.
[5]Total Kjeldahl Nitrogen.
[6]Concentrations in 1:10 (soil:1M KCl) extract, NH_3 and NO_3 are expressed as N.

TABLE AI-11: CONCENTRATIONS OF CHEMICAL CONSTITUENTS IN THE 0- TO 6-INCH DEPTH OF FOUR AMENDMENTS OF SEDIMENT AND BIOSOLIDS MIXTURES IN THE USX RESEARCH AND DEMONSTRATION PLOTS IN SPRING 2003[1]

		Amendment							
		0% Biosolids		25% Biosolids		50% Biosolids		100% Biosolids	
Parameter	Unit	East[2]	West[3]	East[2]	West[3]	East[2]	West[3]	East[2]	West[3]
pH[4]		7.4	7.4	7.1	7.2	7.1	7.3	6.4	6.5
EC[4]	dS/m	0.33	0.43	0.30	0.27	0.60	0.29	1.3	0.75
Total P	mg/kg	543	566	7,105	7,924	11,753	10,142	27,530	28,076
Avail. P	”	15	17	245	207	254	257	545	517
TKN[5]	”	2,051	2,213	5,974	6,233	8,556	8,106	17,384	16,338
KCl-NH_3[6]	”	2.9	3.4	3.3	3.8	5.0	4.7	25	15
KCl-NO_3[6]	”	2.6	2.6	10	9.0	11	10	101	38
H_2O-NH_3[4]	”	0.40	0.40	0.50	0.50	0.90	0.80	4.4	3.6
H_2O-NO_3[4]	”	2.8	3.1	12	11	13	12	105	44
Exch. Ca	”	648	630	1,014	849	1,007	902	1,290	1,153
Exch. Mg	”	14	8.9	55	60	54	61	130	126
Exch. Na	”	118	113	151	185	213	270	692	715
Exch. K	”	4,004	3,767	5,542	5,763	6,795	6,189	6,951	7,122

[1]Values are the mean values for two replicate samples taken from four subplots.
[2]Six-inch thick layer of silty clay loam was placed beneath the amendments.
[3]Amendments were placed directly on the slag.
[4]Concentrations in 1:2 (soil:water) extract, NH_3 and NO_3 are expressed as N.
[5]Total Kjeldahl Nitrogen.
[6]Concentrations in 1:10 (soil:1M KCl) extract, NH_3 and NO_3 are expressed as N.

TABLE AI-12: CONCENTRATIONS OF CHEMICAL CONSTITUENTS IN THE 6- TO 10-INCH DEPTH OF FOUR AMENDMENTS OF SEDIMENT AND BIOSOLIDS MIXTURES IN THE USX RESEARCH AND DEMONSTRATION PLOTS IN SPRING 2003[1]

		Amendment							
		0% Biosolids		25% Biosolids		50% Biosolids		100% Biosolids	
Parameter	Unit	East[2]	West[3]	East[2]	West[3]	East[2]	West[3]	East[2]	West[3]
pH[4]		7.6	7.9	7.3	7.6	7.4	7.7	6.6	7.0
EC[4]	dS/m	0.55	0.29	1.2	0.48	1.5	0.50	3.2	2.3
Total P	mg/kg	2,591	2,999	4,973	7,443	15,574	17,212	12,722	24,500
Avail. P	”	147	60	171	159	299	292	219	400
TKN[5]	”	1,572	2,057	4,287	4,853	5,082	7,457	15,877	14,783
KCl-NH_3[6]	”	3.7	2.6	4.7	4.0	5.5	7.1	26	16
KCl-NO_3[6]	”	2.0	2.7	17	13	12	11	179	94
H_2O-NH_3[4]	”	0.40	0.40	1.4	0.60	1.4	1.00	5.2	5.6
H_2O-NO_3[4]	”	2.0	3.1	20	16	14	15	213	117
Exch. Ca	”	614	638	834	830	833	1,006	1,475	1,473
Exch. Mg	”	21	11	59	32	47	52	175	162
Exch. Na	”	112	122	120	133	144	210	584	515
Exch. K	”	5,101	4,677	5,859	6,095	6,707	7,450	7,388	8,741

[1]Values are the mean values for two replicate samples taken from four subplots.
[2]Six-inch thick layer of silty clay loam was placed beneath the amendments.
[3]Amendments were placed directly on the slag.
[4]Concentrations in 1:2 (soil:water) extract, NH_3 and NO_3 are expressed as N.
[5]Total Kjeldahl Nitrogen.
[6]Concentrations in 1:10 (soil:1M KCl) extract, NH_3 and NO_3 are expressed as N.

TABLE AI-13: CONCENTRATIONS OF CHEMICAL CONSTITUENTS IN THE 0- TO 6-INCH DEPTH OF FOUR AMENDMENTS OF SEDIMENT AND BIOSOLIDS MIXTURES IN THE USX RESEARCH AND DEMONSTRATION PLOTS IN FALL 2003[1]

		Amendment							
		0% Biosolids		25% Biosolids		50% Biosolids		100% Biosolids	
Parameter	Unit	East[2]	West[3]	East[2]	West[3]	East[2]	West[3]	East[2]	West[3]
pH[4]		7.7	8.2	7.1	8.1	8.1	7.5	6.5	6.6
EC[4]	dS/m	0.16	0.19	0.35	0.44	0.42	0.49	1.4	1.8
Total P	mg/kg	560	596	8,010	6,859	9,148	13,587	27,999	27,541
Avail. P	”	16	19	260	262	183	269	570	571
TKN[5]	”	1,703	2,016	5,577	5,790	6,370	8,251	16,134	16,047
KCl-NH_3[6]	”	4.7	2.6	3.2	2.3	4.0	3.2	11	10
KCl-NO_3[6]	”	1.2	2.5	29	37	33	69	221	272
H_2O-NH_3[4]	”	0.14	0.97	0.37	0.65	0.69	0.90	3.1	2.3
H_2O-NO_3[4]	”	1.1	2.2	20	33	28	53	205	149
SO_4-S	”	14	14	50	19	57	19	363	458
Org. Carbon	%	2.5	2.4	6.0	6.1	6.8	9.3	16	14
Exch. Ca	mg/kg	2,860	3,535	5,404	6,319	7,389	6,551	6,727	6,854
Exch. Mg	”	507	545	875	788	783	869	1,183	1,132
Exch. Na	”	56	27	79	46	86	64	151	120
Exch. K	”	99	102	152	164	171	205	492	619
Zn	”	62	71	461	359	503	574	1,332	1,288
Cd	”	1.1	1.2	4.7	3.9	5.4	5.8	12	12
Cu	”	21	26	132	106	157	168	392	377
Cr	”	31	97	96	228	343	234	173	202
Fe	”	15,631	15,060	20,409	23,181	25,467	22,372	22,531	22,250
Ni	”	20	26	29	34	39	32	35	34
Pb	”	27	26	60	51	63	73	145	142
Mn	”	482	948	554	1,863	2,976	1,444	394	679
Mo	”	0.81	1.4	3.2	4.4	6.5	5.3	11	10

[1]Values are the mean values for two replicate samples taken from four subplots.
[2]Six-inch thick layer of silty clay loam was placed beneath the amendments.
[3]Amendments were placed directly on the slag.
[4]Concentrations in 1:2 (soil:water) extract, NH_3 and NO_3 are expressed as N.
[5]Total Kjeldahl Nitrogen.
[6]Concentrations in 1:10 (soil:1M KCl) extract, NH_3 and NO_3 are expressed as N.

TABLE AI-14: CONCENTRATIONS OF CHEMICAL CONSTITUENTS IN THE 6- TO 10-INCH DEPTH OF FOUR AMENDMENTS OF SEDIMENT AND BIOSOLIDS MIXTURES IN THE USX RESEARCH AND DEMONSTRATION PLOTS IN FALL 2003[1]

		Amendment							
		0% Biosolids		25% Biosolids		50% Biosolids		100% Biosolids	
Parameter	Unit	East[2]	West[3]	East[2]	West[3]	East[2]	West[3]	East[2]	West[3]
pH[4]		7.8	7.9	7.3	7.8	7.7	7.7	6.5	6.9
EC[4]	dS/m	0.34	0.26	0.41	0.36	0.58	0.46	2.2	2.5
Total P	mg/kg	1,309	668	7,025	5,804	8,295	12,765	28,174	22,430
TKN[5]	”	2,142	2,632	5,882	5,252	7,268	8,676	17,585	14,760
KCl-NH_3[6]	”	2.5	14	2.5	6.3	4.5	6.4	16	8.9
KCl-NO_3[6]	”	1.6	4.4	19	17	20	65	277	222
H_2O-NH_3[4]	”	0.79	1.3	1.7	0.33	2.1	0.72	4.8	1.6
H_2O-NO_3[4]	”	1.3	2.2	19	18	20	69	197	245
SO_4-S	”	14	5.7	11	8.6	27	4.8	190	103
Org. Carbon	”	4.2	4.2	8.9	9.0	18	19	24	24
Exch. Ca	”	5,017	5,023	6,795	5,946	7,569	6,539	7,521	6,927
Exch. Mg	”	710	888	881	905	846	1,029	1,473	1,377
Exch. Na	”	96	123	113	113	115	139	215	207
Exch. K	”	109	213	115	153	173	322	497	567

[1]Values are the mean values for two replicate samples taken from four subplots.
[2]Six-inch thick layer of silty clay loam was placed beneath the amendments.
[3]Amendments were placed directly on the slag.
[4]Concentrations in 1:2 (soil:water) extract, NH_3 and NO_3 are expressed as N.
[5]Total Kjeldahl Nitrogen.
[6]Concentrations in 1:10 (soil:1M KCl) extract, NH_3 and NO_3 are expressed as N.

APPENDIX AII

TURFGRASS PERFORMANCE AND TREE GROWTH DATA

TABLE AII-1: PERFORMANCE SCORES[1] AND RATING FOR THE FOUR TURFGRASS MIXES EVALUATED IN THE USX RESEARCH AND DEMONSTRATION PLOTS IN 2001

Amendment	Turfgrass Mix							
	MWRDGC[2]		SCPD[3]		IDOT[4]		VIDOT 1B[5]	
(% Biosolids)	Score	Rating	Score	Rating	Score	Rating	Score	Rating
Clay-Lined Plots								
0	42	Poor	45	Poor	50	Poor	54	Good
25	67	Good	59	Good	58	Good	61	Good
50	64	Good	63	Good	61	Good	60	Good
100	65	Good	64	Good	64	Good	63	Good
Nonlined Plots								
0	58	Good	43	Poor	45	Poor	45	Poor
25	56	Good	54	Good	50	Poor	51	Good
50	52	Good	54	Good	52	Good	52	Good
100	61	Good	58	Good	60	Good	60	Good

[1]Performance evaluation scores were determined by multiplying turf density and turf color quality scores. The turf density and color quality were given 75 and 25 percent weightage, respectively.
[2]MWRDGC = Metropolitan Water Reclamation District of Greater Chicago: 70 percent tall fescue, 30 percent Kentucky Bluegrass.
[3]SCPD = Standard Chicago Park District turf mix: 70 percent tall fescue, 15 percent creeping red fescue, 10 percent Kentucky Bluegrass, 5 percent redtop.
[4]IDOT 1B = Illinois Department of Transportation low maintenance turf mix: 75 percent tall fescue, 15 percent perennial rye, 10 percent creeping red fescue.
[5]VIDOT1 = Variation of Illinois Department of Transportation low maintenance lawn mix: 50 percent perennial rye, 30 percent Kentucky Bluegrass, 20 percent creeping red fescue.

TABLE AII-2: PERFORMANCE SCORES[1] AND RATING FOR THE FOUR TURFGRASS MIXES EVALUATED IN THE USX RESEARCH AND DEMONSTRATION PLOTS IN 2002

Amendment	Turfgrass Mix							
	MWRDGC[2]		SCPD[3]		IDOT[4]		VIDOT 1B[5]	
(% Biosolids)	Score	Rating	Score	Rating	Score	Rating	Score	Rating
Clay-Lined Plots								
0	24	Very Poor	32	Poor	34	Poor	40	Poor
25	67	Good	68	Good	68	Good	69	Good
50	72	Excellent	66	Good	70	Good	68	Good
100	71	Excellent	69	Good	71	Excellent	68	Good
Nonlined Plots								
0	40	Poor	42	Poor	39	Poor	40	Poor
25	67	Good	66	Good	50	Poor	58	Good
50	74	Excellent	66	Good	49	Poor	52	Poor
100	79	Excellent	71	Excellent	67	Good	61	Good

[1]Performance evaluation scores were determined by multiplying turf density and turf color quality scores. The turf density and color quality were given 75 and 25 percent weightage, respectively.
[2]MWRDGC = Metropolitan Water Reclamation District of Greater Chicago: 70 percent tall fescue, 30 percent Kentucky bluegrass.
[3]SCPD = Standard Chicago Park District turf mix: 70 percent tall fescue, 15 percent creeping red fescue, 10 percent Kentucky bluegrass, 5 percent redtop.
[4]IDOT 1B = Illinois Department of Transportation low maintenance turf mix: 75 percent tall fescue, 15 percent perennial rye, 10 percent creeping red fescue.
[5]VIDOT1 = Variation of Illinois Department of Transportation low maintenance lawn mix: 50 percent perennial rye, 30 percent Kentucky Bluegrass, 20 percent creeping red fescue.

TABLE AII-3: PERFORMANCE SCORES[1] AND RATING FOR THE FOUR TURFGRASS MIXES EVALUATED IN THE USX RESEARCH AND DEMONSTRATION PLOTS IN 2003

Amendment	Turfgrass Mix							
	MWRDGC[2]		SCPD[3]		IDOT[4]		VIDOT 1B[5]	
(% Biosolids)	Score	Rating	Score	Rating	Score	Rating	Score	Rating
Clay-Lined Plots								
0	47	Poor	43	Poor	49	Poor	50	Poor
25	83	Excellent	82	Excellent	84	Excellent	82	Excellent
50	83	Excellent	87	Excellent	91	Excellent	88	Excellent
100	88	Excellent	89	Excellent	91	Excellent	88	Excellent
Nonlined Plots								
0	41	Poor	49	Poor	44	Poor	47	Poor
25	89	Excellent	87	Excellent	65	Good	71	Excellent
50	57	Good	78	Excellent	50	Poor	76	Excellent
100	57	Good	61	Good	72	Excellent	67	Good

[1]Performance evaluation scores were determined by multiplying turf density and turf color quality scores. The turf density and color quality were given 75 and 25 percent weightage, respectively.
[2]MWRDGC = Metropolitan Water Reclamation District of Greater Chicago: 70 percent tall fescue, 30 percent Kentucky bluegrass.
[3]SCPD = Standard Chicago Park District turf mix: 70 percent tall fescue, 15 percent creeping red fescue, 10 percent Kentucky bluegrass, 5 percent redtop.
[4]IDOT 1B = Illinois Department of Transportation low maintenance turf mix: 75 percent tall fescue, 15 percent perennial rye, 10 percent creeping red fescue.
[5]VIDOT1 = Variation of Illinois Department of Transportation low maintenance lawn mix: 50 percent perennial rye, 30 percent Kentucky Bluegrass, 20 percent creeping red fescue.

TABLE AII-4: GROWTH INDEX[1] VALUES FOR ORNAMENTAL AND SHADE TREE SPECIES EVALUATED IN THE CLAY-LINED PLOTS OF THE USX RESEARCH AND DEMONSTRATION PROJECT IN 2001

Tree Type	Amendment			
	0% Biosolids	25% Biosolids	50% Biosolids	100% Biosolids
Ornamental Trees				
Amur Maple	0.4	0.9	1.0	0.9
Apple Serviceberry[2]	0.3	0.3	0.8	0.5
Thornless Cockspur	0.9	0.6	0.9	1.0
Donald Wyman Crabapple	0.7	0.5	1.0	0.9
Zumi Crabapple	0.6	0.4	0.6	0.7
Shade Trees				
Hybrid Maple	1.1	1.1	0.9	1.2
Purple Ash	1.1	1.2	1.3	1.2
Honey Locust	1.6	1.4	1.8	1.5
Cottonless Cottonwood	1.0	1.6	1.4	1.1
Red Oak[3]	0.9	1.3	1.1	1.0
Hybrid Elm[2]	2.5	2.7	2.5	2.8

[1]Growth Index = Tree trunk diameter (ft) x tree height (ft).

[2]Performance evaluation in the 50% and 100% biosolids amendments is based on two years' data because most of the apple serviceberry trees were severely damaged by wildlife in the winter 2002.

[3]Performance evaluation in the 50% and 100% biosolids amendments is based on one year of data because most of the red oak trees were damaged by wildlife in the winter 2001.

TABLE AII-5: GROWTH INDEX[1] VALUES FOR ORNAMENTAL AND SHADE TREE SPECIES EVALUATED IN THE NONLINED PLOTS OF THE USX RESEARCH AND DEMONSTRATION PROJECT IN 2001

Tree Type	Amendment			
	0% Biosolids	25% Biosolids	50% Biosolids	100% Biosolids
Ornamental Trees				
Amur Maple	0.7	0.5	0.6	0.7
Apple Serviceberry[2]	0.5	0.3	0.4	0.6
Thornless Cockspur	0.8	0.8	0.8	0.7
Donald Wyman Crabapple	0.6	0.5	0.7	0.7
Zumi Crabapple	0.3	0.5	0.4	0.5
Shade Trees				
Hybrid Maple	1.4	1.2	1.2	0.9
Purple Ash	1.1	1.3	1.0	1.1
Honey Locust	1.6	1.3	1.4	1.6
Cottonless Cottonwood	1.0	1.5	1.5	1.0
Red Oak[3]	1.1	1.1	1.1	1.6
Hybrid Elm[2]	2.4	2.4	1.9	2.6

[1]Growth Index = Tree trunk diameter (ft) x tree height (ft).

[2]Performance evaluation in the 50% and 100% biosolids amendments is based on two years' data because most of the apple serviceberry trees were severely damaged by wildlife in the winter 2002.

[3]Performance evaluation in the 50% and 100% biosolids amendments is based on one year of data because most of the red oak trees were damaged by wildlife in the winter 2001.

TABLE AII-6: GROWTH INDEX[1] VALUES FOR ORNAMENTAL AND SHADE TREE SPECIES EVALUATED IN THE CLAY-LINED PLOTS OF THE USX RESEARCH AND DEMONSTRATION PROJECT IN 2002

Tree Type	Amendment			
	0% Biosolids	25% Biosolids	50% Biosolids	100% Biosolids
Ornamental Trees				
Amur Maple	0.6	1.2	1.9	1.7
Apple Serviceberry[2]	0.5	0.7	1.3	0.0
Thornless Cockspur	1.1	1.4	1.7	3.0
Donald Wyman Crabapple	1.4	0.9	1.9	1.9
Zumi Crabapple	1.0	0.7	2.1	1.6
Shade Trees				
Hybrid Maple	1.5	2.3	2.3	2.0
Purple Ash	1.5	2.1	1.6	1.7
Honey Locust	2.0	1.9	2.7	2.1
Cottonless Cottonwood	3.8	5.4	4.9	3.6
Red Oak[3]	1.2	2.0	1.7	0.0
Hybrid Elm[2]	3.4	4.1	5.0	3.7

[1]Growth Index = Tree trunk diameter (ft) x tree height (ft).

[2]Performance evaluation in the 50% and 100% biosolids amendments is based on two years' data because most of the apple serviceberry trees were severely damaged by wildlife in the winter 2002.

[3]Performance evaluation in the 50% and 100% biosolids amendments is based on one year of data because most of the red oak trees were damaged by wildlife in the winter 2001.

TABLE AII-7: GROWTH INDEX[1] VALUES FOR ORNAMENTAL AND SHADE TREE SPECIES EVALUATED IN THE NONLINED PLOTS OF THE USX RESEARCH AND DEMONSTRATION PROJECT IN 2002

Tree Type	Amendment			
	0% Biosolids	25% Biosolids	50% Biosolids	100% Biosolids
Ornamental Trees				
Amur Maple	1.8	1.1	1.3	1.6
Apple Serviceberry[2]	1.0	0.9	0.6	1.1
Thornless Cockspur	1.2	1.8	1.4	1.8
Donald Wyman Crabapple	1.6	0.9	1.7	1.1
Zumi Crabapple	1.4	1.1	1.6	1.5
Shade Trees				
Hybrid Maple	1.7	3.2	2.0	1.4
Purple Ash	1.6	2.1	1.4	1.5
Honey Locust	1.9	2.8	2.0	2.0
Cottonless Cottonwood	3.6	5.6	4.9	4.2
Red Oak[3]	1.6	1.8	0.0	0.0
Hybrid Elm[2]	3.4	4.3	3.5	3.6

[1]Growth Index = Tree trunk diameter (ft) x tree height (ft).

[2]Performance evaluation in the 50% and 100% biosolids amendments is based on two years' data because most of the apple serviceberry trees were severely damaged by wildlife in the winter 2002.

[3]Performance evaluation in the 50% and 100% biosolids amendments is based on one year of data because most of the red oak trees were damaged by wildlife in the winter 2001.

TABLE AII-8: GROWTH INDEX[1] VALUES FOR ORNAMENTAL AND SHADE TREE SPECIES EVALUATED IN THE CLAY-LINED PLOTS OF THE USX RESEARCH AND DEMONSTRATION PROJECT IN 2003

Tree Type	Amendment			
	0% Biosolids	25% Biosolids	50% Biosolids	100% Biosolids
Ornamental Trees				
Amur Maple	1.2	1.9	2.3	1.8
Apple Serviceberry[2]	0.3	0.7	0.0	0.0
Thornless Cockspur	1.6	1.3	2.1	1.7
Donald Wyman Crabapple	1.7	0.7	2.0	2.3
Zumi Crabapple	1.5	0.8	1.9	2.1
Shade Trees				
Hybrid Maple	2.1	2.7	3.3	3.0
Purple Ash	2.0	1.5	2.1	2.3
Honey Locust	3.1	3.3	4.0	3.5
Cottonless Cottonwood	6.9	10.3	8.4	10.3
Red Oak[3]	1.1	1.5	1.7	0.0
Hybrid Elm[2]	4.1	5.0	0.0	0.0

[1]Growth Index = Tree trunk diameter (ft) x tree height (ft).
[2]Performance evaluation in the 50% and 100% biosolids amendments is based on two years' data because most of the apple serviceberry trees were severely damaged by wildlife in the winter 2002.
[3]Performance evaluation in the 50% and 100% biosolids amendments is based on one year of data because most of the red oak trees were damaged by wildlife in the winter 2001.

TABLE AII-9: GROWTH INDEX[1] VALUES FOR ORNAMENTAL AND SHADE TREE SPECIES EVALUATED IN THE NONLINED PLOTS OF THE USX RESEARCH AND DEMONSTRATION PROJECT IN 2003

Tree Type	Amendment			
	0% Biosolids	25% Biosolids	50% Biosolids	100% Biosolids
Ornamental Trees				
Amur Maple	2.2	3.0	1.3	1.5
Apple Serviceberry[2]	1.0	0.4	0.9	0.0
Thornless Cockspur	1.4	1.3	1.3	1.4
Donald Wyman Crabapple	2.6	1.8	1.4	1.4
Zumi Crabapple	2.3	1.6	1.2	1.8
Shade Trees				
Hybrid Maple	2.4	3.1	2.9	2.5
Purple Ash	2.0	2.2	2.0	1.7
Honey Locust	3.3	3.1	3.4	3.2
Cottonless Cottonwood	7.5	7.8	9.1	9.6
Red Oak[3]	2.1	2.2	0.0	0.0
Hybrid Elm[2]	4.7	5.4	4.2	0.0

[1]Growth Index = Tree trunk diameter (ft) x tree height (ft).

[2]Performance evaluation in the 50% and 100% biosolids amendments is based on two years' data because most of the apple serviceberry trees were severely damaged by wildlife in the winter 2002.

[3]Performance evaluation in the 50% and 100% biosolids amendments is based on one year of data because most of the red oak trees were damaged by wildlife in the winter 2001.

TABLE AII-10: TRUNK DIAMETER[1] MEASUREMENTS FOR ORNAMENTAL AND SHADE TREE SPECIES EVALUATED IN THE USX RESEARCH AND DEMONSTRATION PLOTS IN 2001

Tree Type	Amendment							
	0% Biosolids		25% Biosolids		50% Biosolids		100% Biosolids	
	Clay-Lined	Nonlined	Clay-Lined	Nonlined	Clay-Lined	Nonlined	Clay-Lined	Nonlined
Ornamental Trees								
Amur Maple	0.9	1.4	1.7	1.2	2.3	1.4	1.9	1.5
Apple Serviceberry	0.7	1.2	0.6	0.7	1.7	0.9	1.2	1.4
Thornless Cockspur	1.1	1.1	1.0	1.1	1.2	1.1	1.2	1.0
Donald Wyman Crabapple	1.3	1.2	1.1	0.9	1.6	1.4	1.8	1.6
Zumi Crabapple	1.3	0.8	1.0	1.1	1.4	1.0	1.3	1.1
Shade Trees								
Hybrid Maple	1.3	1.4	1.3	1.3	1.1	1.3	1.2	1.1
Purple Ash	1.2	1.1	1.2	1.3	1.3	1.1	1.8	1.1
Honey Locust	1.4	1.5	1.3	1.3	1.6	1.4	1.3	1.4
Cottonless Cottonwood	1.1	1.2	1.5	1.5	1.5	1.5	1.3	1.1
Red Oak	0.9	1.0	1.1	1.0	1.1	1.0	1.2	1.4
Hybrid Elm	1.9	1.9	2.1	1.9	1.9	1.7	1.4	1.9

[1]Trunk diameter measured in inches at breast height.

TABLE AII-11: TRUNK DIAMETER[1] MEASUREMENTS FOR ORNAMENTAL AND SHADE TREE SPECIES EVALUATED IN THE USX RESEARCH AND DEMONSTRATION PLOTS IN 2002

Tree Type	Amendment							
	0% Biosolids		25% Biosolids		50% Biosolids		100% Biosolids	
	Clay-Lined	Nonlined	Clay-Lined	Nonlined	Clay-Lined	Nonlined	Clay-Lined	Nonlined
Ornamental Trees								
Amur Maple	1.2	3.1	2.1	1.9	3.5	2.5	3.2	2.8
Apple Serviceberry	1.0	1.9	1.3	1.8	2.6	1.3	---	2.3
Thornless Cockspur	1.4	1.4	1.8	2.4	1.6	1.7	3.0	2.2
Donald Wyman Crabapple	2.4	2.7	1.6	1.7	2.9	3.1	2.9	2.0
Zumi Crabapple	1.9	2.4	1.3	2.1	3.6	2.8	2.8	2.8
Shade Trees								
Hybrid Maple	1.6	1.6	2.0	1.8	2.0	1.9	3.0	1.5
Purple Ash	1.5	1.6	1.7	1.5	1.5	1.4	2.9	1.5
Honey Locust	1.7	1.6	1.6	1.8	2.0	1.6	2.8	1.7
Cottonless Cottonwood	2.7	2.5	3.3	3.0	3.3	3.3	1.8	3.0
Red Oak	1.2	1.4	1.6	1.5	1.4	---	1.5	---
Hybrid Elm	2.3	2.3	2.7	2.7	2.9	2.5	1.7	2.5

[1]Trunk diameter measured in inches at breast height.
---The trees were severely damaged by wildlife.

