National Resources Defense Council

City-Wide Nitrogen Removal Update

November 14, 2006

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Presentation Overview

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- *Why is Nitrogen A Concern?*
- *Sources of Nitrogen*
- *Nitrogen Removal Applied Research Program*
  - *Where Have We Been*
  - *Highlights*
  - *Future Research*

Why Is Nitrogen A Concern?

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- *Nitrogen fuels the growth of phytoplankton*
- *Nitrogen A Contributing Factor → Low Dissolved Oxygen (Hypoxia)*

Water Quality Impact

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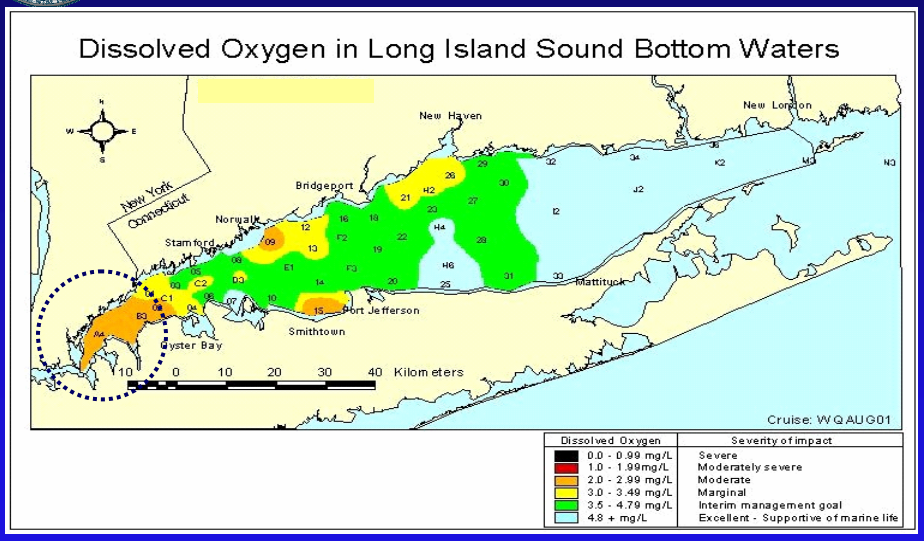

- *WPCPs*
- *Overland Runoff*
- *Agriculture Activities*
- *Traffic Impact*
- *Industrial Emissions*

Timeline Summary

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1988 Ocean Dumping Ban Act

1990 LISS confirmed N as primary source of hypoxia and identifies NYCDEP WPCPs as significant source of N

1993 SPDES permit required pilot testing for N control

1995 BNR Retrofits incorporated at Tallman Island

1998 NYCDEP constructs PO-55 Pilot Testing Facility

1999 Step-feed Biological Nutrient Removal (SF-BNR) identified as most feasible technology

2002 NYCDEP signs ACO laying out nitrogen-reduction schedule

2006 NYCDEP signs Joint Consent Judgment with long-term milestones

NYSDEC mandates drastic effluent TN criteria with pilot testing component to identify the most feasible technology.

Global Search for Innovation

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More than 100 Innovative Technology Facilities Visited and Evaluated

- **Biologically Active Filter**
  - Nitrifying BAF
  - Denitrifying BAF
  - BOD / Nit / Denit BAF's
  - BAF for Nitrogen and Phosphorus Removal with Chemical P Removal
- **Attached Growth Media Systems**
  - Moving Bed Biofilm Reactors (MBBR)
  - Integrated Fixed Film Activated Sludge (IFAS)
  - Hybrid Systems – Retrofits to Activated Sludge
- **Chemical Phosphorus Removal**
- **SHARON Process**
- **ANAMMOX Process**
- **CAMBI Process**
- **OLAND Process**
- **CANON Process**
- **Membrane Bioreactors For Nitrogen & Phosphorus Removal**
- **Membrane Biofilm Reactor**
- **Ultrasonic Destruction Technology**
- **Ozone Destruction Technology**
- **Dual Stage Digestion**
- **Sludge Fermentation**
- **Hot Air Stripping of Ammonia**
- **Denitrifying Filters**
- **High Ballast Settling**
- **Advanced Oxidation**
  - Ultraviolet Radiation
  - Ozone
  - Peroxide
- **High Rate Dissolved Air Flotation**

Applied Research Program

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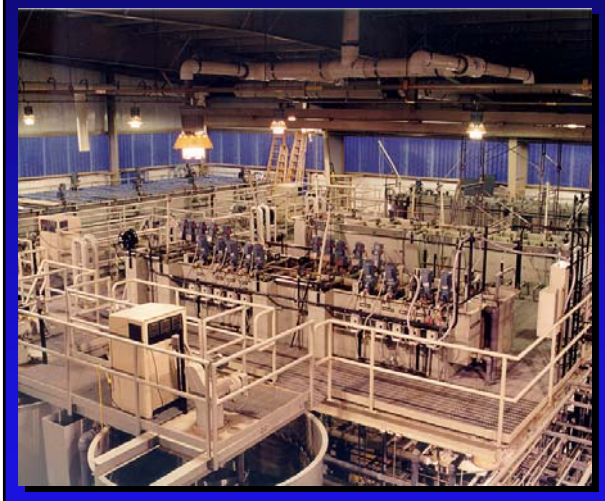

Objectives

- *Maximize TN Removals In Existing Facilities*
- *TN Removal To 3-5 mg/L*
- *Continued Research Of Innovative Processes*

