Metropolitan Water Reclamation District of Greater Chicago

Protecting Our Water Environment

Biosolids Use in Parkland Development at the Former U.S. Steel Southworks Brownfield Site

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Overview

- **Background**
  - Beneficial Uses of The District's Biosolids
  - USX site – A Steel Mill Slag Brownfield
  - Development Plans for The USX Site
  - Problems and Solutions
- **Research and Demonstration Project**
  - Amendments Evaluated
  - Turfgrass and Trees Evaluated
  - Parameters Monitored
  - Summary and Conclusions
- **Biosolids use in the City of Chicago**
  - Chicago Department of Environment (DOE) Policy
  - Chicago Park District's (CPD) Needs

Beneficial Use Program

Beneficial Use of Aged, Air-dried EQ Biosolids

- Biosolids distributed under Controlled Solids Distribution permit
- Illinois Environmental Protection Agency (IEPA) approval through a user information form for each project
- IEPA requires biosolids monitoring and management practices to ensure the protection of environmental and public health
- Biosolids Utilization and Soil Science staff provides technical support to all biosolids users

Potential Beneficial Uses

- **Soil Amendment or Soil Conditioner**
  - **Improve soil fertility or soil tilth**
- **Substitute for Commercial Fertilizers**
  - **Top dressing golf courses**

Examples: **Construction of parks, golf courses, athletic fields**

Example of Projects in Chicago: **Saint Rita High School;**

De LaSalle High School; Chicago River Sculpture Park

Eden Place Nature Center; Harborside International Golf Club


Eden Place Nature Center Before Using Biosolids

Two Truck Loads of Biosolids Transformed the Site Completely!

Harborside International Golf Club

- 453-acre site including two 18 hole courses and golf academy
- Over 500,000 dry tons of District's biosolids used in final cover of landfill
- Hosted Georgia-pacific senior PGA pro Am and SBC senior open
- Voted third best municipal golf course in USA by the golf week magazine

Harborside International Golf Club

Background – USX Brownfield

Brownfields are abandoned and under-utilized properties that plague many metropolitan cities in the U.S.

Example: USX Site – a 570-acre steel mill slag brownfield in metropolitan Chicago

- USX site, formerly known as U.S. Steel Southworks, is located near 86th Street and South Shore
- Steel mill ceased operations in late 1970s
- The site was created by filling Lake Michigan with slag, iron ore, and construction rubble

Development Plans for USX

- Chicago Park District
  - Extend the lakefront park system
  - Convert 120 acres of slag into parkland
- City of Chicago
  - Residential development
  - Commercial/industrial development
  - Create some green space - landscaped area

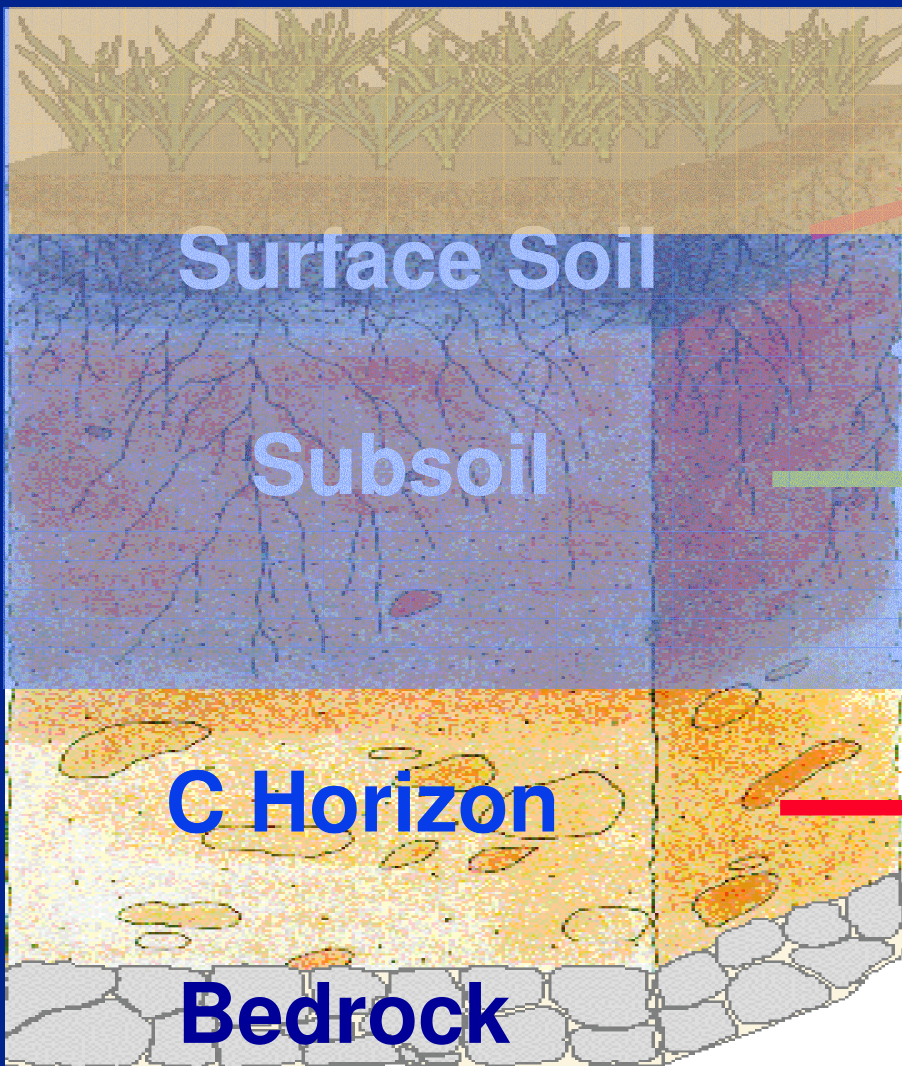
Top View of USX Site

Cross-Sectional View of USX Site

Problems

- Slag is poorly suited to support any type of vegetation because it has
  - Poor fertility and productivity
  - High porosity
  - Extremely heterogeneous nature
  - Poor water holding capacity

A Conceptual Soil Profile



Light texture, high organic carbon

Root zone, highly fertile

Stores moisture, plant nutrients

Zone of clay accumulation

Regulates water movement

Parent material

Solutions

Slag needs to be capped with topsoil to support any plant growth

- **Large quantities of topsoil needed**
  - **Need 1-ft thick cap for Turfgrass**
  - **Need 4-ft thick cap for Trees**

Require ≈ 387,000 cu. yard Topsoil for making 2-ft cap on a 120-acre slag site

- **Cost @ $24 per cu. yard = $9.7 million**

Solutions

The Cost Can Be Reduced?

- By using by-products such as **BIOSOLIDS**

> **Use of 25:75 Biosolids:Topsoil mixture could save $2.4 million**

Why Biosolids?

- Locally available – abundant supply
- No cost
- Desirable properties – nutrients, organic matter

PHYSICAL & CHEMICAL PROPERTIES OF DISTRICT BIOSOLIDS AND TOPSOIL SOLD IN CHICAGO AREA

Parameter	Unit	Biosolids	Topsoil
pH		6.0 – 7.5	5.4 – 11.3 *
EC	dS/m	3 – 10	0.5 – 4.2 *
Organic C	%	15 – 25	1.3 – 24.0 *
TKN	%	1.5 – 2.5	0.05 – 2.2 *
NO_3+NH_3-N	mg/kg	1,000 – 3,000	1.0 – 2,000 *
Total P	%	1.5 – 2.5	0.02 – 0.3 *
Bulk Density	g/cm^3	0.7	1.18
Permeability	In/hr	17 – 30	0.07

*Data from R&D Report Number 03 – 19.

The USX Site Location

USX Site Research And Demonstration Plots

Research and Demonstration Project

COOPERATIVE AGENCIES

AGENCY	DEPARTMENT
District	R&D and M&O
City of Chicago	Planning and Development Dept. of the Environment Streets and Sanitation
Chicago Park District	Landscape Architecture
USX Corporation	Realty Development

Project Goals

- Demonstrate that the quantity of expensive topsoil needed for capping the slag at USX site can be reduced by using biosolids
- Demonstrate the benefits of using biosolids for establishing quality turf and trees at USX
- Demonstrate that use of biosolids at the USX site is environmentally safe

Project Design

- Project was designed to test and compare effectiveness of:
  - Topsoil
  - Biosolids
  - 50% Biosolids/50%Topsoil mixture
  - 25% Biosolids/75% Topsoil mixture

Project Design (contd.)

Evaluated 4 turfgrass mixtures

- **Standard CPD mix** – 70% Kentucky bluegrass, 15% creeping red fescue, 10% perennial rye, 5% redtop
- **Standard MWRDGC mix** – 70% tall fescue, 30% Kentucky bluegrass
- **IDOT 1 B mix** – 75% tall fescue, 15% perennial rye, 10% creeping red fescue
- **VIDOT 1 mix** – 50% perennial rye, 30% Kentucky bluegrass, 20% creeping red fescue

Project Design (contd.)

