

# **Metals in Wastewater Effluent Limits, Treatment & Control Strategies**

*presented by*

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# Why am I getting metals limits?



- 💧 The waterway to which you discharge is impaired – 303d list
- 💧 DEP calculates a need for a water quality based effluent limit (WQBEL)
- 💧 An effluent standard is required
- 💧 A technology based effluent limit is required
- 💧 An EEQ (existing effluent quality) limit is required

# Why Now?



- 💧 Increased monitoring of waterways and WWTP discharges
- 💧 Improved laboratory detection limits
- 💧 Methods for application of water quality criteria are routine
- 💧 More stringent water quality criteria
  - 💧 many criteria below detection limits
  - 💧 acute and chronic aquatic life criteria
  - 💧 carcinogenic and noncarcinogenic human health criteria

# Fresh Water Criteria - Copper



<b><i>Aquatic Life</i></b>		
Acute	12.7 ug/l*	dissolved
Chronic	8.5 ug/l*	dissolved
<b><i>Human Health</i></b>		
Carcinogenic	---	---
Non carcinogenic	1,300 ug/l	total recoverable

*\*for stream hardness of 100 mg/l*

# Saline Water Criteria - Copper



<b><i>Aquatic Life</i></b>		
Acute	4.8 ug/l*	dissolved
Chronic	3.1 ug/l*	dissolved
<b><i>Human Health</i></b>		
Carcinogenic	---	---
Non carcinogenic	---	---

*\*For NY Harbor, acute = 7.9 ug/l; chronic = 5.6 ug/l*

# Fresh Water Criteria - Lead



<b><i>Aquatic Life</i></b>		
Acute	38 ug/l	dissolved
Chronic	5.4 ug/l	dissolved
<b><i>Human Health</i></b>		
Carcinogenic	---	---
Non carcinogenic	5 ug/l	total recoverable

# Saline Water Criteria - Lead



<b><i>Aquatic Life</i></b>		
Acute	210 ug/l	dissolved
Chronic	24 ug/l	dissolved
<b><i>Human Health</i></b>		
Carcinogenic	---	---
Non carcinogenic	---	---

*\*For NY Harbor, acute = 7.9 ug/l; chronic = 5.6 ug/l*

# Fresh Water Criteria - Zinc



<b><i>Aquatic Life</i></b>		
Acute	114 ug/l*	dissolved
Chronic	114 ug/l*	dissolved
<b><i>Human Health</i></b>		
Carcinogenic	---	---
Non carcinogenic	7,400 ug/l	total recoverable

*\*for stream hardness of 100 mg/l*

# Saline Water Criteria - Zinc



<b><i>Aquatic Life</i></b>		
Acute	90 ug/l	dissolved
Chronic	81 ug/l	dissolved
<b><i>Human Health</i></b>		
Carcinogenic	---	---
Non carcinogenic	26,000 ug/l	total recoverable

# Fresh Water Criteria - Arsenic



<b><i>Aquatic Life</i></b>		
Acute	340 ug/l	dissolved
Chronic	150 ug/l	dissolved
<b><i>Human Health</i></b>		
Carcinogenic	0.017 ug/l	total recoverable
Non carcinogenic	---	---

# Saline Water Criteria - Arsenic



<b><i>Aquatic Life</i></b>		
Acute	69 ug/l	dissolved
Chronic	36 ug/l	dissolved
<b><i>Human Health</i></b>		
Carcinogenic	0.061 ug/l	total recoverable
Non carcinogenic	---	---

# Ewing Lawrence Sewerage Authority



<i>Parameter</i>	<i>Limit</i>	<i>Avg. Period</i>
Cadmium	2.9 ug/l	daily maximum
Copper	20 ug/l	daily maximum
Lead	7.1 ug/l	daily maximum
Nickel	210.6 ug/l	daily maximum
Silver	4.4 ug/l	daily maximum
Zinc	128.8 ug/l	daily maximum

