Sequencing Batch Reactors in Wastewater Treatment

Susheel Arora, M.A.Sc., P.Eng.
SBR History

• During the early development of the activated sludge process in the United Kingdom by Ardern and Lockett around 1914, plants were operated using fill-and-draw or batch feed methods.

• Around 1956, development of oxidation ditch technology.

• By the late 1970s, the sequencing batch reactor (SBR) was well established and many small plants were in operation.

• Recent developments in technology made SBRs a more viable option for small to medium size facilities.
Process – Activated Sludge

- **Activated Sludge** systems use suspended natural biological and bacterial growth to remove contaminants. The wastewater is mixed with a bacterial floc in an aeration tank where the contaminants are removed by sorption and subsequent breakdown.

- **Sequencing Batch Reactors (SBR)** are a special form of activated sludge treatment in which all of the treatment process takes place in the reactor tank and clarifiers are not required. This process treats the wastewater in batch mode and each batch is sequenced through a series of treatment stages.
Typical SBR Process

- Wastewater fills the tank, mixing with biomass that settles during the previous cycle.

- Air is added to the tank to aid biological growth and facilitate subsequent waste reduction.

- Mixing and aeration stop during this stage to allow solids to settle to the bottom of the tank.

- Clarified effluent is discharged.

- If necessary, sludge removal occurs during this stage.
Central Colchester: Wastewater Collection & Treatment

- Serves a population of 25,000 people
- 11 Km. Trunk Sewer 4 feet in diameter
- Archimedes Screw Sewage Lift Station
- Sewage Treatment Plant: SBR;
  Ave. Capacity 5 MGD
Plant Performance

• Consistently meets/exceeds the permit requirements; BOD/SS: 30/30
• Overflows happen after 8 MIGD
• Operating Cost $900,000 per year includes Biosolids handling, disposal and leachate treatment from Colchester & Cumberland landfills.
• Staff – 4.5 persons
• Power Cost - $300,000
Sewage Treatment Projects Background

- Call for Proposals – 1995
- Consultant completed an Interim Report in Sept. 1996 recommending replacement of all three treatment plants
- Final Report completed in March 1997
- Three applications made to Infrastructure Program
- Detailed Design and drawings completed by Jan. 1998
Rural Waterwater Collection and Treatment

Three Systems:

1. Brookfield: Population 760
2. Great Village: Population 200
3. Tatamagouche: Population 720

Future Systems: designed with 22% growth over next 20 years.

Municipality’s Goal: Replace these STPs by 2004
Brookfield Sewer System
Existing Brookfield STP
Brookfield STP

- Council authorized design-build in August 2001.
- Approval for funding received in March 2002
- Construction started in August 2002
- Plant commissioned in March 2003
- Warranty period ends March 2005
## Brookfield Plant Performance

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Plant Effluent 2004 Av. Value</th>
<th>NSDEL Permit</th>
<th>NSDEL Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOD (mg/L)</td>
<td>3</td>
<td>20</td>
<td>5/month</td>
</tr>
<tr>
<td>pH</td>
<td>7.3</td>
<td>6.5 – 9.0</td>
<td>Grab</td>
</tr>
<tr>
<td>Fecal Coliform (Count/ml)</td>
<td>3.5</td>
<td>200</td>
<td>5/month</td>
</tr>
<tr>
<td>Suspended Solids (mg/L)</td>
<td>4.2</td>
<td>20</td>
<td>5/month</td>
</tr>
</tbody>
</table>
### Municipality of Colchester

**Brookfield**

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tendering</td>
<td>$1,293.91</td>
</tr>
<tr>
<td>Supplies &amp; Equipment</td>
<td>$46,165.51</td>
</tr>
<tr>
<td>Contractor Payments</td>
<td>$1,647,707.95</td>
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<tr>
<td>Engineering &amp; Testing</td>
<td>$15,261.31</td>
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<tr>
<td>Miscellaneous</td>
<td>$5,346.23</td>
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<tr>
<td>Total</td>
<td>$1,715,775.91</td>
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</tbody>
</table>

