National Biosolids Partnership
Webcast

"BIOSOLIDS 101"

Fundamentals of Practice

October 31, 2012

WELCOMING REMARKS

Sam Hadeed

Biosolids Program Manager
Water Environment Federation
National Biosolids Partnership
Alexandria, VA

WEF Residuals & Biosolids
Committee Staff Liaison

shadeed@wef.org

2

NBP's Commitment to Excellence in Biosolids Management

Starting in January 2010, NBP began offering a series of "no charge" quarterly webcasts devoted to general biosolids management and technical topics of interest to water quality and biosolids professionals:

- Carbon Footprint Implications from Biosolids Management Practices
- Advances in Solids Reduction Processes
- Combined Heat and Power Generation Opportunities at Wastewater Treatment Facilities
- Charting the Future of Biosolids Management: Forum - Findings on Trends and Drivers
- Implementing the New SSI MACT Standards – Issues and Challenges Ahead
- Terminal Island Renewable Energy – LA's Biosolids Slurry and Brine Injection Project
- Renewable Green Energy from Biosolids – POTW Case Studies to Achieve Net Energy Production
- When Opportunity Knocks, How Can Municipalities and POTWs Partner with the Biofuels Industry
- Thermal Hydrolysis Comes to America: DC Water's Blue Plains Digestion Project
- Compliance and Testing Requirements to Meet the Sewage Sludge Incineration MACT Standards – Part 2

1.75 Professional Development Hours for this webcast

http://www.wefnet.org/nbp/

NBP - WEF Resources to Navigate Biosolids Management

www.biosolids.org - Web Page and E-Newsletter

www.wef.org - Biosolids Channel of Access Water Knowledge

WEF 2013 Residuals and Biosolids Specialty Conference
May 5-8 Nashville, TN

http://www.wef.org/ResidualsBiosolids/

4

NBP EMS Certified Agencies

A key component of the NBP program is the EMS and third-party audit program. The following agencies/organizations have an active NBP EMS certification.

Alexandria, VA Renew Enterprises
Louisville & Jefferson Co. KY Metro Sewer District
Metro Denver, CO WW Reclamation District
DC Water
Casella Organics Hawk Ridge Composting Facility
Resource Management Inc., NH
Kent County, DE Regional WTF
City of Albany, OR Wastewater Treatment Plant
City of Chattanooga, TN DPW
City of Fort Worth, TX Water Department
City of Grand Rapids, MI
Greater Moncton Sewerage Commission, Canada
Camden County, NJ Municipal Utility District
Renewable Water Resources – Greenville, SC
City of Santa Rosa, CA Public Utilities
Central Davis County, UT Sewer District
Metro Water Reclamation Dist. of Greater Chicago, IL
Orange County, CA Sanitation District
Orange County, FL Utilities
East Bay Municipal Utility District - Oakland, CA
Encina Wastewater Authority – Carlsbad, CA
City of Raleigh, NC Public Utilities Department
City of Mankato, MN
City of Los Angeles, CA Dept of Public Works
City of Lawrence, KS Dept. of Utilities
Lewiston-Auburn, ME WPA
City of Richmond, VA Public Utilities Dept.
Knoxville Utilities Board, TN

National Biosolids Partnership Certified Management Program

Today's Webcast

"BIOSOLIDS 101"
Fundamentals of Practice

TODAY'S SPEAKERS

Natalie Sierra, PE

Project Manager
Chair, WEF RBC Outreach & Education Committee
RMC Water and Environment
San Francisco, CA

"Biosolids 101 - Introduction"

nsierra@rmcwater.com

7

TODAY'S SPEAKERS

Rhonda Bowen

Biosolids Manager
Past Chair, WEF RBC Outreach & Education Committee
Hampton Roads Sanitation District
Virginia Beach, VA

"Risk Assessment - Methodology Overview"

rbowen@hrsd.com

8

TODAY'S SPEAKERS

Tom Crawford

Biosolids Barrister Emeritus
Milwaukee Metropolitan Sewerage District (retired)
Milwaukee, WI

"Historical Overview of Round 1 Biosolids Land Application"

canoetommy@gmail.com

9

TODAY'S SPEAKERS

Dr. Michael J. McFarland, PE, BCEE

Assistant Professor
Department of Civil & Environmental Engineering
Utah State University
Logan, UT

"Regulations and Management Practices"

farlandm@msn.com

10

Biosolids 101 - Introduction

Natalie Sierra, PE
RMC Water and Environment
nsierra@rmcwater.com

NBP Webcast
October 31, 2012

Overview of Information Presented in Webcast

- **Description of talks:**
  - Science behind the federal biosolids regulation and risk assessment, 40 CFR 503 – Rhonda Bowen
  - History of the 40 CFR 503 – Tom Crawford
  - How the 503 gets implemented – Mike McFarland

> Goal: To introduce participants to the basics of the federal biosolids regulation with a focus on land application

What are Biosolids?

- **Digested**, semi-solid residuals from primary and secondary treatment – the solids & bacteria that are removed during the treatment process
- Typically use "biosolids" to designate *treated* solids, "sludge" for untreated solids
- Rich in plant nutrients (N, P and trace metals)
- **Class B Biosolids** – reduced pathogens, but still present
- **Class A Biosolids** – virtually pathogen-free

Activities Regulated by 503

- Land Application
- Compost, pellets, soil blends distributed or sold in bags or in bulk
- Surface Disposal
- Incineration*

Land Application

Thank You!