Tested Six Shade Tree Species

- Maple *v*. Marmo
- White Ash *v*. Autumn Purple
- Honey Locust *v*. Skyline
- Cottonless Cotonwood *v*. Siouxland
- Red Oak
- Elm *v*. Homestead

Tested Five Ornamental Tree Species

- Amur Maple
- Apple Serviceberry
- Thornless Cockspur Hawthorn
- Crabapple *v*. Zumi
- Crabapple *v*. Donald Wyman

Project Design (contd.)

Subsurface Water Sampling Devices

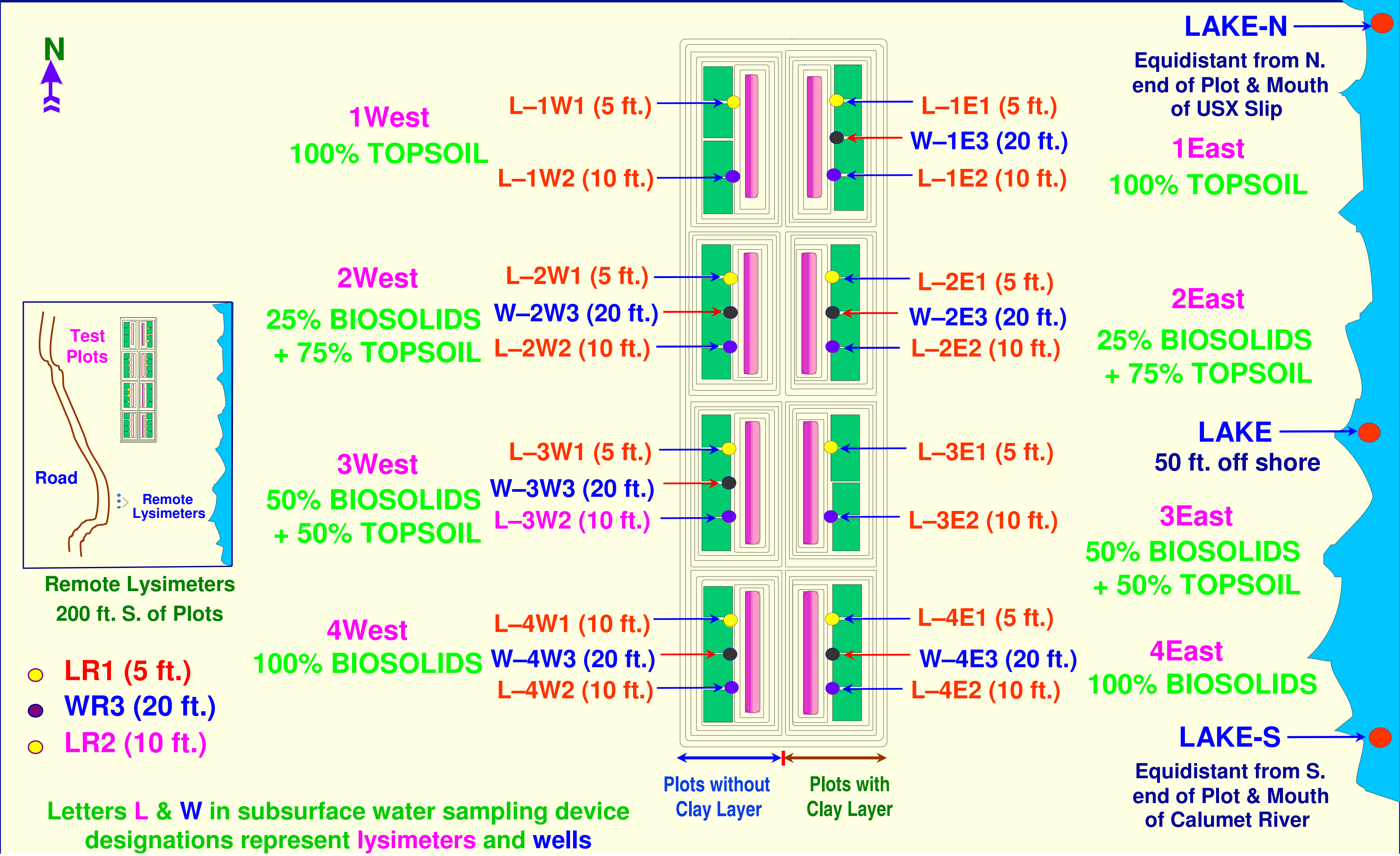
- Installed 9 lysimeters, 5-ft beneath the surface
- Installed 9 lysimeters, 10-ft beneath the surface
- Installed 7 wells, 20-ft beneath the surface

Lake Michigan Water Sampling

- Lake water samples taken from 3 locations – 50-ft off shore corresponding to north end, midpoint, and south end of plots

- **The Project was Approved By The IEPA**

Plot Layout and Water Sampling Locations



Letters L & W in subsurface water sampling device designations represent lysimeters and wells

Plot Set-Up

Installation of Water Sampling Devices

Plots Seeded in Fall 2000

Monitoring Schedule

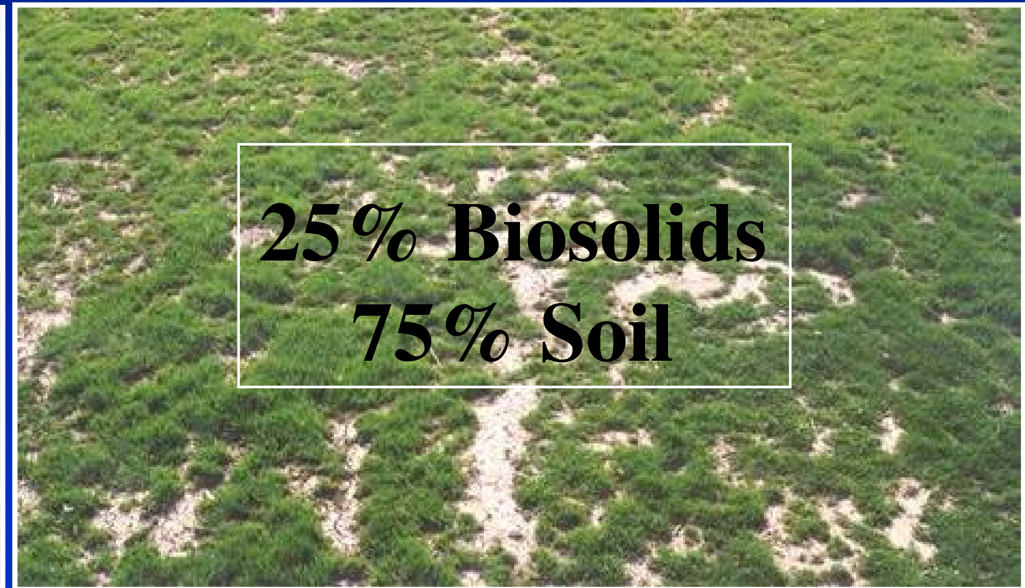
Sampling Type	Frequency	Parameter
Lysimeters, Wells, & Lake	Monthly Quarterly	Nutrients, Fecal Coliform, Trace Elements, Soluble Salts, Organic Priority Pollutants
Soils	Twice Annually	Nutrients, Trace Elements, Organic Carbon, pH, EC
Turf	Twice Annually	Growth, Macro/Micro Nutrients, Trace Elements, Turf Performance (appearance, color, coverage)
Trees	Annually	Growth, Macro/Micro Nutrients, Plant performance (height, stem diameter)