Original Estimate for the new plant - $2.0 million (1998 estimate)

Infrastructure Funding Approved - $1,799,113
Brookfield Operations

- Design wet weather flow 250,000 IGPD.
- Effluent quality consistently below the permit discharge limitations of BOD/SS: 20/20; tertiary quality effluent without filters.
- Operating cost - $60,000; includes part-time operator, sludge transport & handling.
- Power Cost - $20,000
- Operator Time – 4 Hours/week
Replaced Great Village STP
Great Village Sewer System

Community of GREAT VILLAGE

AREA OF POTENTIAL EXPANSION OF SERVICE
# Cost Comparison - Great Village STP Options

<table>
<thead>
<tr>
<th>ITEM</th>
<th>CLR</th>
<th>Design/Build</th>
<th>Brookfield Relocate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replace Pump. Sta.</td>
<td>$35,000</td>
<td>$20,000</td>
<td>$15,000</td>
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<tr>
<td>Grinder/Screening</td>
<td>$20,000</td>
<td>$25,000</td>
<td>n/a</td>
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<tr>
<td>Site Preparation</td>
<td>$34,000</td>
<td>$20,000</td>
<td>n/a</td>
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<tr>
<td>Reactor Basin/Tankage</td>
<td>$60,000</td>
<td>$220,000</td>
<td>$20,000</td>
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<tr>
<td>Equipment</td>
<td>$160,000</td>
<td>$155,000</td>
<td>$53,000</td>
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<tr>
<td>Clarifier</td>
<td>$104,000</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Sludge Storage</td>
<td>$15,000</td>
<td>n/a</td>
<td>n/a</td>
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<tr>
<td>Disinfection System</td>
<td>$50,000</td>
<td>$50,000</td>
<td>$30,000</td>
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<tr>
<td>Electrical/Controls/Generator</td>
<td>$64,000</td>
<td>$60,000</td>
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<tr>
<td>Controls/Lab/Office Building</td>
<td>$48,000</td>
<td>$55,000</td>
<td>$68,000</td>
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<tr>
<td>Relocate Outfall</td>
<td>$10,000</td>
<td>$10,000</td>
<td>$10,000</td>
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<tr>
<td>Siteworks</td>
<td>$100,000</td>
<td>$50,000</td>
<td>$30,000</td>
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<tr>
<td>Miscellaneous</td>
<td>$20,000</td>
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<tr>
<td>Repairs/Sandblasting</td>
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<td>Design Flow Increase</td>
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<tr>
<td>Subtotal</td>
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<td>$685,000</td>
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<tr>
<td>Plus Contingency (10%)</td>
<td>$880,000</td>
<td>$753,500</td>
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<tr>
<td>Plus Engineering (14%)</td>
<td>$1,003,200</td>
<td>n/a</td>
<td>$407,550</td>
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</table>
Great Village STP

- April 2002; Council withdrew application for funding from CNISP.
- Previously authorized the use of Brookfield STP tanks for this facility.
- Construction began in late August 2003.
Great Village Plant Performance

<table>
<thead>
<tr>
<th>Parameter</th>
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<tbody>
<tr>
<td>BOD (mg/L)</td>
<td>3.3</td>
<td>20</td>
<td>5/month</td>
</tr>
<tr>
<td>pH</td>
<td>6.8</td>
<td>6.5 – 9.0</td>
<td>Grab</td>
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<tr>
<td>Fecal Coliform (Count/ml)</td>
<td>4.66</td>
<td>1000</td>
<td>5/month</td>
</tr>
<tr>
<td>Suspended Solids (mg/L)</td>
<td>8.8</td>
<td>20</td>
<td>5/month</td>
</tr>
<tr>
<td>Item</td>
<td>Cost</td>
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<tr>
<td>-------------------</td>
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</tr>
<tr>
<td>Tendering</td>
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<tr>
<td>Supplies &amp; Equipment</td>
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<td>Contractor Payments</td>
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<td>Engineering &amp; Testing</td>
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<td>Miscellaneous</td>
<td>$1414.23</td>
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<tr>
<td>Total</td>
<td>$530,415.71</td>
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</table>

