Arsenic: Municipal Industrial Sources and Biosolids Sinks

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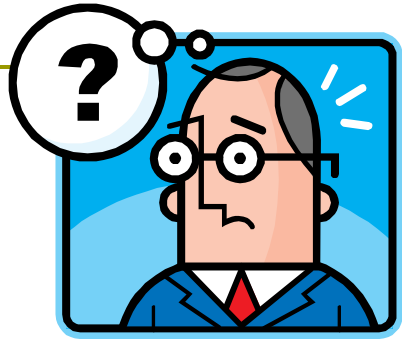
Potential negative impacts to Biosolids from Arsenic Water Treatment Plant backwash



- Answers not exactly clear. More questions than answers
  - Circumstantial evidence might suggest there are impacts, some data inconclusive.
  - What do we mean by negative impact? IPP definition of pass through and interference? If concentrating what is acceptable?

Discussion Summary

- Provide some background of the issue
- Present data and develop more questions
- Discuss possible wwtp remedies to reduce As headwork loading
- Raise awareness in IPP/BS industrial regarding potential impacts and encourage more research.

Regulatory Background of Arsenic

- **The previous drinking water standard was established at 50 ppb in 1975**
- **In 1996, Congress amended the SDWA and directed EPA to propose a new arsenic regulation**

Arsenic Rulemaking

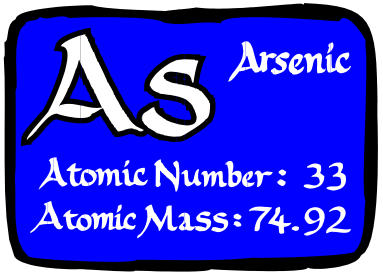
- Final Arsenic Rule
  - January 22, 2001
  - 10.0 ppb standard for arsenic
  - Enforceable on January 23, 2006