Natalie Sierra – nsierra@rmcwater.com

Risk Assessment

Methodology Overview

EPA Guide to Biosolids Risk Assessment

Rhonda L. Bowen
Biosolids Manager
Hampton Roads Sanitation District
Virginia Beach, VA 23471-0911
Email: rbowen@hrsd.com

...applying science & technology to protect water quality

Pollutants are Evaluated for Three Biosolids Management Scenarios

- Incineration
- Disposal in biosolids lagoons (i.e., surface disposal units)
- Application to agricultural land

Four Steps

- **Hazard Identification:**
  - Can the pollutant harm human health and/or environment?
- **Exposure Assessment:**
  - Who is exposed; how are they exposed; how much?
- **Dose-response Evaluation:**
  - If person, animal or plant exposed – what happens?
    - Risk reference doses – daily intake, over lifetime
    - Cancer potential values – likelihood of exposed to develop cancer
- **Risk Characterization:**
  - What is the likelihood of an adverse effect
    - Risk = Hazard x Exposure

Biosolids Task Force

- Determine pollutants of concern
- Develop risk assessment methodologies
- Determine risk based pollutant limits
- Determine management practices
- Issue comprehensive, risk based regulations (Part 503 Rule)

Identification of 200 Pollutants

- Human exposure and health effects
- Plant uptake of pollutants
- Phytotoxicity (adverse effects on plants)
- Effects in domestic animals and wildlife
- Effects in aquatic organisms
- Frequency of pollutant occurrence in biosolids

50 Pollutants Selected

- Probability pollutant would be toxic when exposure occurred
- Likelihood exposure to humans and the environment would occur via biosolids use or disposal
- Availability of toxicity and exposure data
- Best professional judgment

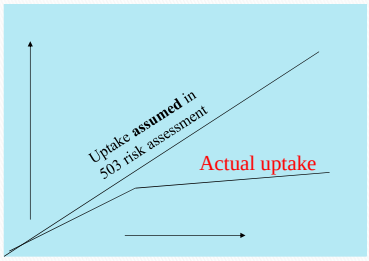
Further Refinements

- EPA conducts worst-case hazard profile assessment
- Science Advisory Board approves general risk assessment methodology
- EPA conducts risk assessments on most exposed individual (MEI)
- Peer review and public comment – further refinements
- EPA conducts National Sewage Sludge Survey
- EPA revises risk assessment – highly exposed individual (HEI), field data, more realistic assumptions and NSSS

Highly Exposed Individual

- 70 years HEI produces 59% of food from home garden (vs 100% for MEI)
- Biosolids amended soil contains max cumulative loading of each pollutant for 70 years
- Food harvested has plant uptake slope (geomean) taken from field studies (vs highest plant uptake for greenhouse studies
- Food consumption apportioned based on age and group (vs max ingestion all ages and groups) over 70 year life

Metal Uptake by Plants



Metal level in Biosolids amended soil

Land Application

- Biosolids applied by a "lifestyle" farmer to either pasture or cropland
  - once every two years
  - agronomic rates
- Climate and soil data to characterize the environmental setting and characterize exposure
  - meteorological
  - climate
- 9 farm resource regions
- 41 climate regions

9 Resource Regions

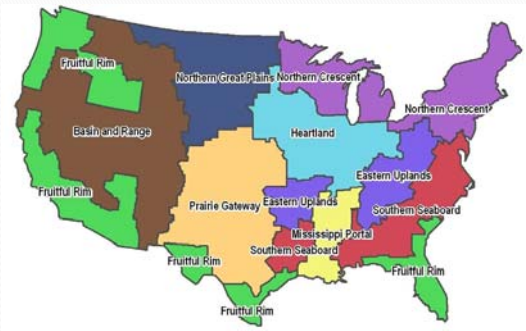


Figure 2-11. Map of the 9 resource regions.

41 Climate Regions

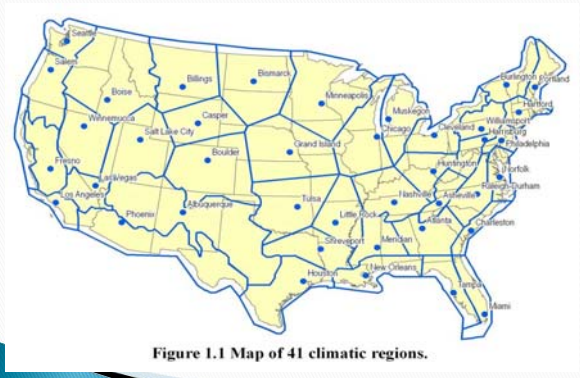
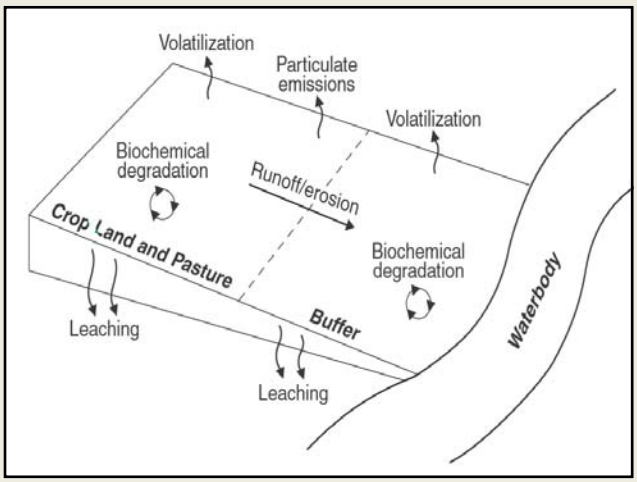
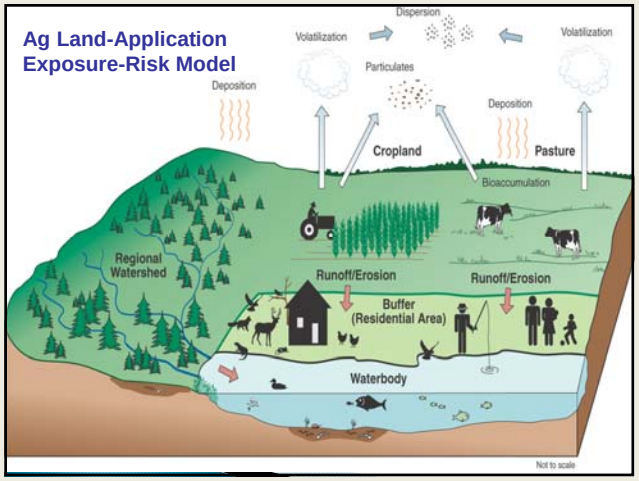
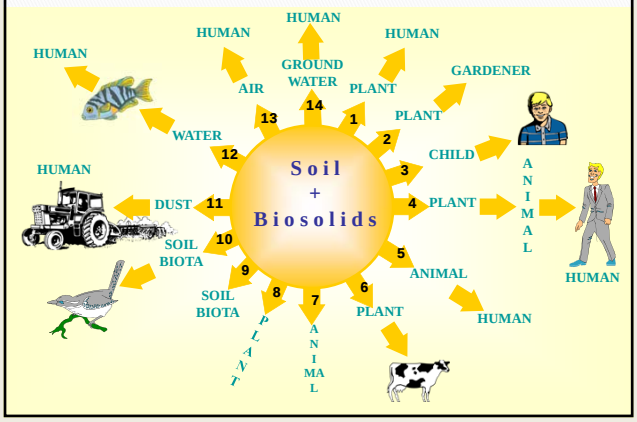


Figure 1.1 Map of 41 climatic regions.