TABLE AII-12: TRUNK DIAMETER[1] MEASUREMENTS FOR ORNAMENTAL AND SHADE TREE SPECIES EVALUATED IN THE USX RESEARCH AND DEMONSTRATION PLOTS IN 2003

	Amendment							
	0% Biosolids		25% Biosolids		50% Biosolids		100% Biosolids	
Tree Type	Clay-Lined	Nonlined	Clay-Lined	Nonlined	Clay-Lined	Nonlined	Clay-Lined	Nonlined
Ornamental Trees								
Amur Maple	2.0	3.2	3.2	4.9	4.0	1.8	3.2	2.5
Apple Serviceberry	0.8	1.9	1.4	0.8	ND[2]	1.2	ND	ND
Thornless Cockspur	2.2	2.0	1.8	1.8	2.8	1.6	2.4	2.1
Donald Wyman Crabapple	2.4	4.1	1.2	2.9	2.9	2.0	3.6	2.3
Zumi Crabapple	2.5	3.3	1.3	3.2	3.6	1.7	3.5	2.3
Shade Trees								
Hybrid Maple	2.2	2.0	2.3	2.4	2.7	2.3	2.4	2.3
Purple Ash	1.9	1.6	1.8	1.9	1.9	1.9	3.6	1.7
Honey Locust	2.3	2.0	2.4	2.8	2.6	2.1	3.5	2.3
Cottonless Cottonwood	4.0	3.9	5.2	4.3	4.5	4.7	2.5	4.7
Red Oak	1.2	1.6	1.3	1.6	1.6	ND	ND	ND
Hybrid Elm	2.9	2.9	3.1	3.4	ND	2.7	2.5	ND

[1]Trunk diameter measured in inches at breast height.
[2] ND = No data. The trees were severely damaged by wildlife.

TABLE AII-13: HEIGHT[1] MEASUREMENTS FOR ORNAMENTAL AND SHADE TREE SPECIES EVALUATED IN THE USX RESEARCH AND DEMONSTRATION PLOTS IN 2001

Tree Type	Amendment							
	0% Biosolids		25% Biosolids		50% Biosolids		100% Biosolids	
	Clay-Lined	Nonlined	Clay-Lined	Nonlined	Clay-Lined	Nonlined	Clay-Lined	Nonlined
Ornamental Trees								
Amur Maple	5.2	5.6	6.3	5.4	5.5	5.3	5.4	5.7
Apple Serviceberry	5.7	5.6	5.8	5.2	5.4	5.3	5.5	5.3
Thornless Cockspur	7.4	7.5	7.6	7.3	9.5	7.1	9.7	7.1
Donald Wyman Crabapple	6.5	5.8	5.6	5.6	7.1	6.0	6.3	5.2
Zumi Crabapple	5.5	5.5	5.4	5.4	5.5	5.5	6.3	5.3
Shade Trees								
Hybrid Maple	7.8	10.8	10.7	11.2	9.6	11.0	10.6	9.7
Purple Ash	10.3	9.5	11.8	12.7	11.4	10.9	10.7	10.1
Honey Locust	11.7	13.0	12.4	12.2	13.2	12.3	11.9	13.9
Cottonless Cottonwood	10.3	9.6	12.6	12.0	11.9	11.9	11.1	11.1
Red Oak	9.8	11.7	12.5	13.3	11.5	12.8	14.3	13.3
Hybrid Elm	11.3	15.3	15.4	15.2	15.4	13.4	14.8	15.8

[1]The height was measured in ft.

TABLE AII-14: HEIGHT[1] MEASUREMENTS FOR ORNAMENTAL AND SHADE TREE SPECIES EVALUATED IN THE USX RESEARCH AND DEMONSTRATION PLOTS IN 2002

	Amendment							
	0% Biosolids		25% Biosolids		50% Biosolids		100% Biosolids	
Tree Type	Clay-Lined	Nonlined	Clay-Lined	Nonlined	Clay-Lined	Nonlined	Clay-Lined	Nonlined
Ornamental Trees								
Amur Maple	6.5	7.1	6.7	6.8	6.5	6.2	6.5	6.6
Apple Serviceberry	5.9	6.3	6.5	5.6	6.1	5.4	ND[2]	5.9
Thornless Cockspur	9.9	10.1	9.6	9.0	12.4	8.1	12.1	8.9
Donald Wyman Crabapple	7.3	7.1	6.9	6.5	8.0	6.8	7.7	6.8
Zumi Crabapple	6.5	6.8	6.8	6.3	7.0	6.3	6.8	6.4
Shade Trees								
Hybrid Maple	11.1	12.9	13.8	12.2	13.5	12.7	13.0	11.3
Purple Ash	12.0	12.3	15.2	14.3	13.1	12.1	13.3	12.3
Honey Locust	14.5	14.4	14.3	14.7	16.3	15.1	15.1	14.7
Cottonless Cottonwood	17.0	17.3	19.4	18.3	17.9	17.8	15.7	16.7
Red Oak	12.2	14.0	15.1	14.4	14.4	ND	ND	ND
Hybrid Elm	18.2	17.9	18.5	16.4	20.3	16.4	17.8	17.3

[1]The height was measured in ft.
[2] ND = No dataThe trees were severely damaged by wildlife.

TABLE AII-15: HEIGHT[1] MEASUREMENTS FOR ORNAMENTAL AND SHADE TREE SPECIES EVALUATED IN THE USX RESEARCH AND DEMONSTRATION PLOTS IN 2003

Tree Type	Amendment							
	0% Biosolids		25% Biosolids		50% Biosolids		100% Biosolids	
	Clay-Lined	Nonlined	Clay-Lined	Nonlined	Clay-Lined	Nonlined	Clay-Lined	Nonlined
Ornamental Trees								
Amur Maple	6.5	7.1	6.7	6.8	6.5	6.2	6.5	6.6
Apple Serviceberry	5.9	6.3	6.5	5.6	ND[2]	5.4	ND	ND
Thornless Cockspur	9.9	10.1	9.6	9.0	12.4	8.1	12.1	8.9
Donald Wyman Crabapple	7.3	7.1	6.9	6.5	8.0	6.8	7.7	6.8
Zumi Crabapple	6.5	6.8	6.8	6.3	7.0	6.3	6.8	6.4
Shade Trees								
Hybrid Maple	11.1	12.9	13.8	12.2	13.5	12.7	13.0	11.3
Purple Ash	12.0	12.3	15.2	14.3	13.1	12.1	13.3	12.3
Honey Locust	14.5	14.4	14.3	14.7	16.3	15.1	15.1	14.7
Cottonless Cottonwood	17.0	17.3	19.4	18.3	17.9	17.8	15.7	16.7
Red Oak	12.2	14.0	15.1	14.4	14.4	ND	ND	ND
Hybrid Elm	18.2	17.9	18.5	16.4	ND	16.4	17.8	ND

[1] The height was measured in ft.
[2] ND = No data. The trees were severely damaged by wildlife.

APPENDIX AIII

CONCENTRATIONS OF NUTRIENTS AND TRACE METALS IN TURFGRASS AND TREES

TABLE AIII-1: MEAN[1] ANNUAL CONCENTRATIONS OF NUTRIENTS AND TRACE METALS IN LEAF TISSUES OF MWRDGC[2] TURF MIX COLLECTED FROM THE CLAY-LINED PLOTS OF THE USX RESEARCH AND DEMONSTRATION PROJECT IN 2001 THROUGH 2003

	Amendment											
	0% Biosolids			25% Biosolids			50% Biosolids			100% Biosolids		
Parameter	2001	2002	2003	2001	2002	2003	2001	2002	2003	2001	2002	2003
	mg/kg											
Zn	25	27	35	49	44	46	71	49	37	135	83	71
Cd	0.53	0.17	0.19	0.63	0.22	0.07	0.89	0.30	0.04	1.16	0.73	0.76
Cu	7.6	6.6	9.4	15.6	10.7	13.5	17.6	12.1	12.2	24.9	15.1	16.4
Cr	0.48	1.18	0.45	0.33	0.62	0.26	0.23	0.63	0.27	0.27	0.65	0.44
Ni	2.33	1.65	1.26	1.56	2.30	1.54	2.95	2.46	2.02	5.24	5.69	5.36
Pb	0.79	0.96	1.73	0.10	0.28	1.53	0.20	0.13	0.80	0.13	0.13	1.60
K	24,160	24,516	24,748	25,559	28,237	26,411	30,039	27,710	27,113	37,692	34,126	31,532
Na	112	73	59	138	153	80	164	77	63	276	172	79
Ca	6,179	6,770	5,473	4,359	4,965	4,147	5,425	4,350	4,217	5,425	4,478	4,101
Mg	4,114	3,618	3,655	3,646	3,526	2,883	4,284	2,929	2,878	4,848	3,637	3,197
Mn	177	60	34	105	30	24	89	39	24	89	165	79
Fe	61	147	89	39	116	92	34	98	92	139	83	106
Mo	10.25	5.91	11.20	5.46	6.34	5.51	8.11	5.59	4.66	6.32	4.24	3.87
N	22,510	23,673	26,233	39,916	39,680	39,575	42,824	39,788	43,483	49,327	39,893	43,194
P	3,439	5,077	5,500	4,932	5,166	4,858	5,988	4,006	4,129	6,264	4,391	4,142
S[3]	8,181	8,673		7,253	9,998		8,214	10,485		7,893	9,978	

[1]Values are the mean of values for fall and spring samplings of composite tissue samples.
[2]MWRDGC = Metropolitan Water Reclamation District of Greater Chicago, mix = 70 percent tall fescue, 30 percent Kentucky bluegrass.
[3]The tissue samples taken in 2003 were not analyzed for S.

TABLE AIII-2: MEAN[1] ANNUAL CONCENTRATIONS OF NUTRIENTS AND TRACE METALS IN LEAF TISSUES OF MWRDGC[2] TURF MIX COLLECTED FROM THE NONLINED PLOTS OF THE USX RESEARCH AND DEMONSTRATION PROJECT IN 2001 THROUGH 2003

Parameter	Amendment											
	0% Biosolids			25% Biosolids			50% Biosolids			100% Biosolids		
	2001	2002	2003	2001	2002	2003	2001	2002	2003	2001	2002	2003
	mg/kg											
Zn	29	32	24	62	48	49	107	61	48	123	77	72
Cd	0.14	0.05	0.12	0.43	0.19	0.15	0.52	0.27	0.26	0.99	0.66	0.37
Cu	8.6	7.1	5.8	15.1	11.3	16.6	19.3	12.0	13.8	23.3	14.2	16.3
Cr	0.48	1.42	1.01	0.43	1.30	0.43	0.46	1.40	0.33	0.41	1.14	0.53
Ni	0.92	1.35	1.76	1.81	1.51	1.36	3.26	2.55	1.35	7.64	6.14	5.05
Pb	0.21	1.70	0.90	0.10	0.58	0.35	0.21	0.41	0.24	0.10	0.31	0.20
K	27,091	24,999	22,566	30,603	23,873	22,492	33,831	25,848	27,841	40,508	28,618	29,639
Na	72	36	20	153	118	44	276	102	88	236	118	98
Ca	5,287	6,982	5,836	5,484	5,134	5,656	7,024	4,731	5,367	5,372	4,047	4,171
Mg	4,540	3,911	3,855	4,237	2,912	2,866	5,300	2,989	3,636	4,585	3,122	3,299
Mn	152	58	63	106	27	26	130	55	38	95	140	96
Fe	67	176	217	32	142	115	87	146	128	130	103	110
Mo	9.18	7.52	7.69	5.79	5.56	5.77	7.49	5.02	4.14	6.95	4.66	4.88
N	28,681	24,865	26,040	40,112	40,835	43,397	47,679	43,230	38,766	49,227	44,378	37,790
P	4,414	4,605	5,293	4,659	3,769	3,818	5,126	4,117	3,877	5,792	4,697	4,215
S[3]	9,840	9,975		8,345	7,535		9,329	8,477		7,336	8,762	

[1]Values are the mean of values for fall and spring samplings of composite tissue samples.
[2]MWRDGC = Metropolitan Water Reclamation District of Greater Chicago, mix = 70 percent tall fescue, 30 percent Kentucky bluegrass.
[3]The tissue samples taken in 2003 were not analyzed for S.

TABLE AIII-3: MEAN[1] ANNUAL CONCENTRATIONS OF NUTRIENTS AND TRACE METALS IN LEAF TISSUES OF SCPD[2] TURF MIX COLLECTED FROM THE CLAY-LINED PLOTS OF THE USX RESEARCH AND DEMONSTRATION PROJECT IN 2001 THROUGH 2003

	Amendment											
	0% Biosolids			25% Biosolids			50% Biosolids			100% Biosolids		
Parameter	2001	2002	2003	2001	2002	2003	2001	2002	2003	2001	2002	2003
	mg/kg											
Zn	50	42	51	118	67	46	104	52	53	201	88	74
Cd	0.16	0.04	0.12	0.42	0.16	0.02	0.47	0.15	0.02	0.53	0.29	0.57
Cu	10.9	7.3	12.5	21.7	15.0	16.3	18.3	13.2	16.0	27.0	14.8	24.0
Cr	0.50	1.54	0.47	0.29	0.79	0.18	0.41	0.47	0.49	0.45	0.56	1.21
Ni	1.39	1.74	1.52	2.41	3.39	1.61	3.23	3.06	2.56	9.69	8.44	7.45
Pb	0.81	0.80	2.13	0.10	0.10	1.40	0.31	0.10	0.20	0.10	0.12	2.55
K	19,113	19,563	22,256	29,682	30,914	27,541	30,730	28,038	29,408	38,354	29,951	31,484
Na	98	48	55	143	120	79	159	85	67	220	107	55
Ca	5,929	7,332	5,632	5,184	4,327	4,328	5,468	4,106	4,934	5,921	3,756	4,465
Mg	3,019	3,449	3,022	4,233	3,324	3,069	3,894	2,995	3,160	4,744	2,972	3,706
Mn	170	88	52	98	47	25	118	38	28	102	172	97
Fe	111	176	118	54	102	98	65	86	94	180	87	319
Mo	7.34	5.68	9.99	10.65	6.90	5.60	9.69	4.46	5.47	12.03	6.20	4.30
N	25,043	21,928	27,667	44,579	43,551	47,475	40,953	38,173	46,950	48,440	44,273	49,550
P	4,184	3,807	5,099	4,736	4,872	4,214	5,649	4,156	4,111	5,721	4,499	4,483
S[3]	8,265	7,643		9,420	10,715		8,160	10,217		10,135	11,072	

[1]Values are the mean of values for fall and spring samplings of composite tissue samples.
[2]SCPD = Standard Chicago Park District, mix = 70 percent tall fescue, 15 percent creeping red fescue, 10 percent Kentucky bluegrass, 5 percent redtop.
[3]The tissue samples taken in 2003 were not analyzed for S.

TABLE AIII-4: MEAN[1] ANNUAL CONCENTRATIONS OF NUTRIENTS AND TRACE METALS IN LEAF TISSUES OF SCPD[2] TURF MIX COLLECTED FROM THE NONLINED PLOTS OF THE USX RESEARCH AND DEMONSTRATION PROJECT IN 2001 THROUGH 2003

	Amendment											
	0% Biosolids			25% Biosolids			50% Biosolids			100% Biosolids		
Parameter	2001	2002	2003	2001	2002	2003	2001	2002	2003	2001	2002	2003
	mg/kg											
Zn	40	32	36	95	56	57	138	69	57	147	89	75
Cd	0.12	0.03	0.07	0.20	0.11	0.19	0.33	0.13	0.18	0.42	0.31	0.31
Cu	7.6	6.6	7.0	18.4	13.6	15.5	22.2	12.7	15.4	30.4	16.0	19.3
Cr	1.20	1.23	0.74	0.46	0.84	0.40	0.55	1.22	0.39	0.38	1.07	0.45
Ni	2.03	1.47	1.73	2.20	1.99	1.94	3.80	3.56	2.75	11.63	6.94	6.95
Pb	0.74	0.89	0.39	0.10	0.23	0.20	0.51	0.29	0.20	0.10	0.34	0.20
K	22,173	23,167	21,129	31,120	25,894	28,899	32,801	25,305	27,745	38,664	27,174	29,748
Na	71	24	31	295	98	140	278	128	53	171	86	68
Ca	5,808	6,459	5,470	6,295	4,503	5,078	7,111	4,862	5,019	5,859	4,132	4,292
Mg	3,403	3,193	2,916	4,188	3,038	3,265	5,327	3,314	3,395	4,286	3,039	3,095
Mn	345	65	47	122	30	28	153	56	35	105	182	84
Fe	99	196	155	43	100	107	98	129	103	159	119	98
Mo	6.99	6.16	8.38	6.21	6.23	5.29	9.76	6.16	4.52	15.43	7.01	6.19
N	23,368	24,727	26,431	46,804	42,963	47,414	49,343	42,698	40,689	52,993	44,678	37,776
P	4,306	4,309	4,405	5,451	4,478	4,149	5,575	4,311	4,058	6,010	4,829	4,438
S[3]	9,244	9,886		8,530	9,147		8,919	8,973		10,581	10,786	

[1]Values are the mean of values for fall and spring samplings of composite tissue samples.
[2]SCPD = Standard Chicago Park District, mix = 70 percent tall fescue, 15 percent creeping red fescue, 10 percent Kentucky bluegrass, 5 percent redtop.
[3]The tissue samples taken in 2003 were not analyzed for S.

TABLE AIII-5: MEAN[1] ANNUAL CONCENTRATIONS OF NUTRIENTS AND TRACE METALS IN LEAF TISSUES OF IDOT 1B[2] TURF MIX COLLECTED FROM THE CLAY-LINED PLOTS OF THE USX RESEARCH AND DEMONSTRATION PROJECT IN 2001 THROUGH 2003

	Amendment											
	0% Biosolids			25% Biosolids			50% Biosolids			100% Biosolids		
Parameter	2001	2002	2003	2001	2002	2003	2001	2002	2003	2001	2002	2003
	mg/kg											
Zn	30	28	41	127	61	49	102	57	58	225	121	98
Cd	0.35	0.14	0.27	0.65	0.24	0.02	0.55	0.24	0.35	0.67	0.48	0.30
Cu	5.9	5.9	11.4	18.3	12.1	12.4	21.5	10.8	15.0	32.0	18.6	17.6
Cr	0.54	1.20	0.52	0.42	0.74	0.18	0.35	0.99	0.42	0.38	0.52	0.40
Ni	2.71	1.59	1.96	2.67	3.25	1.62	2.73	2.69	2.41	7.53	7.57	4.48
Pb	0.69	0.49	2.20	0.10	0.14	1.40	0.29	0.30	1.73	0.10	0.24	1.83
K	18,064	23,370	22,590	29,237	32,152	29,004	33,525	30,777	31,605	41,815	37,877	32,560
Na	100	85	69	407	236	187	376	249	270	270	243	315
Ca	6,575	7,371	5,828	6,616	4,640	4,715	6,823	5,609	5,297	6,737	4,694	5,513
Mg	3,231	3,695	3,214	5,352	3,832	3,493	5,058	3,936	3,858	5,402	3,939	4,545
Mn	144	76	50	127	54	27	93	38	25	90	193	105
Fe	105	107	112	51	95	85	34	111	107	193	84	184
Mo	11.67	6.38	10.57	9.82	6.88	6.42	11.01	4.60	4.38	16.13	6.93	3.68
N	17,967	22,127	24,609	48,386	39,835	43,507	51,577	38,874	44,568	51,585	47,979	46,804
P	3,780	4,631	4,944	4,884	4,783	4,361	6,456	4,865	4,159	6,188	5,314	4,379
S[3]	7,380	9,564		7,610	10,175		7,536	9,895		11,133	11,007	

[1]Values are the mean of values for fall and spring samplings of composite tissue samples.
[2]IDOT 1B = Illinois Department of Transportation low maintenance turf mix = 75 percent tall fescue, 15 percent perennial rye, 10 percent creeping red fescue.
[3]The tissue samples taken in 2003 were not analyzed for S.

TABLE AIII-6: MEAN[1] ANNUAL CONCENTRATIONS OF NUTRIENTS AND TRACE METALS IN LEAF TISSUES OF IDOT 1B[2] TURF MIX COLLECTED FROM THE NONLINED PLOTS OF THE USX RESEARCH AND DEMONSTRATION PROJECT IN 2001 THROUGH 2003

	Amendment											
	0% Biosolids			25% Biosolids			50% Biosolids			100% Biosolids		
Parameter	2001	2002	2003	2001	2002	2003	2001	2002	2003	2001	2002	2003
	mg/kg											
Zn	37	31	39	106	62	43	120	63	59	245	94	114
Cd	0.17	0.06	0.09	0.20	0.14	0.13	0.34	0.27	0.14	0.69	0.40	0.44
Cu	7.5	5.7	6.5	17.4	10.9	10.2	18.4	10.3	13.7	32.0	15.5	15.8
Cr	0.73	1.46	1.07	0.34	0.94	0.69	0.77	1.43	0.59	0.42	1.18	0.77
Ni	1.64	1.32	1.46	2.74	1.64	1.27	4.44	2.44	2.40	8.77	7.59	5.59
Pb	0.69	1.15	0.98	0.15	0.33	0.33	0.34	0.37	0.35	0.10	0.29	0.20
K	21,010	20,993	19,814	34,675	28,177	25,645	34,012	27,615	24,814	40,247	27,635	30,989
Na	114	58	32	242	350	476	269	228	167	282	131	198
Ca	5,637	6,870	6,089	6,439	5,191	5,529	6,662	5,156	5,355	7,939	4,063	5,781
Mg	3,672	3,642	2,941	4,672	3,836	3,626	4,920	3,731	3,665	6,041	2,998	4,507
Mn	244	61	57	99	32	34	155	61	34	95	175	157
Fe	81	182	216	46	109	174	133	127	136	211	100	135
Mo	9.84	7.63	10.62	10.02	6.14	4.68	9.58	5.11	5.18	19.25	7.31	6.42
N	23,717	19,807	24,818	45,384	40,699	42,322	43,932	37,599	35,699	54,570	44,040	42,145
P	4,204	3,587	3,771	6,158	4,731	3,655	5,763	4,345	3,938	6,262	4,770	4,451
S[3]	8,578	6,685		9,781	8,551		5,623	8,993		10,849	10,324	

[1] Values are the mean of values for fall and spring samplings of composite tissue samples.

[2] IDOT 1B = Illinois Department of Transportation low maintenance turf mix = 75 percent tall fescue, 15 percent perennial rye, 10 percent creeping red fescue.

[3] The tissue samples taken in 2003 were not analyzed for S.

TABLE AIII-7: MEAN[1] ANNUAL CONCENTRATIONS OF NUTRIENTS AND TRACE METALS IN LEAF TISSUES OF VIDOT1[2] TURF MIX COLLECTED FROM THE CLAY-LINED PLOTS OF THE USX RESEARCH AND DEMONSTRATION PROJECT IN 2001 THROUGH 2003

	Amendment											
	0% Biosolids			25% Biosolids			50% Biosolids			100% Biosolids		
Parameter	2001	2002	2003	2001	2002	2003	2001	2002	2003	2001	2002	2003
	mg/kg											
Zn	35	30	38	97	74	50	108	60	69	163	127	91
Cd	0.18	0.04	0.04	0.27	0.17	0.02	0.25	0.16	0.35	0.43	0.29	0.24
Cu	7.4	6.2	8.8	18.3	13.8	16.6	21.4	10.9	19.9	28.5	14.2	21.4
Cr	0.58	1.30	0.41	0.33	0.79	0.20	0.22	0.66	0.60	0.43	1.05	0.24
Ni	2.07	2.08	1.51	2.53	3.40	1.96	2.82	2.93	3.56	5.61	8.32	6.28
Pb	0.19	0.53	1.58	0.10	0.24	2.58	0.10	0.10	2.28	0.10	0.48	1.53
K	20,046	20,324	22,356	29,440	32,039	28,038	30,158	28,146	30,027	35,397	31,146	32,063
Na	87	52	54	121	231	40	287	152	210	193	140	165
Ca	6,852	7,675	6,304	4,829	5,482	4,343	6,961	5,025	4,975	6,881	4,634	4,865
Mg	3,127	3,293	3,115	3,671	3,847	2,883	4,456	3,305	3,391	4,914	3,476	3,833
Mn	198	85	59	99	47	26	92	35	28	106	197	79
Fe	91	142	113	41	113	84	40	92	190	145	102	135
Mo	11.66	4.33	7.54	12.10	7.23	6.66	10.90	5.61	5.91	15.09	7.55	5.37
N	22,719	21,155	26,554	44,503	41,857	39,437	41,726	40,565	46,146	52,755	40,797	42,433
P	4,393	4,634	5,264	5,107	4,975	5,180	4,521	5,071	4,426	6,383	4,637	4,625
S[3]	9,485	9,930		9,780	11,186		8,839	9,664		11,231	11,083	

[1]Values are the mean of values for fall and spring samplings of composite tissue samples.
[2]VIDOT1 = Variation of Illinois Department of Transportation low maintenance lawn mix = 50 percent perennial rye, 30 percent Kentucky bluegrass, 20 percent creeping red fescue.
[3]The tissue samples taken in 2003 were not analyzed for S.

TABLE AIII-8: MEAN[1] ANNUAL CONCENTRATIONS OF NUTRIENTS AND TRACE METALS IN LEAF TISSUES OF VIDOT1[2] TURF MIX COLLECTED FROM THE NONLINED PLOTS OF THE USX RESEARCH AND DEMONSTRATION PROJECT IN 2001 THROUGH 2003

	Amendment											
	0% Biosolids			25% Biosolids			50% Biosolids			100% Biosolids		
Parameter	2001	2002	2003	2001	2002	2003	2001	2002	2003	2001	2002	2003
	mg/kg											
Zn	39	32	34	119	55	46	143	64	69	258	114	93
Cd	0.09	0.04	0.10	0.15	0.10	0.11	0.33	0.18	0.19	0.47	0.29	0.24
Cu	8.4	5.8	7.6	16.3	10.8	12.9	22.3	11.0	15.8	29.5	14.1	17.8
Cr	1.24	1.75	0.63	0.80	0.84	0.29	0.30	1.19	0.85	0.51	1.22	0.76
Ni	2.09	1.21	1.32	2.55	1.83	1.24	3.92	2.26	2.63	9.28	6.79	6.08
Pb	0.86	1.13	1.16	0.94	0.21	0.20	0.10	0.25	0.20	0.10	0.29	0.20
K	20,335	18,487	22,373	31,673	24,123	28,149	30,972	24,341	26,865	38,647	27,169	28,869
Na	94	41	36	190	80	83	240	77	81	316	106	79
Ca	6,433	7,012	5,706	6,334	4,336	4,538	7,476	4,033	4,992	7,799	4,655	4,643
Mg	3,531	3,043	3,147	4,503	2,788	2,954	5,463	2,741	3,558	5,458	3,432	3,617
Mn	390	62	52	170	32	27	98	47	30	120	216	119
Fe	85	193	130	63	93	98	90	99	89	203	95	118
Mo	10.32	8.05	15.03	8.75	6.75	4.97	11.54	6.26	4.95	20.49	9.80	7.37
N	25,948	19,716	27,379	44,237	36,889	43,208	50,917	36,618	39,853	54,234	39,526	40,813
P	4,325	3,922	5,275	5,784	4,036	4,162	5,798	4,092	4,248	6,468	4,568	4,158
S[3]	8,645	7,257		11,927	9,284		9,906	9,635		14,217	10,043	

[1]Values are the mean of values for fall and spring samplings of composite tissue samples.
[2]VIDOT1 = Variation of Illinois Department of Transportation low maintenance lawn mix = 50 percent perennial rye, 30 percent Kentucky bluegrass, 20 percent creeping red fescue.
[3]The tissue samples taken in 2003 were not analyzed for S.

