Design and Management of CDFs

Effluent and Runoff Quality Assessment

Susan Bailey
US Army ERDC, Vicksburg, MS

Susan.E.Bailey@usace.army.mil
Topics

• Regulatory definition & requirements
• Environmental concerns
• Tiered approach
• Testing & Modeling
• Controls
• Recap
“...the term ‘discharge of dredged material’ ... includes... the runoff or overflow from a contained land or water disposal area...”
CWA Regulatory Provisions

• Water Quality Standards
  - Adopted per 40 CFR 131
  - Narrative or numeric criteria
  - Dissolved or total concentrations

• Initial Mixing
  - As per 40 CFR 230.3(m)
  - Normally expressed as a distance from point of discharge or area around the discharge
Conceptual Model - Contaminant Pathways

Birds/Wildlife

Plant/Animal Uptake

Precipitation

Volatilization

Surface Runoff

Weir

Effluent

SURFACE WATER

Dike

Unsaturated

Seepage

Saturated

Infiltration

Leachate

Ground Water

Air Quality
### Characteristics

#### Effluent vs. Runoff

<table>
<thead>
<tr>
<th></th>
<th>Effluent</th>
<th>Runoff</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Occurrence / Duration</strong></td>
<td>Continuous discharge during disposal &amp; initial dewatering</td>
<td>Discrete events throughout life of facility</td>
</tr>
<tr>
<td></td>
<td>Weeks to months</td>
<td>Hours to days</td>
</tr>
<tr>
<td><strong>Flow Rate</strong></td>
<td>Dredge discharge rate for hydraulic dredges</td>
<td>Depends on rainfall intensity, duration, CDF area and site management</td>
</tr>
<tr>
<td></td>
<td>Minimal effluent flow rate if mechanically dredged</td>
<td></td>
</tr>
<tr>
<td><strong>Characteristics</strong></td>
<td>TSS &lt; 100 mg/L for estuarine or &lt; a few g/L for freshwater</td>
<td>TSS dependent on holding time, 100 mg/L to a few g/L</td>
</tr>
<tr>
<td></td>
<td>Dissolved contaminants in equilibrium with influent slurry of 70 to 250 g/L unoxidized DM</td>
<td>Dissolved contaminants in equilibrium with runoff slurry of 0.5 to 15 g/L unoxidized DM or 0.05 to 3 g/L oxidized DM</td>
</tr>
<tr>
<td></td>
<td>Total contaminant is a function of TSS and contaminant concentration of fines</td>
<td>Total contaminant is a function of TSS and contaminant concentration of fines</td>
</tr>
</tbody>
</table>
### Tiered Approach

- **Tier 1 - Existing information**
- **Tier 2 - Partitioning (screening assessment)**
- **Tier 3 – Testing**
  - **Effluent**
    - Contaminant Evaluations: Column Settling Test, EET chemistry
  - **Runoff**
    - SLRP chemistry, RSLS chemistry
  - Toxicity: EET toxicity, SLRP/RSLS toxicity
- **Tier 4 – Case specific studies**
CDF Effluent
Supernatant Water Interactions

- Incoming Dredged Material
- Turbulent Mixing and Oxygenation
- Atmospheric Oxygenation
- Wind Mixing
- Sedimentation of Supernatant Particles
- Flux of Dissolved Fraction Plus Particles
- Entainment and Mixing of Fine Particles

Bottom Deposit

Effluent
Receiving Waters

Dredged Material Assessment and Management Seminar
15-17 April 2008, Sacramento, CA
Basis of Effluent Quality Predictions

• Partitioning
  ➢ Theoretical (screening spreadsheets)

• Testing
  ➢ Contaminant mobilization - Modified Elutriate Sedimentation – Column Settling
  ➢ Total = Dissolved + Particle Associated

• Unoxidized conditions
Modified Elutriate Test

1. Mix sediment and water to expected influent concentration
2. Aerate in 4L cylinder for 1 hr
3. Settle for expected mean field retention time up to 24 hr maximum
4. Extract sample and split
5. Centrifugation or 0.45um filtration

- Suspended Solids Determination
- Chemical Analysis Total Concentration
- Chemical Analysis Dissolved Concentration
Modified Elutriate Test Setup
Extraction of Elutriate
Column Settling Test

- **Column**
  - 8-in diameter, > 6-ft tall
  - Ports every 6 in.