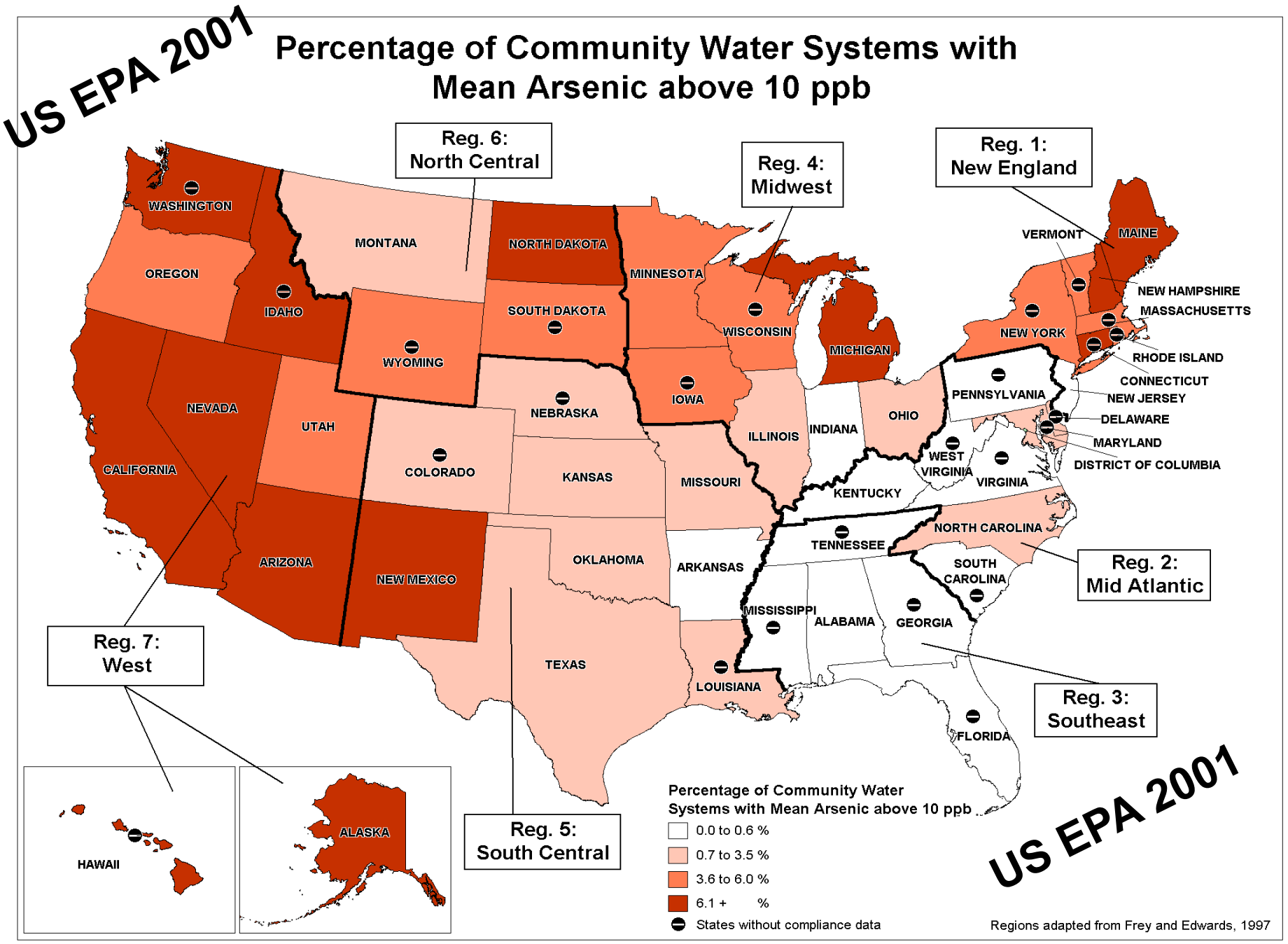
Arsenic Rule

- New MCL applies to all CWSs and NTNCWs
- Estimate that ~450 MI systems will exceed MCL

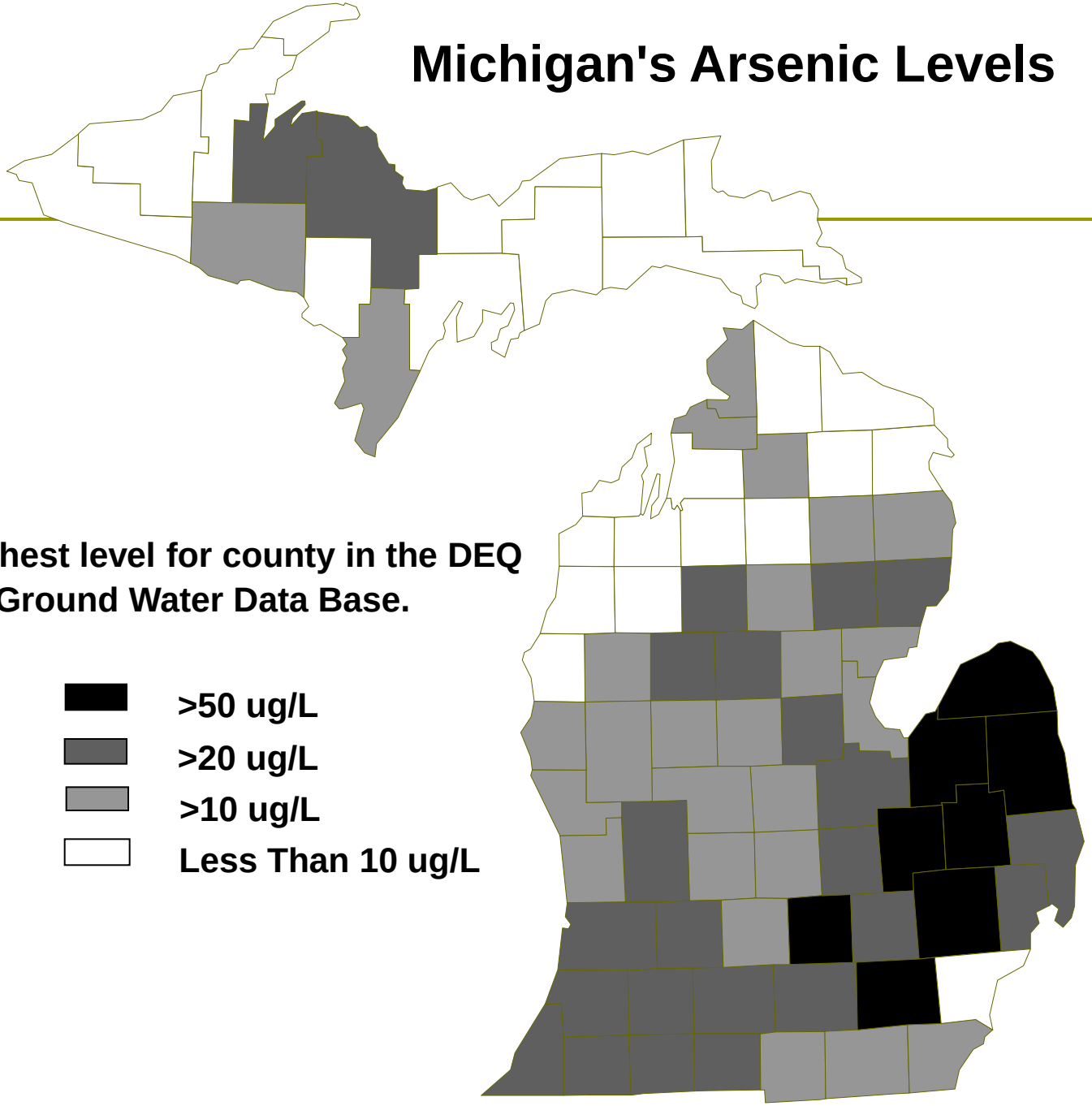
Arsenic Occurrence

- Naturally occurring element
- Found throughout the United States
- Weathers from rocks and soils
- Primarily found in ground waters
- Also associated with wood preserving, mining, agriculture, pulp and paper production, burning of fossil fuels