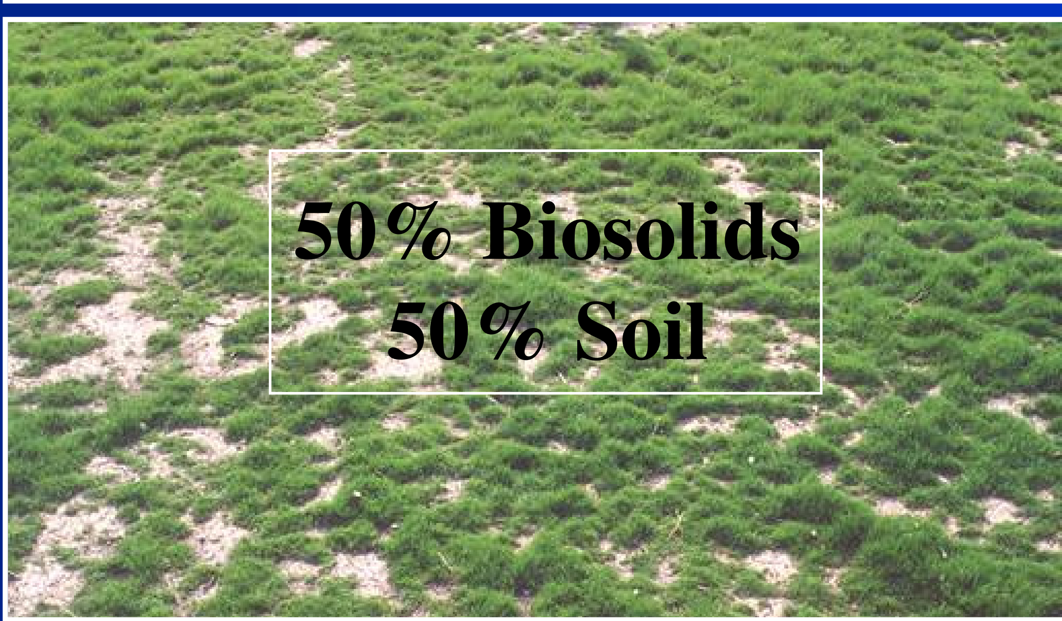
Soil Fertility Status of The USX Plots

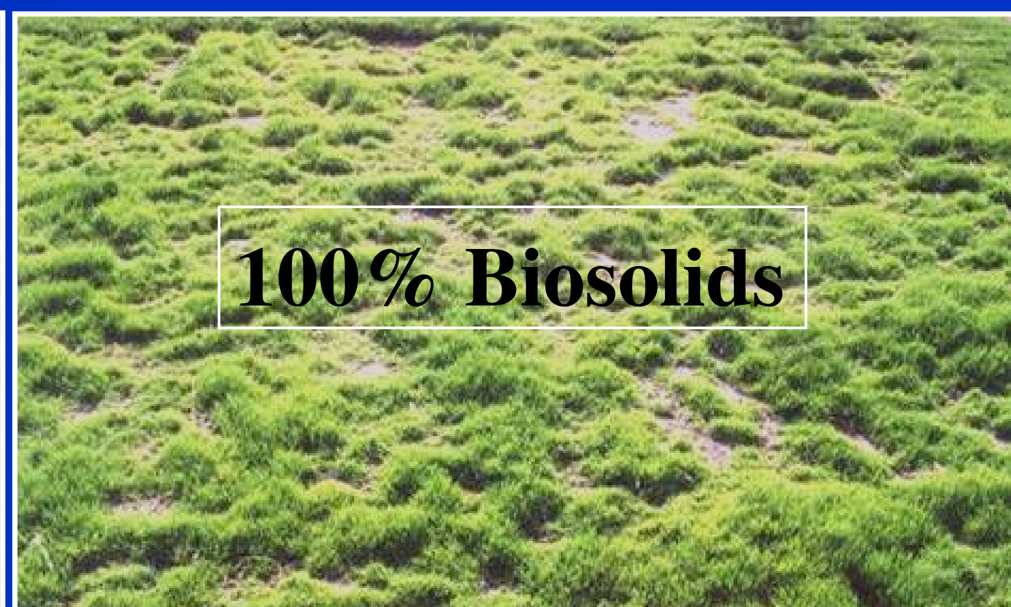
		USX Plots			Prairie
Parameter	Unit	Topsoil	25% BS	100% BS	Soils
Organic C	%	2.3	6.2	15.7	4.6
pH		7.4	7.1	6.4	6.2
EC	dS/m	0.3	0.6	2.0	0.13
TKN	mg/kg	1,575	4,780	13,340	4,150
Inorg.-N	mg/kg	5.2	48.4	227.2	6.9
Avail. P	mg/kg	20	245	520	21

BS = Biosolids

Research Plots About A Month Later

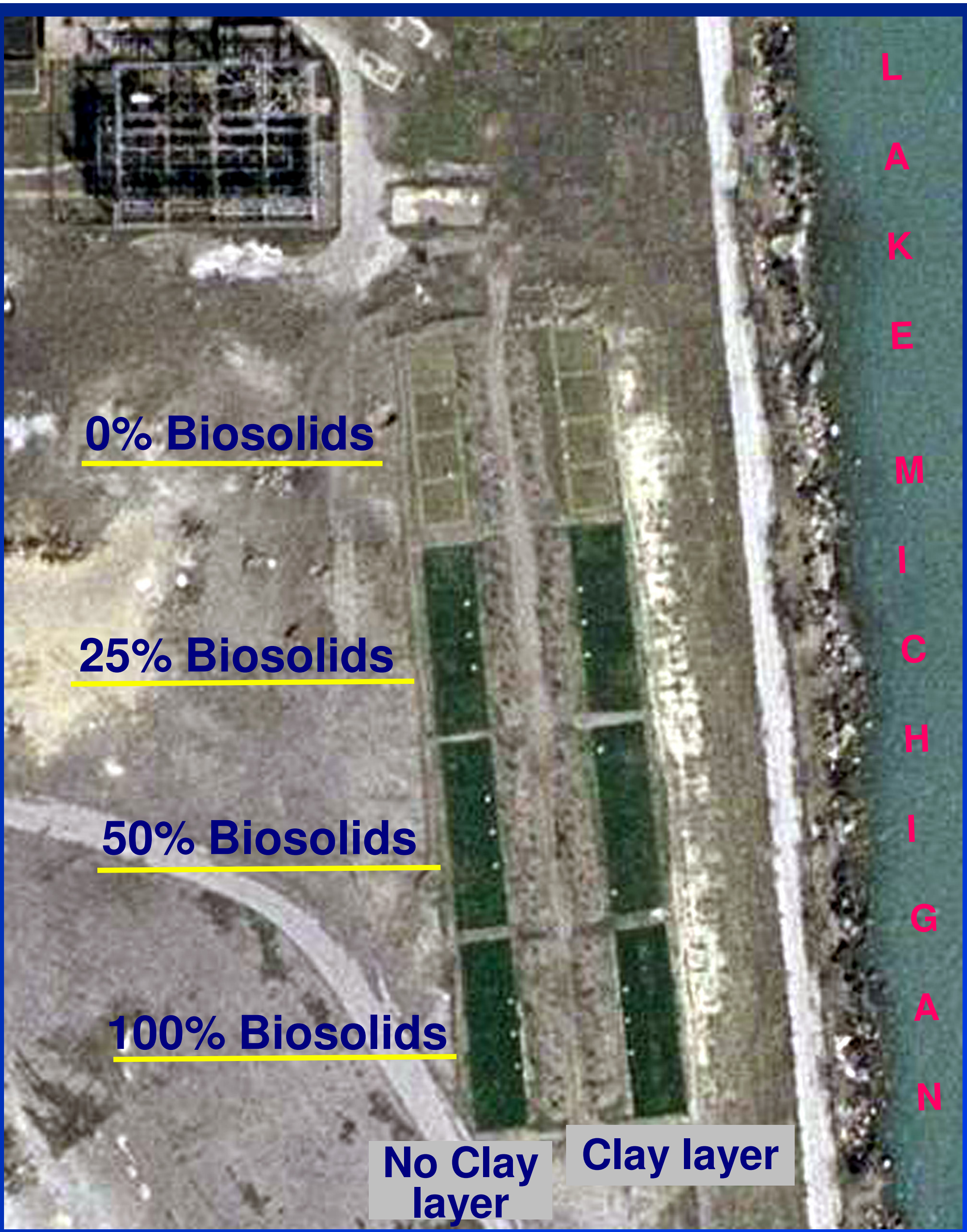






An Aerial View of The USX Plots

(Photo taken on 4/10/02)