14 - Pathway Risk Assessment



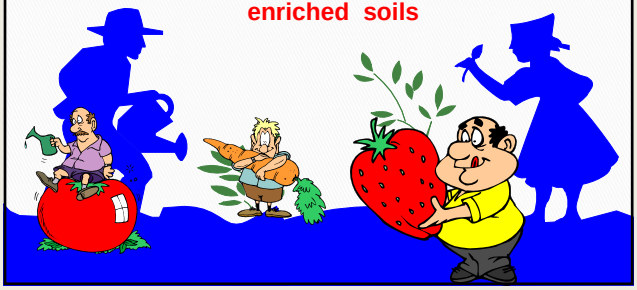
Part 503 Risk Assessment

Table 4.1
Exposure Pathways Used in the Part 503 Risk Assessment.

Pathway	Description of Highly Exposed Individual
1. Sludge→Soil→Plant→Human	Human (except home gardener) lifetime ingestion of plants grown in sludge-amended soil
2. Sludge→Soil→Plant→Human	Human (home gardener) lifetime ingestion of plants grown in sludge-amended soil
3. Sludge→Human	Human (child) ingesting sludge
4. Sludge→Soil→Plant→Animal→Human	Human lifetime ingestion of animal products (animals raised on forage grown on sludge-amended soil)
5. Sludge→Soil→Animal→Human	Human lifetime ingestion of animal products (animals ingest sludge directly)
6. Sludge→Soil→Plant→Animal	Animal lifetime ingestion of plants grown on sludge-amended soil
7. Sludge→Soil→Animal	Animal lifetime ingestion of sludge
8. Sludge→Soil→Plant	Plant toxicity due to taking up sludge pollutants when grown in sludge-amended soils
9. Sludge→Soil→Organism	Soil organism ingesting sludge-soil mixture
10. Sludge→Soil→Predator	Predator of soil organisms that have been exposed to sludge-amended soils
11. Sludge→Soil→Airborne dust→Human	Adult human lifetime inhalation of particles (dust) [e.g., tractor driver tilling a field]
12. Sludge→Soil→Surface water→Human	Human lifetime drinking surface water and ingesting fish containing pollutants in sludge
13. Sludge→Soil→Air→Human	Human lifetime inhalation of pollutants in sludge that volatilize to air
14. Sludge→Soil→Groundwater→Human	Human lifetime drinking well water containing pollutants from sludge that leach from soil to groundwater

Pathway Example: Biosolids → Soil → Plant → Human

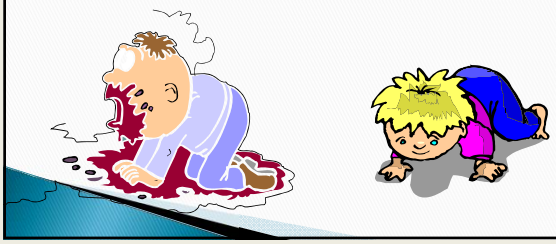
Significant portion of certain crops eaten by the Farm Family are grown on Biosolids enriched soils



Pathway Example: Biosolids → Soil → Human (Child)

Mean soil ingestion rates are cited as

100 mg/d for children (5 years)

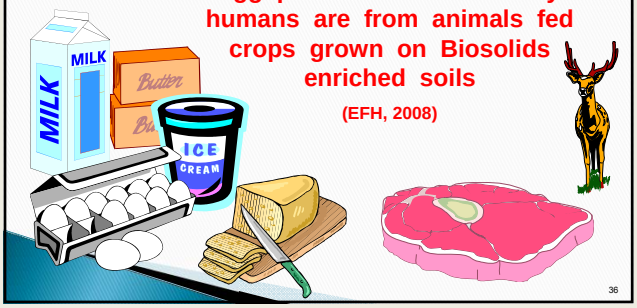


35

Pathway Example: Biosolids → Soil → Plant → Animal → Human

Up to 49% of meat, dairy and egg products consumed by humans are from animals fed crops grown on Biosolids enriched soils

(EFH, 2008)



36

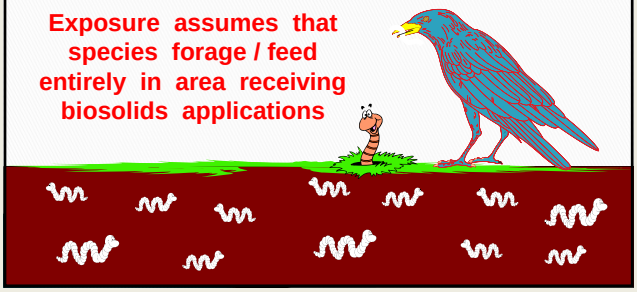
Pathway Example	Biosolids → Soil → Surface Water / Fish → Human

Human lifetime exposure through drinking surface water and ingesting fish containing pollutants in biosolids

Pathway Example	Biosolids → Soil → Organism → Predator

Wildlife foraging on soil organisms that have been exposed to biosolids–amended soil

Exposure assumes that species forage / feed entirely in area receiving biosolids applications



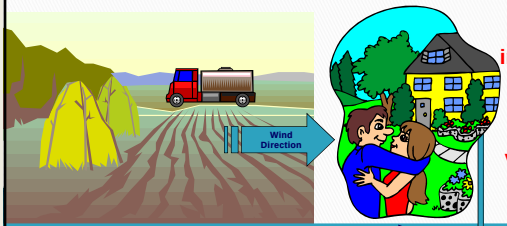
Pathway Example	Biosolids → Soil → Plant