TABLE AIII-9: ANNUAL CONCENTRATIONS OF NUTRIENTS AND TRACE METALS IN LEAF TISSUES OF AMUR MAPLE COLLECTED FROM THE CLAY-LINED PLOTS OF THE USX RESEARCH AND DEMONSTRATION PROJECT IN 2001 THROUGH 2003

	Amendment											
	0% Biosolids			25% Biosolids			50% Biosolids			100% Biosolids		
Parameter	2001	2002	2003	2001	2002	2003	2001	2002	2003	2001	2002	2003
	mg/kg											
Zn	38	43	32	51	49	70	68	54	72	62	72	22
Cd	0.20	0.02	0.02	0.25	0.20	0.26	0.43	0.16	0.36	0.63	0.67	0.02
Cu	8.7	11.3	9.3	5.1	12.3	0.1	6.2	2.8	0.1	4.6	3.3	5.0
Cr	0.61	0.76	0.66	0.89	1.39	0.42	0.66	0.41	0.78	0.98	0.38	0.58
Ni	0.28	0.57	7.28	0.38	0.77	0.70	0.60	0.26	0.50	0.95	0.17	1.26
Pb	1.14	0.28	0.53	1.51	1.60	0.20	1.28	0.33	1.10	1.58	0.20	0.85
K	6,079	6,220	7,884	6,959	6,496	10,473	9,003	6,336	7,835	9,476	5,665	9,016
Na	48	70	21	36	47	20	34	49	47	46	10	20
Ca	14,221	14,024	11,461	15,851	11,671	12,163	16,227	11,900	14,560	14,761	14,179	19,876
Mg	3,353	3,038	2,751	3,303	2,524	2,893	3,294	2,561	3,143	3,550	2,834	8,954
Mn	38	27	23	113	79	97	195	69	91	350	305	181
Fe	65	163	106	112	179	83	126	103	201	101	75	138
Mo	0.28	0.60	0.90	0.55	0.60	0.90	0.70	0.60	0.90	1.10	0.89	1.50
N	16,146	19,467	24,411	19,481	21,265	24,935	20,287	21,714	24,316	19,067	21,305	23,317
P	3,169	2,223	2,494	1,854	1,353	2,417	1,820	1,254	1,675	2,462	1,390	1,984
S[1]	4,924	947		7,662	23		6,588	1,654		8,503	1,629	

[1]The tissue samples taken in 2003 were not analyzed for S.

TABLE AIII-10: ANNUAL CONCENTRATIONS OF NUTRIENTS AND TRACE METALS IN LEAF TISSUES OF AMUR MAPLE COLLECTED FROM THE NONLINED PLOTS OF THE USX RESEARCH AND DEMONSTRATION PROJECT IN 2001 THROUGH 2003

	Amendment											
	0% Biosolids			25% Biosolids			50% Biosolids			100% Biosolids		
Parameter	2001	2002	2003	2001	2002	2003	2001	2002	2003	2001	2002	2003
	mg/kg											
Zn	47	45	45	55	49	42	51	40	24	70	74	70
Cd	0.10	0.02	0.07	0.30	0.14	0.10	0.28	0.18	0.02	0.60	0.57	0.62
Cu	12.3	12.7	7.8	5.4	2.0	0.3	5.8	2.3	5.6	4.1	3.0	2.5
Cr	0.76	0.50	0.52	1.09	0.37	0.53	0.71	0.20	1.08	0.88	0.52	0.69
Ni	0.45	0.57	2.59	0.53	0.18	1.96	0.88	0.07	3.82	0.75	0.58	1.30
Pb	1.74	0.20	7.50	2.55	1.15	0.45	1.90	0.20	1.30	1.60	0.40	0.55
K	5,854	5,714	6,739	7,808	7,245	11,970	8,675	5,884	6,833	11,406	7,459	8,396
Na	57	54	26	39	49	20	43	10	20	31	51	20
Ca	15,381	12,710	13,057	16,284	13,040	9,495	16,437	12,836	20,127	13,289	12,748	10,796
Mg	3,473	2,752	3,085	3,342	2,582	2,454	3,321	2,736	6,771	2,902	2,565	8,333
Mn	44	26	27	91	28	20	151	47	205	241	216	129
Fe	105	142	149	171	150	121	133	80	168	108	105	
Mo	0.33	0.60	0.90	1.03	0.60	0.90	1.15	0.60	3.85	1.43	0.60	2.10
N	13,836	19,916	22,126	19,413	22,940	24,649	20,961	22,368	24,126	22,133	22,735	22,698
P	3,324	2,476	2,057	1,718	1,222	1,860	1,850	1,198	1,821	2,968	1,540	4,096
S[1]	10,133	1,283		9,341	1,672		8,702	5,732		17,462	2,032	

[1]The tissue samples taken in 2003 were not analyzed for S.

TABLE AIII-11: ANNUAL CONCENTRATIONS OF NUTRIENTS AND TRACE METALS IN LEAF TISSUES OF APPLE SERVICEBERRY COLLECTED FROM THE CLAY-LINED PLOTS OF THE USX RESEARCH AND DEMONSTRATION PROJECT IN 2001 THROUGH 2003

	Amendment											
	0% Biosolids			25% Biosolids			50% Biosolids			100% Biosolids		
Parameter	2001	2002	2003	2001	2002	2003	2001	2002	2003	2001	2002	2003
	mg/kg											
Zn	18	37	34	24	23	25	26	35	37	33	21	78
Cd	0.01	0.02	0.02	0.10	0.05	0.17	0.01	0.04	0.25	0.10	0.02	0.60
Cu	5.4	6.6	3.9	5.0	8.9	1.3	7.2	5.3	9.4	7.0	6.3	3.1
Cr	1.19	0.84	0.90	0.99	0.96	0.33	0.79	0.36	0.81	1.43	0.68	0.63
Ni	0.40	0.72	1.75	0.80	0.97	0.48	1.35	0.52	4.13	1.90	0.15	1.20
Pb	1.94	0.20	2.10	1.16	1.30	0.20	1.33	0.23	0.55	2.05	1.00	0.25
K	6,839	11,145	7,897	7,584	8,943	9,310	7,095	9,395	4,799	7,558	7,802	7,835
Na	25	59	20	19	41	20	23	10	20	28	40	20
Ca	20,506	19,606	25,719	18,934	16,420	14,854	16,854	19,209	6,309	17,796	8,512	10,529
Mg	4,868	3,955	5,477	4,575	3,753	3,692	4,754	3,837	3,017	4,390	2,526	7,773
Mn	107	63	70	306	130	187	346	126	160	394	32	115
Fe	158	193	246	94	113	56	109	52	254	132	162	125
Mo	0.40	1.16	0.90	1.23	2.30	2.81	2.68	2.84	5.02	3.45	0.60	1.35
N	16,170	18,445	21,032	15,306	20,325	23,650	15,467	19,181	21,603	19,407	14,360	27,886
P	3,739	4,502	3,072	4,157	1,488	1,843	4,104	2,045	1,718	2,730	2,031	2,661
S[1]	5,298	2,058		9,574	-13		6,512	10,651		10,705	2,095	

[1]The tissue samples taken in 2003 were not analyzed for S.

TABLE AIII-12: ANNUAL CONCENTRATIONS OF NUTRIENTS AND TRACE METALS IN LEAF TISSUES OF APPLE SERVICEBERRY COLLECTED FROM THE NONLINED PLOTS OF THE USX RESEARCH AND DEMONSTRATION PROJECT IN 2001 THROUGH 2003

	Amendment											
	0% Biosolids			25% Biosolids			50% Biosolids			100% Biosolids		
Parameter	2001	2002	2003	2001	2002	2003	2001	2002	2003	2001	2002	2003
	mg/kg											
Zn	25	43	40	28	33	22	30	33	59	31	35	32
Cd	0.01	0.02	0.02	0.10	0.07	0.08	0.03	0.07	0.27	0.10	0.28	0.31
Cu	5.9	7.4	3.8	5.7	4.4	1.2	6.4	4.9	2.2	8.4	5.3	4.8
Cr	0.96	1.12	0.94	1.44	0.87	0.82	1.11	0.37	0.88	1.18	0.47	0.86
Ni	0.63	0.73	0.70	0.65	0.52	0.89	1.55	0.28	1.09	1.90	1.05	2.61
Pb	1.76	0.28	1.15	3.05	1.70	1.00	2.00	0.38	0.80	1.63	0.20	0.55
K	8,504	11,980	9,598	7,600	9,205	9,259	7,783	7,106	8,857	8,893	9,652	9,115
Na	29	58	20	37	38	20	17	10	20	21	12	20
Ca	19,304	21,622	22,026	20,087	20,254	16,177	19,667	19,586	13,614	14,601	15,991	13,598
Mg	5,178	3,821	4,307	4,463	4,187	4,836	4,539	4,071	8,795	3,920	3,635	9,052
Mn	161	94	62	93	71	52	426	224	131	329	551	112
Fe	114	219	165	225	191	110	137	75	146	108	68	200
Mo	0.58	1.00	1.01	1.35	2.64	3.08	2.13	1.70	1.90	4.23	5.92	2.00
N	15,256	19,058	19,128	18,437	21,755	22,555	15,452	21,346	22,650	17,915	21,469	29,124
P	4,643	4,853	4,766	1,749	1,301	1,551	4,714	2,279	1,769	4,274	2,855	2,930
S[1]	10,921	1,266		6,970	2,658		7,737	13,624		12,540	3,743	

[1]The tissue samples taken in 2003 were not analyzed for S.

TABLE AIII-13: ANNUAL CONCENTRATIONS OF NUTRIENTS AND TRACE METALS IN LEAF TISSUES OF THORNLESS COCKSPUR COLLECTED FROM THE CLAY-LINED PLOTS OF THE USX RESEARCH AND DEMONSTRATION PROJECT IN 2001 THROUGH 2003

	Amendment											
	0% Biosolids			25% Biosolids			50% Biosolids			100% Biosolids		
Parameter	2001	2002	2003	2001	2002	2003	2001	2002	2003	2001	2002	2003
	mg/kg											
Zn	18	25	26	17	22	24	21	22	26	21	23	32
Cd	0.05	0.02	0.03	0.05	0.10	0.16	0.05	0.08	0.08	0.15	0.10	0.22
Cu	7.9	8.4	7.3	5.6	7.4	0.8	7.6	4.7	6.1	8.5	6.9	6.9
Cr	0.59	0.63	0.55	0.34	0.77	0.32	0.41	0.27	0.78	0.73	1.45	0.74
Ni	1.05	0.61	0.64	0.78	0.57	1.04	0.95	0.07	4.12	1.65	0.83	2.27
Pb	0.84	0.20	1.45	0.51	0.58	0.43	0.40	0.20	2.75	0.85	0.20	0.95
K	5,296	9,373	7,178	6,169	6,345	9,377	4,940	5,133	5,106	5,103	5,555	7,325
Na	41	67	33.60	35	53	20.00	46	11	20.00	66	70	20.00
Ca	27,329	26,785	29,724	24,104	31,260	22,687	30,472	32,830	18,700	24,679	30,928	22,630
Mg	4,679	3,926	4,848	4,351	4,328	4,061	5,429	5,040	5,044	5,580	5,222	7,263
Mn	48	29	19	28	26	21	64	40	125	78	98	128
Fe	101	149	166	81	111	89	95	69	164	111	89	164
Mo	0.10	0.60	0.90	0.35	0.80	0.91	0.53	0.60	3.50	0.55	0.86	2.15
N	19,052	22,368	23,602	22,789	23,593	26,363	12,647	24,451	27,315	22,128	26,903	23,697
P	1,829	2,471	2,709	1,442	1,554	1,757	1,207	1,385	1,795	1,960	2,073	4,127
S[1]	4,965	1,690		8,209	46		5,287	6,735		35,885	2,273	

[1]The tissue samples taken in 2003 were not analyzed for S.

TABLE AIII-14: ANNUAL CONCENTRATIONS OF NUTRIENTS AND TRACE METALS IN LEAF TISSUES OF THORNLESS COCKSPUR COLLECTED FROM THE NONLINED PLOTS OF THE USX RESEARCH AND DEMONSTRATION PROJECT IN 2001 THROUGH 2003

	Amendment											
	0% Biosolids			25% Biosolids			50% Biosolids			100% Biosolids		
Parameter	2001	2002	2003	2001	2002	2003	2001	2002	2003	2001	2002	2003
	mg/kg											
Zn	19	27	25	22	25	25	20	21	24	19	24	26
Cd	0.05	0.02	0.05	0.10	0.11	0.15	0.05	0.07	0.16	0.08	0.07	0.02
Cu	8.3	11.3	6.3	6.7	6.1	1.9	7.2	4.9	3.9	7.5	6.6	7.7
Cr	0.54	0.82	0.47	0.66	0.68	0.86	0.50	0.23	0.70	0.70	0.85	0.70
Ni	1.21	0.95	0.60	0.80	0.44	1.27	1.14	0.07	2.35	1.36	0.56	2.38
Pb	0.95	0.20	1.10	1.31	0.74	0.64	0.75	0.20	0.65	0.84	0.20	0.48
K	5,263	8,085	6,580	5,876	6,218	8,428	4,930	4,946	5,870	5,267	5,571	10,495
Na	51	70	26.80	46	54	20.19	40	11	20.00	52	52	30.43
Ca	28,344	29,768	28,089	24,931	32,493	24,013	27,723	32,760	19,971	23,880	30,583	18,369
Mg	4,677	4,260	4,633	4,839	4,837	4,407	5,317	5,053	5,808	5,346	4,875	6,992
Mn	48	30	17	40	33	26	67	42	150	70	94	159
Fe	98	154	133	131	145	128	110	63	152	115	76	117
Mo	0.10	0.60	0.90	0.41	0.70	0.80	0.60	0.60	2.30	0.54	0.73	1.46
N	19,203	23,900	22,960	23,245	25,309	27,053	17,504	25,269	24,316	22,615	27,393	22,460
P	1,777	2,019	2,443	1,464	1,488	1,733	1,349	1,341	1,564	1,922	2,076	3,700
S[1]	8,935	1,166		6,720	865		7,204	7,149		23,666	2,350	

[1]The tissue samples taken in 2003 were not analyzed for S.

TABLE AIII-15: ANNUAL CONCENTRATIONS OF NUTRIENTS AND TRACE METALS IN LEAF TISSUES OF DONALD WYMAN CRABAPPLE COLLECTED FROM THE CLAY-LINED PLOTS OF THE USX RESEARCH AND DEMONSTRATION PROJECT IN 2001 THROUGH 2003

	Amendment											
	0% Biosolids			25% Biosolids			50% Biosolids			100% Biosolids		
Parameter	2001	2002	2003	2001	2002	2003	2001	2002	2003	2001	2002	2003
	mg/kg											
Zn	11	14	11	17	23	28	17	20	34	19	33	29
Cd	0.01	0.02	0.02	0.05	0.02	0.02	0.01	0.02	0.25	0.08	0.02	0.03
Cu	6.5	6.2	3.0	6.0	13.0	2.2	8.0	5.3	4.6	8.0	6.5	7.8
Cr	0.34	0.80	0.36	0.46	0.99	0.26	0.39	0.20	0.76	0.60	0.33	0.89
Ni	1.03	1.18	1.51	1.15	0.96	0.49	0.93	0.20	2.37	1.18	1.43	2.80
Pb	0.34	0.20	0.28	0.69	0.90	0.20	0.68	0.20	0.75	1.08	0.20	0.70
K	11,416	9,906	11,741	11,856	11,127	14,833	8,498	12,472	7,181	15,028	11,630	11,261
Na	29	53	20	34	44	20	25	10	20	29	29	20
Ca	15,106	16,771	16,216	16,819	16,850	10,131	13,894	14,300	25,207	9,289	18,976	19,481
Mg	2,713	3,002	3,032	2,963	3,323	2,687	2,893	3,362	7,118	2,304	3,238	11,199
Mn	38	29	19	43	42	34	65	61	141	152	151	143
Fe	52	165	115	60	134	90	116	29	123	56	62	393
Mo	0.38	0.60	0.90	0.55	0.85	0.90	0.73	1.07	2.60	1.48	0.84	2.15
N	18,358	20,121	20,841	20,321	20,897	24,411	16,895	20,570	21,222	20,313	23,062	21,936
P	2,504	2,120	1,674	1,827	1,619	2,282	1,514	1,601	2,035	3,055	3,234	3,667
S[1]	5,991	1,860		7,447	-3		6,250	9,729		25,296	3,039	

[1]The tissue samples taken in 2003 were not analyzed for S.

TABLE AIII-16: ANNUAL CONCENTRATIONS OF NUTRIENTS AND TRACE METALS IN LEAF TISSUES OF DONALD WYMAN CRABAPPLE COLLECTED FROM THE NONLINED PLOTS OF THE USX RESEARCH AND DEMONSTRATION PROJECT IN 2001 THROUGH 2003

	Amendment											
	0% Biosolids			25% Biosolids			50% Biosolids			100% Biosolids		
Parameter	2001	2002	2003	2001	2002	2003	2001	2002	2003	2001	2002	2003
	mg/kg											
Zn	14	16	12	18	22	13	20	22	22	20	35	35
Cd	0.02	0.02	0.02	0.04	0.02	0.02	0.01	0.02	0.02	0.08	0.03	0.04
Cu	6.8	8.2	3.2	7.0	9.0	2.6	7.8	5.2	6.2	7.7	6.2	6.6
Cr	0.41	1.07	0.35	0.64	0.74	0.83	0.41	0.42	0.84	0.54	0.43	1.55
Ni	1.04	1.17	1.18	1.10	0.81	0.53	1.18	0.28	2.65	1.19	1.31	3.14
Pb	0.78	0.68	0.25	1.23	0.70	0.35	0.79	0.20	4.50	0.88	0.20	1.48
K	11,099	10,053	12,268	12,640	10,818	14,401	10,339	11,598	12,081	14,364	11,519	7,700
Na	41	71	20	32	46	32	25	10	40	24	26	62
Ca	17,256	15,865	16,406	15,129	18,398	12,275	14,184	15,627	15,287	10,056	18,716	23,348
Mg	2,607	2,789	2,944	2,977	3,537	2,968	2,784	3,412	6,144	2,299	3,166	5,290
Mn	48	34	22	51	44	33	80	75	92	127	142	250
Fe	51	185	107	75	140	86	103	62	118	62	71	287
Mo	0.46	0.82	0.90	0.73	0.79	0.82	1.23	1.20	1.03	1.50	0.82	1.50
N	17,156	19,569	20,698	20,506	21,837	23,531	17,952	21,591	21,650	19,973	23,267	22,555
P	2,374	1,802	1,779	1,894	1,664	2,150	1,785	1,680	2,273	2,955	3,178	3,588
S[1]	7,399	954		6,303	1,158		8,373	6,055		16,998	2,867	

[1]The tissue samples taken in 2003 were not analyzed for S.

TABLE AIII-17: ANNUAL CONCENTRATIONS OF NUTRIENTS AND TRACE METALS IN LEAF TISSUES OF ZUMI CRABAPPLE COLLECTED FROM THE CLAY-LINED PLOTS OF THE USX RESEARCH AND DEMONSTRATION PROJECT IN 2001 THROUGH 2003

	Amendment											
	0% Biosolids			25% Biosolids			50% Biosolids			100% Biosolids		
Parameter	2001	2002	2003	2001	2002	2003	2001	2002	2003	2001	2002	2003
	mg/kg											
Zn	15	19	14	21	24	27	24	19	30	20	20	29
Cd	0.01	0.02	0.02	0.01	0.02	0.03	0.01	0.02	0.02	0.05	0.02	0.03
Cu	6.6	6.7	4.0	5.9	4.0	2.2	7.6	4.4	5.9	7.0	10.0	7.8
Cr	0.51	1.23	0.77	0.69	0.79	1.34	0.91	0.35	0.69	0.78	0.43	0.89
Ni	0.95	1.29	1.13	1.43	0.69	2.10	1.00	0.10	2.40	1.85	3.38	2.80
Pb	0.84	0.60	0.50	0.99	1.25	2.75	1.73	0.20	0.20	1.78	0.20	0.70
K	10,651	11,394	12,041	10,116	12,266	8,614	13,750	10,234	8,619	10,823	11,878	11,261
Na	34	93	38	51	55	20	43	10	20	44	47	20
Ca	15,456	15,029	15,801	15,631	14,485	27,271	14,279	12,847	20,214	10,909	11,224	19,481
Mg	2,528	2,664	2,562	2,459	2,930	3,933	2,387	3,039	8,557	2,529	2,497	11,199
Mn	44	38	26	88	57	50	140	102	138	302	248	143
Fe	52	253	182	62	185	321	70	27	192	54	70	390
Mo	0.55	0.69	0.90	1.00	1.10	0.90	1.53	1.56	3.30	1.55	1.23	2.15
N	16,096	18,650	19,508	17,892	20,488	20,746	18,359	21,510	20,746	19,118	22,776	21,936
P	2,134	1,507	1,817	1,747	1,788	1,920	2,087	1,573	2,044	3,075	2,845	3,667
S[1]	10,864	1,676		8,112	1,505		9,836	7,261		21,911	2,561	

[1]The tissue samples taken in 2003 were not analyzed for S.

TABLE AIII-18: ANNUAL CONCENTRATIONS OF NUTRIENTS AND TRACE METALS IN LEAF TISSUES OF ZUMI CRABAPPLE COLLECTED FROM THE NONLINED PLOTS OF THE USX RESEARCH AND DEMONSTRATION PROJECT IN 2001 THROUGH 2003

	Amendment											
	0% Biosolids			25% Biosolids			50% Biosolids			100% Biosolids		
Parameter	2001	2002	2003	2001	2002	2003	2001	2002	2003	2001	2002	2003
	mg/kg											
Zn	17	20	19	27	23	21	31	20	22	23	24	23
Cd	0.01	0.02	0.02	0.01	0.02	0.02	0.01	0.02	0.02	0.05	0.02	0.04
Cu	7.2	19.8	4.4	6.8	3.6	0.4	7.8	5.3	6.5	6.8	5.7	7.2
Cr	0.54	1.68	0.54	1.39	0.87	0.90	0.66	0.84	0.61	0.88	0.45	0.50
Ni	1.00	1.31	0.94	1.03	0.60	0.73	1.10	0.25	1.20	1.73	0.83	2.13
Pb	1.19	1.30	1.15	3.15	1.15	1.05	1.13	0.20	0.80	1.25	0.20	0.20
K	11,706	11,460	9,535	9,563	10,496	10,495	12,345	10,822	14,755	12,233	11,203	9,408
Na	51	84	20	47	100	127	42	44	20	51	62	20
Ca	17,136	16,132	18,329	14,892	17,387	19,168	14,067	14,365	10,459	11,094	13,243	16,847
Mg	2,471	2,543	2,916	2,670	2,991	2,684	2,644	3,203	14,693	2,039	2,650	9,346
Mn	48	38	27	72	46	35	161	111	163	265	223	134
Fe	73	213	145	205	184	180	87	125	121	59	73	181
Mo	0.75	0.93	0.90	1.45	0.84	0.90	1.85	1.50	2.15	1.55	0.97	2.45
N	16,955	18,241	21,127	18,280	21,265	20,651	17,656	20,693	21,508	19,601	21,918	23,174
P	2,342	1,498	1,279	1,518	1,381	1,932	2,115	1,746	2,224	3,048	2,677	3,510
S[1]	7,096	19		8,062	1,650		9,870	2,234		5,137	2,461	

[1]The tissue samples taken in 2003 were not analyzed for S.

TABLE AIII-19: ANNUAL CONCENTRATIONS OF NUTRIENTS AND TRACE METALS IN LEAF TISSUES OF MARMO HYBRID MAPLE COLLECTED FROM THE CLAY-LINED PLOTS OF THE USX RESEARCH AND DEMONSTRATION PROJECT IN 2001 THROUGH 2003

	Amendment											
	0% Biosolids			25% Biosolids			50% Biosolids			100% Biosolids		
Parameter	2001	2002	2003	2001	2002	2003	2001	2002	2003	2001	2002	2003
	mg/kg											
Zn	65	51	31	59	62	67	47	53	78	51	75	87
Cd	0.20	0.03	0.03	0.43	0.18	0.42	0.68	0.55	0.78	0.43	1.02	1.17
Cu	12.7	6.7	6.0	6.7	1.7	2.21	4.9	1.0	2.4	4.9	2.8	3.4
Cr	2.10	1.07	1.03	1.29	0.35	0.48	0.98	0.44	1.70	1.90	0.77	0.92
Ni	1.30	0.25	2.63	1.18	0.40	0.72	0.83	0.68	1.47	0.83	1.04	2.04
Pb	3.95	1.90	0.55	2.66	0.95	1.10	1.68	0.80	2.05	3.48	0.40	1.15
K	4,952	4,916	7,653	5,828	5,559	6,968	5,066	4,634	7,433	6,303	7,536	6,683
Na	37	22	20	19	22	52	21	24	80	31	94	42
Ca	14,746	17,034	21,828	16,293	19,647	15,739	20,818	22,830	30,324	16,923	21,057	17,476
Mg	4,863	4,989	7,591	4,463	4,568	4,161	5,487	5,222	6,345	4,761	4,679	4,187
Mn	460	107	195	362	181	116	511	187	188	394	428	510
Fe	178	269	113	172	146	114	90	93	300	99	113	169
Mo	0.25	0.60	2.25	0.40	0.60	0.90	0.29	0.60	0.90	0.21	0.60	0.90
N	15,523	16,607	18,794	19,114	20,243	24,649	17,737	20,529	21,555	17,275	21,019	22,698
P	2,466	1,741	1,753	2,346	1,754	1,916	2,033	1,681	2,372	2,697	2,761	2,749
S[1]	6,215	2,495		8,849	3,870		5,290	3,860		11,562	1,803	

[1]The tissue samples taken in 2003 were not analyzed for S.

TABLE AIII-20: ANNUAL CONCENTRATIONS OF NUTRIENTS AND TRACE METALS IN LEAF TISSUES OF MARMO HYBRID MAPLE COLLECTED FROM THE NONLINED PLOTS OF THE USX RESEARCH AND DEMONSTRATION PROJECT IN 2001 THROUGH 2003

	Amendment											
	0% Biosolids			25% Biosolids			50% Biosolids			100% Biosolids		
Parameter	2001	2002	2003	2001	2002	2003	2001	2002	2003	2001	2002	2003
	mg/kg											
Zn	76	50	39	59	69	53	45	67	64	54	87	100
Cd	0.20	0.02	0.02	0.55	0.55	0.38	0.53	0.49	0.56	1.30	1.29	1.57
Cu	14.9	5.8	6.0	5.0	3.5	2.0	4.9	1.8	2.51	3.3	1.8	4.1
Cr	2.41	0.66	0.59	2.16	0.98	0.63	1.10	1.12	1.26	0.60	0.61	0.82
Ni	2.05	0.51	0.75	1.20	0.98	0.75	1.73	0.80	1.41	0.74	0.59	5.16
Pb	5.71	4.55	0.75	5.26	4.05	1.95	2.45	2.10	1.45	1.55	0.45	4.50
K	5,015	5,019	5,702	5,101	5,948	6,486	7,951	6,411	7,096	9,032	4,976	6,222
Na	52	16	20	30	44	34	35	67	60	43	64	57
Ca	16,151	17,188	14,404	19,196	19,759	17,315	16,026	17,541	19,775	15,033	25,561	22,285
Mg	5,254	4,748	4,100	4,756	4,896	3,972	4,318	4,610	4,531	3,754	5,384	4,846
Mn	347	82	38	449	136	47	359	179	203	353	510	642
Fe	212	338	165	288	356	148	115	175	241	77	35	155
Mo	0.23	0.60	0.90	0.28	0.60	0.90	0.61	0.60	0.90	0.40	0.60	0.90
N	17,693	18,159	19,508	19,742	22,449	21,746	18,704	18,282	22,079	19,137	22,858	23,697
P	2,792	1,788	1,633	1,811	1,533	1,684	2,052	1,554	1,963	3,298	2,674	2,965
S[1]	6,757	3,961		9,681	5,426		4,998	1,420		27,723	4,307	

[1]The tissue samples taken in 2003 were not analyzed for S.