US EPA 2001
Percentage of Community Water Systems with Mean Arsenic above 10 ppb
Reg. 6: North Central
Reg. 4: Midwest
Reg. 1: New England
WASHINGTON
OREGON
CALIFORNIA
IDAHO
NEVADA
MONTANA
WYOMING
UTAH
ARIZONA
COLORADO
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LOUISIANA
WISCONSIN
ILLINOIS
MICHIGAN
INDIANA
OHIO
KENTUCKY
TENNESSEE
MISSISSIPPI
ALABAMA
GEORGIA
FLORIDA
SOUTH CAROLINA
NORTH CAROLINA
VIRGINIA
WEST VIRGINIA
PENNSYLVANIA
NEW YORK
VERMONT
MAINE
NEW HAMPSHIRE
MASSACHUSETTS
RHODE ISLAND
CONNECTICUT
NEW JERSEY
DELAWARE
MARYLAND
DISTRICT OF COLUMBIA
Reg. 2: Mid Atlantic
Reg. 3: Southeast
Reg. 5: South Central
Reg. 7: West
HAWAII
ALASKA
Percentage of Community Water Systems with Mean Arsenic above 10 ppb
0.0 to 0.6 %
0.7 to 3.5 %
3.6 to 6.0 %
6.1 + %
States without compliance data
US EPA 2001
Regions adapted from Frey and Edwards, 1997

Michigan's Arsenic Levels



Highest level for county in the DEQ Ground Water Data Base.

- **>50 ug/L**
- **>20 ug/L**
- **>10 ug/L**
- **Less Than 10 ug/L**

Arsenic Water Chemistry

Arsenic Species

As (III) - **$H_3AsO_3^0$** , $H_2AsO_3^{-1}$, $HAsO_3^{-2}$

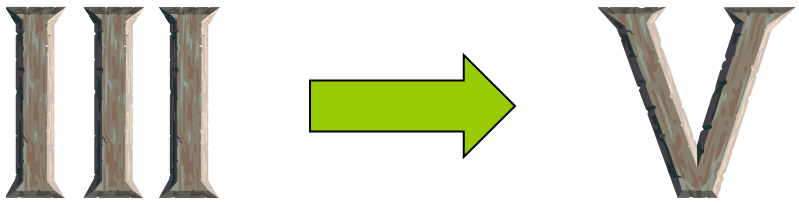
As (V) - $H_3AsO_4^0$, **$HAsO_4^{-1}$** , **AsO_4^{-2}**

Arsenic Chemistry

For maximum As removal

oxidize As (III) to As (V)

before applying treatment



As III Oxidation

Effective!

- **Free Chlorine**
- **Potassium Permanganate**
- **Ozone**
- **Solid Oxidizing Media** **(MnO_2 solids)**

Ineffective

- **Chloramine**
- **Chlorine Dioxide**
- **UV Radiation**

Typical Arsenic water treatment options

- **Conventional iron removal**
- **Modified iron removal**
- Anion exchange
- **Adsorptive media**
  - **-Iron based**
  - -Alumina based

Conventional Iron Removal

- If you can remove iron, you can usually remove arsenic.
- Oxidation converts arsenic (III), *arsenite*, to arsenic (V), *arsenate*.
- Ratio of iron to arsenic should be at least 20:1 for effective removal of As.
- Most ground waters in MI are in As (III) state, so a strong oxidant (CL_2, $KmMn0_4$) may have to be used to covert to (III) to (V).
- Backwash will contain both Fe and As.

Adsorption medias

- Adsorption is contaminant removal from water by attachment onto the surface of a porous solid

  - Advantage - Binds and removes some of the As in backwash.
  - Disadvantage - Varying levels of success and Costs associated with periodic removal / disposal of spent media.

Backwash Water Considerations

- Conventional iron, modified iron and anion removal systems are backwashed/regenerated every 1-7 days and will contain arsenic in the backwash water.
- Adsorption based medias are backwashed every 7-30 days depending a raw water quality.
- Backwash water from adsorptive media MAY contain elevated levels of As, depending how system is designed (i.e. is As bound to the naturally occurring iron in the raw water or is adsorbed onto the media?)

Backwash Disposal Options

Liquid Residuals Brine, Backwash Water, Rinse Water, Acid Neutraliztion Water, Concentrate			
Disposal Option	**Waste Type**	**Applicable Authority**	**Key Considerations**
Discharge directly to surface waters	Non-hazardous	CWA	▫NPDES Permit ▫Appropriate receiving body
Discharge to a Publicly Owned Treatment Works (POTW)	Non-hazardous	CWA	▫Meet MAHL, POTW and state requirements *Preferred option for most*
Injection to a Class 1 UIC Well	Hazardous, Non-hazardous, & Mixed	SDWA/UIC Regs.	▫Expensive, complex, and few wells ▫Permit required
Injection to a Class V UIC Well	Non-hazardous	SDWA/UIC Regs.	▫Injection prohibited if it will endanger an underground source of drinking water

ATP backwash disposal alternatives

- NPDES Gen Permit –
  - As monitoring requirement. No limit /Report (150 ug/l monthly – 680 ug/l daily)
    - Difficult to obtain with convention iron removal system
  - Presently ATP with adsorptive media more likely candidate for general permit….
    - However some discussion with permits unit of applying the Rule 57 number of 10 ug/l to all surface water discharges.