# Ewing Lawrence Sewerage Authority



<i>Parameter</i>	<i>Limit</i>	<i>Data</i>
Cadmium	2.9 ug/l	< 1 - 722
Copper	20 ug/l	5 - 90
Lead	7.1 ug/l	1 - 18
Nickel	210.6 ug/l	2.9 - 95
Silver	4.4 ug/l	< 0.5 - 6
Zinc	128.8 ug/l	15 - 89

# Borough of Washington



<i>Parameter</i>	<i>Limit</i>	<i>Avg. Period</i>
Cadmium	4.4 ug/l	daily maximum
Copper	40.5 ug/l	daily maximum
Zinc	257 ug/l	daily maximum

# Borough of Washington



<i>Parameter</i>	<i>Limit</i>	<i>Data</i>
Cadmium	4.4 ug/l	< 0.4 - 18
Copper	40.5 ug/l	5.8 - 50
Zinc	257 ug/l	14 - 590

# Town of Hammonton



<i>Parameter</i>	<i>Limit</i>	<i>Avg. Period</i>
Lead	5.8 ug/l	monthly average
Lead	5.8 ug/l	daily maximum

# Town of Hammonton



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<i>Parameter</i>	<i>Limit</i>	<i>Data</i>
Lead	5.8 ug/l	1 - 25



# Evesham Woodstream



<i>Parameter</i>	<i>Limit</i>	<i>Avg. Period</i>
Copper	18.8 ug/l	monthly average



# Evesham Woodstream



<i>Parameter</i>	<i>Limit</i>	<i>Data</i>
Copper	18.8 ug/l	10 - 38



# Burlington County RR Complex



<i>Parameter</i>	<i>Limit</i>	<i>Avg. Period</i>
Arsenic	0.017 ug/l	monthly average
Cadmium	1.1 ug/l	daily maximum
Lead	3.16 ug/l	daily maximum

# Burlington County RR Complex



<i>Parameter</i>	<i>Limit</i>	<i>Data</i>
Arsenic	0.017 ug/l	< 1 - 6.8
Cadmium	1.1 ug/l	< 2.5 - 10
Lead	3.16 ug/l	< 1 - 130

# What Do I Do?



- 💧 Evaluate operations data
  - 💧 *Are data representative?*
  - 💧 *Outliers?*
  
- 💧 Evaluate effluent limit
  - 💧 *Is it right?*
  - 💧 *Alternatives to remove or relax limit?*
  
- 💧 Evaluate ways to reduce effluent concentration
  - 💧 *Treatment alternatives?*
  - 💧 *Source reduction?*