Original Estimate for the new plant - $1.0 million (1998 estimate)
Great Village Operations

- Design wet weather flow 70,000 I GPD.
- Effluent quality consistently below the permit discharge limitations of BOD/SS: 20/20; tertiary quality effluent without filters
- Operating cost - $30,000; includes part-time operator, sludge transport & handling.
- Power Cost - $7,000
- Operator Time – 4 hours a week
Tatamagouche Sewer System

Area of Potential Expansion of Services

Community of Tatamagouche
Tatamagouche STP

- Feb. 2004; Funding approved from CNSIP
- June 2004; Consultant hired to design the new plant.
- Scheduled Plant Commissioning April 2005.
Tatamagouche STP - Proposed
### Tatamagouche

#### $$$

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
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<tbody>
<tr>
<td>Contractor</td>
<td>$1,704,135</td>
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<td>Engineering</td>
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<td>Electrical Panel</td>
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<tr>
<td>Total</td>
<td>$1,906,339 plus Tax</td>
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</table>

Infrastructure Funding Approved – $1,639,007
Tatamagouche Operations

- Design wet weather flow 300,000 l GPD.
- *Expected* Effluent quality *to be* below the permit discharge limitations of BOD/SS: 20/20; tertiary quality effluent without filters
- Budget Operating cost - $80,000; includes part-time operator, sludge transport & handling.
- Estimated Power Cost - $25,000
Baddeck STP (1.7 MGD, $2.2M)
Pugwash STP (0.5 MGD, $1.6M)
Wastewater Treatment Plant Cost Estimates

Cost Estimate ($) vs Flow (m³/d)

- Lagoon
- SBR
- Linear (Lagoon)
- Poly. (SBR)
Planning for an SBR

✓ Get accurate flow monitoring data
✓ Inflow/Infiltration considerations
✓ Wastewater Characteristics
✓ Community Growth Patterns
✓ Site Adaptation/Selection
✓ Access to skilled operators
SBR Selection

✓ Different configurations of the SBR
  - Equalization/non Equalization
  - Two Cell/Four Cell Design
  - Fill cycle variations
  - Different Aeration systems
  - Decanter designs
  - Sludge wasting mechanisms
  - Controls and Automation
  - Configuration to site
SBR Selection Contd.

✓ Different vendors have their own designs
✓ Wastewater Characteristics
✓ Community Growth Patterns
✓ Site Adaptation/Selection
✓ Access to skilled operators
Pugwash STP (0.5 MGD, $1.6M)
Advantages of SBR

• Small footprint
• Maximum day flow sizing, not peak hourly.
• Can handle large fluctuations in flow and influent quality
• No hydraulic connection between incoming sewage and the outfall
• Flexibility and control
• Deeper tanks, better AOTR
• Modular, adaptable to retrofits & upgrades
• Full back up systems
Disadvantages

• Requires highly skilled team to design and construct the facilities
• Highly skilled operators
• Can be higher in operating cost, you do not control the cost of electricity.
• Bigger disinfection system, batch discharge
• More mechanical equipment
Main Points to Consider

- No matter what type of plant you decide, remember these facilities often times become the boundary of a community.
- Do not oversize, go modular and have back up systems.
- Select readily available equipment.
- Choose open architecture and non-proprietary control systems.
- Trained operators is a must for SBRs.
- Consider high level of automation.
- Hire an operator in the planning stage.
- Optimize plant to start with (InfraGuide Best Practices); one additional hp costs $1,000 more per year to run.
- Set up an equipment reserve as a maintenance cost.
- UV Disinfection.
- Biosolids handling and disposal.
Acknowledgements

Halifax Regional Water Commission

Municipality of the County of Colchester

&

You all
Questions??????