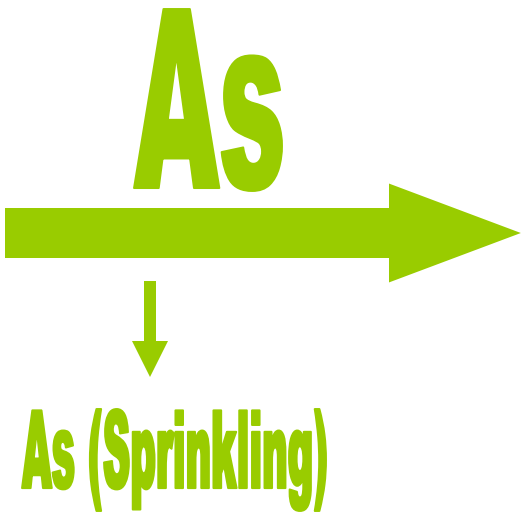
ATP R &D Phase – circa 2000

-concerns surface on As backwash

- Some in wastewater industry expressed concerns regarding POTWs receiving As backwash.
  - Inhibition of unit process?
  - As precipitant concentrating in the residuals?
- Others felt impacts were unlikely or minimal
  - Mass balance -

Mass Balance

- Original Water System
  - All arsenic from wells & eventual to WWTP
    - Concentration & Flow Constant
  - Exception Losses (Minor) from distribution system
    - Sprinkling and Fire Hydrants



IPP Perspective-

- Part 23 Rules -R323.2303(1)
  - "…non domestic user may not introduce into any POTW any pollutant that causes pass-through or interference…"
    - Interference roughly defined as a discharge inhibits process or sludge processes, use or disposal.
  - Not aware of unit process inhibition from As backwash.
  - Q -Is the backwash inhibiting sludge process use or disposal?

Biosolids Perspective - Part 24 Rules R 323.2409(5)

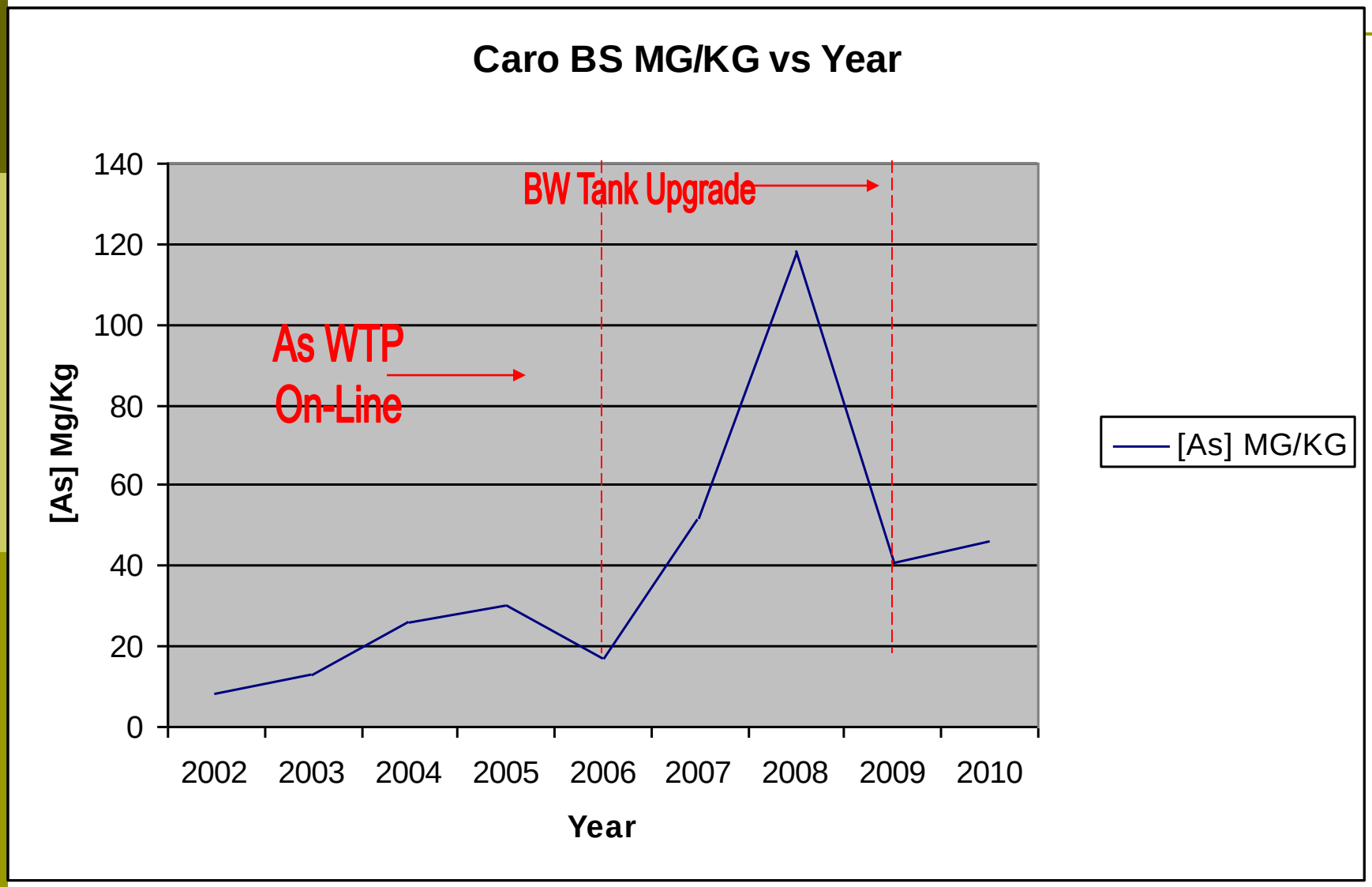
TABLE 1 -- CEILING POLLUTANT CONCENTRATIONS