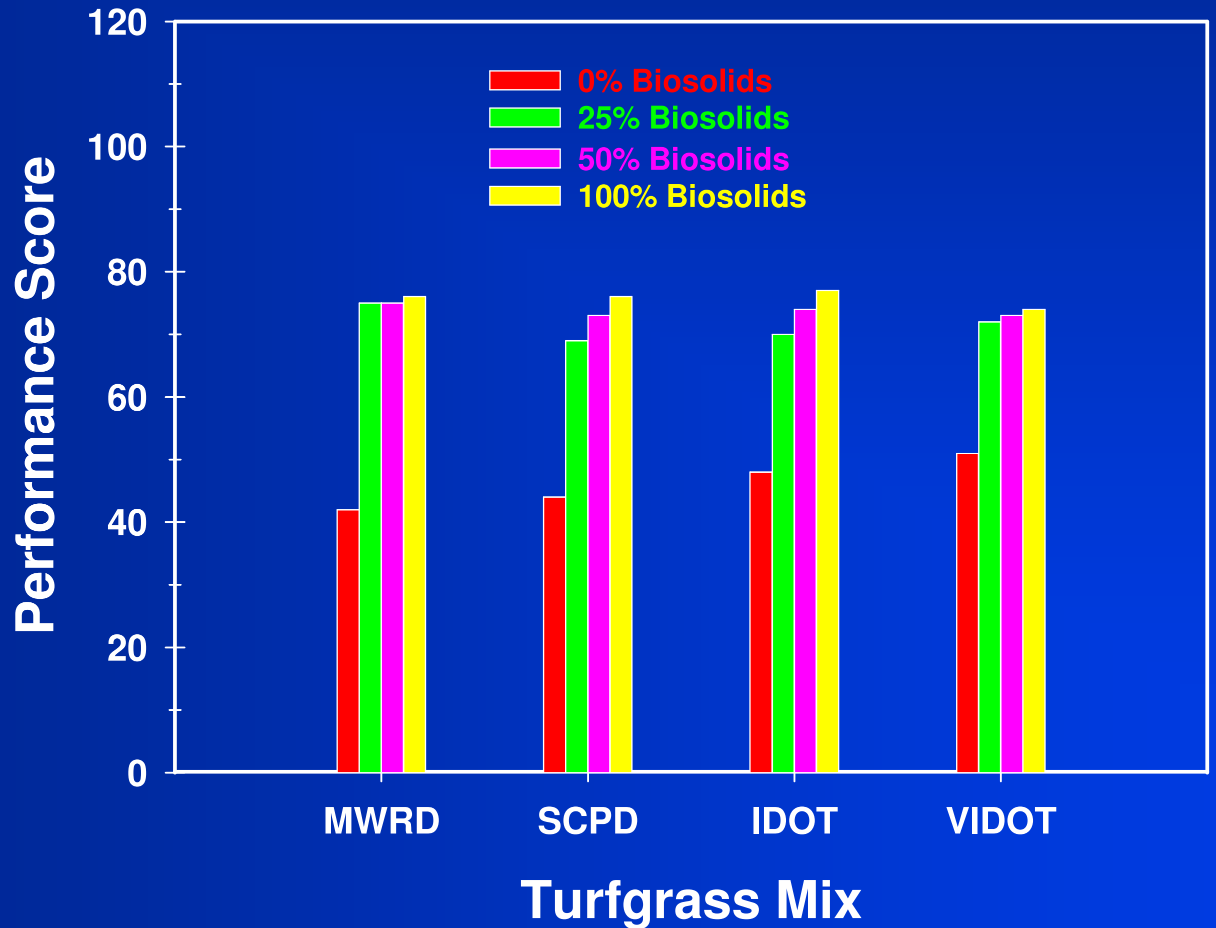



Research Plots In Late Summer 2003


Turfgrass In Late Summer 2003

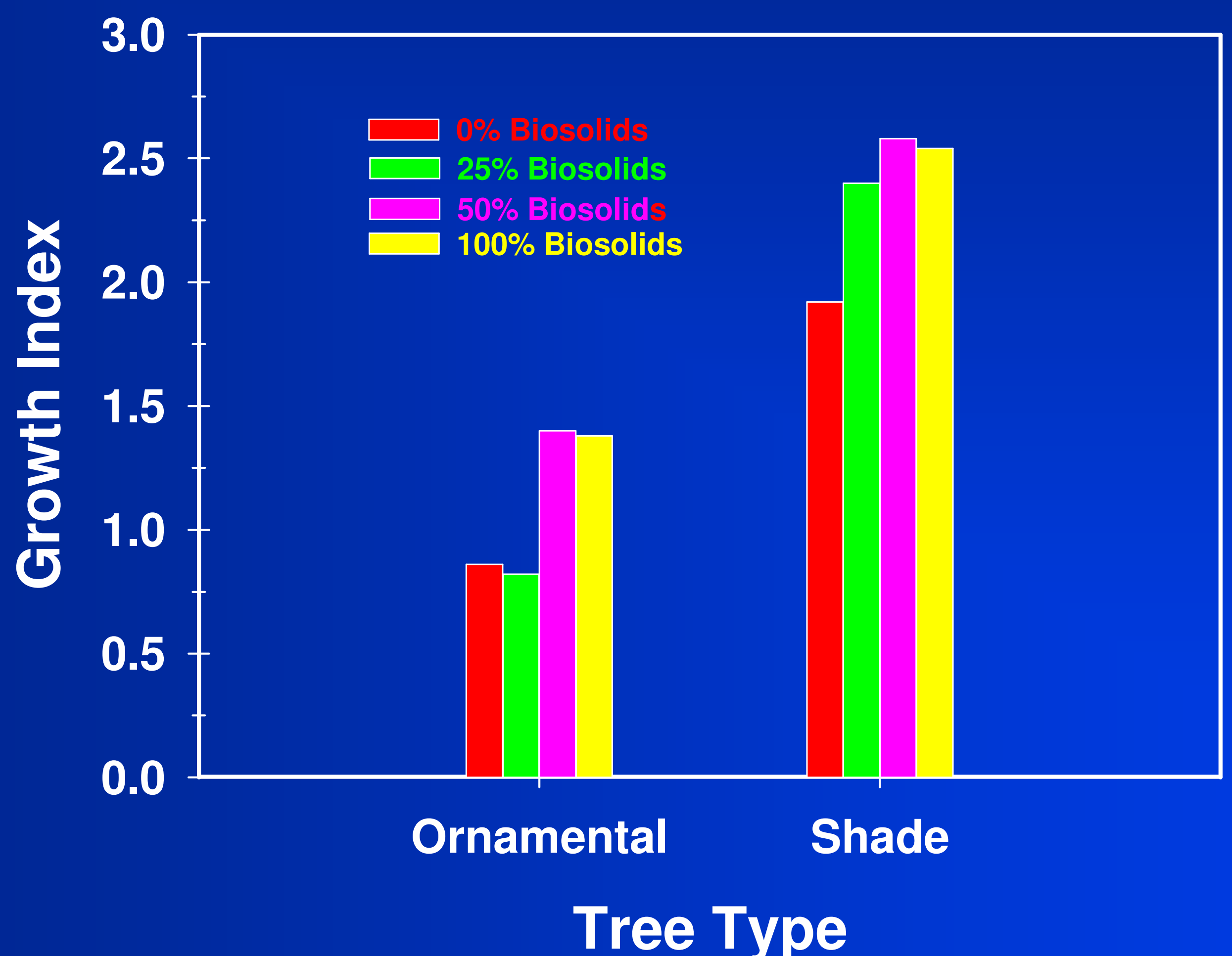
Performance of Turfgrass Mixes

Performance Score = 0.75 x turf density score + 0.25 x turf color quality score



Performance of Ornamental and Shade Trees

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



Trace Metals in Leaves of Ornamental Trees from the USX Plots and a Local Park

	USX Plots			
Parameter	Topsoil	25% BS	100% BS	Local Park
	mg/kg			
Zn	26	29	36	31
Cd	0.03	0.09	0.19	0.07
Cu	7.8	4.7	6.3	8.9
Cr	0.74	0.83	0.78	0.55
Ni	0.95	0.78	1.49	1.61
Pb	1.06	1.19	0.82	0.2
Mo	0.68	1.09	1.64	0.9

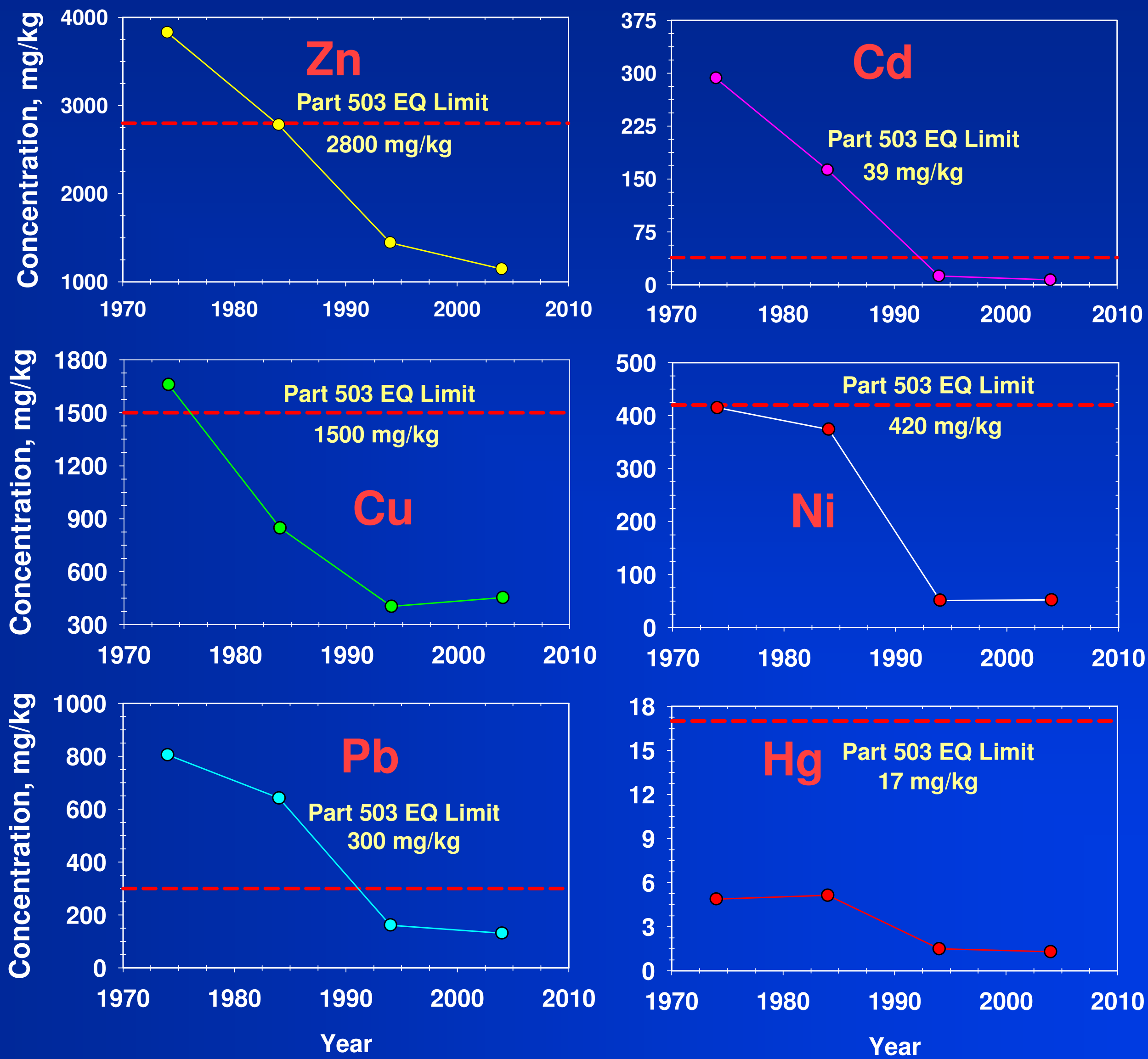
Trace Metals in Leaves of Shade Trees from the USX Plots and a Local Park