Plant toxicity due to taking up pollutants when grown in biosolids–amended soil

Biosolids can cause growth reduction in sensitive plants

Pathway Examples	Biosolids → Soil → GW → Human → Air → Human

Human lifetime drinking well water containing pollutants from biosolids that leached from soil to ground water

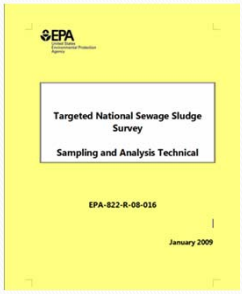


Humans lifetime inhalation of biosolids pollutants that volatilize to air

Ground Water Flow Direction → Well

POLLUTANT	CONTROLLING PATHWAY	PATHWAY SCENARIO
Arsenic Cadmium Lead Mercury Selenium	3	Child Eating Biosolids
Molybdenum	6	Animal Eating Feed
Copper Nickel Zinc	8	Plant Phytotoxicity

Targeted National Sewage Sludge Survey



http://water.epa.gov/scitech/wastetech/biosolids/biosolids_index.cfm

TNSSS Design

- Designed to provide nationally representative results
- Statistically selected 74 POTWs to represent 3,337 POTWs that met the following criteria:
  - Flow greater than 1 MGD
  - Secondary treatment or better
  - Located in the contiguous United States
- Peer-reviewed both survey design and analytical methods
- Sampled treated sewage sludge

TNSSS Design (cont)

Collected 84 samples at 74 POTWs in 35 states August 2006 – March 2007

Measured 145 analytes, including:

- 97 pharmaceuticals, steroids and hormones
  - ✓ 72 antibiotics and drugs (Rx and OTC)
  - ✓ 25 steroids and hormones
- 28 metals
- 11 polybrominated diphenyl ethers (PBDEs)
- 4 polycyclic aromatic hydrocarbons (PAHs)
- 3 inorganic ions
- 2 semivolatile organics

TNSSS Findings – Occurrence

Wide variation in minimum and maximum levels

Wide variation in detection frequency:

- 16 analytes (11%) not detected
- 129 analytes (89%) detected in at least one sample
- Most non-pharmaceuticals were detected in more than 50 of 84 samples
- Pharmaceuticals/steroids/hormones ranged from 0 to all 84 samples
- 42 analytes detected in 100% of samples (3 pharmaceuticals; 3 steroids & hormones; 36 metals, inorganic ions, organics)

Analyte	Use	# Detects (total=84)	Concentration Range Dry-Weight (ug/kg)
Flame Retardants			
BDE-47 (Tetra)	Reduces flammability	84	73 – 5,000
BDE-99 (Penta)		84	64 – 4,000
BDE-153 (Hexa)		84	9 – 410
BDE-209 (Deca)		83	150 – 17,000
Pharmaceuticals			
Azithromycin	Antibiotic	80	8 – 5,205
Diphenhydramine	Antihistimine	84	37 – 5,730
Caffeine	Psychoactive stimulant	39	65 – 1,100
Carbamazepine	Anticonvulsant	80	9 – 6,030
Cimetidine	Ant-acid	74	4 – 8,330
Ciprofloxacin	Antibiotic - strong	84	75 – 40,800
Fluoxetine	Antidepressant	79	10 – 3,130
Ibuprofen	Anti-inflammatory / Analgesic	54	99 – 11,900
Miconazole	Antifungal	80	7 – 9,210
Tetracycline	Antibiotic	81	38 – 5,270
Triclocarban	Antibacterial	84	187 – 441,000
Triclosan	Antibacterial	79	334 – 133,000

Analyte	Use	# Detects (total=84)	Concentration Range Dry-Weight (ug/kg)
Steroids / Hormones			
Campesterol	Plant sterol	84	2,840 – 524,000
Cholestanol	Cholesterol derivative	84	3,860 – 4,590,000
Coprostanol	Cholesterol derivative	84	7,720 – 43,700,00
Epicoprostanol	Pheromone	83	868 – 1,030,000
17 alpha-Estradiol	Estrogen replacement	5	16 - 48
17α-Ethynyl Estradiol	Widely prescribed estrogen	0	NA
β-Stigmastanol	Plant steroid	83	3,400 – 1,330,000
Stigmasterol	Plant steroid	76	455 – 56,500
Testosterone	Steroid hormone	17	30 – 2,040
PAHs, Semi-Volatile Organic Compounds			
Bis (2-ethylhexyl) phthalate	Plasticizer	84	657 – 310,000
4-Chloroaniline	Aniline derivative	63	51 – 5,900
Fluoranthene	Intermediate	77	45 – 12,000
Pyrene	Intermediate	72	44 – 14,000

Next Steps

Assess availability of data

Characterize risk where data are sufficient

- Evaluate exposure and effects to human and ecological receptors
  - 10 pollutants
  - 135 pollutants
- Biosolids Core Risk Assessment Model

Rick Stevens

U.S. Environmental Protection Agency
Office of Water
Office of Science and Technology
Health and Ecological Criteria Division
Washington, D.C.
202-566-1135
Stevens.Rick@epa.gov

http://water.epa.gov/scitech/wastetech/biosolids/

Historical Overview of Round 1 Biosolids Land Application Regulations

Thomas J. Crawford
Biosolids Barrister Emeritus
Milwaukee, Wisconsin

NBP Webcast
October 31, 2012

Political Climate of Round 1

- No dog in that fight - Congress imposed CWA mandates
  - Reagan Revolution - EPA budget cut 22%
  - New Federalism Devolution - biosolids use and disposal stays local
  - Administrator Anne Gorsuch - Superfund-gate, Rita Lavelle's perjury, contempt of Congress, Gorsuch "thrown-under-the-bus"
- Just before publication EPA back-off a proposed 98% cap during OMB review (98% Cr = 840 mg/kg)
- Signed Nov. 25, 1992 - George H. W. Bush lame duck administration
- Published Feb. 19, 1993 - Bill Clinton (pro-environment)

Before Risk Assessment

- Milorganite® - marketed as slow release N turf fertilizer since 1926
- Few state limits (Tobacco food crop)
- Fertilizer regulates only N-P-K label
- 1970s - Food crop cadmium (Cd) uptake
- Maryland 1st environmental permit
  - 50 ppm Cd limit, Milorganite hit 120 ppm Cd
- Milwaukee adopts local Cd limit
  - Master Lock discharged 80% of Cd

Regulatory Paradigms

If not best available control technology, then what?