TABLE AIII-21: ANNUAL CONCENTRATIONS OF NUTRIENTS AND TRACE METALS IN LEAF TISSUES OF AUTUMN PURPLE ASH COLLECTED FROM THE CLAY-LINED PLOTS OF THE USX RESEARCH AND DEMONSTRATION PROJECT IN 2001 THROUGH 2003

	Amendment											
	0% Biosolids			25% Biosolids			50% Biosolids			100% Biosolids		
Parameter	2001	2002	2003	2001	2002	2003	2001	2002	2003	2001	2002	2003
	mg/kg											
Zn	22	15	41	22	13	13	19	11	15	19	15	19
Cd	0.01	0.02	0.05	0.01	0.02	0.02	0.01	0.02	0.02	0.01	0.04	0.02
Cu	13.2	20.6	6.0	9.3	6.2	7.0	8.9	6.0	6.3	12.4	8.6	7.3
Cr	1.23	0.96	0.43	0.96	0.63	0.86	0.70	0.42	0.79	1.10	0.97	0.86
Ni	0.80	0.57	0.52	0.78	0.41	1.15	1.30	0.51	0.57	0.63	1.05	0.95
Pb	3.68	1.70	0.20	2.86	0.75	2.10	1.90	0.25	0.75	2.38	0.80	1.40
K	5,063	9,008	5,611	5,261	8,220	11,067	9,276	8,721	10,586	4,286	8,170	8,002
Na	19	11	20	17	10	25	14	10	39	10	81	20
Ca	16,249	20,615	14,043	13,188	17,391	20,894	14,983	17,243	12,496	12,411	22,689	17,014
Mg	4,298	4,003	5,548	3,415	2,984	2,672	3,366	3,505	2,984	3,667	3,583	2,833
Mn	48	42	117	41	32	38	51	39	63	36	86	90
Fe	299	323	231	268	238	288	118	151	195	245	203	241
Mo	0.13	0.60	2.15	0.33	0.60	0.90	0.89	0.73	0.90	0.59	0.95	0.90
N	18,805	25,350	25,839	18,203	26,331	25,935	18,593	24,451	23,650	17,744	25,718	25,363
P	1,649	1,605	1,355	1,316	1,113	1,177	1,860	1,243	1,461	1,448	1,706	1,564
S[1]	5,221	2,938		9,952	4,138		5,738	4,778		10,893	2,007	

[1]The tissue samples taken in 2003 were not analyzed for S.

TABLE AIII-22: ANNUAL CONCENTRATIONS OF NUTRIENTS AND TRACE METALS IN LEAF TISSUES OF AUTUMN PURPLE ASH COLLECTED FROM THE NONLINED PLOTS OF THE USX RESEARCH AND DEMONSTRATION PROJECT IN 2001 THROUGH 2003

	Amendment											
	0% Biosolids			25% Biosolids			50% Biosolids			100% Biosolids		
Parameter	2001	2002	2003	2001	2002	2003	2001	2002	2003	2001	2002	2003
	mg/kg											
Zn	23	17	16	24	20	15	20	18	17	21	14	20
Cd	0.01	0.02	0.02	0.01	0.02	0.02	0.01	0.02	0.02	0.01	0.02	0.02
Cu	10.6	9.0	14.1	14.0	9.9	6.1	11.9	7.5	7.2	8.9	8.8	8.4
Cr	1.09	0.39	1.10	1.54	0.59	1.05	0.98	0.64	1.09	1.13	0.45	1.26
Ni	0.83	0.60	2.45	0.93	0.51	0.64	0.83	0.63	0.77	0.76	0.85	1.17
Pb	3.56	3.10	4.05	4.56	2.20	2.05	2.63	0.55	1.30	3.75	0.35	2.40
K	4,553	8,710	11,107	3,595	8,517	7,824	4,105	8,503	6,976	3,975	6,683	8,371
Na	25	10	20	14	22	20	13	56	20	25	12	25
Ca	15,173	17,864	17,672	18,376	20,700	21,986	16,073	18,140	16,310	13,573	18,901	10,904
Mg	4,517	3,409	3,566	5,486	4,122	3,952	4,830	3,682	3,230	4,017	3,882	2,747
Mn	68	102	62	42	48	35	49	59	70	49	81	84
Fe	319	301	300	374	266	269	244	176	246	244	113	271
Mo	0.15	0.60	0.90	0.48	0.60	0.90	0.71	1.57	0.90	0.55	0.60	0.90
N	17,145	23,348	22,936	20,123	25,105	27,791	21,456	22,409	25,697	17,775	25,023	24,507
P	1,535	1,568	1,169	1,262	1,091	1,091	1,252	1,329	1,315	1,454	1,850	1,658
S[1]	4,564	5,346		7,019	4,717		8,485	2,869		18,383	5,542	

[1]The tissue samples taken in 2003 were not analyzed for S.

TABLE AIII-23: ANNUAL CONCENTRATIONS OF NUTRIENTS AND TRACE METALS IN LEAF TISSUES OF SKYLINE HONEY LOCUST COLLECTED FROM THE CLAY-LINED PLOTS OF THE USX RESEARCH AND DEMONSTRATION PROJECT IN 2001 THROUGH 2003

	Amendment											
	0% Biosolids			25% Biosolids			50% Biosolids			100% Biosolids		
Parameter	2001	2002	2003	2001	2002	2003	2001	2002	2003	2001	2002	2003
	mg/kg											
Zn	32	29	25	30	23	27	42	33	27	34	32	29
Cd	0.01	0.02	0.02	0.01	0.02	0.02	0.01	0.02	0.02	0.01	0.10	0.05
Cu	7.1	9.7	12.2	6.1	2.6	4.7	12.3	3.0	4.0	5.3	2.5	2.8
Cr	0.78	0.46	0.57	0.66	0.13	0.45	0.90	0.38	0.66	0.45	0.37	0.49
Ni	0.38	0.09	10.84	0.28	0.08	0.91	0.53	0.08	0.66	0.18	0.25	1.68
Pb	3.20	2.70	3.35	2.56	0.20	0.65	3.25	0.20	1.35	1.35	0.20	1.50
K	8,146	11,484	13,710	9,681	14,135	17,453	10,846	10,862	14,275	13,608	15,744	14,557
Na	142	43	48	138	39	64	136	75	65	70	103	76
Ca	14,469	21,236	20,512	16,403	16,682	15,197	18,828	26,548	19,731	16,523	17,808	18,034
Mg	3,240	3,336	3,022	2,891	2,161	2,349	3,605	3,346	2,722	2,372	2,278	2,305
Mn	72	51	38	50	23	22	74	76	47	87	78	63
Fe	89	79	144	153	105	112	55	71	143	55	31	131
Mo	0.30	0.60	0.90	0.48	0.60	0.90	0.74	0.75	1.03	0.96	1.00	0.90
N	18,752	27,884	29,981	25,209	30,703	35,360	25,680	33,563	29,108	33,974	36,790	32,075
P	2,754	4,300	3,123	2,566	1,455	2,165	3,084	1,815	2,123	3,588	3,061	3,386
S[1]	5,144	9,167		15,250	7,689		7,682	8,330		9,133	9,105	

[1]The tissue samples taken in 2003 were not analyzed for S.

TABLE AIII-24: ANNUAL CONCENTRATIONS OF NUTRIENTS AND TRACE METALS IN LEAF TISSUES OF SKYLINE HONEY LOCUST COLLECTED FROM THE NONLINED PLOTS OF THE USX RESEARCH AND DEMONSTRATION PROJECT IN 2001 THROUGH 2003

	Amendment											
	0% Biosolids			25% Biosolids			50% Biosolids			100% Biosolids		
Parameter	2001	2002	2003	2001	2002	2003	2001	2002	2003	2001	2002	2003
	mg/kg											
Zn	38	32	28	31	37	28	31	43	32	31	34	32
Cd	0.03	0.02	0.02	0.03	0.04	0.02	0.01	0.08	0.02	0.05	0.02	0.04
Cu	8.0	15.3	14.8	5.3	2.7	3.6	6.7	4.6	4.1	5.7	2.8	2.7
Cr	0.96	0.22	0.55	0.86	0.44	0.78	0.63	1.42	0.57	0.40	0.24	0.52
Ni	0.40	0.07	0.40	0.38	1.19	1.74	0.40	0.70	0.61	0.34	0.17	0.45
Pb	4.96	2.25	1.10	3.39	2.10	1.35	2.58	0.40	0.20	1.20	0.20	0.40
K	7,831	12,959	12,020	9,251	13,286	14,048	14,461	12,669	19,831	15,152	16,428	11,995
Na	152	71	20	94	136	105	119	97	38	71	85	44
Ca	15,916	21,089	20,563	21,653	22,133	22,165	14,068	19,185	14,077	13,853	14,332	19,034
Mg	3,205	2,759	3,171	3,584	2,960	3,095	2,489	2,532	2,331	1,999	1,992	2,724
Mn	71	37	41	69	33	31	58	85	43	58	50	70
Fe	118	99	174	143	121	181	130	119	144	82	18	148
Mo	0.25	0.60	0.90	0.65	0.60	0.90	0.99	1.25	0.90	0.90	0.66	0.90
N	19,427	27,025	33,265	25,646	29,640	32,408	27,508	32,541	35,122	32,798	34,298	34,265
P	3,367	3,702	2,396	2,380	1,538	1,865	2,752	1,941	2,405	3,739	2,774	3,403
S[1]	4,663	8,307		7,016	9,627		8,600	5,101		18,066	9,285	

[1]The tissue samples taken in 2003 were not analyzed for S.

TABLE AIII-25: ANNUAL CONCENTRATIONS OF NUTRIENTS AND TRACE METALS IN LEAF TISSUES OF SIOUXLAND COTTONLESS COTTONWOOD COLLECTED FROM THE CLAY-LINED PLOTS OF THE USX RESEARCH AND DEMONSTRATION PROJECT IN 2001 THROUGH 2003

	Amendment											
	0% Biosolids			25% Biosolids			50% Biosolids			100% Biosolids		
Parameter	2001	2002	2003	2001	2002	2003	2001	2002	2003	2001	2002	2003
	mg/kg											
Zn	258	276	329	363	249	333	311	261	304	255	277	264
Cd	2.63	5.94	7.68	3.60	5.44	6.88	3.50	3.45	5.27	2.78	4.67	4.27
Cu	11.9	9.8	11.9	7.9	6.2	7.3	7.8	6.2	6.9	6.4	5.8	6.4
Cr	0.25	0.14	0.28	0.34	0.10	0.39	0.35	0.36	0.52	0.53	0.44	0.43
Ni	2.05	1.78	2.90	0.80	0.57	1.34	1.40	1.23	1.94	1.49	0.97	1.43
Pb	0.50	0.85	0.20	0.94	0.20	0.20	0.63	0.20	0.20	0.85	0.20	0.20
K	17,196	18,064	16,443	17,061	16,805	15,200	21,883	19,305	17,621	20,319	20,338	16,114
Na	32	46	50	48	15	56	42	48	77	62	102	76
Ca	10,851	14,145	16,828	12,613	14,783	17,654	10,208	10,689	15,584	11,283	13,850	15,415
Mg	4,032	3,766	4,024	3,887	4,103	4,233	3,924	4,760	4,371	5,056	4,587	4,114
Mn	87	55	50	130	80	70	166	156	91	124	168	128
Fe	119	88	98	95	60	86	67	36	98	86	19	80
Mo	0.88	0.66	0.90	5.30	2.56	1.16	4.24	3.71	2.13	3.70	3.01	2.10
N	26,332	30,417	21,317	26,906	32,092	25,459	25,919	34,339	25,839	29,851	32,092	27,077
P	2,142	2,340	1,848	4,291	3,175	4,389	4,919	3,872	4,789	6,278	6,057	8,550
S[1]	17,637	16,832		9,029	11,828		6,344	15,818		8,511	16,748	

[1]The tissue samples taken in 2003 were not analyzed for S.

TABLE AIII-26: ANNUAL CONCENTRATIONS OF NUTRIENTS AND TRACE METALS IN LEAF TISSUES OF SIOUXLAND COTTONLESS COTTONWOOD COLLECTED FROM THE NONLINED PLOTS OF THE USX RESEARCH AND DEMONSTRATION PROJECT IN 2001 THROUGH 2003

	Amendment											
	0% Biosolids			25% Biosolids			50% Biosolids			100% Biosolids		
Parameter	2001	2002	2003	2001	2002	2003	2001	2002	2003	2001	2002	2003
	mg/kg											
Zn	379	272	320	307	229	255	310	333	280	297	290	291
Cd	2.73	4.06	0.02	3.47	3.71	4.22	2.58	3.77	4.65	3.63	4.78	5.35
Cu	9.8	9.4	12.8	7.5	6.3	7.6	7.4	7.3	6.4	7.2	5.6	6.2
Cr	0.31	0.31	0.43	0.56	0.29	0.43	0.45	1.48	0.38	0.55	0.35	0.51
Ni	1.25	0.91	2.18	1.30	1.01	2.33	0.98	1.72	1.42	1.71	0.56	2.05
Pb	1.56	1.25	0.20	1.84	0.20	0.20	1.00	0.20	0.20	0.98	0.20	0.30
K	14,921	15,340	15,582	17,071	23,449	16,339	23,663	19,502	13,528	26,004	17,766	14,943
Na	63	38	53	49	40	56	28	152	68	50	57	64
Ca	13,733	16,710	17,593	11,433	10,297	15,832	9,043	12,915	15,658	10,513	15,223	17,334
Mg	5,094	4,726	4,673	3,954	3,875	4,116	3,825	4,866	4,603	4,114	4,198	4,753
Mn	104	65	53	131	54	48	140	149	98	105	179	154
Fe	158	125	102	106	36	90	68	90	69	84	25	81
Mo	1.05	0.61	0.90	4.70	2.25	1.51	4.51	4.21	1.95	4.23	2.99	1.89
N	20,165	28,864	23,174	28,030	29,926	27,553	26,558	31,152	26,506	20,095	33,399	22,300
P	2,317	1,970	1,727	3,869	3,478	3,738	5,499	3,838	6,144	9,455	6,691	8,017
S[1]	5,056	8,089		6,344	13,694		7,448	5,047		11,786	15,273	

[1]The tissue samples taken in 2003 were not analyzed for S.

TABLE AIII-27: ANNUAL CONCENTRATIONS OF NUTRIENTS AND TRACE METALS IN LEAF TISSUES OF RED OAK COLLECTED FROM THE CLAY-LINED PLOTS OF THE USX RESEARCH AND DEMONSTRATION PROJECT IN 2001 THROUGH 2003

	Amendment											
	0% Biosolids			25% Biosolids			50% Biosolids			100% Biosolids		
Parameter	2001	2002	2003	2001	2002	2003	2001	2002	2003	2001	2002	2003
	mg/kg											
Zn	46	32	37	39	50	41	37	48	50	ND	ND	ND
Cd	0.10	0.02	0.02	0.05	0.02	0.02	0.03	0.03	0.03	ND	ND	ND
Cu	6.1	3.9	5.4	4.9	3.2	2.62	4.7	3.7	3.23	ND	ND	ND
Cr	0.93	0.23	0.43	0.69	0.28	0.39	0.90	0.61	0.90	ND	ND	ND
Ni	0.80	0.42	0.70	0.75	0.61	1.31	0.83	0.50	1.01	ND	ND	ND
Pb	2.38	1.60	0.20	1.69	0.60	0.75	1.68	0.30	0.55	ND	ND	ND
K	6,246	7,396	7,866	4,708	7,185	8,514	5,678	7,299	8,745	ND	ND	ND
Na	37	12	20	48	16	33	34	14	36	ND	ND	ND
Ca	13,391	10,526	10,650	14,961	14,170	7,852	15,171	12,699	9,321	ND	ND	ND
Mg	4,371	3,002	2,721	4,294	3,552	2,514	3,115	3,622	3,482	ND	ND	ND
Mn	168	65	46	334	253	124	81	687	344	ND	ND	ND
Fe	204	109	105	173	148	102	124	105	166	ND	ND	ND
Mo	1.00	2.84	2.94	2.58	4.59	6.09	2.59	2.56	1.24	ND	ND	ND
N	17,428	19,140	22,079	18,484	24,329	23,364	17,501	20,039	25,268	ND	ND	ND
P	1,562	1,278	1,332	1,775	1,486	1,375	2,248	1,793	1,478	ND	ND	ND
S[1]	18,954	7,229		6,404	8,028		6,671	6,484		ND	ND	ND

[1]The tissue samples taken in 2003 were not analyzed for S.
ND = No data, trees were damaged by wildlife in the winter of 2001.

TABLE AIII-28: ANNUAL CONCENTRATIONS OF NUTRIENTS AND TRACE METALS IN LEAF TISSUES OF RED OAK COLLECTED FROM THE NONLINED PLOTS OF THE USX RESEARCH AND DEMONSTRATION PROJECT IN 2001 THROUGH 2003

	Amendment											
	0% Biosolids			25% Biosolids			50% Biosolids			100% Biosolids		
Parameter	2001	2002	2003	2001	2002	2003	2001	2002	2003	2001	2002	2003
	mg/kg											
Zn	57	49	44	54	55	26	ND	ND	ND	ND	ND	ND
Cd	0.01	0.02	0.02	0.01	0.02	0.02	ND	ND	ND	ND	ND	ND
Cu	6.2	5.3	8.17	4.0	2.2	5.26	ND	ND	ND	ND	ND	ND
Cr	0.74	0.65	0.63	0.93	0.40	0.80	ND	ND	ND	ND	ND	ND
Ni	1.28	0.44	0.35	1.00	0.47	0.74	ND	ND	ND	ND	ND	ND
Pb	2.39	3.00	0.55	3.00	1.60	4.25	ND	ND	ND	ND	ND	ND
K	5,293	7,946	12,723	6,516	6,683	7,014	ND	ND	ND	ND	ND	ND
Na	55	15	48	56	12	103	ND	ND	ND	ND	ND	ND
Ca	16,673	12,951	27,911	15,021	11,358	16,603	ND	ND	ND	ND	ND	ND
Mg	4,036	3,364	4,445	3,466	4,071	2,304	ND	ND	ND	ND	ND	ND
Mn	97	75	28	107	73	23	ND	ND	ND	ND	ND	ND
Fe	192	253	131	180	196	182	ND	ND	ND	ND	ND	ND
Mo	1.55	2.51	0.90	0.74	0.60	0.90	ND	ND	ND	ND	ND	ND
N	18,362	22,981	30,695	21,349	26,494	26,411	ND	ND	ND	ND	ND	ND
P	1,696	1,657	2,277	1,529	1,204	2,222	ND	ND	ND	ND	ND	ND
S[1]	6,304	4,411		9,211	8,455		ND	ND		ND	ND	

[1]The tissue samples taken in 2003 were not analyzed for S.
ND = No data, trees were damaged by wildlife in the winter of 2001.

TABLE AIII-29: ANNUAL CONCENTRATIONS OF NUTRIENTS AND TRACE METALS IN LEAF TISSUES OF HOMESTEAD HYBRID ELM COLLECTED FROM THE CLAY-LINED PLOTS OF THE USX RESEARCH AND DEMONSTRATION PROJECT IN 2001 THROUGH 2003

	Amendment											
	0% Biosolids			25% Biosolids			50% Biosolids			100% Biosolids		
Parameter	2001	2002	2003	2001	2002	2003	2001	2002	2003	2001	2002	2003
	mg/kg											
Zn	45	33	39	45	41	35	39	35	ND	58	53	ND
Cd	0.01	0.02	0.02	0.01	0.02	0.02	0.01	0.02	ND	0.01	0.05	ND
Cu	9.0	8.9	6.0	10.8	8.5	6.6	12.2	9.6	ND	14.7	12.9	ND
Cr	0.95	0.18	0.59	0.34	0.31	0.815475	0.40	0.27	ND	0.94	0.69	ND
Pb	2.25	0.95	0.75	0.46	0.25	1.20	0.28	0.20	ND	0.85	0.20	ND
K	9,853	21,453	5,702	16,806	14,080	5,194	14,791	13,899	ND	17,734	16,254	ND
Na	100	56	20	35	63	68	45	61	ND	39	82	ND
Ca	23,521	16,470	14,404	19,756	25,411	15,309	22,283	26,907	ND	20,103	19,715	ND
Mg	3,486	3,286	4,100	3,243	4,348	2,612	4,100	4,661	ND	3,808	3,907	ND
Mn	65	20	38	81	58	36	161	94	ND	178	118	ND
Fe	155	65	165	114	55	188	71	50	ND	82	26	ND
Mo	0.55	0.72	0.90	1.98	1.33	0.90	3.24	2.41	ND	1.90	1.97	ND
N	24,279	30,866	19,508	36,987	39,283	30,980	39,422	37,240	ND	42,475	41,652	ND
P	4,006	2,944	1,633	3,409	3,210	1,751	3,371	3,239	ND	3,998	3,821	ND
S[1]	35,542	3,214		8,400	3,410		5,358	2,688		28,629	3,411	

[1]The tissue samples taken in 2003 were not analyzed for S.
ND = No data, trees were damaged by wildlife in the winter of 2002.

TABLE AIII-30: ANNUAL CONCENTRATIONS OF NUTRIENTS AND TRACE METALS IN LEAF TISSUES OF HOMESTEAD HYBRID ELM COLLECTED FROM THE NONLINED PLOTS OF THE USX RESEARCH AND DEMONSTRATION PROJECT IN 2001 THROUGH 2003

	Amendment											
	0% Biosolids			25% Biosolids			50% Biosolids			100% Biosolids		
Parameter	2001	2002	2003	2001	2002	2003	2001	2002	2003	2001	2002	2003
	mg/kg											
Zn	54	50	31	43	37	26	41	39	ND	55	46	ND
Cd	0.01	0.02	0.02	0.03	0.02	0.02	0.01	0.02	ND	0.01	0.02	ND
Cu	10.0	9.5	8.2	11.8	6.1	5.3	11.1	10.1	ND	13.1	10.3	ND
Cr	0.84	0.33	0.63	0.73	0.94	0.80	0.40	0.64	ND	0.45	0.35	ND
Ni	2.93	0.57	0.35	0.53	0.53	0.74	0.53	0.35	ND	0.71	0.47	ND
Pb	2.69	0.75	0.55	1.23	0.70	4.25	0.63	0.20	ND	0.55	0.20	ND
K	10,701	16,294	12,723	17,013	14,723	7,014	17,306	11,253	ND	17,999	13,400	ND
Na	67	43	48	39	64	103	53	143	ND	68	55	ND
Ca	23,966	22,672	27,911	22,706	26,076	16,603	23,841	31,574	ND	20,268	21,364	ND
Mg	3,893	4,671	4,445	4,282	4,500	2,304	3,706	5,135	ND	3,576	4,092	ND
Mn	57	29	28	67	35	23	130	111	ND	179	148	ND
Fe	167	106	131	124	154	182	76	109	ND	87	25	ND
Mo	0.93	0.71	0.90	2.21	1.08	0.90	2.74	2.77	ND	2.05	1.64	ND
N	28,150	33,808	30,695	36,101	38,629	26,411	42,193	39,242	ND	35,594	45,943	ND
P	4,214	2,612	2,277	3,228	2,625	2,222	3,731	3,308	ND	4,005	3,664	ND
S[1]	10,820	1,916		6,664	2,325		7,300	1,215		9,998	7,469	

[1]The tissue samples taken in 2003 were not analyzed for S.
ND = No data, trees were damaged by wildlife in winter of 2002.