	USX Plots			
Parameter	Topsoil	25% BS	100% BS	Local Park
	----------------------------------	mg/kg	----------------------------------	
Zn	83	81	99	208
Cd	0.83	0.85	1.25	5.83
Cu	9.6	5.8	6.7	10.5
Cr	0.69	0.71	0.60	0.72
Ni	1.24	0.78	0.84	0.91
Pb	2.15	1.67	0.98	1.10
Mo	0.94	1.47	1.42	0.90

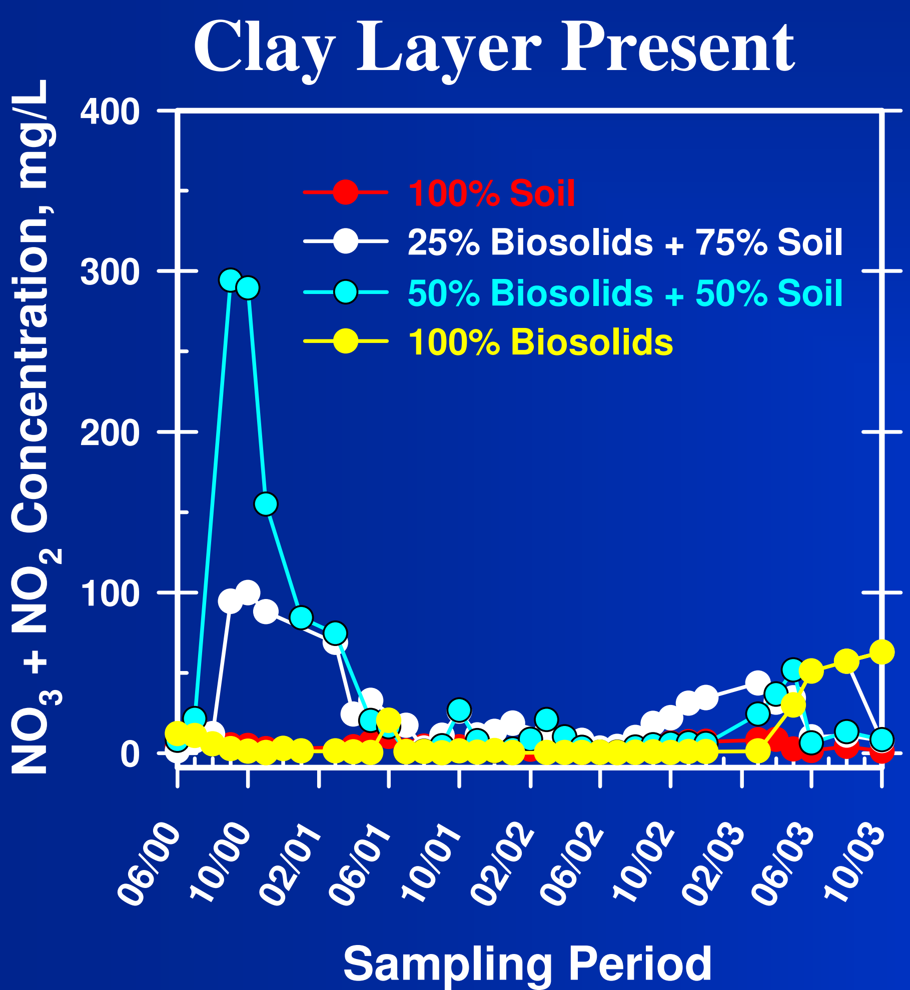
Trace Metals in The District Biosolids & Part 503 EQ Limits

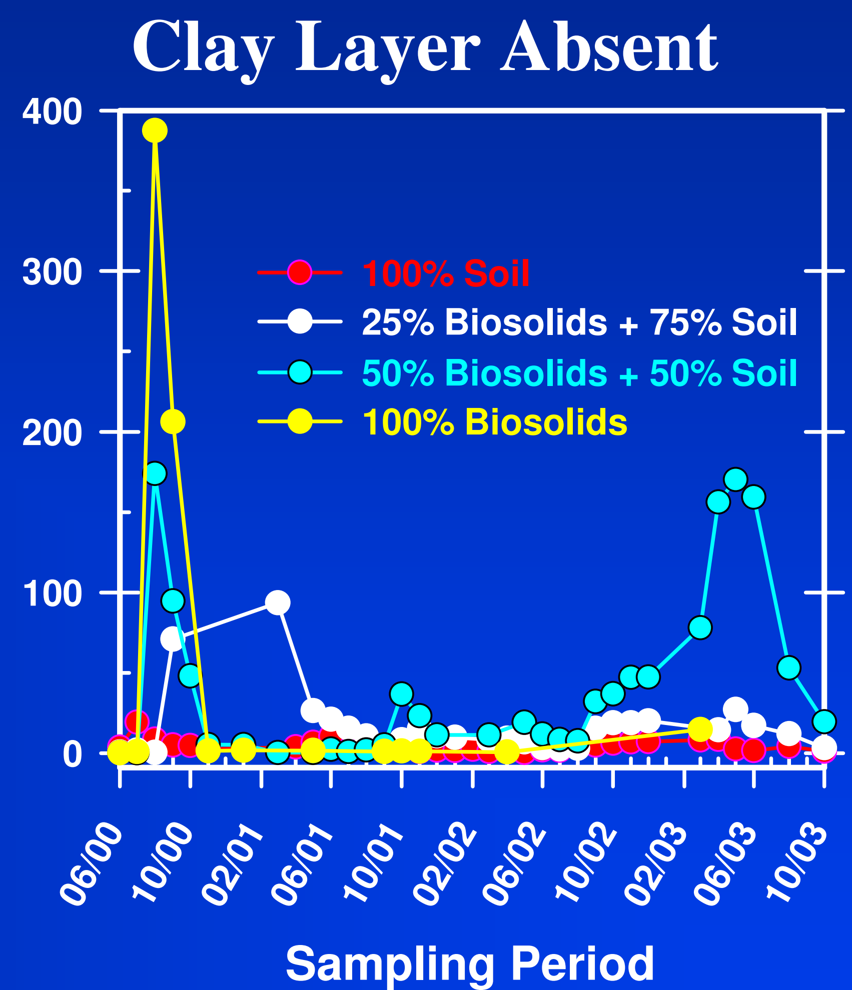
Parameter	Mean Biosolids Concentration: Stickney SWRP	Mean Biosolids Concentration: Calumet SWRP	Part 503 EQ Limit
	------- mg/kg -------		
Zn	765	1023	2,800
Cu	381	397	1,500
Cd	3	4	39
Ni	61	35	420
Pb	126	114	300
Mo	17	15	75
Hg	0.6	0.6	17
As	9	7	41
Se	2	6	100

Trends in Trace Metals Concentrations Since Enactment of The Clean Water Act of 1972