- **Fill column with slurry at expected influent solids concentration**
  - \( C_{sl} = \% \text{Fines} + (3 \times \% \text{Coarse}) \)

- **15 day test**
  - Sample supernatant TSS
  - Record interface height

- **Predict rate of settling and effluent TSS**
  - SETTLE model
Effluent Toxicity Evaluation

• Effluent elutriate used as test medium
• Procedure same as for open water
  - Expose test organisms to dilution series of whole effluent elutriate
    - Must be sufficiently clear for organisms to be visible
  - End result is LC50 or EC50 expressed as percentage of original effluent elutriate concentration
  - Detailed procedures in ITM
• Compare with effluent concentration at the boundary of the allowable mixing zone
  - Must not exceed 0.01 of LC50 or EC50
ADDAMS Effluent Quality Modules

- **SETTLE**
  - CDF sizing for storage and effluent TSS

- **EFQUAL**
  - Reduction of modified elutriate data
    - Determine COC
  - Water quality standards compliance
  - Dilution requirements

- **LAT-E**
  - Analysis of water column bioassay test to determine toxicity (LC50) of CDF effluent

- **EFFLUENT**
  - Windows version of the above two modules
CDF Surface Runoff Process
Basis of Runoff Water Quality Predictions

• Partitioning
  ➢ Theoretical (screening spreadsheets)

• Testing
  ➢ SLRP/RSLS

• Total and Dissolved

• Oxidized and Unoxidized Conditions
  ➢ Unoxidized analysis may not be necessary
Simplified Laboratory Runoff Procedure (SLRP) Wet Sediment

- 3 gal sediment
- Common laboratory equipment
- Dilute to representative TSS
- Agitate for one hour
- Analyze contaminant concentrations
  - Filtered for soluble
  - Unfiltered for total
# Field SS Measurements

<table>
<thead>
<tr>
<th>Sediment (mg/L)</th>
<th>SS, Wet</th>
<th>SS, Dry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indiana</td>
<td>6600</td>
<td>56</td>
</tr>
<tr>
<td>Black Rock</td>
<td>10326</td>
<td>167</td>
</tr>
<tr>
<td>Everett</td>
<td>6900</td>
<td>1000</td>
</tr>
<tr>
<td>New Bedford</td>
<td>7730</td>
<td>268</td>
</tr>
<tr>
<td>Oakland Inner</td>
<td>4447</td>
<td>1686</td>
</tr>
<tr>
<td>Oakland Outer</td>
<td>9140</td>
<td>970</td>
</tr>
<tr>
<td>Pinole Shoal</td>
<td>1500</td>
<td>618</td>
</tr>
<tr>
<td>West Richmond</td>
<td>3290</td>
<td>2340</td>
</tr>
<tr>
<td>Santa Fe</td>
<td>6240</td>
<td>2130</td>
</tr>
</tbody>
</table>
SLRP SS Concentrations
SLRP - Dry Sediment

- Air dry to < 5% moisture and grind
- Oxidize with $\text{H}_2\text{O}_2$, dry and regrind
- Re-slurrry at TSS 50, 500, 5,000 mg/l, agitate and extract
- Analyze for total and dissolved contaminants
SLRP Procedures

**Unoxidized (Wet)**

Sediment

DI Water

<table>
<thead>
<tr>
<th>Concentration</th>
<th>500 mg/L</th>
<th>5000 mg/L</th>
<th>50,000 mg/L</th>
</tr>
</thead>
</table>

Agitate 1 hr

Split Sample

Filter

Dissolved Chemical Analysis

Total Chemical Analysis

TSS Analysis

**Oxidized (Dry)**

Sediment

Dried Sediment

Oxidized Sediment

Air dry

Grind

Add H₂O₂

Dry, Regrind

Filter

Dissolved Chemical Analysis

Total Chemical Analysis

TSS Analysis

Dried Sediment¹ or Oxidized Sediment²

DI Water

<table>
<thead>
<tr>
<th>Concentration</th>
<th>50 mg/L</th>
<th>500 mg/L</th>
<th>5000 mg/L</th>
</tr>
</thead>
</table>