APPENDIX AIV

CONCENTRATIONS OF CHEMICAL CONSTITUENTS IN SUBSURFACE AND LAKE WATER

TABLE AIV-1: MEAN[1] ANNUAL CONCENTRATIONS OF CHEMICAL CONSTITUENTS IN WATER SAMPLES COLLECTED MONTHLY FROM LAKE MICHIGAN AND FROM LYSIMETERS AND WELLS IN THE USX RESEARCH AND DEMONSTRATION PLOTS IN JUNE THROUGH DECEMBER 2000

		Sample Point Identification[2]					
Parameter	Unit	L-1E1 @ 5-ft	L-1E2 @ 10-ft	W-1E3 @ 20-ft	L-2E1 @ 5-ft	L-2E2 @ 10-ft	W-2E3 @ 20-ft
pH		7.8	7.3	7.5	7.9	7.6	7.4
EC	mS/m	132	97	115	121	135	135
TDS[3]	mg/L	1,646	2,655	1,347	1,897	2,205	1,357
Cl^-	”	25	27	47	24	28	269
$SO_4^=$	”	816	132	539	277	935	338
TKN	”	2.44	1.35	0.83	3.52	1.96	0.73
NH_3-N	”	0.28	0.29	0.19	0.43	0.33	0.20
NO_2-N	”	0.56	1.11	0.02	1.05	1.02	0.01
NO_3-N	”	6.77	6.67	0.82	49.4	4.09	0.12
Total P	”	0.18	0.14	0.09	0.12	0.11	0.06
Alkalinity[4]	”	281	189	334	180	268	368
Hardness	”	922	993	787	919	1,281	578
Cd	”	<0.003	<0.003	<0.003	<0.003	<0.003	0.004
Cr	”	0.013	0.026	0.006	0.013	0.018	0.008
Cu	”	0.018	0.028	0.011	0.025	0.019	0.012
Hg	µg/L	<0.1	0.15	<0.1	<0.1	0.14	<0.1
Ni	mg/L	<0.02	<0.02	<0.02	0.10	<0.02	0.10
Pb	”	<0.03	<0.03	<0.03	<0.03	0.03	<0.03
Zn	”	0.008	0.017	0.007	0.018	<0.006	0.008
FC[5]	#/100 mL	ND	ND	ND	ND	ND	ND

TABLE AIV-1 (CONTINUED): MEAN[1] ANNUAL CONCENTRATIONS OF CHEMICAL CONSTITUENTS IN WATER SAMPLES COLLECTED MONTHLY FROM LAKE MICHIGAN AND FROM LYSIMETERS AND WELLS IN THE USX RESEARCH AND DEMONSTRATION PLOTS IN JUNE THROUGH DECEMBER 2000

		Sample Point Identification[2]				
Parameter	Unit	L-3E1 @ 5-ft	L-3E2 @ 10-ft	L-4E1 @ 5-ft	L-4E2 @ 10-ft	W-4E3 @ 20-ft
pH		7.6	7.6	8.7	8.0	7.6
EC	mS/m	237	176	109	165	127
TDS[3]	mg/L	3,024	2,354	1,277	2,740	1,591
Cl^-	”	53	162	113	63	132
$SO_4^=$	”	1,252	880	131	1,069	720
TKN	”	7.10	5.71	14.81	2.74	1.38
NH_3-N	”	0.90	1.90	9.83	0.33	0.50
NO_2-N	”	10.6	25.2	1.96	1.65	0.05
NO_3-N	”	124	62.8	3.07	20.1	3.88
Total P	”	0.12	0.13	0.13	0.14	0.06
Alkalinity[4]	”	61	119	198	326	97
Hardness	”	1,446	1,291	149	1,347	732
Cd	”	<0.003	<0.003	<0.003	<0.003	<0.003
Cr	”	0.013	0.009	0.007	0.007	0.006
Cu	”	0.034	0.034	0.016	0.030	0.012
Hg	µg/L	<0.1	<0.1	0.22	<0.1	0.10
Ni	mg/L	0.10	0.10	<0.02	<0.02	0.10
Pb	”	<0.03	<0.03	0.04	<0.03	<0.03
Zn	”	0.006	<0.006	<0.006	<0.006	0.110
FC[5]	#/100 mL	ND	ND	ND	ND	ND

TABLE AIV-1 (CONTINUED): MEAN[1] ANNUAL CONCENTRATIONS OF CHEMICAL CONSTITUENTS IN WATER SAMPLES COLLECTED MONTHLY FROM LAKE MICHIGAN AND FROM LYSIMETERS AND WELLS IN THE USX RESEARCH AND DEMONSTRATION PLOTS IN JUNE THROUGH DECEMBER 2000

		Sample Point Identification[2]				
Parameter	Unit	L-1W1 @ 5-ft	L-1W2 @ 10-ft	L-2W1 @ 5-ft	L-2W2 @ 10-ft	W-2W3 @ 20-ft
pH		8.1	7.5	8.1	7.9	7.5
EC	mS/m	141	172	129	142	148
TDS[3]	mg/L	NA	2,078	1,171	2,145	1,265
Cl^-	”	NA	27	17	28	103
$SO_4^=$	”	NA	780	320	421	361
TKN	”	NA	1.42	4.19	3.16	0.94
NH_3-N	”	NA	0.24	0.58	0.34	0.39
NO_2-N	”	NA	1.32	0.40	1.03	0.02
NO_3-N	”	NA	7.00	18.0	4.36	0.35
Total P	”	NA	0.14	0.16	0.15	0.08
Alkalinity[4]	”	NA	291	111	246	444
Hardness	”	NA	771	381	1,041	501
Cd	”	NA	<0.003	<0.003	<0.003	<0.003
Cr	”	NA	0.007	0.007	0.013	0.006
Cu	”	NA	0.031	0.018	0.023	0.011
Hg	µg/L	NA	0.10	0.16	0.12	<0.1
Ni	mg/L	NA	<0.02	<0.02	<0.02	0.02
Pb	”	NA	<0.03	<0.03	<0.03	<0.03
Zn	”	NA	0.014	<0.006	0.009	0.027
FC[5]	#/100 mL	NA	ND	ND	ND	ND

TABLE AIV-1 (CONTINUED): MEAN[1] ANNUAL CONCENTRATIONS OF CHEMICAL CONSTITUENTS IN WATER SAMPLES COLLECTED MONTHLY FROM LAKE MICHIGAN AND FROM LYSIMETERS AND WELLS IN THE USX RESEARCH AND DEMONSTRATION PLOTS IN JUNE THROUGH DECEMBER 2000

		Sample Point Identification[2]					
Parameter	Unit	L-3W1 @ 5-ft	L-3W2 @ 10-ft	W-3W3 @20-ft	L-4W1 @ 5-ft	L-4W2 @ 10-ft	W-4W3 @ 20-ft
pH		7.8	7.7	7.6	7.7	7.5	7.6
EC	mS/m	163	193	135	221	110	145
TDS[3]	mg/L	1,946	2,702	1,195	2,508	1,561	1,183
Cl^-	”	22	83	135	25	41	88
$SO_4^=$	”	926	1,068	371	1,749	637	339
TKN	”	6.32	2.17	0.62	20.6	11.2	0.89
NH_3-N	”	0.87	0.28	0.22	6.89	7.07	0.45
NO_2-N	”	1.20	0.07	0.01	2.33	6.78	0.06
NO_3-N	”	52.5	2.61	0.13	117	6.09	0.36
Total P	”	0.18	0.10	0.09	0.42	0.21	0.06
Alkalinity[4]	”	118	99	284	222	89	304
Hardness	”	1,414	1,286	554	2,303	696	572
Cd	”	<0.003	<0.003	<0.003	<0.003	0.010	<0.003
Cr	”	0.016	0.025	<0.006	0.015	0.019	0.006
Cu	”	0.040	0.028	0.007	0.058	0.051	0.018
Hg	µg/L	<0.1	<0.1	0.10	0.11	<0.1	0.11
Ni	mg/L	0.03	<0.02	0.02	0.06	<0.02	0.02
Pb	”	<0.03	<0.03	0.03	<0.03	<0.03	0.03
Zn	”	0.010	<0.006	0.012	0.009	0.048	0.012
FC[5]	#/100 mL	ND	ND	ND	ND	ND	ND

TABLE AIV-1 (CONTINUED): MEAN[1] ANNUAL CONCENTRATIONS OF CHEMICAL CONSTITUENTS IN WATER SAMPLES COLLECTED MONTHLY FROM LAKE MICHIGAN AND FROM LYSIMETERS AND WELLS IN THE USX RESEARCH AND DEMONSTRATION PLOTS IN JUNE THROUGH DECEMBER 2000

Parameter	Unit	Sample Point Identification[2]					
		L-R1 @ 5-ft	L-R2 @ 10-ft	W-R3 @ 20-ft	LAKE-N	LAKE	LAKE-S
pH		7.9	8.0	7.6	7.6	7.7	7.6
EC	mS/m	142	189	122	31	31	32
TDS[3]	mg/L	1,542	2,673	1,143	204	204	215
Cl^-	”	14	85	50	12	13	13
$SO_4^=$	”	433	1,394	380	28	26	27
TKN	”	1.39	1.44	0.70	0.17	0.27	0.40
NH_3-N	”	0.31	0.28	0.38	0.06	0.07	0.07
NO_2-N	”	0.62	0.44	0.01	0.01	0.01	0.01
NO_3-N	”	0.24	3.62	0.24	0.30	0.33	0.37
Total P	”	0.10	0.11	0.08	0.07	0.08	0.07
Alkalinity[4]	”	296	626	336	110	106	105
Hardness	”	324	1,840	652	143	139	140
Cd	”	<0.003	<0.003	0.003	<0.003	<0.003	<0.003
Cr	”	<0.006	0.020	0.009	0.006	0.006	0.008
Cu	”	0.024	0.030	0.013	0.006	0.007	0.007
Hg	µg/L	<0.1	<0.1	0.11	<0.1	<0.1	<0.1
Ni	mg/L	<0.02	<0.02	0.02	<0.02	0.02	<0.02
Pb	”	<0.03	<0.03	<0.03	<0.03	<0.03	0.03
Zn	”	<0.006	0.017	0.008	0.007	0.007	0.011
FC[5]	#/100 mL	ND	ND	ND	7	30	45

[1]MDL was used in calculating the mean. If all values were less than the MDL, the mean is reported as <MDL.
[2]The clay-lined plots are designated E and nonlined plots are designated W. The first number 1, 2, 3, and 4 are amendment designations for 0, 25, 50, and 100 percent biosolids, respectively. The last number 1, 2 and 3 are designations for lysimeters at 5-ft and 10-ft depths and well at 20-ft depth, respectively. Remote lysimeters and well were located 200 ft. south of the plots and are designated LR and WR, respectively. Lake sampling locations are designated Lake-N, Lake, and Lake-S.
[3]Total dissolved solids.
[4]Expressed as $CaCO_3$ equivalent.
[5]Fecal coliform.
NA = No analysis; insufficient sample.
ND = Not detected.

TABLE AIV-2: MEAN[1] ANNUAL CONCENTRATIONS OF CHEMICAL CONSTITUENTS IN WATER SAMPLES COLLECTED MONTHLY FROM LAKE MICHIGAN AND FROM LYSIMETERS AND WELLS IN THE USX RESEARCH AND DEMONSTRATION PLOTS IN 2001

Parameter	Unit	Sample Point Identification[2]					
		L-1E1 @ 5-ft	L-1E2 @ 10-ft	W-1E3 @ 20-ft	L-2E1 @ 5-ft	L-2E2 @ 10-ft	W-2E3 @ 20-ft
pH		7.4	7.4	7.5	7.9	7.6	7.7
EC	mS/m	223	291	203	216	285	203
TDS[3]	mg/L	1,624	1,949	1,450	1,985	2,268	1,154
Cl^-	”	17	30	37	24	25	106
$SO_4^=$	”	345	NA	483	650	806	351
TKN	”	1.05	1.45	0.51	3.84	2.34	0.77
NH_3-N	”	0.138	0.117	0.227	0.136	0.226	0.475
NO_2-N	”	0.033	0.040	0.019	0.543	0.317	0.031
NO_3-N	”	3.84	10.1	0.589	22.5	29.3	0.701
Total P	”	0.16	0.17	0.09	0.25	0.15	0.09
Alkalinity[4]	”	510	466	487	366	402	375
Hardness	”	738	1,617	856	1,122	1,257	574
As	”	<0.08	<0.08	0.09	0.17	<0.08	<0.08
Cd	”	0.016	0.010	<0.007	<0.007	<0.007	<0.007
Cr	”	0.034	0.035	0.016	0.035	0.019	0.013
Cu	”	0.084	0.076	0.016	0.151	0.035	0.011
Hg	µg/L	<0.04	<0.04	<0.04	<0.04	0.07	0.05
Mn	mg/L	0.281	1.49	1.13	0.642	1.27	1.21
Ni	”	0.09	0.14	0.05	0.12	0.07	0.04
Pb	”	0.11	<0.06	0.06	0.13	0.11	0.06
Sb	”	0.13	0.15	0.08	0.16	0.13	0.07
Zn	”	0.043	0.066	0.013	0.056	0.018	0.012
FC[5]	#/100 mL	ND	ND	ND	ND	ND	ND

TABLE AIV-2 (CONTINUED): MEAN[1] ANNUAL CONCENTRATIONS OF CHEMICAL CONSTITUENTS IN WATER SAMPLES COLLECTED MONTHLY FROM LAKE MICHIGAN AND FROM LYSIMETERS AND WELLS IN THE USX RESEARCH AND DEMONSTRATION PLOTS IN 2001

		Sample Point Identification[2]				
Parameter	Unit	L-3E1 @ 5-ft	L-3E2 @ 10-ft	L-4E1 @ 5-ft	L-4E2 @ 10-ft	W-4E3 @ 20-ft
pH		7.7	7.7	8.9	7.4	7.4
EC	mS/m	218	177	158	249	224
TDS[3]	mg/L	1,849	1,484	1,327	2,505	1,558
Cl^-	”	26	22	114	21	81
$SO_4^=$	”	460	714	138	1,052	812
TKN	”	5.05	4.42	42.2	2.86	1.40
NH_3-N	”	0.546	1.15	27.3	1.37	1.10
NO_2-N	”	0.750	0.069	0.091	0.162	0.035
NO_3-N	”	22.9	1.69	2.52	8.43	0.832
Total P	”	0.17	0.18	0.67	0.16	0.08
Alkalinity[4]	”	217	263	366	388	69
Hardness	”	995	764	100	1,303	703
As	”	0.16	<0.08	<0.08	<0.08	0.09
Cd	”	<0.007	<0.007	<0.007	<0.007	0.007
Cr	”	0.027	0.027	0.014	0.046	0.016
Cu	”	0.091	0.092	0.037	0.067	0.014
Hg	µg/L	0.09	0.08	0.60	0.15	<0.04
Mn	mg/L	0.479	0.980	0.102	0.629	5.64
Ni	”	0.10	0.11	0.07	0.13	0.10
Pb	”	<0.06	0.11	<0.06	0.10	0.06
Sb	”	0.16	0.14	0.12	0.13	0.09
Zn	”	0.039	0.028	0.017	0.017	0.207
FC[5]	#/100 mL	ND	ND	ND	ND	ND

TABLE AIV-2 (CONTINUED): MEAN[1] ANNUAL CONCENTRATIONS OF CHEMICAL CONSTITUENTS IN WATER SAMPLES COLLECTED MONTHLY FROM LAKE MICHIGAN AND FROM LYSIMETERS AND WELLS IN THE USX RESEARCH AND DEMONSTRATION PLOTS IN 2001

Parameter	Unit	Sample Point Identification[2]				
		L-1W1 @ 5-ft	L-1W2 @ 10-ft	L-2W1 @ 5-ft	L-2W2 @ 10-ft	W-2W3 @ 20-ft
pH		8.0	7.5	7.7	7.9	7.7
EC	mS/m	234	292	240	256	191
TDS[3]	mg/L	3,152	2,543	2,201	2,335	1,082
Cl^-	”	22	23	15	18	109
$SO_4^=$	”	NA	1,481	758	846	301
TKN	”	1.64	2.09	3.02	3.21	0.59
NH_3-N	”	0.120	0.136	0.230	0.374	0.305
NO_2-N	”	<0.006	0.059	0.089	0.043	0.021
NO_3-N	”	20.4	22.6	25.0	4.52	0.616
Total P	”	<0.08	0.16	0.23	0.17	0.09
Alkalinity[4]	”	412	383	498	697	357
Hardness	”	1,816	1,848	1,030	1,589	433
As	”	<0.08	0.16	<0.08	0.20	0.08
Cd	”	<0.007	<0.007	<0.007	0.013	<0.007
Cr	”	0.058	0.032	0.025	0.041	0.010
Cu	”	0.228	0.134	0.081	0.070	0.009
Hg	µg/L	<0.04	<0.04	<0.04	0.09	0.04
Mn	mg/L	0.218	0.316	0.243	0.567	0.441
Ni	”	0.24	0.11	0.08	0.10	0.04
Pb	”	0.16	0.12	0.12	0.13	<0.06
Sb	”	0.22	0.16	0.17	0.23	0.07
Zn	”	0.080	0.086	0.040	0.046	0.024
FC[5]	#/100 mL	NA	ND	ND	ND	ND

TABLE AIV-2 (CONTINUED): MEAN[1] ANNUAL CONCENTRATIONS OF CHEMICAL CONSTITUENTS IN WATER SAMPLES COLLECTED MONTHLY FROM LAKE MICHIGAN AND FROM LYSIMETERS AND WELLS IN THE USX RESEARCH AND DEMONSTRATION PLOTS IN 2001

		Sample Point Identification[2]					
Parameter	Unit	L-3W1 @ 5-ft	L-3W2 @ 10-ft	W-3W3 @20-ft	L-4W1 @ 5-ft	L-4W2 @ 10-ft	W-4W3 @ 20-ft
pH		7.9	7.8	7.8	8.1	7.7	7.4
EC	mS/m	229	392	185	217	210	259
TDS[3]	mg/L	1,746	3,242	1,064	1,554	1,631	1,572
Cl^-	”	21	39	71	20	54	60
$SO_4^=$	”	659	1,975	373	390	898	727
TKN	”	4.98	1.96	0.44	6.57	19.9	1.03
NH_3-N	”	1.74	0.327	0.223	0.488	15.1	0.726
NO_2-N	”	0.115	0.621	0.009	0.233	1.01	0.030
NO_3-N	”	8.59	1.79	0.175	1.08	0.484	0.210
Total P	”	0.19	0.16	0.08	0.37	0.20	0.09
Alkalinity[4]	”	300	219	285	372	111	279
Hardness	”	779	2,018	542	1,178	716	928
As	”	0.16	0.19	0.08	0.21	<0.08	0.10
Cd	”	<0.007	<0.007	<0.007	<0.007	<0.007	0.007
Cr	”	0.024	0.040	0.011	0.037	0.019	0.015
Cu	”	0.077	0.113	0.012	0.163	0.101	0.041
Hg	µg/L	0.09	<0.04	0.05	0.09	0.11	0.04
Mn	mg/L	0.228	0.591	0.614	1.99	0.307	4.84
Ni	”	0.09	0.11	0.04	0.14	0.08	0.08
Pb	”	0.12	0.15	<0.06	0.14	<0.06	0.06
Sb	”	0.15	0.21	0.07	0.21	<0.07	0.09
Zn	”	0.042	0.073	0.041	0.120	0.034	0.281
FC[5]	#/100 mL	ND	ND	2	ND	ND	ND

TABLE AIV-2 (CONTINUED): MEAN[1] ANNUAL CONCENTRATIONS OF CHEMICAL CONSTITUENTS IN WATER SAMPLES COLLECTED MONTHLY FROM LAKE MICHIGAN AND FROM LYSIMETERS AND WELLS IN THE USX RESEARCH AND DEMONSTRATION PLOTS IN 2001

Parameter	Unit	Sample Point Identification[2] L-R1 @ 5-ft	L-R2 @ 10-ft	W-R3 @ 20-ft	LAKE-N	LAKE	LAKE-S
pH		7.3	7.5	7.4	7.2	7.2	7.2
EC	mS/m	142	189	153	105	128	112
TDS[3]	mg/L	1,368	1,687	1,054	337	194	251
Cl^-	”	9	24	39	13	14	15
$SO_4^=$	”	273	228	350	23	24	23
TKN	”	0.83	0.59	0.55	0.26	0.26	0.24
NH_3-N	”	0.160	0.201	0.354	0.052	0.047	0.047
NO_2-N	”	0.041	0.020	0.032	0.014	0.009	0.009
NO_3-N	”	1.04	0.983	0.535	0.507	0.465	0.657
Total P	”	0.17	0.17	0.14	0.10	0.09	0.09
Alkalinity[4]	”	544	775	354	104	107	106
Hardness	”	549	948	632	140	140	143
As	”	0.17	<0.08	0.08	0.08	<0.08	<0.08
Cd	”	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Cr	”	0.017	0.023	0.010	0.009	0.008	0.009
Cu	”	0.349	0.108	0.012	0.007	0.007	0.007
Hg	µg/L	<0.04	<0.04	<0.04	0.04	0.05	0.04
Mn	mg/L	0.104	0.045	0.523	0.045	0.041	0.038
Ni	”	0.66	0.12	0.04	0.03	0.04	0.04
Pb	”	0.12	0.12	<0.06	<0.06	<0.06	<0.06
Sb	”	0.15	0.16	0.08	<0.07	<0.07	<0.07
Zn	”	0.366	0.077	0.027	0.012	0.011	0.019
FC[5]	#/100 mL	ND	ND	ND	89	15	7

[1]MDL was used in calculating the mean. If all values were less than the MDL, the mean is reported as <MDL.

[2]The clay-lined plots are designated E and nonlined plots are designated W. The first number 1, 2, 3, and 4 are amendment designations for 0, 25, 50, and 100 percent biosolids, respectively. The last number 1, 2 and 3 are designations for lysimeters at 5-ft and 10-ft depths and well at 20-ft depth, respectively. Remote lysimeters and well were located 200 ft. south of the plots and are designated LR and WR, respectively. Lake sampling locations are designated Lake-N, Lake, and Lake-S.

[3]Total dissolved solids.

[4]Expressed as $CaCO_3$ equivalent.

[5]Fecal coliform.

NA = No analysis; insufficient sample.

ND = Not detected.

TABLE AIV-3: MEAN[1] ANNUAL CONCENTRATIONS OF CHEMICAL CONSTITUENTS IN WATER SAMPLES COLLECTED MONTHLY FROM LAKE MICHIGAN AND FROM LYSIMETERS AND WELLS IN THE USX RESEARCH AND DEMONSTRATION PLOTS IN 2002

		Sample Point Identification[2]					
Parameter	Unit	L-1E1 @ 5-ft	L-1E2 @ 10-ft	W-1E3 @ 20-ft	L-2E1 @ 5-ft	L-2E2 @ 10-ft	W-2E3 @ 20-ft
pH		7.9	8.0	7.7	8.1	7.8	7.6
EC	mS/m	121	122	110	118	156	126
TDS[3]	mg/L	1,335	1,183	989	1,425	2,032	1,034
Cl^-	”	15.9	3.4	27.6	11.9	12.7	68.5
$SO_4^=$	”	301	233	285	384	692	269
TKN	”	1.07	1.09	0.44	3.69	1.78	0.45
NH_3-N	”	0.08	0.10	0.20	0.36	0.08	0.19
NO_2-N	”	0.071	0.035	0.010	0.047	0.036	0.014
NO_3-N	”	3.18	1.95	0.166	15.4	5.61	0.378
Total P	”	0.13	0.12	0.06	0.55	0.12	0.06
Alkalinity[4]	”	492	478	413	397	487	421
Hardness	”	782	855	614	906	1,154	554
As	”	0.09	0.14	0.05	0.09	0.12	0.05
Cd	”	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Cr	”	0.039	0.037	0.013	0.025	0.025	0.011
Cu	”	0.065	0.028	0.013	0.068	0.057	0.013
Hg	µg/L	0.10	0.10	0.06	0.10	0.10	0.05
Mn	mg/L	0.463	0.111	1.60	0.640	0.536	0.921
Ni	”	0.059	0.087	0.038	0.076	0.071	0.035
Pb	”	0.07	0.09	0.04	0.08	0.08	0.04
Sb	”	0.09	0.13	0.05	0.09	0.10	0.05
Zn	”	0.043	0.032	0.020	0.036	0.044	0.018
FC[5]	#/100 mL	ND	ND	ND	ND	ND	ND

TABLE AIV-3 (CONTINUED): MEAN[1] ANNUAL CONCENTRATIONS OF CHEMICAL CONSTITUENTS IN WATER SAMPLES COLLECTED MONTHLY FROM LAKE MICHIGAN AND FROM LYSIMETERS AND WELLS IN THE USX RESEARCH AND DEMONSTRATION PLOTS IN 2002

Parameter	Unit	Sample Point Identification[2]				
		L-3E1 @ 5-ft	L-3E2 @ 10-ft	L-4E1 @ 5-ft	L-4E2 @ 10-ft	W-4E3 @ 20-ft
pH		8.1	7.8	9.3	8.2	7.7
EC	mS/m	117	187	106	225	121
TDS[3]	mg/L	1,173	1,904	1,497	2,235	1,043
Cl^-	”	12.9	14.2	125	18.3	53.4
$SO_4^=$	”	355	786	116	1,250	506
TKN	”	3.37	3.14	55.1	2.32	1.18
NH_3-N	”	0.15	0.77	32.6	0.39	0.82
NO_2-N	”	0.303	0.086	0.059	0.079	0.010
NO_3-N	”	5.8	3.26	0.37	3.40	0.136
Total P	”	0.13	0.12	0.15	0.11	0.06
Alkalinity[4]	”	400	397	463	411	135
Hardness	”	897	1,161	170	1,400	481
As	”	0.10	0.10	<0.04	0.08	0.05
Cd	”	<0.004	<0.004	<0.004	<0.004	<0.004
Cr	”	0.021	0.022	0.012	0.022	0.012
Cu	”	0.070	0.047	0.044	0.075	0.012
Hg	µg/L	0.11	0.12	0.42	<0.04	0.05
Mn	mg/L	0.347	1.051	0.315	0.519	1.17
Ni	”	0.069	0.067	0.067	0.059	0.038
Pb	”	0.09	0.08	0.07	0.07	0.03
Sb	”	0.11	0.10	<0.03	0.11	0.05
Zn	”	0.035	0.037	0.023	0.033	0.017
FC[5]	#/100 mL	ND	ND	ND	ND	ND

TABLE AIV-3 (CONTINUED): MEAN[1] ANNUAL CONCENTRATIONS OF CHEMICAL CONSTITUENTS IN WATER SAMPLES COLLECTED MONTHLY FROM LAKE MICHIGAN AND FROM LYSIMETERS AND WELLS IN THE USX RESEARCH AND DEMONSTRATION PLOTS IN 2002

Parameter	Unit	Sample Point Identification[2]				
		L-1W1 @ 5-ft	L-1W2 @ 10-ft	L-2W1 @ 5-ft	L-2W2 @ 10-ft	W-2W3 @ 20-ft
pH		7.6	7.7	7.7	8.0	7.6
EC	mS/m	109	260	134	179	100
TDS[3]	mg/L	NA	3,406	1,482	2,416	842
Cl-	”	NA	12.5	8.4	12.2	52.1
$SO_4^=$	”	NA	1,539	316	593	194
TKN	”	2.36	1.36	1.80	2.29	0.34
NH_3-N	”	0.08	0.12	0.10	0.06	0.17
NO_2-N	”	<0.005	0.125	0.027	0.034	0.008
NO_3-N	”	0.594	21.8	10.5	0.730	0.297
Total P	”	0.08	0.14	0.12	0.13	0.06
Alkalinity[4]	”	NA	338	616	897	370
Hardness	”	NA	1,668	829	1,576	444
As	”	NA	0.11	0.10	0.15	0.05
Cd	”	NA	<0.004	<0.004	0.010	<0.004
Cr	”	NA	0.027	0.023	0.030	0.009
Cu	”	NA	0.064	0.057	0.044	0.013
Hg	µg/L	NA	0.10	0.09	0.13	0.05
Mn	mg/L	NA	0.334	0.200	0.398	0.292
Ni	”	NA	0.077	0.065	0.073	0.029
Pb	”	NA	0.10	0.09	0.11	0.034
Sb	”	NA	0.12	0.10	0.16	0.06
Zn	”	NA	0.048	0.034	0.050	0.012
FC[5]	#/100 mL	NA	ND	ND	ND	1

TABLE AIV-3 (CONTINUED): MEAN[1] ANNUAL CONCENTRATIONS OF CHEMICAL CONSTITUENTS IN WATER SAMPLES COLLECTED MONTHLY FROM LAKE MICHIGAN AND FROM LYSIMETERS AND WELLS IN THE USX RESEARCH AND DEMONSTRATION PLOTS IN 2002

Parameter	Unit	Sample Point Identification[2]					
		L-3W1 @ 5-ft	L-3W2 @ 10-ft	W-3W3 @20-ft	L-4W1 @ 5-ft	L-4W2 @ 10-ft	W-4W3 @ 20-ft
pH		7.8	7.8	7.7	8.2	8.0	7.8
EC	mS/m	116	185	115	136	154	128
TDS[3]	mg/L	1,351	3,092	1,039	2,284	2,046	1,199
Cl^-	”	10.8	15.2	51.1	58.8	81.4	46.6
$SO_4^=$	”	351	NA	311	868	808	466
TKN	”	2.25	1.39	0.61	4.11	23.2	1.10
NH_3-N	”	0.09	0.07	0.37	0.18	16.1	0.73
NO_2-N	”	0.068	0.011	0.010	0.024	0.389	0.022
NO_3-N	”	22.1	0.887	0.178	0.169	0.193	0.123
Total P	”	0.12	0.11	0.06	0.88	0.13	0.07
Alkalinity[4]	”	436	262	394	260	101	308
Hardness	”	758	1,463	559	1,210	790	684
As	”	0.10	0.11	0.06	0.14	<0.04	0.06
Cd	”	<0.004	0.009	<0.004	<0.004	<0.004	0.005
Cr	”	0.020	0.028	0.010	0.046	0.012	0.012
Cu	”	0.074	0.030	0.014	0.055	0.145	0.027
Hg	µg/L	0.12	0.10	0.06	0.09	0.22	0.05
Mn	mg/L	0.107	0.310	0.765	1.45	0.318	2.87
Ni	”	0.048	0.067	0.034	0.160	0.057	0.058
Pb	”	0.08	0.11	0.04	0.10	0.06	0.04
Sb	”	0.10	0.10	0.05	0.12	0.07	0.05
Zn	”	0.038	0.037	0.056	0.050	0.047	0.136
FC[5]	#/100 mL	ND	ND	ND	ND	ND	4

TABLE AIV-3 (CONTINUED): MEAN[1] ANNUAL CONCENTRATIONS OF CHEMICAL CONSTITUENTS IN WATER SAMPLES COLLECTED MONTHLY FROM LAKE MICHIGAN AND FROM LYSIMETERS AND WELLS IN THE USX RESEARCH AND DEMONSTRATION PLOTS IN 2002

Parameter	Unit	Sample Point Identification[2]					
		L-R1 @ 5-ft	L-R2 @ 10-ft	W-R3 @ 20-ft	LAKE-N	LAKE	LAKE-S
pH		7.7	7.8	7.6	7.8	7.8	7.8
EC	mS/m	100	112	108	91	86	93
TDS[3]	mg/L	1,122	1,178	991	201	201	210
Cl^-	”	6.2	21.5	30.7	17.4	24.3	19.0
$SO_4^=$	”	NA	260	321	26.9	25.9	26.0
TKN	”	0.80	0.97	0.53	0.16	0.21	0.18
NH_3-N	”	0.06	0.41	0.35	0.02	0.02	0.02
NO_2-N	”	0.013	0.080	0.025	0.008	0.008	0.008
NO_3-N	”	0.935	1.50	0.246	0.393	0.411	0.336
Total P	”	0.14	0.12	0.07	0.07	0.06	0.06
Alkalinity[4]	”	601	635	340	132	122	109
Hardness	”	505	756	589	147	145	149
As	”	0.08	0.11	0.05	<0.04	0.04	0.04
Cd	”	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Cr	”	0.022	0.019	0.009	0.003	0.004	0.004
Cu	”	0.164	0.070	0.017	0.008	0.011	0.008
Hg	µg/L	0.08	0.09	0.04	0.05	0.05	0.06
Mn	mg/L	0.127	0.285	0.798	0.013	0.020	0.015
Ni	”	0.080	0.238	0.026	0.012	0.014	0.012
Pb	”	0.11	0.08	0.04	<0.03	<0.03	<0.03
Sb	”	0.09	0.10	0.05	0.03	0.03	0.03
Zn	”	0.230	0.081	0.016	0.011	0.012	0.010
FC[5]	#/100 mL	ND	ND	ND	11	8	7

[1]MDL was used in calculating the mean. If all values were less than the MDL, the mean is reported as <MDL.