- **Land application**
  - "discharge" of pollutants, "recycle" nutrients or "disposal" of solid or hazardous waste?
  - 1988 Congress bans Deep Ocean disposal
  - Dumping till 1993
- **Precautionary Principle**
  - No pollutant above soil background
- **Risk assessment - Do no harm**
  - Allow additional trace pollutants to soil without adverse effects

Domestic Sewage Exclusion

- Before Subpart B of Part 503 (2/19/1993)
  - 40 CFR Part 257 (1977). Cd, pathogen reduction and PCBs (soil incorporation if over 10 & less than 50)
- Solid waste means . . . sludge from a waste water treatment plant . . . except [bio-]solids . . . from point sources subject to [NPDES] permits . . . . 42 USC section 6903 (27)
- - action forcing deadlines to promulgate risk based limits and practices, section 405 of CWA

Three branches of government + citizen groups, states & stakeholders

- **Without land application standards that limit the concentration of pollutants in biosolids, Removal Credits could not be granted to industrial users**
  - Natural Resources Defense Council (NRDC) v. EPA, 790 F.2d 289 (3rd Cir. 1986) (Reagan 1984 pretreatment rule invalid)
- **1987 Amendments to CWA**
  - Congress briefly extended the mandate of the Court of Appeals until August 31, 1987 to promulgate biosolids standards

Another egregious failure of EPA to perform nondiscretionary duty

- "We leave for another day the puzzling question of how to compel a recalcitrant agency to perform a duty it has repeatedly by order to carry out, by Congress and the courts. Until that time, we wash our hands of the sludge problem."
  - Chicago Assn. of Commerce v. EPA, 873 F.2d 1025 (7th Cir. April 1989) (no removal credits until biosolids standards) (Cudahy, J.)
- Part 503 proposed Feb. 6, 1989
- Gather more data - NSSS

Pretreatment Matures

Section 519 Report to Congress (1991)

- Enhance pretreatment standards
- Improve local limits and programs
- Improve scientific basis of pretreatment limits
- Aggressive enforcement against NPDES permittees both SIUs and POTWs

◦ Phase 1 (1989) EPA enforces against 61 POTWs
◦ Phase 2 (1990) 69 more POTWs and 186 SIUs
◦ Initiative results in 670 penalty actions by EPA, states and POTWs (not including citizen suits)

Round1- Petitions for Review

◦ Leather Industries - most requested removal credit from Part 424 BACT (3,000 mg/kg chromium)
◦ City of Pueblo, CO (selenium toddler access to highways)
◦ Mil. Metro (pellet bag sale is different use/low risk)
◦ AMSA (now NACWA) (Chicago dedicated farms not disposal)
◦ Three Molybdenum Petitioners settled after EPA reconsidered the Mo limits, 59 Fed. Reg. 9095 (Feb 25, 1994)
◦ Anti-biosolids Advocates did not challenge the Part 503 paradigm, nor intervene in the cases

D.C. Circuit

- Cases transferred and consolidated D.C. Cir. Appeal Court
- Wine glass of heat dried pellets
- Oral argument, Judge Wald ask EPA about the difference between studies of toxic Hex-Cr and nontoxic Trivalent chromium
- Congress ordered:
  - Numeric standards and management practices adequate to protect public health and the environment from any reasonably anticipated adverse effects of each pollutant
- Limits must have some relationship to risk
  - Based on evidence of risk, not merely a margin of safety

Summary of Argument

- Gross Application Scenario arbitrarily included all "sludge uses" to wit: heat dried bag sales to homeowners
- Statistically derived pollutant "caps" not based on concentrations which may adversely affect health or environment - not risk based according to law
- Limits not based on risk will mislead consumers on the degree of safety. False government compelled speech undercuts public acceptance
- Chicago's dedicated "beneficial" use sites wrongly misclassified as "disposal sites" - Stigma
- Relief requested - remand on heat dried pellet use and invalid standards not based on risk assessment.

Failure to Explain Choices

- Agency must justify its failure to take account of circumstances that appear to warrant different treatment for different parties
- Either justify "one-size-fits-all" highly conservative assumptions on the rate and durance of biosolids use or provided more tailored caps that fit the data in the record on heat dried pellet use
  - 10 mt/ha x 100 years vs. 2.2 mt/ha x 20 yrs

Would States follow the Part 503 Risk Assessment?

- Upon remand, MMSD did not pursue new pollutant standards for pellets sold in bags to consumers based on actual application rates
  - Decade of State rule making proceedings
- Begin 48-state annual reporting
- Begin paying fees (often dry tons sold)
- How many 503 state issued permits?
  - One time state approval (NOI)
  - Full NPDES permitting

Duplicative State Rules - Some Frustration

- Limited State interest in delegation of Part 503 program
  - No $$ = no incentive to seek delegation
- State law variation expected
  - Florida Urban Turf Rule
- State regulation varies for Bags vs. Bulk use
- Florida rule variance
  - Analytic results must be in-State certified lab
  - NELAP certification (National Environmental Laboratory Certification Program)

Chromium 1200 ppm or No Limit?