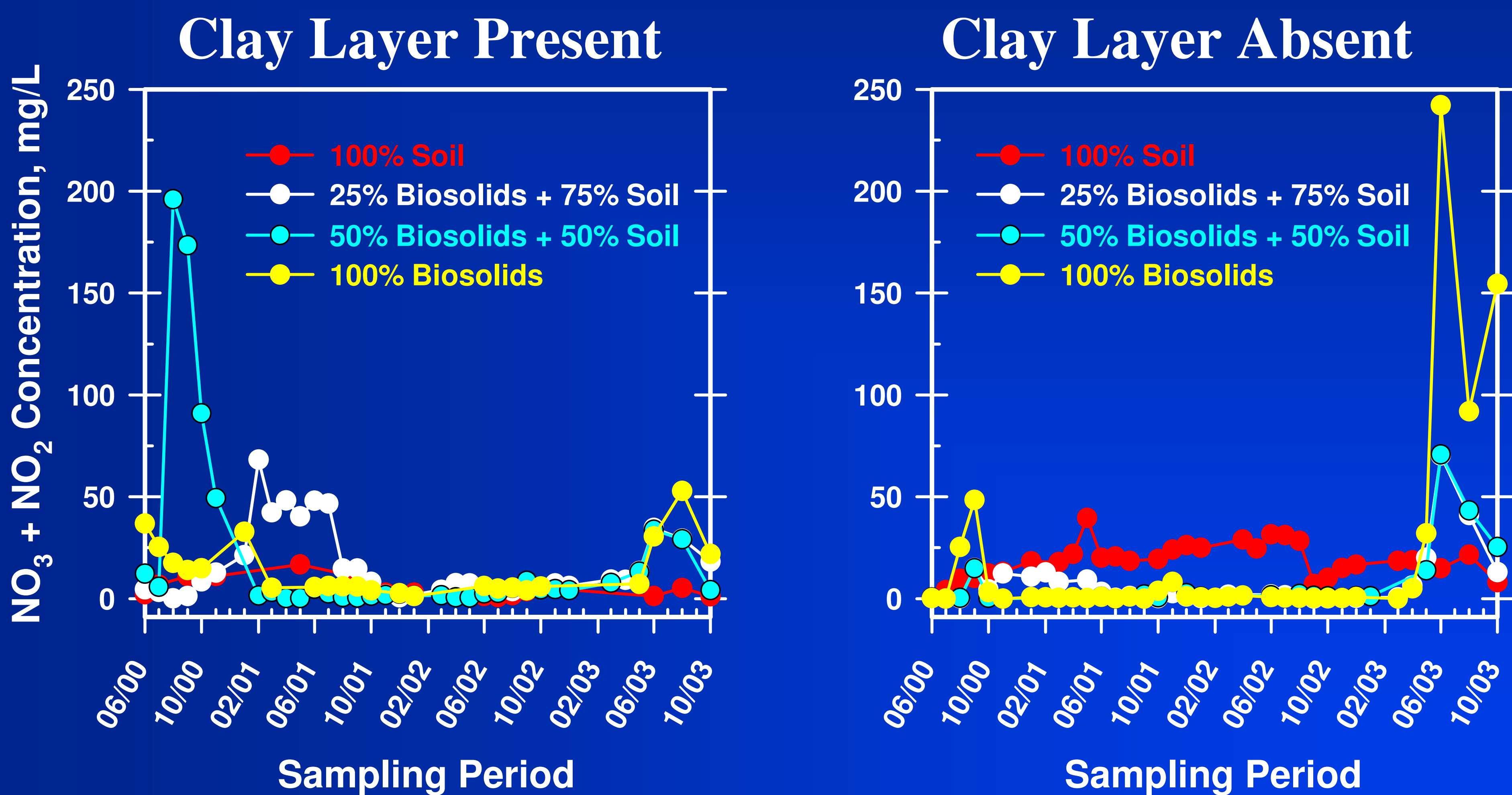


NO_3+NO_2 in 5-ft Deep Lysimeters

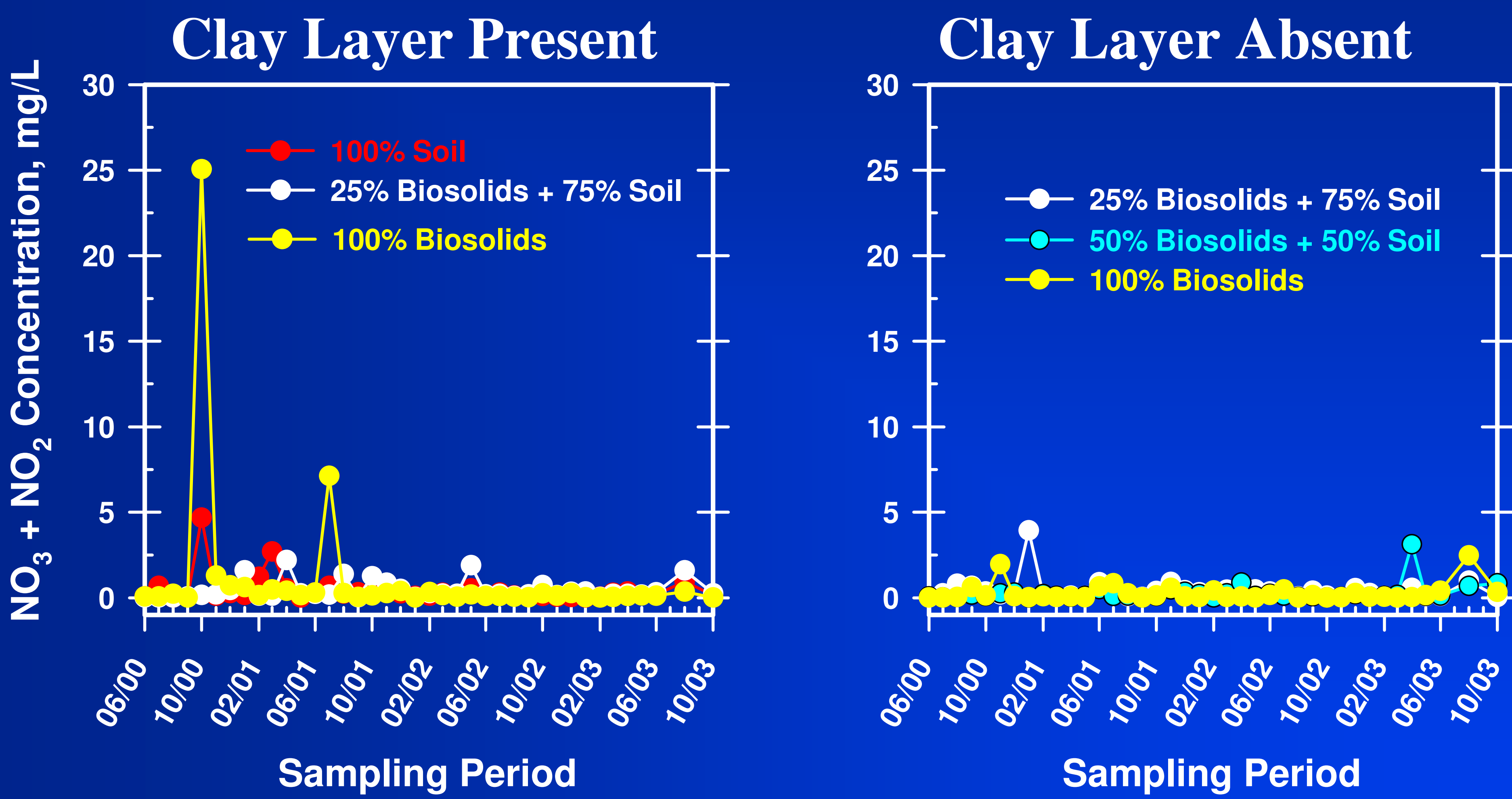




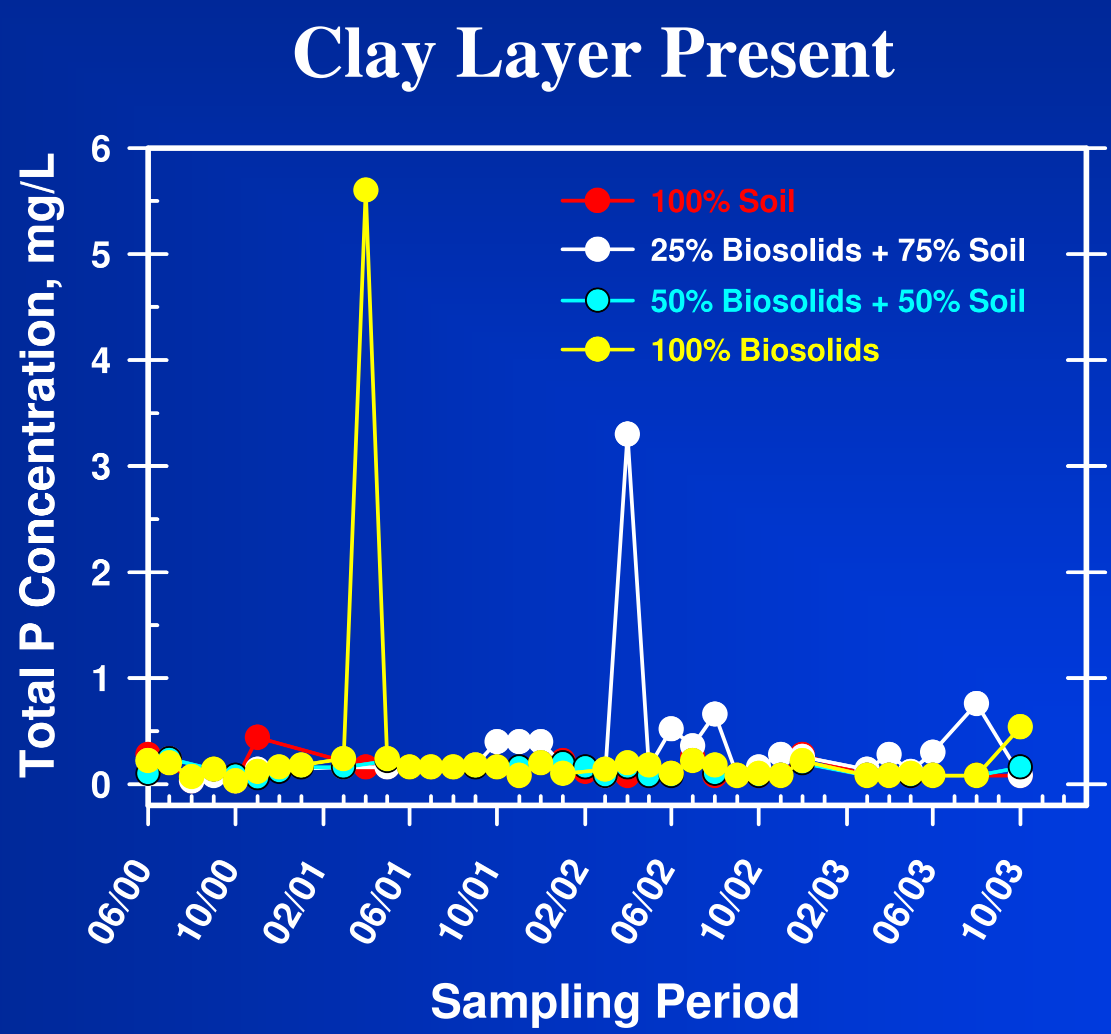
NO_3+NO_2 in 10-ft Deep Lysimeters



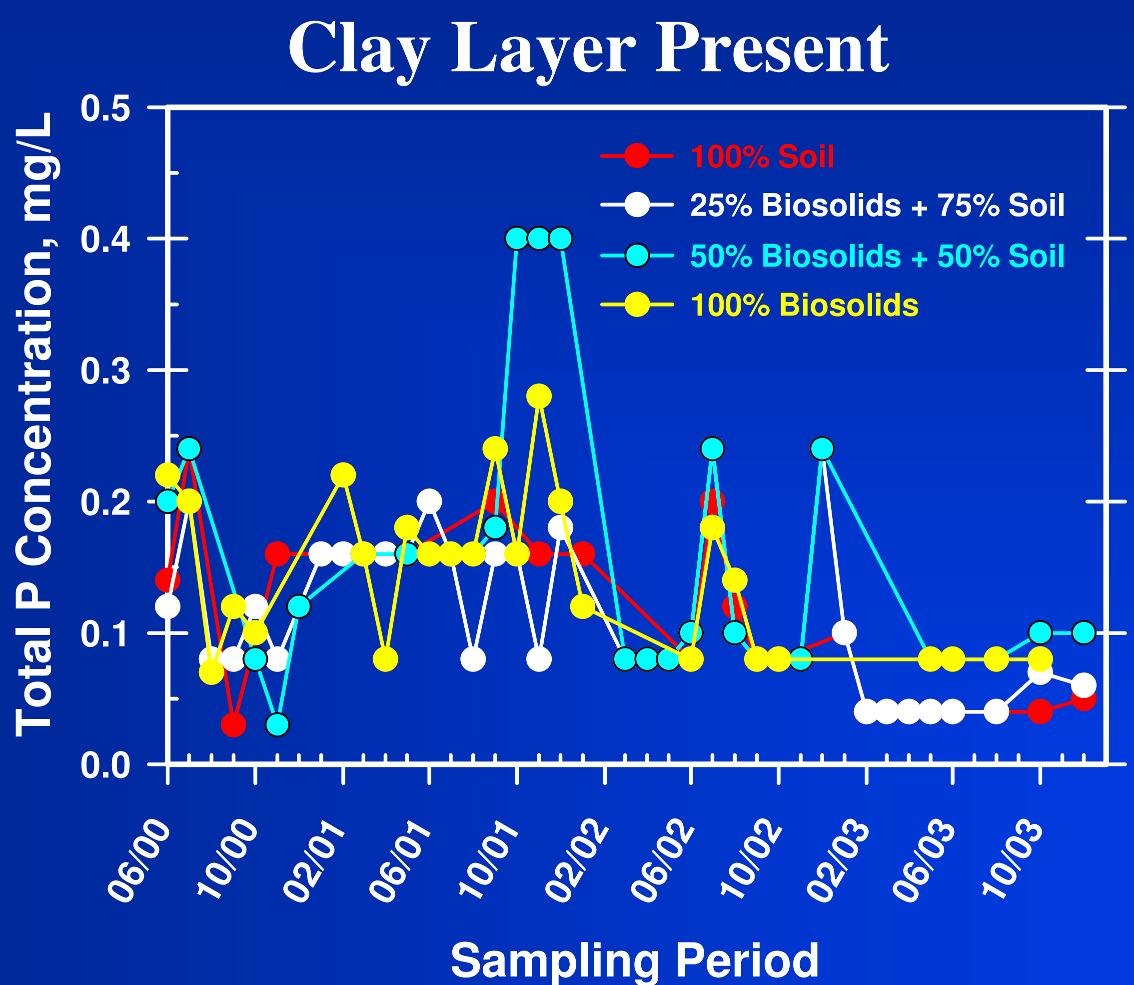
NO_3+NO_2 in 20-ft Deep Wells



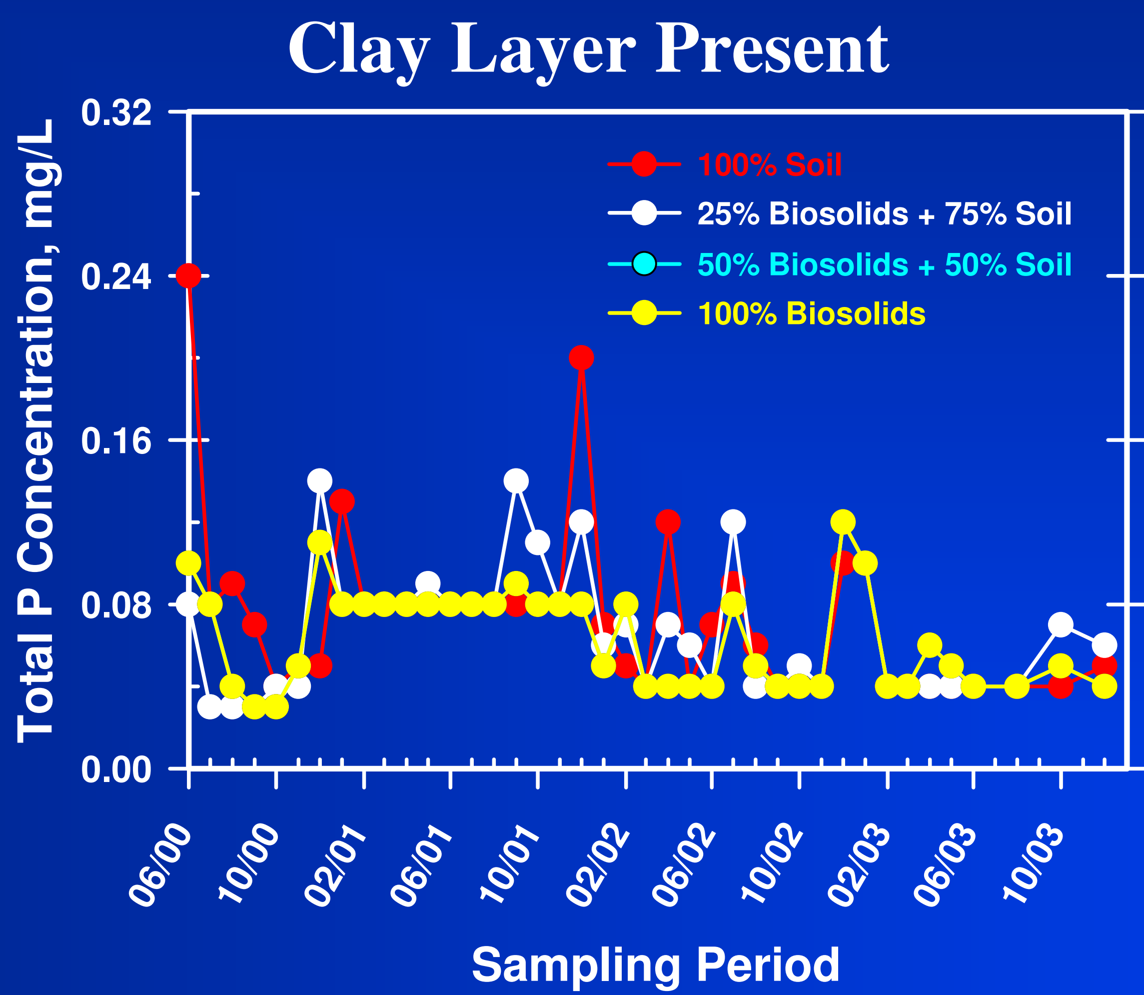
Total P in 5-ft Deep Lysimeters



Total P in 10-ft Deep Lysimeters



Total P in 20-ft Deep Wells



Trace Metals in the Lake and 5-ft Deep Lysimeters in the Plots

Parameter	Lake	Slag	Soil	100% Biosolids
	---------- mg L^{-1} ----------			
As	0.045	0.107	0.160	0.141
Cd	0.004	0.009	0.014	0.007
Cr	0.005	0.016	0.058	0.027
Cu	0.006	0.202	0.228	0.077
Hg (µg/L)	0.021	0.088	0.080	0.090
Ni	0.019	0.314	0.024	0.100
Pb	0.087	0.087	0.160	0.073
Zn	0.012	0.279	0.080	0.048

