Sediment Stability in the Lower Passaic River –
Integration of Multiple Lines of Evidence

Fourth Passaic River Symposium
June 22, 2010

Michael Barbara, mab.consulting, LLC
Marcia Greenblatt, AECOM
John Connolly, Anchor QEA
LPRRP Remedial Investigation

- Performed by the Cooperating Parties Group

- Critical study to fully characterize site for selection of optimal remedies

- RI Activities include:
  - Sequential bathymetric surveys
  - Sediment coring program
  - Benthic and fish tissue collection
  - Water column (physical and chemical) data collection
  - Hydrodynamic, sediment transport, and chemical fate and transport models
Sediment Stability Assessment

Lines of evidence that must be considered in the evaluation of sediment stability in the LPR:

- Time trends in surface sediment COPC concentrations
- Patterns of deposition in the sediment bed
- Vertical patterns of COPC concentrations in sediment cores
- Sedimentation rates in sediment cores
- Predicted bottom shear stresses
- Measured changes in river bathymetry
- Modeling of sediment transport

“Especially for larger sites, a “lines of evidence” approach should be used to evaluate the extent of sediment and contaminant movement and resultant exposure for various areas of the water body.”

2008 Low Resolution Coring Program Summary

• 110 cores
  – Along the 17.4 miles of the LPR
  – In the major tributaries and Dundee Canal
  – In Dundee Lake

• Chemical data
  – Dioxins
  – PCBs (aroclors, congeners, homologs)
  – Pesticides (HRMS, 8081)
  – Herbicides
  – Metals, titanium, Hg, butyltins, CN
  – VOCs, SVOCs, PAHs, TEPH

• Radiochemistry data
  – Be-7, Cs-137, Pb-210, K40

• Physical data
  – Grain size, specific gravity, bulk density, Atterberg Limits
Sediment Stability Assessment

Lines of evidence that must be considered in the evaluation of sediment stability in the LPR:

- Time trends in surface sediment COPC concentrations
- **Patterns of deposition in the sediment bed**
- Vertical patterns of COPC concentrations in sediment cores
- Sedimentation rates in sediment cores
- Predicted bottom shear stresses
- Measured changes in river bathymetry
- Modeling of sediment transport
Cs-137 Profile – Dating Markers

Introduction of Cs-137 to the atmosphere – 1954 sediment horizon

Peak Cs-137 to the atmosphere – 1963 sediment horizon

Declining Cs-137 concentrations

Net sedimentation rate = 0.07 ft/yr

Net sedimentation rate = 0.3 ft/yr

Net sedimentation rate = 0.07 ft/yr
Example
Undisturbed Cs-137 Profiles from the LRC

077 – RM 12.84

030 – RM 4.25

007 – RM 0.41
Example
Disturbed
Cs-137 Profiles
from the LRC

049 – RM 7.86

112 – Saddle River

001 – RM -0.15
# Classification of Cs-137 Profiles

<table>
<thead>
<tr>
<th>Classification of Core</th>
<th>Onset (1954)</th>
<th>Peak (1963)</th>
<th>Decrease Near Surface</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>Well-maintained profile, onset and burial evident. Provides three markers for calculation of three sedimentation rates.</td>
</tr>
<tr>
<td>B</td>
<td>--</td>
<td>X</td>
<td>X</td>
<td>Measurable peak, burial evident, but no onset. Only two markers for calculation of one sedimentation rate.</td>
</tr>
<tr>
<td>C</td>
<td>X</td>
<td>--</td>
<td>--</td>
<td>May have little/no burial at the surface, but onset evident. One sedimentation rate can be calculated.</td>
</tr>
<tr>
<td>D</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>Cs-137 may or may not be present. If present no pattern indicative of consistent deposition.</td>
</tr>
</tbody>
</table>
Classification of Cs-137 Profiles

<table>
<thead>
<tr>
<th>Number of Cores</th>
<th>% cores with A or B Cs-137 profiles</th>
</tr>
</thead>
<tbody>
<tr>
<td>All LPR Cores</td>
<td>92</td>
</tr>
<tr>
<td>RM 0-1</td>
<td>13</td>
</tr>
<tr>
<td>RM 1-8</td>
<td>40</td>
</tr>
<tr>
<td>RM 8-12</td>
<td>18</td>
</tr>
<tr>
<td>&gt; RM 12</td>
<td>21</td>
</tr>
</tbody>
</table>

Model predicts high velocities

Last dredged in 1949

Last dredged in 1983
Sediment Stability Assessment

Lines of evidence that must be considered in the evaluation of sediment stability in the LPR:

• Time trends in surface sediment COPC concentrations
• Patterns of deposition in the sediment bed
• **Vertical patterns of COPC concentrations in sediment cores**
• Sedimentation rates in sediment cores
• Predicted bottom shear stresses
• Measured changes in river bathymetry
• Modeling of sediment transport
Vertical Chemical Profiles

2,3,7,8-TCDD (ng/kg)

Total DDx (mg/kg)

Mercury (mg/kg)
Percent of LRC locations where the depth of the peak COPC concentration was at or below the depth of the peak Cs-137 concentration.
Cs-137 and COPC Profiles have Generally Remained Stable through Several Large Flow Events

~1 in 40 year flow
Sediment Stability Assessment

Lines of evidence that must be considered in the evaluation of sediment stability in the LPR:

- Time trends in surface sediment COPC concentrations
- Patterns of deposition in the sediment bed
- Vertical patterns of COPC concentrations in sediment cores
- **Sedimentation rates in sediment cores**
- Predicted bottom shear stresses
- Measured changes in river bathymetry
- Modeling of sediment transport
High surficial concentrations observed at locations with low burial rates
045 – RM 7.0

067 – RM 10.93

057 – RM 8.99
LRC provides important lines of evidence to support sediment stability evaluation

- The sediment bed has generally been stable over the past 45 years.

- Geomorphology and dredging history can explain sedimentation patterns.

- The peak chemical concentrations are generally buried at depth and are most commonly at or below the 1963 sediment horizon.

- Surficial chemical concentrations are influenced by burial rate. High surficial chemical concentrations are observed at locations with low burial rate.
Questions?