- States may regulate Cr
  - Ossification of science
  - State agency rule making burdens & procedures
- Non pica toddler soil consumption most sensitive pathway
- Plant uptake minor to irrelevant risk
- No evidence that caps would prevent "backsliding" of biosolids quality
- Law does not require pollutant elimination

Selenium – explain toddler risk on highways

- Pueblo - I/I naturally high selenium
- Pathway 3 = HEI non-pica toddler daily consumption of biosolids/soil
- 100 mg/kg Se table 1 ceiling in biosolids
- 100 kg/hectare Se table 2 cumulative = toddler safe
- Pueblo's actual biosolids use = application to highway median strips with low potential for public contact or toddlers

99th percentile caps not based on risk-related

- More restrictive caps are not lawful merely because more restrictive
- Little risk from land application biosolids
- Margin of safety is not a blanket one-way ratchet to tighten standards
  - "Statutes do more than point in a direction such as 'more safety.' They achieve a particular amount of that objective, at a particular costs in other interests. An agency cannot treat a statute as authorizing an indefinite march in a single direction." Judge Posner

Mo Revisited

- Molybdenosis eradicated
- 44 mg/kg rounded down to 40 mg/kg protects grazing ruminants the risk of molybdenum induced copper deficiency via forage grown on biosolids
  - George O'Connor, Robert Brobst, Rufus Chaney, Ron Kincaid, Lee McDowell, Gary Pierzynski, Alan Rubin and Gary Van Riper, A Modified Risk Assessment to Establish Molybdenum Standards for Land Application of Biosolids, J. of Environ. Qual. 30:1490-1507 (2001)

Pollutants eligible for Removal Credits

- Part 403, App G lists PCBs at 4.6 mg/kg
- App G = no adverse effect level based on most limiting of 14 pathways for 12 organic pollutants
- 2.3 mg/kg is "corrected" PCB limit
  - Rufus Chaney, James Ryan & George O'Connor. Pathway Analysis of Terrestrial Risks in Land-Applied Biosolids Based on Field Measured Transfer Coefficients, Proceedings of the Conference on Management of Fate of Toxic Organics in Sludge Applied to Land. Tech. U of Denmark, Copenhagen (April 30 to May 2, 1997)

30 years later

- Few "corrections" to 1993 rule
- Pretreatment works
- Industrial discharges to POTWs down
- Residential trace organic chemicals (TOrCs)
- No harm from biosolids pollutants in soil managed pursuant to Part 503 paradigm
- Beneficial use widely accepted, except organic-food-certification-discrimination of biosolids organic pedigree

Thank You!!

Tom Crawford
canoetommy@gmail.com

1539 North 50th Street
Milwaukee, WI 53208-2210
mobile: 1-414-241-5350

BIOSOLIDS 101

Fundamentals of Practice

REGULATIONS AND MANAGEMENT PRACTICES

Dr. Michael J. McFarland, PE, BCEE
Department of Civil and Environmental Engineering
Utah State University
Logan, UT
farlandm@msn.com

NBP Webcast
October 31, 2012

REGULATORY OVERVIEW

- The term "biosolids" reflects the **beneficial** characteristics of residual solids generated from **municipal** wastewater treatment processes.
- The 40 CFR Part 503 rule also applies to **domestic** septage.

73

REGULATORY OVERVIEW

Land Application of biosolids includes a number of **beneficial** uses:

1. *Agricultural land for food production*
2. *Agricultural land for production of feed and fiber crops*
3. *Pasture and rangeland*
4. *Non-agricultural land (e.g., forests)*
5. *Disturbed lands (e.g., highway embankments, mine reclamation, etc.)*
6. *Construction sites and gravel pits*
7. *Public contact sites (e.g., parks, cemeteries)*
8. *Home lawns and gardens*

74

Basics of 40 CFR Part 503

- To comply with 40 CFR Part 503 Subpart B, biosolids quality **and** reuse practices must meet the following **enforceable** criteria:

1. ***Pollutant Limits***
2. ***Pathogen Control Class (Class A or B)***
3. ***Vector Attraction Reduction Level***

75

Pollutant Limits[1]

(40 CFR Part 503.13)

POLLUTANT	Table 1 Ceiling Concentration Limits (mg/kg)	Table 2 Cumulative Pollutant Loading Rates (kg/ha)	Table 3 Pollutant Concentration Limits (mg/kg)	Table 4 Annual Pollutant Loading Rates (kg/ha)
Arsenic (Total)	75	41 (37 lb/ac)	41	2.0
Cadmium (Total)	85	39 (35 lb/ac)	39	1.9
Copper (Total)	4,300	1,500 (1,335 lb/ac)	1,500	75
Lead (Total)	840	300 (268 lb/ac)	300	15
Mercury (Total)	57	17 (15 lb/ac)	17	0.85
Molybdenum (Total)	75	**	**	**
Nickel (Total)	420	420 (375 lb/ac)	420	21
Selenium (Total)	100	100 (89 lb/ac)	100	5.0
Zinc (Total)	7,500	2,800 (2,500 lb/ac)	2,800	140

[1]Dry Mass Basis
** Molybdenum Limits Deleted From Regulation Pending Regulatory Consideration

76

Pollutant Limits (40 CFR Part 503.13)

- No biosolids can be land applied if they exceed the Ceiling Concentration Limits listed in Table 1.

- Other limits apply to specific biosolids use or disposal options.

77

Pollutant Limits (40 CFR Part 503.13)

- If biosolids pollutant concentrations meet the Table 3 values, land appliers are offered two important regulatory benefits:

1. There are no limits on the lifetime quantity of pollutants that can be applied to a site.
2. The biosolids application rate is dependent ONLY on the AGRONOMIC rate.

78

Pollutant Limits (40 CFR Part 503.13)

- The EPA defines the AGRONOMIC RATE as the biosolids land application rate that provides nitrogen at a level that just satisfies the crop nitrogen requirement.

79

AGRONOMIC RATE CALCULATIONS

- Except for land reclamation, the Part 503 rule requires that biosolids be land applied at a rate that is equal to or less than the AGRONOMIC RATE.

80

AGRONOMIC RATE CALCULATIONS

- Estimating the Agronomic Rate Requires Knowledge of:

1. *Nitrogen levels in soil*
2. *Crop nitrogen requirement*
3. *Nitrogen availability in biosolids*
4. *Nitrogen losses (e.g., volatilization)*

81

AGRONOMIC RATE CALCULATIONS

- Selecting crops with high nitrogen demands (*e.g.*, forages, soybeans, *etc.*) will minimize the amount of land required for biosolids land application.