Organic Priority Pollutants In The Lysimeters

- Water samples were analyzed for 111 organic Priority Pollutants.
- Most of the compounds detected were below the analytical detection limits except:
  - Bis(2-ethylhexyl)phthalate = 380(2) and 6,133(1) ppb
  - Phenanthrene = 10(1) and 50(2) ppb
  - Anthracene = 14(1) ppb
  - Fluoranthene = 27(2) ppb
  - Phenol = 129(2), 79(2) and 167(3) ppb
  - Methyl Chloride = 6(2) ppb
  - Methylene Chloride = 4(1) ppb
  - 1,1,1-Tricholoroethane = 2(1) ppb

Summary And Conclusions

Benefits

- Mixtures of biosolids and soil were very effective for capping slag materials to establish vegetation.
- Inclusion of biosolids in the soil cap significantly improved its fertility and productivity.
- Turfgrass and trees performed better in the plots amended with biosolids and soil mixtures.
- Use of 25% biosolids + 75% soil mixture for capping slag materials for vegetating a 120-acre parcel would save $2.4 million.

Summary And Conclusions

Little or No Environmental Impact

- Trace metals in plant tissues from the soil and biosolids plots and a local park were identical.
- Use of biosolids did not result in elevated levels of organic priority pollutants, trace metals, and fecal coliforms in the subsurface water.
- Biosolids use to cap the slag is environmentally safe and had little impact on the subsurface water quality and no impact on the lake water quality.

Next Step!

Biosolids Use in the City of Chicago

- A large market for the District's biosolids is available within the City of Chicago
- The City of Chicago DOE policy dictates that any material (soil or biosolids) used in the city must meet TACO
- Currently, the District is working with DOE to address biosolids/TACO issue

T A C O?

It's not lunch time, yet!

Special Requirements

- **TACO – Tiered Approach to Corrective Action Objectives**
  - Illinois Administrative Code Title 35 Part 742
  - Voluntary program of clean-up objectives for contaminated sites in Illinois (results in issuance of NFR letter)
  - Based on potential human exposure to soil and groundwater due to anticipated site redevelopment
  - Compliance with any of the 3 tiers of standards:

    - Tier 1 - Default, based on worst case scenarios

    - Tier 2 - Based on site specific models

    - Tier 3 – Based on "Site Specific Risk Assessment"

TACO Standards

- **Standards established for over 140 pollutants**

  - Inorganics – 24
  - Volatile organic compounds – 37
  - Semi-volatile organic compounds – 43
  - Polychlorobiphenyls (PCBs) – 6
  - Organochlorine pesticides – 23
  - Other organic compounds – 7

TACO Analysis of Biosolids

- **General Findings**
  - Nearly 40 pollutants in TACO have levels below the laboratory reporting limits
  - Background soil levels of many pollutants exceed the TACO limit
  - TACO risk assessment is not specific to biosolids and is very conservative

- **Tier 1 Residential - Soil Ingestion Pathway**
  - Only 8 out of ~140 listed pollutants exceeded TACO limit

Biosolids Risk Assessment

Risk Assessment Model Evaluated

7 Potential Land Use Scenarios

Athletic fields; Playgrounds; Picnic areas; Parking lots
Community gardens; Multiuse trails; Park buildings

5 Potential Receptors

Park District employee; Construction worker; Landscaping site preparation worker; Landscaping maintenance worker; Recreational visitor (both child and youth)

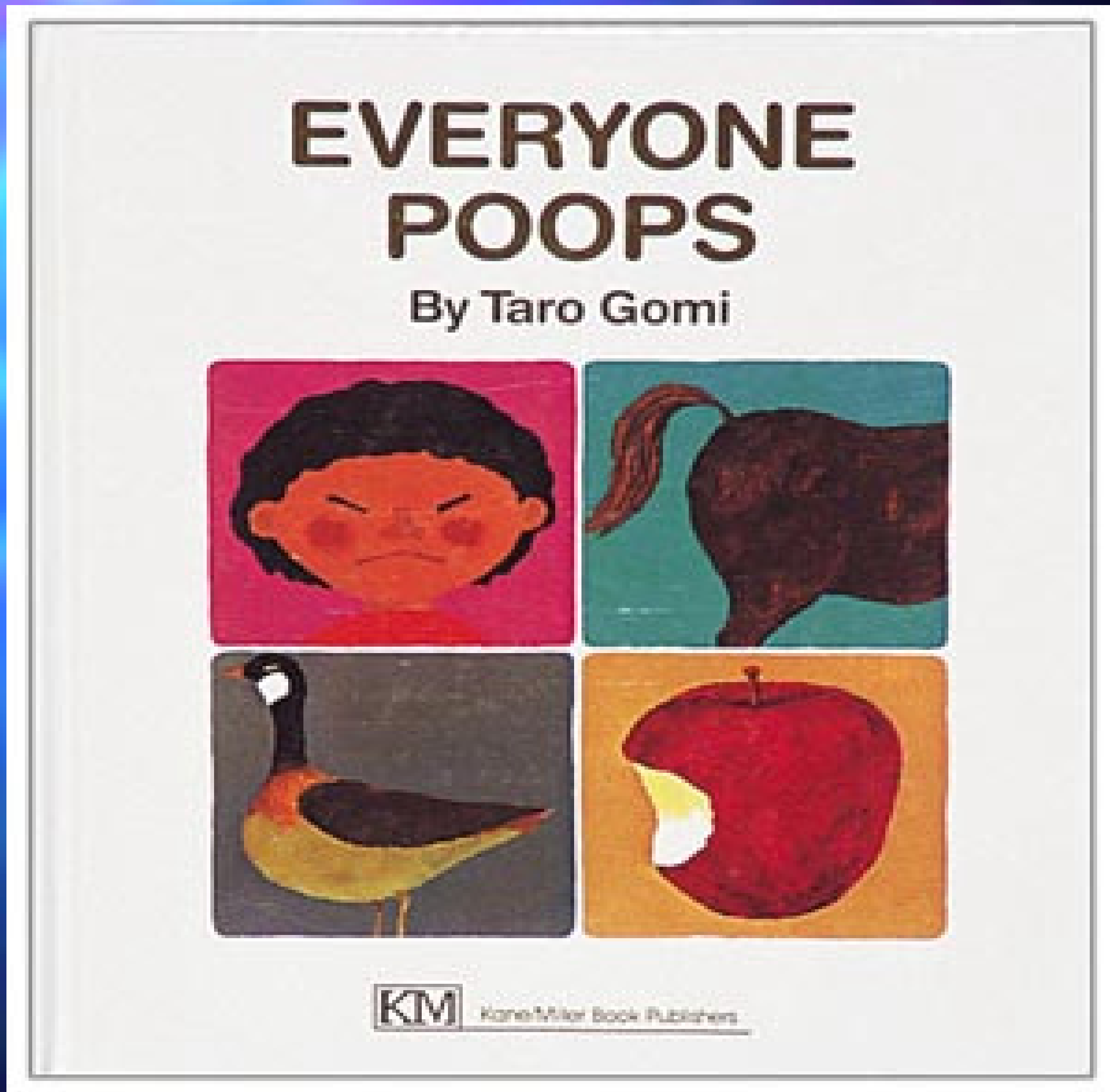
3 Exposure Pathways

Soil ingestion; Inhalation of fugitive dust; Dermal contact with soil

Biosolids Risk Assessment Results

- Evaluated 7 Polycyclic Aromatic Hydrocarbons (PAHs)

PAH	Conc., mg/kg	Limit, mg/kg
• Benzo[*a*]anthracene	0.7 – 5.7	4.7
• Benzo[a]pyrene	1.1 – 7.3	1.3
• Benzo[*b*]fluoranthene	1.1 – 6.1	4.7
• Benzo[*k*]fluoranthene	1.7 – 11	47
• Chrysene	1.3 – 8.5	470
• Dibenzo[*a,h*]anthracene	<0.8 – <2.2	0.47
• Indeno[*1,2,3-cd*]pyrene	0.9 - 4.5	4.7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