[2]The clay-lined plots are designated E and nonlined plots are designated W. The first number 1, 2, 3, and 4 are amendment designations for 0, 25, 50, and 100 percent biosolids, respectively. The last number 1, 2 and 3 are designations for lysimeters at 5-ft and 10-ft depths and well at 20-ft depth, respectively. Remote lysimeters and well were located 200 ft. south of the plots and are designated LR and WR, respectively. Lake sampling locations are designated Lake-N, Lake, and Lake-S.

[3]Total dissolved solids.

[4]Expressed as $CaCO_3$ equivalent.

[5]Fecal coliform.

NA = No analysis; insufficient sample.

ND = Not detected.

TABLE AIV-4: MEAN[1] ANNUAL CONCENTRATIONS OF CHEMICAL CONSTITUENTS IN WATER SAMPLES COLLECTED MONTHLY FROM LAKE MICHIGAN AND FROM LYSIMETERS AND WELLS IN THE USX RESEARCH AND DEMONSTRATION PLOTS IN 2003

Parameter	Unit	Sample Point Identification[2]					
		L-1E1 @ 5-ft	L-1E2 @ 10-ft	W-1E3 @ 20-ft	L-2E1 @ 5-ft	L-2E2 @ 10-ft	W-2E3 @ 20-ft
pH		7.7	7.9	7.4	7.9	7.6	7.3
EC	mS/m	129	123	119	128	193	135
TDS[3]	mg/L	1,352	NA	1,070	1,473	2.544	1,053
Cl^-	”	29.4	NA	33.9	17.7	20.5	65.7
$SO_4^=$	”	373	NA	324	384	783	286
TKN	”	1.20	1.03	0.29	3.01	2.18	0.35
NH_3-N	”	0.16	0.94	0.10	0.10	0.10	0.16
NO_2-N	”	0.117	2.640	0.026	0.040	0.035	0.012
NO_3-N	”	4.26	1.67	0.28	23.00	19.03	0.37
Total P	”	NA	NA	0.06	0.32	0.11	0.06
Alkalinity[4]	”	628	NA	439	500	565	404
Hardness	”	904	NA	658	964	1,553	553
As	”	<0.004	NA	<0.002	<0.004	<0.004	<0.002
Cd	”	<0.0006	NA	<0.0003	<0.0006	<0.0006	<0.0003
Cr	”	0.0183	NA	0.0028	0.0060	0.0060	0.0025
Cu	”	0.025	NA	0.004	0.044	0.064	0.002
Hg	µg/L	0.69	NA	0.22	0.45	0.15	0.05
Mn	mg/L	0.114	NA	0.881	0.337	0.169	1.387
Ni	”	0.008	NA	0.003	0.007	0.013	0.002
Pb	”	0.0120	NA	0.0049	0.0103	0.012	0.0048
Sb	”	0.0120	NA	0.0094	0.0132	0.0216	0.0077
Zn	”	0.422	NA	0.177	0.113	0.149	0.192
FC[5]	#/100 mL	<1	<1	12	<1	<1	<1

TABLE AIV-4 (CONTINUED): MEAN[1] ANNUAL CONCENTRATIONS OF CHEMICAL CONSTITUENTS IN WATER SAMPLES COLLECTED MONTHLY FROM LAKE MICHIGAN AND FROM LYSIMETERS AND WELLS IN THE USX RESEARCH AND DEMONSTRATION PLOTS IN 2003

Parameter	Unit	Sample Point Identification[2] L-3E1 @ 5-ft	L-3E2 @ 10-ft	L-4E1 @ 5-ft	L-4E2 @ 10-ft	W-4E3 @ 20-ft
pH		7.8	7.5	9.0	7.8	7.5
EC	mS/m	169	222	149	229	125
TDS[3]	mg/L	1,671	2,906	1,716	3,120	1,026
Cl^-	”	NA	30.4	133.6	36.7	49.8
$SO_4^=$	”	568	1,047	248	1,208	450
TKN	”	3.82	3.90	60.28	2.20	1.15
NH_3-N	”	0.08	0.97	37.07	0.35	0.90
NO_2-N	”	0.036	0.997	32.463	0.139	0.016
NO_3-N	”	23.4	16.96	7.95	28.03	0.10
Total P	”	0.10	0.09	0.20	0.08	0.05
Alkalinity[4]	”	521	526	351	463	143
Hardness	”	1,202	1,523	184	1,566	457
As	”	<0.004	<0.004	<0.004	<0.004	<0.002
Cd	”	<0.0006	<0.0006	<0.0006	<0.0006	<0.0003
Cr	”	0.0064	0.0050	0.0027	0.0040	0.0025
Cu	”	0.056	0.068	0.017	0.014	NA
Hg	µg/L	0.15	0.11	0.70	0.14	0.17
Mn	mg/L	0.949	0.761	0.026	0.207	1.367
Ni	”	0.0097	0.0085	0.0255	0.0140	0.0042
Pb	”	0.0317	0.0196	0.0062	0.0147	0.0046
Sb	”	0.0152	0.0180	0.0130	0.0247	0.0082
Zn	”	0.138	0.131	0.015	0.125	0.061
FC[5]	#/100 mL	<1	<1	<1	<1	6

TABLE AIV-4 (CONTINUED): MEAN[1] ANNUAL CONCENTRATIONS OF CHEMICAL CONSTITUENTS IN WATER SAMPLES COLLECTED MONTHLY FROM LAKE MICHIGAN AND FROM LYSIMETERS AND WELLS IN THE USX RESEARCH AND DEMONSTRATION PLOTS IN 2003

Parameter	Unit	Sample Point Identification[2]				
		L-1W1 @ 5-ft	L-1W2 @ 10-ft	L-2W1 @ 5-ft	L-2W2 @ 10-ft	W-2W3 @ 20-ft
pH		7.1	734	736	7.9	7.3
EC	mS/m	145	260	154	219	111
TDS[3]	mg/L	NA	3,324	1,336	2,918	868
Cl^-	”	NA	15	24	20	60
$SO_4^=$	”	NA	1,517	251	745	251
TKN	”	NA	1.11	2.77	3.64	0.52
NH_3-N	”	NA	0.26	0.10	0.11	0.33
NO_2-N	”	NA	0.79	0.07	0.16	0.01
NO_3-N	”	NA	16.3	12.8	25.2	0.345
Total P	”	NA	0.09	NA	0.09	0.10
Alkalinity[4]	”	NA	397	604	896	317
Hardness	”	NA	1,776	695	1,715	442
As	”	NA	<0.004	<0.004	<0.004	<0.002
Cd	”	NA	0.0006	<0.0006	<0.0006	<0.0003
Cr	”	NA	0.0056	0.0052	0.0063	0.0017
Cu	”	NA	0.014	0.038	0.030	0.003
Hg	µg/L	NA	0.46	0.12	0.15	0.06
Mn	mg/L	NA	0.358	0.069	0.179	0.365
Ni	”	NA	0.0067	0.0070	0.0077	0.0020
Pb	”	NA	0.0132	0.012	0.0117	0.0046
Sb	”	NA	0.0265	0.0118	0.0200	0.0070
Zn	”	NA	1.253	0.370	0.216	0.111
FC[5]	#/100 mL	NA	<1	<1	<1	<1

TABLE AIV-4 (CONTINUED): MEAN[1] ANNUAL CONCENTRATIONS OF CHEMICAL CONSTITUENTS IN WATER SAMPLES COLLECTED MONTHLY FROM LAKE MICHIGAN AND FROM LYSIMETERS AND WELLS IN THE USX RESEARCH AND DEMONSTRATION PLOTS IN 2003

		Sample Point Identification[2]					
Parameter	Unit	L-3W1 @ 5-ft	L-3W2 @ 10-ft	W-3W3 @20-ft	L-4W1 @ 5-ft	L-4W2 @ 10-ft	W-4W3 @ 20-ft
pH		7.7	7.5	7.4	8.0	7.4	7.4
EC	mS/m	195	237	132	265	221	137
TDS[3]	mg/L	1,816	2,316	1,039	2,848	3,040	1,114
Cl^-	”	44.8	22.5	41.7	27.8	74.8	37.6
$SO_4^=$	”	490	1,052	336	1,213	966	397
TKN	”	2.02	2.78	0.54	7.12	28.93	1.13
NH_3-N	”	0.14	0.37	0.42	0.08	16.19	0.88
NO_2-N	”	0.021	1.661	0.085	NA	40.93	0.045
NO_3-N	”	106	28.61	0.54	14.61	60.37	0.43
Total P	”	0.08	0.09	0.07	0.68	0.24	0.06
Alkalinity[4]	”	461	240	372	570	210	335
Hardness	”	1,259	1,202	595	1,804	1,364	644
As	”	<0.004	<0.004	<0.002	<0.004	<0.004	<0.002
Cd	”	<0.0006	<0.0006	<0.0003	<0.0006	<0.0006	0.0005
Cr	”	0.0056	0.0052	0.0022	0.0080	0.0036	0.0028
Cu	”	0.034	0.139	<0.002	<0.002	0.384	<0.002
Hg	µg/L	0.08	0.10	0.06	0.08	0.31	0.09
Mn	mg/L	0.114	0.490	1.337	2.577	0.294	2.004
Ni	”	0.0060	0.0056	NA	0.0220	0.0332	0.0043
Pb	”	0.0112	0.0380	0.0050	0.0160	0.0340	0.0053
Sb	”	0.0210	0.0195	0.0083	NA	0.0148	0.0091
Zn	”	0.251	0.098	0.098	0.016	0.318	0.152
FC[5]	#/100 mL	<1	<1	<1	<1	<1	1

TABLE AIV-4 (CONTINUED): MEAN[1] ANNUAL CONCENTRATIONS OF CHEMICAL CONSTITUENTS IN WATER SAMPLES COLLECTED MONTHLY FROM LAKE MICHIGAN AND FROM LYSIMETERS AND WELLS IN THE USX RESEARCH AND DEMONSTRATION PLOTS IN 2003

		Sample Point Identification[2]					
Parameter	Unit	L-R1 @ 5-ft	L-R2 @ 10-ft	W-R3 @ 20-ft	LAKE-N	LAKE	LAKE-S
pH		7.6	7.5	7.1	7.7	7.7	7.7
EC	mS/m	76.4	129.7	130.8	27.9	36.1	30.8
TDS[3]	mg/L	NA	1,320	985	203	201	198
Cl^-	”	30.1	22.2	33.1	32.5	12.2	12.8
$SO_4^=$	”	NA	317	396	28	29	28
TKN	”	6.90	0.50	0.40	0.21	0.19	0.21
NH_3-N	”	0.54	0.16	0.29	0.03	0.03	0.03
NO_2-N	”	0.301	0.371	0.019	0.002	0.002	0.003
NO_3-N	”	2.26	3.17	0.27	0.31	0.32	0.57
Total P	”	0.11	0.14	0.14	0.04	0.05	0.03
Alkalinity[4]	”	423	687	374	146	103	103
Hardness	”	515	760	637	135	134	135
As	”	<0.004	<0.004	<0.002	<0.002	<0.002	<0.002
Cd	”	0.0008	<0.0006	0.0004	<0.0006	0.0003	<0.0006
Cr	”	0.0133	0.0035	0.0021	0.0010	0.0010	0.0010
Cu	”	0.028	0.239	<0.002	<0.002	0.002	0.002
Hg	µg/L	0.16	0.18	0.10	0.04	0.05	0.04
Mn	mg/L	0.009	0.156	1.099	0.012	0.014	0.039
Ni	”	0.0230	0.0820	<0.002	0.0035	<0.0020	<0.0020
Pb	”	0.0187	0.0315	0.0056	0.0017	0.0025	0.0017
Sb	”	0.0080	0.0190	0.0097	0.0043	0.0030	0.0043
Zn	”	0.320	0.355	0.184	0.019	0.013	0.012
FC[5]	#/100 mL	<1	<1	<1	5	4	8

[1]MDL was used in calculating the mean. If all values were less than the MDL, the mean is reported as <MDL.

[2]The clay-lined plots are designated E and nonlined plots are designated W. The first number 1, 2, 3, and 4 are amendment designations for 0, 25, 50, and 100 percent biosolids, respectively. The last number 1, 2 and 3 are designations for lysimeters at 5-ft and 10-ft depths and well at 20-ft depth, respectively. Remote lysimeters and well were located 200 ft. south of the plots and are designated LR and WR, respectively. Lake sampling locations are designated Lake-N, Lake, and Lake-S.

[3]Total dissolved solids.

[4]Expressed as $CaCO_3$ equivalent.

[5]Fecal coliform.

NA = No analysis; insufficient sample.

TABLE AIV-5: CONCENTRATIONS OF TKN, AMMONIA-N, NITRITE-N, AND NITRATE-N IN WATER SAMPLES COLLECTED FROM 5-FT DEEP LYSIMETER IN THE 0 PERCENT BIOSOLIDS CLAY-LINED PLOT OF THE USX RESEARCH AND DEMONSTRATION PROJECT DURING 2000 THROUGH 2003

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	mg/L											
2000												
TKN	ND	ND	ND	ND	ND	0.96	1.86	7.87	2.34	1.02	0.58	NA
NH_3-N	ND	ND	ND	ND	ND	0.38	0.36	0.20	0.38	0.22	0.14	NA
NO_2-N	ND	ND	ND	ND	ND	0.09	1.208	1.234	0.740	0.062	<0.003	NA
NO_3-N	ND	ND	ND	ND	ND	3.63	18.03	7.49	4.19	4.72	2.58	NA
2001												
TKN	NA	NA	NA	0.88	0.68	2.14	0.44	1.48	1.72	1	0.46	0.66
NH_3-N	NA	NA	NA	0.16	0.166	0.468	0.088	0.134	0.096	0.104	<0.009	<0.018
NO_2-N	NA	NA	NA	0.016	0.038	0.098	<0.012	0.052	0.018	0.036	0.009	0.014
NO_3-N	NA	NA	NA	3.80	6.54	10.24	1.41	4.18	2.02	3.87	0.86	1.66
2002												
TKN	1.2	0.8	0.36	0.78	0.72	1.5	1.2	1.68	1.06	1.22	1.30	NA
NH_3-N	<0.04	<0.04	<0.04	0.08	<0.04	0.24	0.08	0.06	0.16	<0.04	0.06592	0.06
NO_2-N	0.014	0.036	<0.010	0.018	<0.010	0.2	0.136	0.384	<0.010	<0.010	<0.010	<0.010
NO_3-N	1.47	2.24	1.03	1.20	0.02	1.73	1.52	3.81	4.86	6.13	6.91	7.23
2003												
TKN	NA	NA	1.48	0.8	0.66	1.12	ND	1.86	ND	1.28	ND	NA
NH_3-N	NA	NA	0.14	0.14	0.04	0.04	ND	0.58	ND	0.04	ND	NA
NO_2-N	NA	NA	<0.01	0.01	<0.010	<0.010	ND	0.324	ND	0.018	ND	NA
NO_3-N	NA	NA	8.10	8.52	2.45	1.52	ND	3.86	ND	1.13	ND	NA

ND = Not determined.
NA = No analysis, insufficient sample.

TABLE AIV-6: CONCENTRATIONS OF TKN, AMMONIA-N, NITRITE-N, AND NITRATE-N IN WATER SAMPLES COLLECTED FROM 10-FT DEEP LYSIMETER IN THE 0 PERCENT BIOSOLIDS CLAY-LINED PLOT OF THE USX RESEARCH AND DEMONSTRATION PROJECT DURING 2000 THROUGH 2003

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	mg/L											
2000												
TKN	ND	ND	ND	ND	ND	0.3	1.8	NA	2.14	NA	1.14	NA
NH_3-N	ND	ND	ND	ND	ND	0.12	0.32	NA	0.48	NA	0.24	NA
NO_2-N	ND	ND	ND	ND	ND	0.366	2.964	NA	0.874	NA	0.244	NA
NO_3-N	ND	ND	ND	ND	ND	1.81	3.89	NA	10.17	NA	10.82	NA
2001												
TKN	NA	NA	NA	NA	0.66	NA	NA	NA	2.24	NA	1.46	NA
NH_3-N	NA	NA	NA	NA	0.24	NA	NA	NA	0.082	NA	0.03	NA
NO_2-N	NA	NA	NA	NA	0.056	NA	NA	NA	0.048	NA	0.016	NA
NO_3-N	NA	NA	NA	NA	16.7	NA	NA	NA	10.64	NA	2.88	NA
2002												
TKN	0.74	NA	NA	NA	NA	1.9	1.1	1.06	0.76	1.01	NA	NA
NH_3-N	0.06	NA	NA	NA	NA	0.26	0.14	0.04	0.06	<0.04	NA	NA
NO_2-N	0.024	NA	NA	NA	NA	0.146	<0.010	<0.010	<0.010	<0.010	NA	NA
NO_3-N	2.87	NA	NA	NA	NA	1.18	0.79	1.71	3.61	5.41	NA	NA
2003												
TKN	NA	NA	NA	NA	NA	NA	ND	1.08	ND	0.98	ND	NA
NH_3-N	NA	NA	NA	NA	NA	0.14	ND	2.56	ND	0.12	ND	NA
NO_2-N	NA	NA	NA	NA	NA	<0.010	ND	2.64	ND	<0.01	ND	NA
NO_3-N	NA	NA	NA	NA	NA	1.24	ND	2.594	ND	1.17	ND	NA

ND = Not determined.
NA = No analysis, insufficient sample.

TABLE AIV-7: CONCENTRATIONS OF TKN, AMMONIA-N, NITRITE-N, AND NITRATE-N IN WATER SAMPLES COLLECTED FROM 20-FT DEEP WELL IN THE 0 PERCENT BIOSOLIDS CLAY-LINED PLOT OF THE USX RESEARCH AND DEMONSTRATION PROJECT DURING 2000 THROUGH 2003

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	mg/L											
2000												
TKN	ND	ND	ND	ND	ND	1.14	0.15	2.21	0.31	0.31	0.68	1.04
NH_3-N	ND	ND	ND	ND	ND	0.14	0.05	0.14	0.15	0.18	0.31	0.36
NO_2-N	ND	ND	ND	ND	ND	0.018	0.017	<0.003	<0.003	0.077	0.005	0.012
NO_3-N	ND	ND	ND	ND	ND	0.068	0.682	<0.007	0.036	4.604	0.115	0.262
2001												
TKN	0.75	0.46	0.74	0.38	0.32	0.39	0.27	0.48	0.27	0.61	0.82	0.64
NH_3-N	0.48	0.26	0.41	0.12	0.161	0.228	0.085	0.226	0.055	0.252	0.102	0.346
NO_2-N	0.015	<0.006	0.122	0.016	0.017	<0.006	<0.006	<0.006	0.007	0.007	0.009	<0.012
NO_3-N	0.149	1.213	2.575	0.528	<0.009	0.294	0.697	0.239	0.312	0.316	0.488	0.246
2002												
TKN	0.59	0.3	0.13	0.28	0.69	0.47	0.55	0.84	0.31	0.330	0.544	0.26
NH_3-N	0.37	0.3	0.04	0.04	0.16	0.19	0.21	0.28	0.17	0.165	0.222	0.28
NO_2-N	0.009	0.013	0.005	0.016	0.01	0.008	<0.005	<0.005	0.033	<0.005	<0.005	<0.005
NO_3-N	0.094	0.119	0.282	0.192	0.539	0.107	0.296	0.129	0.041	0.103	0.052	0.033
2003												
TKN	0.54	0.26	0.3	0.16	0.21	<0.08	ND	0.23	ND	0.14	ND	0.5
NH_3-N	0.21	0.24	0.13	<0.02	0.03	0.02	ND	<0.02	ND	0.02	ND	0.05
NO_2-N	<0.005	0.006	<0.005	<0.005	<0.005	<0.005	ND	0.02	ND	0.006	ND	0.073
NO_3-N	0.022	0.051	0.286	0.364	0.173	0.191	ND	0.933	ND	0.146	ND	0.313

ND = Not determined.
NA = No analysis, insufficient sample.

TABLE AIV-8: CONCENTRATIONS OF TKN, AMMONIA-N, NITRITE-N, AND NITRATE-N IN WATER SAMPLES COLLECTED FROM 5-FT DEEP LYSIMETER IN THE 25 PERCENT BIOSOLIDS CLAY-LINED PLOT OF THE USX RESEARCH AND DEMONSTRATION PROJECT DURING 2000 THROUGH 2003

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	mg/L											
2000												
TKN	ND	ND	ND	ND	ND	1.08	1.18	4.33	5.44	4.88	4.2	NA
NH_3-N	ND	ND	ND	ND	ND	0.24	0.4	0.51	0.76	0.44	0.2	NA
NO_2-N	ND	ND	ND	ND	ND	0.078	2.254	3.046	0.804	0.084	0.018	NA
NO_3-N	ND	ND	ND	ND	ND	1.282	5.278	8.876	93.52	99.71	87.88	NA
2001												
TKN	NA	NA	4.18	NA	2.14	NA	2.84	3.08	4.76	4.84	4.5	4.4
NH_3-N	NA	NA	0.52	0.08	0.146	NA	0.088	0.124	0.152	<0.018	0.034	0.066
NO_2-N	NA	NA	2.98	0.43	0.43	NA	0.468	0.074	0.398	<0.012	0.05	0.044
NO_3-N	NA	NA	65.79	23.69	32.19	NA	16.71	2.93	10.57	26.01	11.14	13.36
2002												
TKN	4.26	NA	2.76	6.28	3.82	2.94	3.32	3.88	2.46	3.527	3.659	NA
NH_3-N	<0.04	NA	<0.04	2.82	0.46	0.1	0.08	0.14	0.08	0.066	<0.04	0.08
NO_2-N	0.014	NA	0.018	0.036	0.018	0.024	0.33	<0.010	0.034	<0.010	<0.010	<0.010
NO_3-N	18.47	NA	12.65	8.04	7.80	2.98	3.75	9.69	18.28	21.91	30.93	34.36
2003												
TKN	NA	NA	3.1	2.56	3.28	3.42	ND	3.46	ND	2.22	ND	NA
NH_3-N	NA	NA	0.16	<0.04	0.1	0.1	ND	0.06	ND	0.1	ND	NA
NO_2-N	NA	NA	0.058	<0.010	<0.010	<0.010	ND	0.05	ND	0.012	ND	NA
NO_3-N	NA	NA	43.50	31.54	34.33	9.96	ND	11.06	ND	7.64	ND	NA

ND = Not determined.
NA = No analysis, insufficient sample.

TABLE AIV-9: CONCENTRATIONS OF TKN, AMMONIA-N, NITRITE-N, AND NITRATE-N IN WATER SAMPLES COLLECTED FROM 10-FT DEEP LYSIMETER IN THE 25 PERCENT BIOSOLIDS CLAY-LINED PLOT OF THE USX RESEARCH AND DEMONSTRATION PROJECT DURING 2000 THROUGH 2003

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	mg/L											
2000												
TKN	ND	ND	ND	ND	ND	1.14	1.74	3.95	1.68	1.68	1.58	NA
NH_3-N	ND	ND	ND	ND	ND	0.24	0.22	0.3	0.36	0.48	0.36	NA
NO_2-N	ND	ND	ND	ND	ND	0.662	1.598	0.088	0.578	1.34	1.846	NA
NO_3-N	ND	ND	ND	ND	ND	3.938	1.738	0.068	0.768	7.088	10.916	NA
2001												
TKN	1.34	2.82	3.26	2.92	2.92	2.96	2.88	1.8	2.14	2.18	1.23	1.62
NH_3-N	0.56	0.4	0.5	0.2	0.314	0.274	0.104	0.086	0.14	0.054	0.043	0.038
NO_2-N	0.964	0.238	0.202	0.266	0.148	0.4	0.472	0.407	0.448	0.126	0.117	0.012
NO_3-N	20.378	67.948	42.112	47.952	40.156	47.632	46.208	14.283	14.236	8.11	1.828	0.592
2002												
TKN	NA	NA	1.42	1.92	2.06	1.68	1.96	1.58	1.96	1.895	1.582	NA
NH_3-N	NA	NA	<0.04	0.06	0.04	0.08	0.06	0.06	0.24	0.082	0.049	0.04
NO_2-N	NA	NA	0.02	0.018	<0.010	0.01	<0.010	0.068	0.198	<0.010	<0.010	<0.010
NO_3-N	NA	NA	4.356	7.608	7.43	5.572	4.208	3.658	5.068	4.656	7.382	6.194
2003												
TKN	NA	NA	1.64	1.14	1.48	3.1	ND	2.76	ND	2.96	ND	NA
NH_3-N	NA	NA	0.22	<0.04	0.04	0.1	ND	0.04	ND	0.08	ND	NA
NO_2-N	NA	NA	<0.01	0.01	<0.010	<0.010	ND	0.036	ND	0.058	ND	NA
NO_3-N	NA	NA	9.31	9.20	13.47	34.72	ND	29.32	ND	18.16	ND	NA

ND = Not determined.
NA = No analysis, insufficient sample.

TABLE AIV-10: CONCENTRATIONS OF TKN, AMMONIA-N, NITRITE-N, AND NITRATE-N IN WATER SAMPLES COLLECTED FROM 20-FT DEEP WELLS IN THE 25 PERCENT BIOSOLIDS CLAY-LINED PLOT OF THE USX RESEARCH AND DEMONSTRATION PROJECT DURING 2000 THROUGH 2003

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	mg/L											
2000												
TKN	ND	ND	ND	ND	ND	0.28	0.42	2.47	0.33	0.29	0.22	1.09
NH_3-N	ND	ND	ND	ND	ND	0.22	0.15	0.19	0.18	0.19	0.21	0.25
NO_2-N	ND	ND	ND	ND	ND	<0.003	<0.003	<0.003	<0.003	0.017	0.008	0.031
NO_3-N	ND	ND	ND	ND	ND	<0.007	<0.007	0.017	0.073	0.146	0.181	0.421
2001												
TKN	0.78	0.28	4.43	0.4	0.73	0.41	0.51	0.4	0.51	0.26	0.25	0.25
NH_3-N	0.58	0.19	3.35	0.21	0.433	0.265	0.239	0.202	0.089	0.028	0.017	0.091
NO_2-N	0.072	<0.006	0.019	0.022	0.016	0.041	0.01	0.077	0.007	0.047	0.041	0.019
NO_3-N	1.539	0.116	0.113	2.18	0.236	0.185	0.17	1.309	0.026	1.22	0.834	0.488
2002												
TKN	0.24	0.24	0.15	0.17	0.19	0.69	0.35	0.42	0.33	0.544	1.632	NA
NH_3-N	0.12	0.18	0.04	0.04	<0.02	0.1	0.07	0.09	0.18	0.206	0.997	0.18
NO_2-N	0.006	0.014	0.01	0.012	0.008	0.013	0.016	<0.005	0.068	<0.005	<0.005	<0.005
NO_3-N	0.044	0.268	0.236	0.223	1.893	0.183	0.209	0.11	0.134	0.738	0.15	0.348
2003												
TKN	0.54	0.25	0.31	0.19	0.25	0.31	ND	0.23	ND	0.38	ND	0.67
NH_3-N	0.21	0.21	0.18	0.15	0.11	0.14	ND	0.09	ND	0.28	ND	0.07
NO_2-N	<0.005	0.005	<0.005	<0.005	<0.005	<0.005	ND	0.012	ND	0.007	ND	0.024
NO_3-N	0.355	0.046	0.227	0.218	0.184	0.306	ND	1.587	ND	0.254	ND	0.134

ND = Not determined.
NA = No analysis, insufficient sample.