Pollutant	Ceiling Concentration milligrams per kilogram (on a dry weight basis)
Arsenic	75
Cadmium	85
Copper	4300
Lead	840
Mercury	57
Molybdenum	75
Nickel	420
Selenium	100
Zinc	7500

TABLE 3 -- POLLUTANT CONCENTRATIONS

Pollutant	Concentration milligrams per kilogram (on a dry weight basis)
Arsenic	41
Cadmium	39
Copper	1500
Lead	300
Mercury	17
Nickel	420
Selenium	100
Zinc	2800

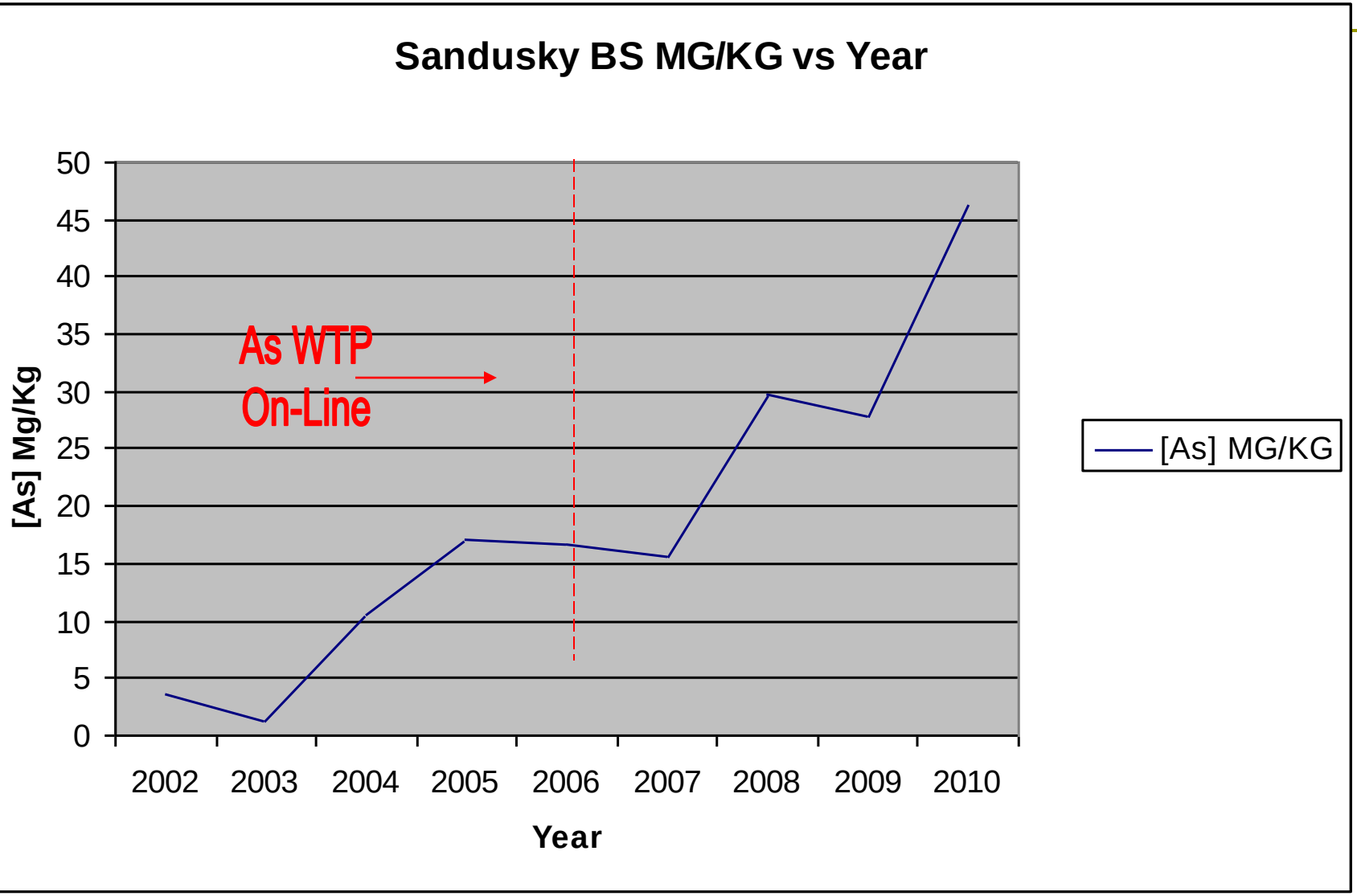
Lets look at the data!