# Data Outliers



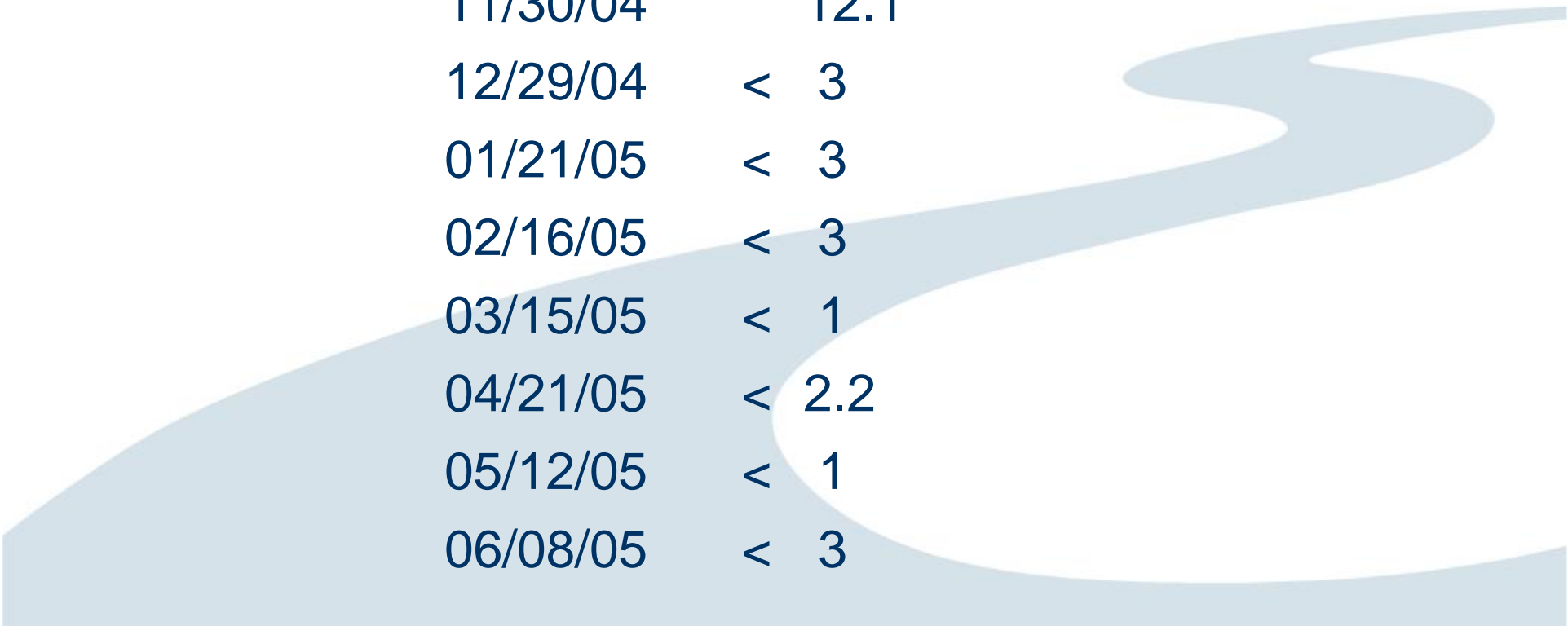
- 💧 Use statistical tests to exclude outliers from data set
- 💧 Outliers are data points that are not representative of the general population of data
  - 💧 Sampling errors
    - 💧 Sample contamination
    - 💧 Use clean techniques
  - 💧 Lab errors
  - 💧 Changed source loadings

# Data Outliers – Lead Example



07/14/04	<	1
08/19/04	<	1
09/16/04	<	3
10/14/04	<	1
11/30/04		12.1
12/29/04	<	3
01/21/05	<	3
02/16/05	<	3
03/15/05	<	1
04/21/05	<	2.2
05/12/05	<	1
06/08/05	<	3

*All concentrations  
in ug/l*



# Data Outliers – Cadmium Example



01/16/03	< 0.5	01/22/04	< 0.3
02/11/03	722	02/05/04	0.78
03/12/03	546	03/11/04	< 0.3
04/10/03	646	04/07/04	< 0.3
05/15/03	32	05/12/04	< 0.3
06/05/03	500	06/08/04	< 0.3
07/17/03	< 0.5	07/14/04	< 0.3
08/07/03	212	08/19/04	< 1
09/04/03	< 0.5	09/16/04	< 1
10/17/03	< 1	10/14/04	< 0.3
11/07/03	< 0.3	11/30/04	< 0.3
12/10/03	0.31	12/29/04	< 1

# Data Outliers – Bis Example



07/17/03	< 2	07/14/04	< 2
08/07/03	< 2	08/19/04	< 2
09/04/03	< 2	09/16/04	< 2
10/17/03	< 2	10/14/04	< 2
11/07/03	< 2	11/30/04	< 2
12/10/03	< 2	12/29/04	< 2
01/22/04	< 2	01/21/05	41
02/05/04	< 2	02/16/05	53
03/11/04	< 2	03/15/05	16
04/07/04	< 2	04/21/05	110
05/12/04	< 2	05/12/05	32
06/08/04	< 2	06/08/05	24

# Critical Factors for Effluent Limit



- 💧 Dilution in receiving water
- 💧 Hardness
  - 💧 *Effluent and receiving water*
  - 💧 *Low flow conditions – higher at low flow*
  - 💧 *Higher hardness gives less stringent water quality criterion*
- 💧 Dissolved versus Total Recoverable
  - 💧 *Translator*
- 💧 Site specific toxicity
  - 💧 *Water Effect Ratio (WER)*