1For Nutrients/Organics; 2For Metals
SLRP Predicted Copper

Copper, µg/l

Suspended Solids, mg/l

- Wet Total
- Wet Dissolved
- Dry Total
- Dry Dissolved

ERDC

Dredged Material Assessment and Management Seminar
15-17 April 2008, Sacramento, CA
Rainfall Simulator/Lysimeter System (RSLS)

- 600 gal sediment from dredging site
- Specialized equipment
- Conduct test on wet sediment (unoxidized) first
- Allow sediment to dry 6 months, then repeat test on oxidized sediment
RSLS Test Equipment

SYSTEMS FOR EVALUATING CONTAMINANT LOADINGS DURING STORM RUNOFF

VARIABLE SLOPE AND DEPTH SOIL.lysimeter

RUNOFF QUANTITY AND QUALITY MONITORING

RAINFALL SIMULATOR
RSLS Test Specifics

- **Rainfall**
  - 5.08 cm/hr (2 in/hr)
  - 30 min event
  - 3 events on consecutive days

- **Sample**
  - Runoff rate - every minute
  - pH, TSS, EC
    - Every minute up to 15 min, then every 5 min
  - Chemical analysis
    - composite of 5, 15 and 25 min after runoff begins
    - dissolved and total

- **Can modify test to match site-specific conditions**
Runoff Toxicity Evaluation

- Simulated runoff from SLRP or RSLS used as medium
  - Whole water (not filtered)
  - Sufficiently clear for organisms to be visible
- Procedure same as for open water
  - Expose organisms to dilution series of test medium
  - End result is LC50 or EC50, expressed as percentage of original simulated runoff concentration
  - Detailed procedures in ITM
- Compare with runoff concentration at boundary of allowable mixing zone
  - Must not exceed 0.01 of LC50/EC50 (or NOEL/LOEL)
ADDAMS Runoff Quality Programs

• RUNQUAL
  - Compares predicted runoff WQ with standards
  - Determines COC
  - Dilution requirements

• LAT-R
  - Analysis of water column bioassay test to determine toxicity (LC50) of CDF runoff

• RUNOFF
  - Windows version of the above two modules
Schematic of a Mixing Zone for a Single Effluent Source
# CDF Effluent Mixing Models

<table>
<thead>
<tr>
<th>Model/Technique</th>
<th>Hydrodynamics</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dilution Volume</td>
<td>Steady Uniform</td>
<td>General</td>
</tr>
<tr>
<td>MacIntyre</td>
<td>Steady Uniform</td>
<td>Riverine</td>
</tr>
<tr>
<td>CDFATE (CORMIX)</td>
<td>Steady Uniform</td>
<td></td>
</tr>
<tr>
<td>TABS</td>
<td>Unsteady Nonuniform</td>
<td>Tidally influenced Rivers &amp; Estuaries</td>
</tr>
</tbody>
</table>
Contaminant Controls

• **TSS & Particulate Associated Contaminants**
  - Operational modifications – retention time
  - Filtration
  - Chemical flocculants
  - Engineered controls – vegetation, capping

• **Dissolved**
  - Treatment
    - Carbon adsorption
    - Ion exchange
    - Chemical or UV oxidation
    - Biological
Polymer Addition
Filter Cell
Runoff SS Controls

![Graph showing the change in suspended solids over time for different conditions: Veg, Detritus, and Bare. The graph plots suspended solids (mg/l) against time (minutes).]
Summary

• **EFFLUENT**
  • Tier II Screening
  • Column settling
  • **Modified elutriate**
    ➢ Accurate
    ➢ Relatively inexpensive
    ➢ Generally conservative

• **RUNOFF**
  • Tier II Screening
  • **RSLS**
    ➢ Time and material intensive
  • **SLRP**
    ➢ Rapid
    ➢ Conservative

• **Controls**
  ➢ Operational
  ➢ Treatment

• **Controls**
  ➢ Operational
  ➢ Treatment
  ➢ Engineered