Caro BS MG/KG vs Year
[As] Mg/Kg
140
120
100
80
60
40
20
0
2002
2003
2004
2005
2006
2007
2008
2009
2010
Year
BW Tank Upgrade
As WTP
On-Line
[As] MG/KG

Caro ATP backwash tank

- Original design ineffective - outlet at bottom of tank
- Raised outlet and allow backwash to settle
- Use City owned vac truck to periodically remove As precipitant
- Place As precipitant on wwtp drying beds and lanfill.

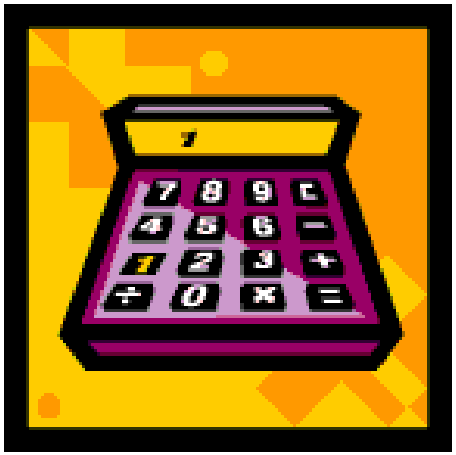
Sandusky As Concentrations

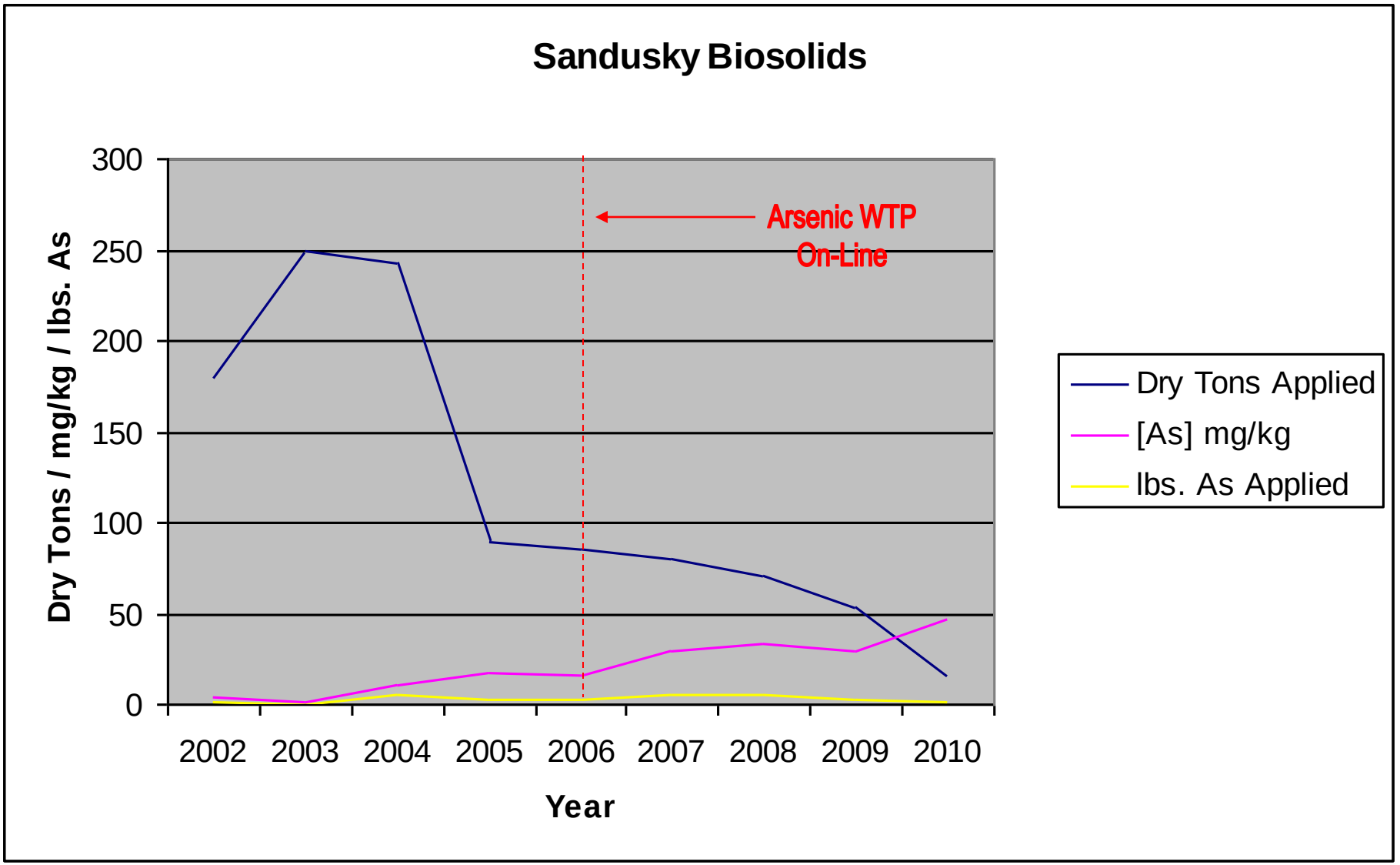


Mass Balance

- Q = Flow Rate, GPD
- C = Concentration, mg/l
- M =Mass, Lbs/Day

- $C \times Q \times 8.34 \times 10^{-6} = M$




Sandusky Biosolids
Dry Tons / mg/kg / lbs. As
300
250
200
150
100
50
0
2002
2003
2004
2005
2006
2007
2008
2009
2010
Year
Arsenic WTP
On-Line
Dry Tons Applied
[As] mg/kg
lbs. As Applied