# Translators



- 💧 Translator = ratio of dissolved concentration to total recoverable concentration.
- 💧 Many water quality criteria are dissolved
- 💧 Effluent data are total recoverable
- 💧 Need method to convert
- 💧 Translator  $< 1.0$  -- ***the smaller the better!***
  - 💧 Divide dissolved criterion by translator to get total recoverable criterion
  - 💧 Multiply total recoverable effluent concentration by translator to get dissolved effluent concentration

# Default Translators



	Freshwater Acute	Freshwater Chronic	Saline Acute	Saline Chronic
Copper	0.96	0.96	0.83	0.83
Lead	0.791	0.791	0.951	0.951
Zinc	0.978	0.986	0.946	0.946
Arsenic	1.0	1.0	1.0	1.0

# Actual Translators



	Default Freshwater Acute	Default Freshwater Chronic	<b><i>Actual</i></b>
Copper	0.96	0.96	<b><i>0.4 – 0.6</i></b>
Lead	0.791	0.791	<b><i>0.4 – 0.6</i></b>
Zinc	0.978	0.986	<b><i>0.6 – 0.8</i></b>

# Water Effect Ratio - WER



- 💧 WER is the ratio of site specific toxicity to laboratory toxicity
- 💧 Many metals are less toxic in site specific waters than in lab waters
- 💧  $WER > 1.0$  -- ***the larger the better!***
- 💧 Multiply water quality criterion by WER
- 💧 WER effectively increases the water quality criterion
- 💧 Applicable to aquatic life criteria only

# WER – Copper Example



	Default Criterion <b>WER = 1</b>	Actual Criterion <b>WER = 2</b>	Actual Criterion <b>WER = 4</b>	Actual Criterion <b>WER = 6</b>
Acute Aquatic Life	12.7 ug/l*	25.4 ug/l*	50.8 ug/l*	76.2 ug/l*
Chronic Aquatic Life	8.5 ug/l*	17.0 ug/l*	34 ug/l*	51 ug/l*

*\*for stream hardness of 100 mg/l*

# Reduce Effluent Concentration



## 💧 Sources

💧 Industrial

💧 Individual Residential

💧 Area Residential

💧 Potable Water

💧 WWTP facilities / operations

## 💧 IPP Program

💧 Periodic data review

💧 Independent monitoring

💧 *consider temporal aspects*

💧 Influent and sewer system monitoring

# Treatment Control Strategies



- 💧 Most research done for industrial wastes with higher concentrations
  - 💧 Not always directly applicable to treatment at low concentrations
- 💧 Look for correlations with other operational control parameters
  - 💧 Temperature
  - 💧 MCRT
  - 💧 pH
  - 💧 SS concentrations

# Treatment Control Strategies



- 💧 Metals uptake by biomass
  - 💧 Process is physicochemical not necessarily related to biological activity
  - 💧 Fast, within hours
  - 💧 Order of uptake:
    1. Hg, Ag, Pb, Cu, Cr
    2. Zn, Cd
    3. Ni, Co

# Treatment Control Strategies



- 💧 Effluent suspended solids concentrations
  - 💧 Total recoverable metals concentration generally directly proportional to SS concentration
  - 💧 Ratio of dissolved to total metals generally inversely proportional to SS concentration (i.e. at low SS, all metal is dissolved)
  - 💧 Need site specific data

# Treatment Control Strategies



## 💧 pH

- 💧 Generally better removal at higher pH
- 💧 Potential for better metals removal with upward pH adjustment but removal may level off in pH range of 8
- 💧 Bench tests provide easy assessment

# Treatment Control Strategies



Arsenic	5 ug/l	Ferric hydroxide co-ppt
Arsenic	1 ug/l	Adsorption with metal (iron) oxide media
Copper	10 – 20 ug/l	Sulfide ppt
Zinc	100 ug/l	Hydroxide ppt at pH 11
Cadmium	8 ug/l	Sulfide ppt
Mercury	1 – 5 ug/l	Ion exchange
Mercury	0.5 – 5 ug/l	Ferric hydroxide co-ppt



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***Questions???***