TABLE AIV-11: CONCENTRATIONS OF TKN, AMMONIA-N, NITRITE-N, AND NITRATE-N IN WATER SAMPLES COLLECTED FROM 5-FT DEEP LYSIMETER IN THE 50 PERCENT BIOSOLIDS CLAY-LINED PLOT OF THE USX RESEARCH AND DEMONSTRATION PROJECT DURING 2000 THROUGH 2003

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	mg/L											
2000												
TKN	ND	ND	ND	ND	ND	2.06	2.36	11.82	10.74	9.74	5.9	NA
NH_3-N	ND	ND	ND	ND	ND	0.52	0.26	0.69	1.22	1.66	1.04	NA
NO_2-N	ND	ND	ND	ND	ND	0.16	1.41	NA	18.16	24.60	7.07	NA
NO_3-N	ND	ND	ND	ND	ND	7.75	19.95	NA	276.10	264.86	147.85	NA
2001												
TKN	5.18	NA	9.74	NA	5.08	4.26	2.28	4.78	4.76	7.48	4.2	2.74
NH_3-N	1.46	NA	1.64	NA	0.458	0.306	0.292	0.448	0.51	0.284	0.044	<0.018
NO_2-N	2.882	NA	2.046	NA	0.596	0.736	0.064	0.138	0.066	0.364	0.496	0.114
NO_3-N	81.298	NA	72.404	NA	19.572	15.61	0.556	0.954	4.382	26.348	7.156	1.174
2002												
TKN	2.82	2.92	6.98	3.9	2.26	2.04	3.32	3.52	2.7	3.543	3.115	NA
NH_3-N	0.06	<0.04	0.18	0.24	0.08	0.22	0.38	0.12	0.08	0.330	0.049	<0.04
NO_2-N	0.02	0.038	2.546	0.302	0.166	0.062	0.21	0.216	0.026	0.024	<0.010	<0.010
NO_3-N	2.516	8.476	18.172	9.856	3.296	0.338	0.296	3.508	5	5.746	6.248	5.84
2003												
TKN	NA	NA	3.5	2.62	3.94	4.2	ND	5.1	ND	3.54	ND	NA
NH_3-N	NA	NA	0.12	<0.04	0.04	0.04	ND	0.08	ND	0.12	ND	NA
NO_2-N	NA	NA	0.044	0.026	<0.010	<0.010	ND	0.052	ND	0.02	ND	NA
NO_3-N	NA	NA	24.178	36.64	51.678	6.23	ND	13.178	ND	8.204	ND	NA

ND = Not determined.
NA = No analysis, insufficient sample.

TABLE AIV-12: CONCENTRATIONS OF TKN, AMMONIA-N, NITRITE-N, AND NITRATE-N IN WATER SAMPLES COLLECTED FROM 10-FT DEEP LYSIMETER IN THE 50 PERCENT BIOSOLIDS CLAY-LINED PLOT OF THE USX RESEARCH AND DEMONSTRATION PROJECT DURING 2000 THROUGH 2003

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	mg/L											
2000												
TKN	ND	ND	ND	ND	ND	1.7	1.26	NA	10.5	8.5	6.58	NA
NH_3-N	ND	ND	ND	ND	ND	0.18	0.18	2.26	3.02	2.8	2.94	NA
NO_2-N	ND	ND	ND	ND	ND	0.87	2.32	37.12	42.05	51.71	17.1	NA
NO_3-N	ND	ND	ND	ND	ND	11.42	3.45	158.89	131.42	39.22	32.27	NA
2001												
TKN	NA	5.38	6.46	1.16	2.94	4.2	4.16	4.72	5.66	6.3	4.58	3.02
NH_3-N	NA	1.5	1.74	0.26	0.676	0.99	1.338	1.294	1.198	1.948	1.182	0.474
NO_2-N	NA	<0.012	0.106	0.018	0.028	0.22	0.19	0.074	0.014	0.016	0.036	0.044
NO_3-N	NA	1.548	3.15	0.193	0.158	4.554	2.292	0.664	0.502	1.38	1.76	2.336
2002												
TKN	1.88	NA	3.34	2.46	2.76	1.82	2.12	NA	2.42	NA	1.912	NA
NH_3-N	0.1	NA	0.18	0.76	0.64	0.24	0.12	0.06	0.22	5.817	0.247	<0.04
NO_2-N	0.022	NA	0.062	0.026	<0.010	0.336	0.056	0.182	0.152	0.082	<0.010	<0.010
NO_3-N	1.382	NA	1.64	0.54	0.536	2.166	2.73	5.082	8.568	4.416	4.648	4.156
2003												
TKN	NA	NA	1.14	NA	3.52	4.96	ND	9.22	ND	1.18	ND	3.36
NH_3-N	NA	NA	<0.04	NA	0.04	0.34	ND	3.38	ND	0.12	ND	<0.04
NO_2-N	NA	NA	<0.01	NA	<0.010	0.35	ND	3.60	ND	0.01	ND	0.03
NO_3-N	NA	NA	7.76	NA	13.22	33.49	ND	25.57	ND	4.1	ND	17.61

ND = Not determined.
NA = No analysis, insufficient sample.

TABLE AIV-13: CONCENTRATIONS OF TKN, AMMONIA-N, NITRITE-N, AND NITRATE-N IN WATER SAMPLES COLLECTED FROM 5-FT DEEP LYSIMETER IN THE 100 PERCENT BIOSOLIDS CLAY-LINED PLOT OF THE USX RESEARCH AND DEMONSTRATION PROJECT DURING 2000 THROUGH 2003

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	mg/L											
2000												
TKN	ND	ND	ND	ND	ND	2.28	2.72	8.12	16.16	16.92	28.64	28.8
NH_3-N	ND	ND	ND	ND	ND	0.18	0.32	6.13	8.7	13.74	18.7	21.02
NO_2-N	ND	ND	ND	ND	ND	0.50	5.31	5.50	2.09	0.19	0.05	0.07
NO_3-N	ND	ND	ND	ND	ND	11.63	5.52	0.18	0.59	0.88	0.07	2.64
2001												
TKN	31.58	NA	41.82	39.76	NA	21.92	59.94	57.70	29.06	58.50	30.54	51.10
NH_3-N	20.02	NA	28.32	31.46	17.41	15.78	39.03	37.76	16.80	36.81	18.42	38.19
NO_2-N	0.194	NA	0.084	0.082	0.056	0.194	0.06	0.174	0.011	0.03	0.029	0.092
NO_3-N	1.042	NA	1.092	0.606	0.176	20.134	0.726	0.67	0.039	1.36	0.55	1.358
2002												
TKN	61.1	NA	61.96	48.24	50.4	49.8	57.62	58.88	NA	55.257	52.406	NA
NH_3-N	34.54	NA	38.42	30.34	25.68	26.64	32.04	38.22	31.56	35.036	32.268	34.34
NO_2-N	0.09	NA	0.04	0.038	0.024	0.116	0.016	0.268	<0.010	<0.010	0.024	<0.010
NO_3-N	0.112	NA	0.22	0.248	0.26	0.268	0.19	0.102	0.656	0.31	0.882	0.822
2003												
TKN	NA	NA	53.44	53.44	54.36	66.52	ND	66.4	ND	67.54	ND	NA
NH_3-N	NA	NA	35.06	NA	26.54	39.26	ND	39.92	ND	44.58	ND	NA
NO_2-N	NA	NA	0.364	NA	17.841	48.327	ND	50.08	ND	41.092	ND	NA
NO_3-N	NA	NA	0.902	NA	12.063	2.714	ND	7.004	ND	21.694	ND	NA

ND = Not determined.
NA = No analysis, insufficient sample.

TABLE AIV-14: CONCENTRATIONS OF TKN, AMMONIA-N, NITRITE-N, AND NITRATE-N IN WATER SAMPLES COLLECTED FROM 10-FT DEEP LYSIMETER IN THE 100 PERCENT BIOSOLIDS CLAY-LINED PLOT OF THE USX RESEARCH AND DEMONSTRATION PROJECT DURING 2000 THROUGH 2003

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	mg/L											
2000												
TKN	ND	ND	ND	ND	ND	2.36	1.22	6.51	2.28	1.32	NA	NA
NH_3-N	ND	ND	ND	ND	ND	0.22	0.2	0.38	0.52	0.34	NA	NA
NO_2-N	ND	ND	ND	ND	ND	1.13	3.61	1.37	1.50	0.64	NA	NA
NO_3-N	ND	ND	ND	ND	ND	35.72	21.80	16.20	12.58	14.25	NA	NA
2001												
TKN	1.4	NA	1.4	NA	NA	1	1.54	7.86	3.18	3.58	NA	2.9
NH_3-N	0.58	NA	0.46	NA	NA	0.26	0.968	4.896	0.43	1.804	NA	1.548
NO_2-N	0.108	NA	<0.012	NA	NA	0.08	0.464	0.262	0.272	0.044	NA	0.054
NO_3-N	32.75	NA	5.30	NA	NA	5.59	5.77	5.79	5.63	4.02	NA	2.622
2002												
TKN	2.14	NA	NA	NA	NA	6.12	1.8	1.6	1.22	1.022	NA	NA
NH_3-N	0.56	NA	NA	NA	NA	1.18	0.26	0.12	0.12	0.115	NA	NA
NO_2-N	<0.010	NA	NA	NA	NA	0.388	0.038	<0.010	<0.010	0.016	NA	NA
NO_3-N	1.22	NA	NA	NA	NA	5.77	4.84	5.41	3.95	5.96	NA	NA
2003												
TKN	NA	NA	NA	NA	0.72	2.94	ND	3.64	ND	1.5	ND	NA
NH_3-N	NA	NA	NA	NA	0.14	0.48	ND	0.56	ND	0.2	ND	NA
NO_2-N	NA	NA	NA	NA	<0.010	0.288	ND	0.062	ND	0.068	ND	NA
NO_3-N	NA	NA	NA	NA	7.26	30.24	ND	52.79	ND	21.81	ND	NA

ND = Not determined.
NA = No analysis, insufficient sample.

TABLE AIV-15: CONCENTRATIONS OF TKN, AMMONIA-N, NITRITE-N, AND NITRATE-N IN WATER SAMPLES COLLECTED FROM 20-FT DEEP WELL IN THE 100 PERCENT BIOSOLIDS CLAY-LINED PLOT OF THE USX RESEARCH AND DEMONSTRATION PROJECT DURING 2000 THROUGH 2003

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	mg/L											
2000												
TKN	ND	ND	ND	ND	ND	2.36	1.22	6.51	2.28	1.32	NA	NA
NH_3-N	ND	ND	ND	ND	ND	0.22	0.2	0.38	0.52	0.34	NA	NA
NO_2-N	ND	ND	ND	ND	ND	1.132	3.61	1.37	1.50	0.64	NA	NA
NO_3-N	ND	ND	ND	ND	ND	35.724	21.80	16.20	12.58	14.25	NA	NA
2001												
TKN	1.13	0.86	1.02	2.59	1.13	1.74	2.42	1.22	1.62	1.08	1.13	0.8
NH_3-N	0.55	0.72	0.72	2.43	0.993	1.298	1.693	0.944	1.07	1	1.081	0.718
NO_2-N	0.028	<0.006	<0.006	0.017	0.017	0.057	0.108	0.063	0.04	0.025	0.043	0.01
NO_3-N	0.598	0.154	0.488	0.391	0.131	0.246	7.015	0.206	0.012	0.117	0.239	0.389
2002												
TKN	1.14	0.88	1.35	1.24	1.26	1.21	1.37	1.46	1.31	1.121	0.931	0.87
NH_3-N	0.71	0.7	0.9	1.14	0.58	0.71	0.72	0.85	0.99	0.775	0.923	0.82
NO_2-N	<0.005	0.025	0.017	0.01	0.015	0.014	0.006	<0.005	0.008	<0.005	<0.005	<0.005
NO_3-N	0.017	0.311	0.142	0.053	0.179	0.099	0.107	0.056	0.028	0.256	0.116	0.273
2003												
TKN	1.27	0.87	1.94	1	0.98	1.3	ND	0.9	ND	0.8	ND	1.31
NH_3-N	0.86	0.85	1.75	0.8	0.74	0.74	ND	0.73	ND	0.83	ND	0.8
NO_2-N	<0.005	0.005	<0.005	<0.005	<0.005	<0.005	ND	0.02	ND	<0.005	ND	0.022
NO_3-N	0.027	0.007	0.049	0.096	0.132	0.122	ND	0.339	ND	0.011	ND	0.106

ND = Not determined.
NA = No analysis, insufficient sample.

TABLE AIV-16: CONCENTRATIONS OF TKN, AMMONIA-N, NITRITE-N, AND NITRATE-N IN WATER SAMPLES COLLECTED FROM 5-FT DEEP LYSIMETER IN THE 0 PERCENT BIOSOLIDS NONLINED PLOT OF THE USX RESEARCH AND DEMONSTRATION PROJECT DURING 2000 THROUGH 2003

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	mg/L											
2000												
TKN	ND	ND	ND	ND	ND	NA	NA	NA	NA	NA	NA	NA
NH_3-N	ND	ND	ND	ND	ND	NA	NA	NA	NA	NA	NA	NA
NO_2-N	ND	ND	ND	ND	ND	NA	NA	NA	NA	NA	NA	NA
NO_3-N	ND	ND	ND	ND	ND	NA	NA	NA	NA	NA	NA	NA
2001												
TKN	NA	NA	NA	NA	NA	NA	NA	NA	1.64	NA	NA	NA
NH_3-N	NA	NA	NA	NA	NA	NA	NA	NA	0.12	NA	NA	NA
NO_2-N	NA	NA	NA	NA	NA	NA	NA	NA	<0.012	NA	NA	NA
NO_3-N	NA	NA	NA	NA	NA	NA	NA	NA	20.41	NA	NA	NA
2002												
TKN	NA	NA	NA	NA	NA	NA	NA	4.64	NA	NA	NA	NA
NH_3-N	NA	NA	NA	NA	NA	NA	NA	0.14	NA	NA	NA	NA
NO_2-N	NA	NA	NA	NA	NA	NA	NA	<0.010	NA	NA	NA	NA
NO_3-N	NA	NA	NA	NA	NA	NA	NA	3.54	NA	NA	NA	NA
2003												
TKN	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
NH_3-N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
NO_2-N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
NO_3-N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

ND = Not determined.
NA = No analysis, insufficient sample.

TABLE AIV-17: CONCENTRATIONS OF TKN, AMMONIA-N, NITRITE-N, AND NITRATE-N IN WATER SAMPLES COLLECTED FROM 10-FT DEEP LYSIMETER IN THE 0 PERCENT BIOSOLIDS NONLINED PLOT OF THE USX RESEARCH AND DEMONSTRATION PROJECT DURING 2000 THROUGH 2003

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	mg/L											
2000												
TKN	ND	ND	ND	ND	ND	0.82	0.9	3.22	1.88	1.08	0.62	NA
NH_3-N	ND	ND	ND	ND	ND	0.16	0.26	0.25	0.3	0.22	0.22	NA
NO_2-N	ND	ND	ND	ND	ND	0.056	0.788	2.119	2.434	1.406	1.146	NA
NO_3-N	ND	ND	ND	ND	ND	0.436	3.384	7.649	7.724	10.926	11.91	NA
2001												
TKN	0.88	NA	1.2	6.7	2.28	3.22	1.44	1.44	NA	1.08	1.34	1.36
NH_3-N	0.24	NA	0.16	0.12	0.22	0.21*	0.22	0.084	NA	<0.018	0.022	0.07
NO_2-N	0.108	NA	<0.012	0.03	0.074	0.186	0.032	0.056	NA	<0.012	0.056	0.024
NO_3-N	18.232	NA	17.856	21.858	39.586	19.946	20.62	18.432	NA	19.418	23.96	26.132
2002												
TKN	0.82	NA	NA	1.14	1.26	1.22	2.06	2.7	10.939	1.104	ND	
NH_3-N	0.06	NA	NA	0.06	<0.04	<0.04	<0.04	0.56	0.2	0.049	0.099	<0.04
NO_2-N	0.022	NA	NA	0.022	<0.010	1.11	<0.010	0.036	<0.010	<0.010	<0.010	<0.010
NO_3-N	24.88	NA	NA	28.99	24.63	30.50	31.15	28.32	7.25	10.19	15.02	16.67
2003												
TKN	NA	NA	0.68	0.6	0.52	1.34	NA	2.82	NA	0.72	NA	NA
NH_3-N	NA	NA	0.04	<0.04	0.04	0.04	NA	1.1	NA	0.08	NA	NA
NO_2-N	NA	NA	<0.010	<0.010	<0.010	<0.010	NA	1.556	NA	0.018	NA	NA
NO_3-N	NA	NA	18.55	18.82	17.35	14.90	NA	19.99	NA	8.06	NA	NA

ND = Not determined.
NA = No analysis, insufficient sample.

TABLE AIV-18: CONCENTRATIONS OF TKN, AMMONIA-N, NITRITE-N, AND NITRATE-N IN WATER SAMPLES COLLECTED FROM 5-FT DEEP LYSIMETER IN THE 25 PERCENT BIOSOLIDS NONLINED PLOT OF THE USX RESEARCH AND DEMONSTRATION PROJECT DURING 2000 THROUGH 2003

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	mg/L											
2000												
TKN	ND	ND	ND	ND	ND	1.36	1.08	10.05	4.28	NA	NA	NA
NH_3-N	ND	ND	ND	ND	ND	0.34	0.3	0.41	1.28	NA	NA	NA
NO_2-N	ND	ND	ND	ND	ND	0.232	0.866	0.263	0.23	NA	NA	NA
NO_3-N	ND	ND	ND	ND	ND	0.454	0.916	0.136	70.616	NA	NA	NA
2001												
TKN	NA	NA	3.62	NA	2.2	5.78	1.98	2.62	NA	2.3	2.96	2.66
NH_3-N	NA	NA	0.36	NA	0.148	0.788	0.2	0.256	NA	0.036	0.028	0.022
NO_2-N	NA	NA	0.294	NA	0.118	0.058	0.04	0.132	NA	<0.012	0.034	0.022
NO_3-N	NA	NA	93.244	NA	26.25	20.88	15.31_	10.42	NA	8.07	14.93	10.66
2002												
TKN	2.4	NA	1.42	2	1.88	0.98	1.54	1.86	1.92	2.044	1.994	NA
NH_3-N	0.08	NA	<0.04	0.08	<0.04	0.2	0.08	0.16	0.08	<0.04	0.264	<0.04
NO_2-N	0.044	NA	<0.010	0.016	0.014	0.022	0.012	<0.010	0.136	<0.010	<0.010	<0.010
NO_3-N	9.71	NA	8.20	9.20	6.92	3.34	2.45	3.00	15.26	18.72	18.88	20
2003												
TKN	NA	NA	NA	NA	1.4	3.38	NA	3.14	NA	NA	NA	3.14
NH_3-N	NA	NA	NA	0.06	0.04	0.04	NA	0.32	NA	0.04	NA	<0.04
NO_2-N	NA	NA	NA	<0.005	<0.010	<0.010	NA	0.166	NA	0.012	NA	0.026
NO_3-N	NA	NA	NA	14.40	27	17.11	NA	11.75	NA	3.19	NA	3.312

ND = Not determined.
NA = No analysis, insufficient sample.

TABLE AIV-19: CONCENTRATIONS OF TKN, AMMONIA-N, NITRITE-N, AND NITRATE-N IN WATER SAMPLES COLLECTED FROM 10-FT DEEP LYSIMETER IN THE 25 PERCENT BIOSOLIDS NONLINED PLOT OF THE USX RESEARCH AND DEMONSTRATION PROJECT DURING 2000 THROUGH 2003

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	mg/L											
2000												
TKN	ND	ND	ND	ND	ND	1.3	1.9	6.47	4.12	2.7	2.44	NA
NH_3-N	ND	ND	ND	ND	ND	0.26	0.26	0.18	0.72	<0.02	0.28	NA
NO_2-N	ND	ND	ND	ND	ND	0.224	<0.003	<0.003	3.206	0.562	2.186	NA
NO_3-N	ND	ND	ND	ND	ND	0.044	<0.007	0.115	11.838	3.964	10.176	NA
2001												
TKN	2.12	2.88	2.14	NA	2.6	7.50	1.94	2.3	3.34	3.1	3.66	3.76
NH_3-N	0.12	0.16	0.12	NA	0.122	2.62	0.162	0.066	0.088	0.118	0.334	0.202
NO_2-N	0.03	<0.012	<0.012	NA	0.026	0.056	0.012	0.098	<0.012	<0.012	0.152	0.046
NO_3-N	10.74	12.854	8.16	NA	9.286	3.28	0.322	1.254	0.074	0.254	2.538	0.904
2002												
TKN	2.54	NA	2.78	NA	NA	1.58	2.72	3.02	1.68	1.912	2.06	NA
NH_3-N	0.08	NA	<0.04	NA	NA	<0.04	0.06	<0.04	0.06	<0.04	0.165	<0.04
NO_2-N	0.014	NA	0.018	NA	NA	0.13	0.054	0.048	<0.010	<0.010	<0.010	<0.010
NO_3-N	0.266	NA	1.864	NA	NA	1.894	1.574	1.434	0.03	0.146	0.356	0.452
2003												
TKN	NA	NA	1.7	2.18	2.92	5.72	ND	6.28	ND	3.06	ND	NA
NH_3-N	NA	NA	0.1	<0.04	0.04	0.04	ND	0.28	ND	0.1	ND	NA
NO_2-N	NA	NA	<0.010	<0.010	<0.010	<0.010	ND	0.234	ND	0.084	ND	NA
NO_3-N	NA	NA	0.618	6.5	20.01	70.268	ND	40.77	ND	12.90	ND	NA

ND = Not determined.
NA = No analysis, insufficient sample.

TABLE AIV-20: CONCENTRATIONS OF TKN, AMMONIA-N, NITRITE-N, AND NITRATE-N IN WATER SAMPLES COLLECTED FROM 20-FT DEEP WELL IN THE 25 PERCENT BIOSOLIDS NONLINED PLOT OF THE USX RESEARCH AND DEMONSTRATION PROJECT DURING 2000 THROUGH 2003

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	mg/L											
2000												
TKN	ND	ND	ND	ND	ND	1.48	0.2	1.72	0.42	0.46	1.46	0.84
NH_3-N	ND	ND	ND	ND	ND	0.8	0.11	0.26	0.19	0.36	0.64	0.35
NO_2-N	ND	ND	ND	ND	ND	0.016	0.006	<0.003	0.078	0.014	0.047	0.01
NO_3-N	ND	ND	ND	ND	ND	<0.007	0.246	0.82	0.629	0.343	0.153	0.269
2001												
TKN	1.65	0.67	0.6	0.48	0.4	0.34	0.6	0.73	0.85	0.25	0.29	0.16
NH_3-N	0.49	0.39	0.32	0.4	0.291	0.27	0.218	0.601	0.43	0.061	0.08	0.104
NO_2-N	0.094	<0.006	<0.006	0.013	0.008	0.026	<0.006	<0.006	<0.006	0.054	0.01	0.011
NO_3-N	3.845	0.176	0.043	0.113	0.107	0.881	0.403	0.092	0.045	0.337	0.904	0.441
2002												
TKN	0.59	0.5	0.26	0.25	0.21	0.25	0.35	0.51	0.14	0.354	0.313	ND
NH_3-N	0.35	0.36	0.13	0.19	<0.02	<0.02	0.03	0.08	0.19	0.214	0.255	0.25
NO_2-N	0.014	0.01	0.005	0.009	0.01	0.017	0.01	<0.005	0.006	<0.005	<0.005	<0.005
NO_3-N	0.311	0.032	0.458	0.517	0.479	0.34	0.246	0.082	0.402	0.121	0.029	0.552
2003												
TKN	0.61	0.35	0.47	0.57	0.33	0.65	ND	0.56	ND	0.45	ND	0.71
NH_3-N	0.32	0.33	0.46	0.39	0.26	0.29	ND	0.21	ND	0.48	ND	0.21
NO_2-N	<0.005	0.006	<0.005	0.006	<0.005	<0.005	ND	0.03	ND	0.012	ND	0.007
NO_3-N	0.275	0.107	<0.005	0.569	0.086	0.096	ND	0.968	ND	0.042	ND	0.62

ND = Not determined.
NA = No analysis, insufficient sample.

TABLE AIV-21: CONCENTRATIONS OF TKN, AMMONIA-N, NITRITE-N, AND NITRATE-N IN WATER SAMPLES COLLECTED FROM 5-FT DEEP LYSIMETER IN THE 50 PERCENT BIOSOLIDS NONLINED PLOT OF THE USX RESEARCH AND DEMONSTRATION PROJECT DURING 2000 THROUGH 2003

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	mg/L											
TKN	ND	ND	ND	ND	ND	1.12	2.86	7.24	12.76	10.26	3.7	NA
NH_3-N	ND	ND	ND	ND	ND	0.32	0.58	0.55	2.02	1.1	0.62	NA
NO_2-N	ND	ND	ND	ND	ND	0.262	0.09	2.103	2.486	1.994	0.262	NA
NO_3-N	ND	ND	ND	ND	ND	0.082	0.03	171.785	92.062	45.994	5.076	NA
2001												
TKN	2.64	NA	4.14	NA	2.58	17.28	2.74	3.3	4.1	5.2	5.16	2.64
NH_3-N	1.1	NA	1.26	NA	0.596	12.758	0.422	0.44	0.414	0.286	0.032	0.05
NO_2-N	0.064	NA	<0.012	NA	0.016	0.094	0.026	0.13	0.412	0.356	0.026	0.018
NO_3-N	5.108	NA	0.332	NA	0.226	2.252	0.868	1.738	4.614	36.324	23.196	11.276
2002												
TKN	NA	NA	1.98	NA	2.34	1.92	2.82	2.92	2	2.1094	1.9446	NA
NH_3-N	NA	NA	<0.04	NA	0.12	<0.04	0.06	0.06	0.08	0.082	<0.04	0.26
NO_2-N	NA	NA	0.018	NA	0.012	0.026	0.104	0.116	0.12	0.194	<0.010	<0.010
NO_3-N	NA	NA	11.238	NA	19.104	11.764	8.254	7.43	31.904	36.70	47.10	47.27
2003												
TKN	NA	NA	1.66	1.88	1.48	3.54	ND	2.28	ND	1.28	ND	NA
NH_3-N	NA	NA	0.22	<0.04	0.2	0.12	ND	0.14	ND	0.04	ND	NA
NO_2-N	NA	NA	<0.01	0.014	<0.010	<0.010	ND	0.03	ND	0.018	ND	NA
NO_3-N	NA	NA	77.99	156.20	170.17	159.31	ND	52.91	ND	19.39	ND	NA

ND = Not determined.
NA = No analysis, insufficient sample.