82

AGRONOMIC RATE CALCULATIONS

- The first step in estimating the AGRONOMIC RATE is to determine the plant available nitrogen (PAN) in biosolids (lbs N per ton or kg N per mt).
- PAN is determined by the nitrate, ammonia and organic nitrogen concentrations in biosolids.

83

AGRONOMIC RATE CALCULATIONS

$$\text{Plant Available Nitrogen per Ton of Biosolids } \left(\frac{\text{lbs N}}{\text{ton}}\right) = (NO_3) + K_v \bullet (NH_4) + K_{MIN} \bullet (N_o)$$

where :

$(NO_3) = \frac{\text{lbs of Nitrate - N}}{\text{ton}}$

$(NH_4) = \frac{\text{lbs of Ammonia - N}}{\text{ton}}$

$(N_o) = \frac{\text{lbs of Organic - N}}{\text{ton}}$

K_v = Ammonia Volatilization Factor (0.5 for liquid biosolids that are surface applied, 1.0 for all others)

K_{MIN} = Mineralization Factor (dependent on the type of biosolids, typically 0.1 to 0.3)

84

AGRONOMIC RATE CALCULATIONS

Biosolids Application Method	Ammonia Volatilization Factor (K_v)
Liquid - surface applied	0.5 (50% ammonia loss)
Liquid - soil injected	1.0 (no loss)
Dewatered - surface applied	1.0 (no loss)

85

Organic Nitrogen Mineralization Factors (K_{MIN})			
Waste Activated Sludge	Aerobically Digested Biosolids	Anaerobically Digested Biosolids	Composted Biosolids
0.40	0.30	0.20	0.10

86

AGRONOMIC RATE CALCULATIONS

- The next step in estimating the **AGRONOMIC RATE** is to determine the residual nitrogen levels in soil in units of lbs per acre (lb/ac-furrow).

- You can either take soil measurements OR you can model the mineralization of organic nitrogen over time.

87

AGRONOMIC RATE CALCULATIONS

- The two types of nitrogen that can be utilized by crops are **nitrate** and **ammonia**.

- To convert soil nitrogen concentrations in **mg N per kg of soil** to **lbs N per acre**, you need to estimate soil bulk density (lbs/ft^3).

88

AGRONOMIC RATE CALCULATIONS

- The final step in estimating the **AGRONOMIC RATE** is to identify the crop and its nitrogen requirement in pounds of nitrogen per acre.

AGRONOMIC RATE CALCULATIONS

- The **AGRONOMIC RATE** equation is given as follows:

$$\text{Agronomic Rate}\left(\frac{\text{tons}}{\text{acre}}\right) = \frac{\text{Adjusted Nitrogen Requiremen t}\left(\frac{\text{lbs N}}{\text{acre}}\right)}{\text{PAN per Ton of Biosolids}\left(\frac{\text{lbs N}}{\text{Ton of Biosolids}}\right)}$$

$$= \frac{\text{Adjusted Nitrogen Requiremen t}\left(\frac{\text{lbs N}}{\text{acre}}\right)}{(NO_3 - N) + K_v \bullet (NH_4^+ - N) + K_{min} \bullet (N_o)}$$

where : $\text{Adjusted Nitrogen Requiremen t}\left(\frac{\text{lbs N}}{\text{acre}}\right) = \text{Crop Requiremen t}\left(\frac{\text{lbs N}}{\text{acre}}\right)$

$$- \text{Soil Residual Nitrogen Level}\left(\frac{\text{lbs N}}{\text{acre}}\right)$$

Pollutant Limits (40 CFR Part 503.13)

- If pollutant concentrations comply with Table 1 BUT exceed Table 3, their lifetime application of pollutants is limited by the Cumulative Pollutant Loading Rate Limit (CPLR) – Table 2.
- Once the CPLR has been reached, NO more biosolids may be land applied!!!

Pollutant Limits (40 CFR Part 503.13)

- When the CPLR limits apply, the land applier MUST determine the site life given a biosolids application rate OR an application rate given a design site life.

Pathogen Control

- In addition to meeting pollutant limits, all land applied biosolids must meet either Class A or Class B pathogen control criteria.
- All biosolids applied to lawns or home gardens and all biosolids sold or given away in bags or other containers must meet Class A pathogen reduction criteria.

Pathogen Control

- Class A pathogen control criteria requires that pathogen concentrations are maintained below detectable levels.
- Class B pathogen control criteria requires that pathogen levels are unlikely to pose a threat to public health and the environment.

Pathogen Control

Class A	Class B
Salmonella species - less than three (3) MPN[1] per four (4) grams total solids (or less than $1 \cdot 10^3$ MPN fecal coliforms per gram total solids)	Fecal Coliforms - less than $2 \cdot 10^6$ colony forming units (CFU) per gram total solids
Enteric viruses - less than one (1) MPN (or plaque forming unit) per four (4) grams total solids	
Viable helminth ova - less than one (1) MPN per four (4) grams total solids	

[1]MPN – Most Probable Number

95

Class A Pathogen Control

- To achieve Class A pathogen control, a facility can choose one of six alternatives.

▪ Alt. 1 - Use of a time/temperature based biosolids treatment process while meeting the pathogen limit based on an indicator organism (fecal coliforms) or *Salmonella sp*.	▪ Alt. 2 - Use of an alkali/air drying stabilization process while also meeting the pathogen based limit.	▪ Alt. 3 - Demonstrate the performance of a process for reducing enteric viruses and helminth ova while meeting the bacteria based pathogen limit.
▪ Alt. 4 - Testing for pathogens – fecal coliform bacteria, enteric viruses and helminth ova at the time biosolids are used or disposed.	▪ Alt. 5 - Biosolids treatment in a process to further reduce pathogens (PFRP).	▪ Alt. 6 - Use a process deemed equivalent to PFRP by the permitting authority.

96

Class B Pathogen Control

- There are three (3) alternatives available for achieving Class B pathogen control criteria.

• Alt. 1 - Determine the concentration of fecal coliforms from a minimum of seven (7) samples taken over a two (2) week period. The samples must demonstrate that the geometric mean fecal coliform concentration is less than $2 \cdot 10^6$ most probable number (MPN) per gram of total solids (dry weight).	• Alt. 2 - Use a process to significantly reduce pathogens (PSRP).	• Alt. 3 - Employ a process determined by the permitting authority to be equivalent to PSRP.