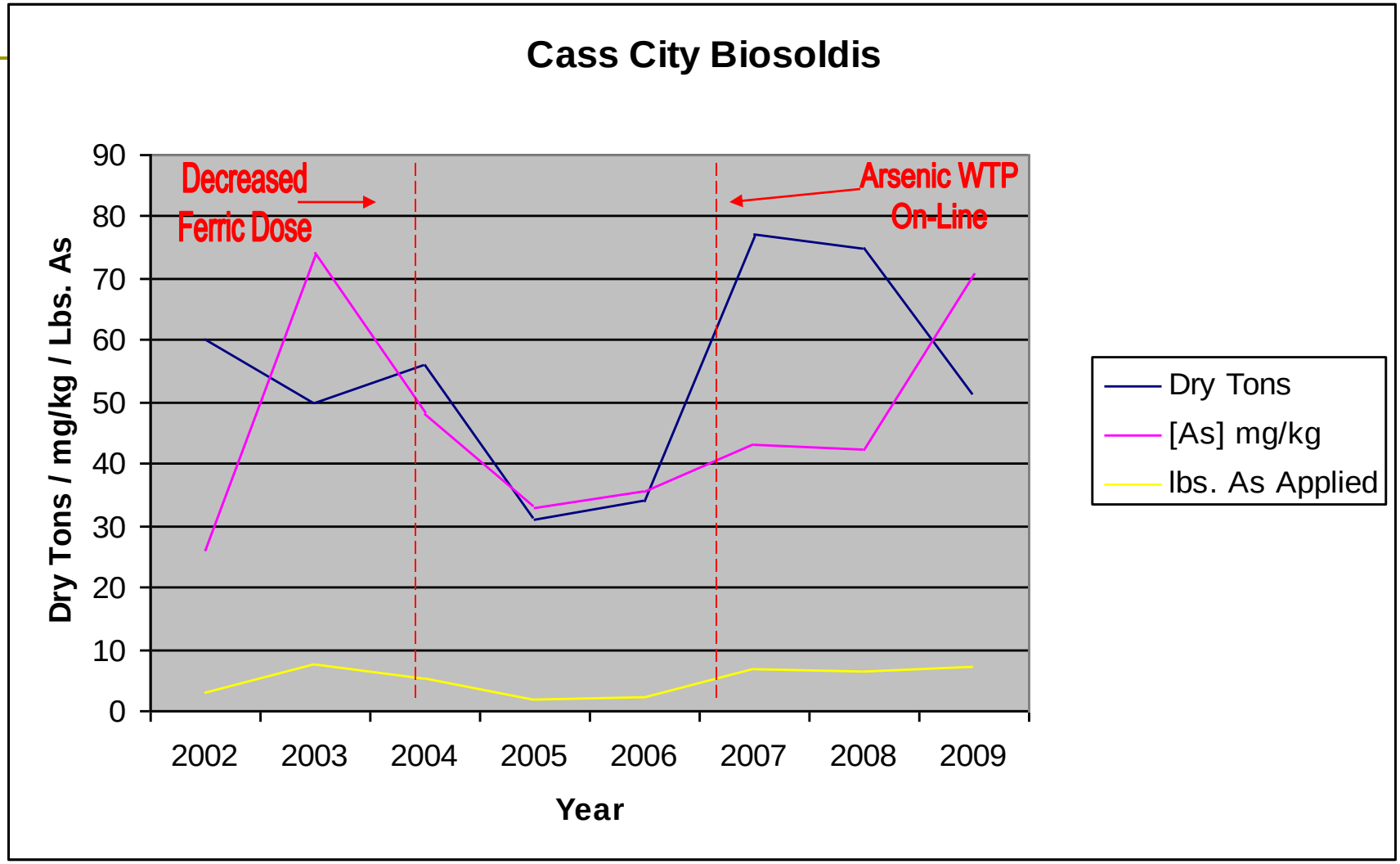
Sandusky

Drinking Water				Biosolids			
Year	Total Gals. Pumped	Ave. Arsenic Concentration (µg/l)	Lbs. Arsenic Produced	Dry Tons Applied	Arsenic Concentration (mg/kg)	lbs. Arsenic in biosolids	Difference Lbs. Arsenic Produced & Applied
2002	**107,237,000**	**12**	10.73	180	3.54	1.27	9.46
2003	**102,620,000**	**12**	10.27	249	1.19	0.59	9.68
2004	**91,572,000**	**12**	9.16	243	10.5	5.10	4.06
2005	**102,605,000**	**12**	10.27	90	17	3.08	TBD
2006	**96,369,000**	**12**	9.64	85	16.15	2.75	6.90
2007	**99,035,000**	**12**	9.91	80	29.7	4.75	5.16
2008	**93,588,000**	**12**	9.37	71	33.25	4.72	4.64
2009	**92,799,000**	**12**	9.29	53	28.8	3.05	6.23
2010	**96,919,000**	**12**	9.70	15	46.5	1.40	8.30
Total [2]	882,744,000	12	88.35	976	20.74	40.48	47.87

Summary of Table - Sandusky

- Pounds of Arsenic from WTP – Similar
- Pounds of Arsenic to Field - Similar
- Tons of BS to Field – Lower
- Concentration of Arsenic in BS – Higher
  - %VS stayed the same
  - Q – where is the remaining As going?

Mass = Concentration X Volume


Cass City Biosoldis
Decreased Ferric Dose
Arsenic WTP On-Line
Dry Tons / mg/kg / Lbs. As
90
80
70
60
50
40
30
20
10
0
2002
2003
2004
2005
2006
2007
2008
2009
Year
Dry Tons
[As] mg/kg
lbs. As Applied

Cass City

Drinking Water				Biosolids			
Year	Total Gals. Pumped	Arsenic Concentration (µg/l)	Lbs. Arsenic Produced	Dry Tons Applied	Arsenic Concentration (mg/kg)	lbs. Arsenic Applied	Difference Lbs. Arsenic Produced & Applied
2002	**111,155,460**	**17**	15.76	60	26	3.12	12.64
2003	**112,693,750**	**17**	15.98	50	74	7.40	8.58
2004	**108,439,680**	**17**	15.37	56	48	5.38	10.00
2005	**99,240,458**	**17**	14.07	31	32.9	2.04	12.03
2006	**100,429,450**	**17**	14.24	34	35.6	2.42	11.82
2007	**134,590,000**	**17**	19.08	77	43.1	6.64	12.44
2008	**153,506,000**	**17**	21.76	75	42.3	6.35	15.42
2009	**154,436,000**	**17**	21.90	51	71.23	7.27	14.63
2010	**121,095,000**	**17**	17.17	0	85.78	0.00	17.17
Total[(1)(3)]	542,961,450	17	76.98	237	48.06	22.78	54.20

Cass City Mass Balance -

- Where is the remaining As going
  - Out the Pipe?? Not Likely.
- Average As Effluent data from 2010 around 3 ug/l with a flow of .204 mgd = about 2 lbs of As a year.

Summary of Table – Cass City

- Pounds of Arsenic from WTP – Similar
- Pounds of Arsenic to Field - Similar
- Tons of BS to Field – Variable
- Concentration of Arsenic in BS – Variable

Mass = Concentration X Volume

Complicating variables in analyzing data

- Sampling dates relative to land application and reporting dates
- Pounds of Biosolids generated vs land applied
- Lab data errors. Is the Biosolids As digestion acid extraction procedures accurately determining true As concentrations in Biosolids?
- How does Iron Arsenate effect extraction?

Final Summary – More ??s than answers

- Seems to be some correlation between Arsenic removal WTPs and additional [As] in Biosolids
- Installation and maintaining an As Backwash tank may offer solution for negative BS impacts.
- Concerns remain over lagoons receiving As backwash
- More in-depth research and analysis needed.
  - Are differences in WWTP operations and sludge reduction effect As levels?
  - Need better Mass Balance/ Better Data including As in WWTP Effluent. Where is the remaining As going?
  - Lab accuracy. How is matrix interference effecting bs As concentrations? Are the Lab extraction proceedures accurately accounting for all [As] in BS.

Questions?

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