TABLE AIV-22: CONCENTRATIONS OF TKN, AMMONIA-N, NITRITE-N, AND NITRATE-N IN WATER SAMPLES COLLECTED FROM 10-FT DEEP LYSIMETER IN THE 50 PERCENT BIOSOLIDS NONLINED PLOT OF THE USX RESEARCH AND DEMONSTRATION PROJECT DURING 2000 THROUGH 2003

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	mg/L											
2000												
TKN	ND	ND	ND	ND	ND	1.2	1.3	4.04	4.4	1.1	0.96	NA
NH_3-N	ND	ND	ND	ND	ND	0.2	0.16	0.17	0.74	0.2	0.2	NA
NO_2-N	ND	ND	ND	ND	ND	0.006	<0.003	<0.003	0.382	0.016	<0.003	NA
NO_3-N	ND	ND	ND	ND	ND	0.506	<0.007	0.324	14.462	0.348	<0.007	NA
2001												
TKN	NA	NA	NA	NA	NA	1.06	1.16	NA	2.38	2.62	3.02	1.52
NH_3-N	NA	NA	NA	NA	NA	0.306	0.37	NA	0.306	0.828	0.096	0.056
NO_2-N	NA	NA	NA	NA	NA	0.026	<0.012	NA	0.188	0.304	2.928	0.266
NO_3-N	NA	NA	NA	NA	NA	0.946	<0.018	NA	1.842	0.286	5.254	2.412
2002												
TKN	1.44	NA	NA	NA	NA	0.62	NA	2.28	1.64	1.269	1.088	NA
NH_3-N	0.1	NA	NA	NA	NA	0.04	NA	0.08	0.06	0.049	0.082	0.08
NO_2-N	0.014	NA	NA	NA	NA	<0.010	NA	<0.010	<0.010	<0.010	<0.010	<0.010
NO_3-N	0.912	NA	NA	NA	NA	1.644	NA	2.24	1.402	1.07	0.44	1.142
2003												
TKN	1.32	NA	NA	NA	0.84	4.98	ND	5.82	ND	1.88	ND	1.86
NH_3-N	0.14	NA	NA	NA	0.06	0.06	ND	1.38	ND	0.2	ND	<0.04
NO_2-N	<0.010	NA	NA	NA	<0.010	<0.010	ND	4.888	ND	0.072	ND	0.024
NO_3-N	1.146	NA	NA	NA	13.92	70.822	ND	38.43	ND	25.24	ND	22.124

ND = Not determined.
NA = No analysis, insufficient sample.

TABLE AIV-23: CONCENTRATIONS OF TKN, AMMONIA-N, NITRITE-N, AND NITRATE-N IN WATER SAMPLES COLLECTED FROM 20-FT DEEP WELL IN THE 50 PERCENT BIOSOLIDS NONLINED PLOT OF THE USX RESEARCH AND DEMONSTRATION PROJECT DURING 2000 THROUGH 2003

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	mg/L											
2000												
TKN	ND	ND	ND	ND	ND	0.84	0.27	1.09	0.77	0.42	0.26	0.7
NH_3-N	ND	ND	ND	ND	ND	0.16	0.2	0.23	0.23	0.22	0.23	0.25
NO_2-N	ND	ND	ND	ND	ND	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.029
NO_3-N	ND	ND	ND	ND	ND	0.086	0.011	0.034	0.176	0.101	0.252	0.266
2001												
TKN	0.63	0.32	0.22	0.43	0.47	0.33	0.36	0.44	0.56	0.48	0.55	0.47
NH_3-N	0.27	0.18	0.13	0.22	0.235	0.185	0.327	0.289	0.218	0.286	0.149	0.185
NO_2-N	0.015	0.007	<0.006	0.008	0.008	0.012	0.006	0.007	<0.006	0.009	0.013	0.01
NO_3-N	0.011	0.202	0.104	0.052	0.095	0.492	0.103	0.11	0.009	0.1	0.478	0.338
2002												
TKN	0.76	0.53	0.3	0.21	0.45	0.65	0.91	0.88	0.58	0.6922	0.7498	NA
NH_3-N	0.42	0.47	0.19	0.11	0.25	0.33	0.36	0.44	0.34	0.4779	0.5356	0.47
NO_2-N	0.01	0.01	0.013	0.012	0.007	0.033	0.011	<0.005	<0.005	<0.005	<0.005	<0.005
NO_3-N	0.21	0.01	0.243	0.883	0.107	0.2	0.106	0.041	0.088	<0.005	0.041	0.205
2003												
TKN	0.85	0.56	0.6	0.75	0.37	0.33	ND	0.44	ND	0.41	ND	0.56
NH_3-N	0.53	0.51	0.5	0.44	0.34	0.32	ND	0.23	ND	0.55	ND	0.37
NO_2-N	0.005	0.006	<0.005	<0.005	<0.005	<0.005	ND	0.023	ND	0.374	ND	0.016
NO_3-N	0.056	0.108	0.17	3.126	0.096	0.123	ND	0.67	ND	0.474	ND	0.016

ND = Not determined.
NA = No analysis, insufficient sample.

TABLE AIV-24: CONCENTRATIONS OF TKN, AMMONIA-N, NITRITE-N, AND NITRATE-N IN WATER SAMPLES COLLECTED FROM 5-FT DEEP LYSIMETER IN THE 100 PERCENT BIOSOLIDS NONLINED PLOT OF THE USX RESEARCH AND DEMONSTRATION PROJECT DURING 2000 THROUGH 2003

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	mg/L											
2000												
TKN	ND	ND	ND	ND	ND	NA	NA	7.12	NA	NA	NA	NA
NH_3-N	ND	ND	ND	ND	ND	NA	NA	0.08	NA	NA	NA	NA
NO_2-N	ND	ND	ND	ND	ND	NA	NA	<0.01	NA	NA	NA	NA
NO_3-N	ND	ND	ND	ND	ND	NA	NA	14.614	NA	NA	NA	NA
2001												
TKN	4.14	NA	NA	NA	7.38	NA	NA	NA	10.14	6.82	4.38	NA
NH_3-N	0.6	NA	NA	NA	0.332	NA	NA	NA	0.12	<0.018	1.37	NA
NO_2-N	0.89	NA	NA	NA	0.03	NA	NA	NA	<0.012	0.022	0.21	NA
NO_3-N	0.748	NA	NA	NA	1.496	NA	NA	NA	0.998	1.212	0.928	NA
2002												
TKN	NA	NA	NA	8.14	NA	NA	NA	NA	NA	NA	NA	NA
NH_3-N	NA	NA	NA	0.34	NA	NA	NA	NA	NA	NA	NA	NA
NO_2-N	NA	NA	NA	0.024	NA	NA	NA	NA	NA	NA	NA	NA
NO_3-N	NA	NA	NA	0.66	NA	NA	NA	NA	NA	NA	NA	NA
2003												
TKN	NA	NA	7.12	NA	NA	NA	ND	NA	ND	NA	ND	NA
NH_3-N	NA	NA	0.08	NA	NA	NA	ND	NA	ND	NA	ND	NA
NO_2-N	NA	NA	<0.01	NA	NA	NA	ND	NA	ND	NA	ND	NA
NO_3-N	NA	NA	14.614	NA	NA	NA	ND	NA	ND	NA	ND	NA

ND = Not determined.
NA = No analysis, insufficient sample.

TABLE AIV-25: CONCENTRATIONS OF TKN, AMMONIA-N, NITRITE-N, AND NITRATE-N IN WATER SAMPLES COLLECTED FROM 5-FT DEEP LYSIMETER IN THE 100 PERCENT BIOSOLIDS NONLINED PLOT OF THE USX RESEARCH AND DEMONSTRATION PROJECT DURING 2000 THROUGH 2003

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	mg/L											
2000												
TKN	ND	ND	ND	ND	ND	1.9	1.68	NA	27.98	20.44	3.8	NA
NH_3-N	ND	ND	ND	ND	ND	0.1	0.1	5.78	16.14	17.32	2.98	NA
NO_2-N	ND	ND	ND	ND	ND	0.15	<0.003	22.349	15.138	3.05	0.014	NA
NO_3-N	ND	ND	ND	ND	ND	0.074	<0.007	2.926	33.35	0.152	<0.007	NA
2001												
TKN	6.7	11.94	19.64	15.34	12.98	15.04	16.46	21.32	29.64	34.04	28.8	27.32
NH_3-N	4.08	8.64	15.92	11.94	9.368	11.716	13.536	20.542	20.398	22.716	21.82	20.904
NO_2-N	0.072	<0.012	0.31	0.52	0.03	0.05	0.052	0.156	0.018	3.264	6.654	0.93
NO_3-N	0.688	0.614	0.062	0.138	0.224	0.814	0.102	0.83	0.044	0.492	1.554	0.244
2002												
TKN	30.16	19.4	26.68	26.96	NA	23.36	24.52	22.8	18.84	21.770	17.222	NA
NH_3-N	20.3	17.5	19.84	20.22	NA	13.96	15.16	13.72	14.7	14.338	13.250	14.26
NO_2-N	0.496	0.17	0.836	1.34	NA	0.624	0.18	0.266	0.2	0.146	0.01	<0.010
NO_3-N	0.16	0.204	0.086	0.178	NA	0.124	0.316	0.156	0.114	0.078	0.176	0.716
2003												
TKN	NA	NA	NA	28.1	NA	19.06	ND	32.48	ND	29.76	ND	35.26
NH_3-N	NA	NA	6.27	21.79	NA	13.8	ND	16.64	ND	17.18	ND	21.46
NO_2-N	NA	NA	<0.005	1.85	7.60	69.78	ND	47.14	ND	67.86	ND	51.318
NO_3-N	NA	NA	0.049	3.152	24.42	172.322	ND	44.73	ND	86.61	ND	91.274

ND = Not determined.
NA = No analysis, insufficient sample.

TABLE AIV-26: CONCENTRATIONS OF TKN, AMMONIA-N, NITRITE-N, AND NITRATE-N IN WATER SAMPLES COLLECTED FROM 20-FT DEEP WELL IN THE 100 PERCENT BIOSOLIDS NONLINED PLOT OF THE USX RESEARCH AND DEMONSTRATION PROJECT DURING 2000 THROUGH 2003

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	mg/L											
2000												
TKN	ND	ND	ND	ND	ND	0.34	0.56	1.75	1.66	0.42	0.44	1.09
NH_3-N	ND	ND	ND	ND	ND	0.16	0.36	0.39	0.92	0.41	0.42	0.48
NO_2-N	ND	ND	ND	ND	ND	<0.003	<0.003	0.021	0.38	0.006	<0.003	0.006
NO_3-N	ND	ND	ND	ND	ND	0.016	0.014	0.027	0.241	0.128	1.973	0.088
2001												
TKN	0.45	0.75	1.51	2.21	0.75	0.84	0.76	1	0.98	1.15	10.97	
NH_3-N	0.42	0.39	1.1	1.69	0.497	0.527	0.507	0.681	0.565	0.682	0.87	0.783
NO_2-N	0.015	<0.006	<0.006	0.032	0.008	0.017	0.127	0.065	<0.006	0.015	0.021	0.045
NO_3-N	0.02	0.085	0.04	0.057	0.02	0.647	0.719	0.198	<0.009	0.126	0.561	0.043
2002												
TKN	0.99	0.8	0.76	0.58	1.12	1.07	1.41	1.49	1.22	1.203	1.426	NA
NH_3-N	0.71	0.72	0.6	0.49	0.64	0.64	0.85	0.86	0.82	0.865	0.791	0.82
NO_2-N	0.012	0.028	0.005	0.008	0.006	0.006	0.17	<0.005	<0.005	<0.005	<0.005	<0.005
NO_3-N	0.028	0.4	0.042	0.067	0.005	0.157	0.319	0.008	0.144	<0.005	0.025	0.272
2003												
TKN	1.35	1.02	1.16	1.12	0.8	1.3	ND	1.07	ND	0.76	ND	1.6
NH_3-N	0.93	0.96	1.01	0.96	0.81	0.8	ND	0.73	ND	0.86	ND	0.85
NO_2-N	<0.005	0.006	<0.005	0.007	<0.005	0.095	ND	0.098	ND	0.044	ND	0.019
NO_3-N	0.066	0.051	<0.005	0.033	0.148	0.322	ND	2.385	ND	0.296	ND	0.105

ND = Not determined.
NA = No analysis, insufficient sample.

TABLE AIV-27: CONCENTRATIONS OF TKN, AMMONIA-N, NITRITE-N, AND NITRATE-N IN WATER SAMPLES COLLECTED FROM 5-FT DEEP LYSIMETER AT A REMOTE LOCATION AT THE USX RESEARCH AND DEMONSTRATION PROJECT SITE DURING 2000 THROUGH 2003

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	mg/L											
2000												
TKN	ND	ND	ND	ND	ND	0.4	1.16	2.06	1.4	0.8	2.52	NA
NH_3-N	ND	ND	ND	ND	ND	0.24	0.18	0.23	0.38	0.16	0.64	NA
NO_2-N	ND	ND	ND	ND	ND	2.396	1.304	<0.003	<0.003	0.01	0.028	NA
NO_3-N	ND	ND	ND	ND	ND	0.308	0.016	0.048	<0.007	0.312	0.736	NA
2001												
TKN	3.8	NA	0.52	NA	<0.12	0.5	0.66	0.76	1.16	0.14	0.52	<0.12
NH_3-N	0.24	NA	0.14	NA	0.138	0.238	0.396	0.232	0.144	<0.018	0.03	0.022
NO_2-N	0.03	NA	0.04	NA	0.05	0.038	0.022	<0.012	0.148	<0.012	0.014	0.044
NO_3-N	0.806	NA	0.218	NA	1.224	1.468	0.41	0.884	1.834	1.244	1.138	1.126
2002												
TKN	<0.16	NA	0.46	0.46	NA	<0.16	1.02	1.18	NA	0.478	2.505	NA
NH_3-N	<0.04	NA	<0.04	0.1	NA	0.04	0.1	0.06	NA	0.049	<0.04	<0.04
NO_2-N	<0.010	NA	0.026	0.02	NA	<0.010	<0.010	<0.010	NA	<0.010	<0.010	<0.010
NO_3-N	0.058	NA	0.348	0.47	NA	0.588	0.346	0.068	NA	0.41	5.804	1.246
2003												
TKN	NA	NA	0.8	NA	NA	0.62	ND	0.74	ND	25.42	ND	NA
NH_3-N	NA	NA	0.24	2.22	NA	0.04	ND	0.14	ND	0.08	ND	NA
NO_2-N	NA	NA	0.018	0.634	NA	<0.010	ND	0.25	ND	<0.010	ND	NA
NO_3-N	NA	NA	2.512	<0.010	NA	1.206	ND	4.974	ND	0.35	ND	NA

ND = Not determined.
NA = No analysis, insufficient sample.

TABLE AIV-28: CONCENTRATIONS OF TKN, AMMONIA-N, NITRITE-N, AND NITRATE-N IN WATER SAMPLES COLLECTED FROM 10-FT DEEP LYSIMETER AT A REMOTE LOCATION AT THE USX RESEARCH AND DEMONSTRATION PROJECT SITE DURING 2000 THROUGH 2003

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	mg/L											
2000												
TKN	ND	ND	ND	ND	ND	ND	1.32	2.11	1.48	1.48	0.8	NA
NH_3-N	ND	ND	ND	ND	ND	ND	0.2	0.25	0.48	0.24	0.22	NA
NO_2-N	ND	ND	ND	ND	ND	ND	0.15	<0.003	0.032	1.99	<0.003	NA
NO_3-N	ND	ND	ND	ND	ND	ND	<0.007	0.097	0.024	17.972	<0.007	NA
2001												
TKN	1.2	0.94	0.48	NA	0.14	0.82	0.9	0.66	0.44	0.24	0.54	0.18
NH_3-N	0.44	0.32	0.2	NA	0.16	0.226	0.544	0.172	0.046	<0.018	0.024	0.058
NO_2-N	0.03	0.012	<0.012	NA	0.026	0.024	<0.012	<0.012	<0.012	<0.012	0.022	0.044
NO_3-N	0.03	6.572	0.372	NA	0.028	0.836	0.146	0.228	0.046	0.082	1.264	1.214
2002												
TKN	0.3	NA	1.1	0.52	0.5	<0.16	0.26	0.52	5.34	0.313	0.659	NA
NH_3-N	0.14	NA	0.1	0.06	0.04	<0.04	0.06	0.04	3.94	<0.04	<0.04	0.04
NO_2-N	0.042	NA	0.03	0.03	0.028	0.694	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
NO_3-N	1.056	NA	0.31	0.33	1.722	1.786	0.094	0.08	0.752	0.23	0.646	9.53
2003												
TKN	1.46	NA	<0.16	NA	0.32	0.18	ND	0.32	ND	0.22	ND	NA
NH_3-N	0.38	NA	<0.04	<0.04	0.04	0.08	ND	0.24	ND	0.04	ND	NA
NO_2-N	<0.010	NA	0.022	<0.010	<0.010	<0.010	ND	0.72	ND	<0.010	ND	NA
NO_3-N	0.746	NA	5.078	0.066	0.204	0.518	ND	12.394	ND	0.074	ND	NA

ND = Not determined.
NA = No analysis, insufficient sample.

TABLE AIV-29: CONCENTRATIONS OF TKN, AMMONIA-N, NITRITE-N, AND NITRATE-N IN WATER SAMPLES COLLECTED FROM 20-FT DEEP WELL AT A REMOTE LOCATION AT THE USX RESEARCH AND DEMONSTRATION PROJECT SITE DURING 2000 THROUGH 2003

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	mg/L											
2000												
TKN	ND	ND	ND	ND	ND	0.28	0.44	1.35	0.62	0.27	0.82	1.14
NH_3-N	ND	ND	ND	ND	ND	0.28	0.29	0.31	0.22	0.27	0.61	0.65
NO_2-N	ND	ND	ND	ND	ND	0.026	<0.003	<0.003	<0.003	0.043	<0.003	0.009
NO_3-N	ND	ND	ND	ND	ND	0.16	0.071	0.091	0.115	0.958	0.139	0.177
2001												
TKN	0.49	0.4	0.32	0.37	0.62	0.24	1.47	0.53	0.49	0.49	0.64	0.59
NH_3-N	0.36	0.15	0.23	0.11	0.369	0.214	1.218	0.28	0.157	0.302	0.392	0.467
NO_2-N	0.266	<0.006	<0.006	0.029	0.008	0.016	0.009	0.006	<0.006	0.022	<0.006	<0.006
NO_3-N	0.46	0.83	0.242	0.914	0.198	1.718	0.22	0.382	0.667	0.259	0.349	0.18
2002												
TKN	0.58	0.55	0.33	0.27	0.35	0.45	0.46	0.65	0.51	0.709	0.750	0.77
NH_3-N	0.51	0.58	0.3	0.24	0.15	0.16	0.19	0.22	0.4	0.470	0.453	0.54
NO_2-N	0.007	0.01	<0.005	0.011	0.022	0.215	0.005	<0.005	<0.005	<0.005	<0.005	<0.005
NO_3-N	0.15	0.569	0.137	0.214	0.237	0.604	0.215	0.389	0.046	0.043	0.305	0.046
2003												
TKN	ND	0.56	0.54	0.43	0.11	<0.08	ND	0.23	ND	0.43	ND	0.53
NH_3-N	ND	0.51	0.53	0.34	0.02	0.07	ND	0.17	ND	0.46	ND	0.23
NO_2-N	ND	0.006	<0.005	<0.005	<0.005	<0.005	ND	0.031	ND	<0.005	ND	<0.005
NO_3-N	ND	0.122	0.253	0.523	0.504	0.287	ND	0.315	ND	0.008	ND	0.125

ND = Not determined.
NA = No analysis, insufficient sample.

TABLE AIV-30: CONCENTRATIONS OF TKN, AMMONIA-N, NITRITE-N, AND NITRATE-N IN WATER SAMPLES COLLECTED FROM LAKE MICHIGAN APPROXIMATELY 50-FT OFF SHORE OF THE MIDDLE OF THE PLOTS AT THE USX RESEARCH AND DEMONSTRATION PROJECT SITE DURING 2000 THROUGH 2003

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	mg/L											
2000												
TKN	ND	ND	ND	ND	ND	0.48	0.26	0.17	0.32	<0.03	0.37	NA
NH_3-N	ND	ND	ND	ND	ND	0.04	0.07	0.1	0.09	0.06	0.08	NA
NO_2-N	ND	ND	ND	ND	ND	0.008	<0.003	0.009	0.018	<0.003	0.009	NA
NO_3-N	ND	ND	ND	ND	ND	0.248	0.21	0.629	0.276	0.342	0.3	NA
2001												
TKN	NA	0.23	NA	0.52	0.07	0.26	0.14	0.31	0.43	0.26	0.09	0.27
NH_3-N	NA	0.08	NA	0.07	0.07	0.079	<0.009	0.026	0.047	0.045	0.024	0.015
NO_2-N	NA	0.014	NA	0.017	0.012	<0.006	<0.006	0.006	<0.006	0.01	<0.006	<0.006
NO_3-N	NA	0.391	NA	0.572	0.312	0.251	0.227	1.09	0.332	0.601	0.395	0.481
2002												
TKN	NA	0.12	0.22	0.16	0.22	0.16	0.4	0.28	0.21	0.173	0.206	ND
NH_3-N	NA	0.02	0.02	<0.02	<0.02	<0.02	0.02	<0.02	0.02	0.025	<0.02	0.03
NO_2-N	NA	0.021	0.017	<0.005	0.006	0.006	0.005	<0.005	<0.005	<0.005	<0.005	<0.005
NO_3-N	NA	0.31	0.398	1.235	0.345	0.274	0.259	0.267	0.338	0.407	0.329	0.356
2003												
TKN	NA	NA	0.14	0.09	0.25	0.26	ND	0.22	ND	<0.08	ND	0.51
NH_3-N	NA	NA	0.06	0.02	0.09	<0.02	ND	<0.02	ND	<0.02	ND	0.02
NO_2-N	NA	NA	<0.005	0.005	<0.005	<0.005	ND	<0.005	ND	<0.005	ND	0.008
NO_3-N	NA	NA	0.398	0.398	1.818	0.247	ND	0.224	ND	0.132	ND	0.303

ND = Not determined.
NA = No analysis, lake frozen.

TABLE AIV-31: CONCENTRATIONS OF TKN, AMMONIA-N, NITRITE-N, AND NITRATE-N IN WATER SAMPLES COLLECTED FROM LAKE MICHIGAN APPROXIMATELY AT 50-FT OFF SHORE AT THE NORTH END OF THE PLOTS AT THE USX RESEARCH AND DEMONSTRATION PROJECT SITE DURING 2000 THROUGH 2003

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	mg/L											
2000												
TKN	ND	ND	ND	ND	ND	ND	0.16	0.18	0.09	0.06	0.37	NA
NH_3-N	ND	ND	ND	ND	ND	ND	0.06	0.04	0.08	0.06	0.08	NA
NO_2-N	ND	ND	ND	ND	ND	ND	<0.003	<0.003	0.019	<0.003	0.017	NA
NO_3-N	ND	ND	ND	ND	ND	ND	0.298	0.253	0.273	0.258	0.41	NA
2001												
TKN	NA	0.44	NA	0.49	0.07	0.21	0.1	0.27	0.4	0.2	<0.06	0.31
NH_3-N	NA	0.08	NA	0.08	0.07	0.08	0.012	0.029	0.05	0.053	0.023	0.045
NO_2-N	NA	0.014	NA	0.017	0.013	<0.006	0.008	0.006	<0.006	0.007	<0.006	0.06
NO_3-N	NA	0.386	NA	0.49	0.322	0.276	0.296	0.24	0.29	0.428	0.416	1.93
2002												
TKN	NA	0.18	0.24	0.18	0.15	0.1	0.37	0.09	0.13	0.082	0.091	ND
NH_3-N	NA	0.02	0.02	<0.02	<0.02	<0.02	0.04	<0.02	0.03	0.025	<0.02	0.04
NO_2-N	NA	0.022	0.017	<0.005	0.005	0.006	0.005	0.008	0.006	<0.005	<0.005	<0.005
NO_3-N	NA	0.333	0.396	0.743	0.322	0.277	0.262	0.397	0.334	0.407	0.496	0.353
2003												
TKN	NA	NA	0.1	0.08	0.17	0.29	ND	0.24	ND	<0.08	ND	0.57
NH_3-N	NA	NA	0.05	0.03	0.1	<0.02	ND	<0.02	ND	<0.02	ND	0.02
NO_2-N	NA	NA	<0.005	0.006	<0.005	<0.005	ND	<0.005	ND	<0.005	ND	0.007
NO_3-N	NA	NA	0.392	0.424	0.326	0.392	ND	0.247	ND	0.134	ND	0.369

ND = Not determined.
NA = No analysis, lake frozen.

TABLE AIV-32: CONCENTRATIONS OF TKN, AMMONIA-N, NITRITE-N, AND NITRATE-N IN WATER SAMPLES COLLECTED FROM LAKE MICHIGAN APPROXIMATELY AT 50-FT OFF SHORE AT THE SOUTH END OF THE PLOTS AT THE USX RESEARCH AND DEMONSTRATION PROJECT SITE DURING 2000 THROUGH 2003

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	mg/L											
2000												
TKN	ND	ND	ND	ND	ND	ND	0.66	0.2	0.51	0.26	0.36	NA
NH_3-N	ND	ND	ND	ND	ND	ND	0.06	0.04	0.1	0.06	0.1	NA
NO_2-N	ND	ND	ND	ND	ND	ND	<0.003	<0.003	0.02	<0.003	0.009	NA
NO_3-N	ND	ND	ND	ND	ND	ND	0.21	0.266	0.616	0.469	0.294	NA
2001												
TKN	NA	0.2	NA	0.47	0.08	0.36	<0.06	0.31	0.36	0.19	0.16	0.22
NH_3-N	NA	0.08	NA	0.08	0.07	0.076	<0.009	0.043	0.036	0.034	0.023	0.015
NO_2-N	NA	0.014	NA	0.017	0.014	<0.006	0.007	0.008	<0.006	<0.006	<0.006	<0.006
NO_3-N	NA	0.383	NA	1.812	0.357	0.317	0.309	1.838	0.3	0.377	0.401	0.479
2002												
TKN	NA	0.16	0.21	0.13	0.24	<0.08	0.44	<0.08	<0.08	0.206	0.165	ND
NH_3-N	NA	0.03	0.02	<0.02	0.02	<0.02	0.02	<0.02	0.02	0.033	0.025	0.04
NO_2-N	NA	0.021	0.017	0.01	0.006	0.006	0.005	<0.005	0.006	<0.005	<0.005	<0.005
NO_3-N	NA	0.327	0.406	0.354	0.383	0.27	0.243	0.265	0.34	0.409	0.334	0.366
2003												
TKN	NA	NA	<0.08	0.09	0.13	0.18	ND	0.12	ND	<0.08	ND	0.79
NH_3-N	NA	NA	0.04	<0.02	0.1	<0.02	ND	0.02	ND	0.03	ND	0.02
NO_2-N	NA	NA	<0.005	<0.005	<0.005	<0.005	ND	<0.005	ND	<0.005	ND	0.007
NO_3-N	NA	NA	0.391	0.55	0.363	0.284	ND	0.231	ND	0.124	ND	1.343

ND = Not determined.
NA = No analysis, lake frozen.