97

Site Restrictions for Class B Biosolids

- Since Class B biosolids may contain significant levels of pathogens, site restrictions that limit crop harvesting, animal grazing and public access must be enforced.

Site Restrictions for Class B Biosolids

• Food crops with harvested parts that touch biosolids and are totally above the land surface shall not be harvested for at least 14 months after biosolids application.	• Animals shall not be allowed to graze on the land for 30 days after application of biosolids.	• Public access to land with a high potential for public exposure shall be restricted for one year after application of biosolids. Public access to land with a low potential for public exposure shall be restricted for 30 days after application of biosolids.
• Food crops with harvested parts below the land surface shall not be harvested for at least 20 months after application of biosolids when the biosolids remain on the land surface for four months or longer prior to incorporation into the soil.	• Turf grown on land where biosolids have been applied shall not be harvested for at least one year after application when the harvested turf is placed on either land with a high potential for public exposure or a lawn, unless otherwise specified by the permitting authority.	
• Food crops with harvested parts below the land surface shall not be harvested for at least 38 months after application of biosolids when the biosolids remain on the land surface for less than four months prior to incorporation into the soil.	• Food crops, feed crops, and fiber crops shall not be harvested for at least 30 days after application of biosolids.	

99

Vector Attraction Reduction

- In addition to pollutant limits and pathogens, land applied biosolids must meet vector attraction reduction requirements.
- Vectors are organisms that can potentially transport pathogens (insects, birds, rodents).

Vector Attraction Reduction

- The Part 503 rule contains ten (10) options for facilities to meet vector attraction reduction requirements.
- The first eight options involve the reduction of the volatile solids or moisture content of the biosolids while the last two involve placing a barrier between biosolids and vectors.

Opt. 1 - Reduction of volatile solids by at least 38% during treatment.	Opt. 4 - Specific Oxygen Uptake Rate for Aerobically Digested Biosolids - Demonstrate that the specific oxygen uptake rate is equal to or less than 1.5 mg oxygen per hour per gram of biosolids at 20 °C (68° F).	Opt. 7 - Moisture Reduction of Biosolids Containing No Unstabilized Solids - The solids content of the biosolids is at least 75%.	Opt. 10 - Biosolids applied to the land surface must be incorporated into the soil within six (6) hours after application to or placement on the land. If Class A biosolids are incorporated, they must be added to the soil within eight (8) hours after the biosolids are discharged from the pathogen reduction process.
Opt. 2 - Additional Digestion of Anaerobically Digested Biosolids- Biosolids lose less than 17% additional volatile solids when digested in a bench scale reactor operated at 30 to 37°C (86° to 98.6° F) for an additional 40 days.	Opt. 5 - Aerobic Process Operated at Greater Than 40°C (104° F) - Biosolids that are aerobically treated for 14 days or longer during which time the temperature must be over 40°C (104° F) and the average temperature higher than 45° C (113° F).	Opt. 8 - Moisture Reduction of Biosolids Containing Unstabilized Solids - The solids content is increased to 90% or greater.	
Opt. 3 - Additional Digestion of Aerobically Digested Biosolids - Biosolids lose less than 15% additional volatile solids digested in the laboratory in a bench scale unit operated at 20°C (68° F) or higher for an additional 30 days.	Opt. 6 - Addition of Alkali - Raise the pH to at least 12. Maintain a pH of at least 12 without addition of more alkali for 2 hours and maintain a pH of at least 11.5 without addition of more alkali for an additional 22 hours.	Opt. 9 - Injecting biosolids below the ground. No significant amount of biosolids may be present on the soil surface within one (1) hour. If Class A biosolids, the injection must occur within eight (8) hours after the biosolids are discharged from the pathogen reduction treatment process.	

10
2

Monitoring Frequency

- The frequency of monitoring pollutants, pathogen concentrations (densities) and VAR depends on the annual land application rate.

US Tons	Metric Tons	Minimum Monitoring Frequency
0 - 320	0 – 290	Once per year
320 - 1,650	290 – 1,500	Once per quarter (4 times per year)
1,650 - 16,500	1,500 – 15, 000	Once per sixty days (6 times per year)
> 16,500	> 15,000	One per month (12 times per year)

10
3

Management Practices

- Endangered Species

1. Land application of biosolids is prohibited if it could negatively impact endangered or threatened species or their designated critical habitat.

2. It is the responsibility of the land applier to determine if land application will adversely effect endangered species or their critical habitat.

Management Practices

- Frozen or Snow Covered Ground

1. Application of biosolids to flooded, frozen or snow covered land is not prohibited by the Part 503 rule
2. Biosolids applied to such land must not enter surface waters or wetlands unless specifically authorized by a permit issued under Sections 402 or 404 of the CWA.

Management Practices

- Distance to Surface Waters

1. Bulk biosolids may not be applied within ten meters (i.e., 33 feet) of any waters of the US unless specified by the permitting authority (i.e. re-vegetation of stream bank).

Management Practices

- Exceptional Quality or EQ Biosolids are exempt from 40 CFR Part 503 general requirements and management practices.
- To be EQ, biosolids must comply with:

1. Table 3 of Part 503 (Pollutant Concentrations)
2. Meet Class A Pathogen Reduction Control
3. Achieve VAR Using One of the First 8 Options

REFERENCES

- McFarland, M. J. 2001. Biosolids Engineering. McGraw-Hill Book Company, Inc., New York, New York - ISBN 0-07-047178-9
- USEPA. 1994. A Plain English Guide to EPA Part 503 Biosolids Rule EPA-832-R-93-003. Office of Wastewater Management, Washington, DC
- USEPA. 1995a. Land Application of Sewage Sludge and Domestic Septage – Process Design Manual. EPA-625-R-95-001

10
8

CONTACT INFORMATION

Dr. Michael J. McFarland, PE, BCEE
Department of Civil and Environmental Engineering
Utah State University
1405 Mount Logan Drive
Logan, UT 84321

farlandm@msn.com
435-994-0905

10
9

QUESTIONS?

11
0