Largest Nutrient Removal Research Program In The World

NYCDEP's 14 Existing WPCPs

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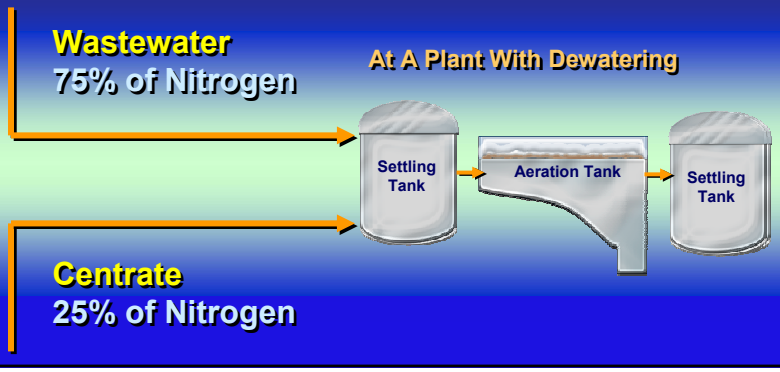
- Designed for Secondary Treatment (organics only)
- Short Hydraulic Detention Times (4 hrs)
- Space Constraints
- Centrate TN Load



Centrate

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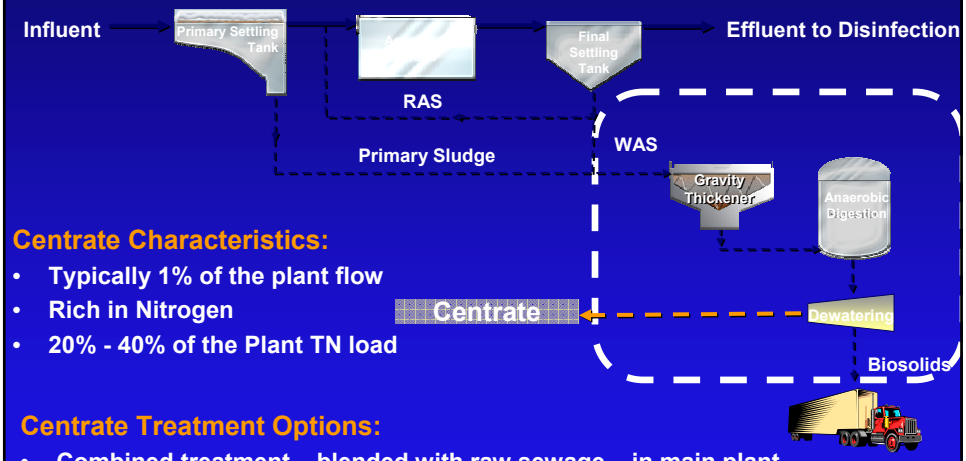
Ocean Dumping Ban Act (1988) = on-site solids management



Centrate Characteristics:

- Typically 1% of the plant flow
- Rich in Nitrogen
- 20% - 40% of the Plant TN load

Centrate Treatment Options:

- Combined treatment – blended with raw sewage – in main plant
- Separate side stream treatment – effluent to activated sludge process

Technology Performance Evaluation

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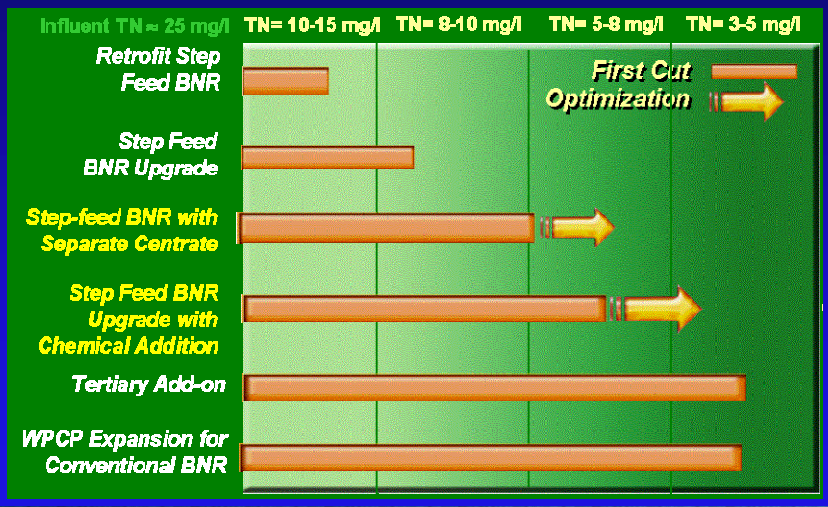
Multi-faceted approach for meeting varying effluent goals



Step-Feed BNR most Cost Effective Technology with Separate Centrate

SHARON® Process Demonstration

Wards Island WPCP, Manhattan NY

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Full-Scale Demonstration Projects

- **Wards Island selected as site for two full-scale Demonstration Facilities:**
  - AT-13 Full-Scale BNR Retrofit
  - SHARON® Demonstration Facility
- **Demonstration facilities part of Phase I Facilities Plan in Judicial Consent Judgment with NYSDEC**
- **AT-13 contract award eminent,**
- **SHARON® contract awarded**

SHARON® Process

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Single reactor system for High Ammonia Removal Over Nitrite

1997	Delft University Pilot Evaluations
1997	First Demonstration In The Netherlands
1998	First Publication
1999	Full-scale Demonstration
1999	Process is Patented
2000	NTAC and VE Team Recommend Evaluation
2003	Additional Installations in The Netherlands
2006	NYCDEP Wards Island SHARON ® Design Completed

- Patented Technology – Delft University of Technology, Grontmij, Water Authority Hollandse Eilanden and Waarden
- Six full-scale SHARON® installations with proven performance record
- **Treatment capacity range: 900 lb N/day to 5,500 lb N/day**
- Simple to operate; robust
- Offers the control and reliability required to realize cost savings

Conventional Systems

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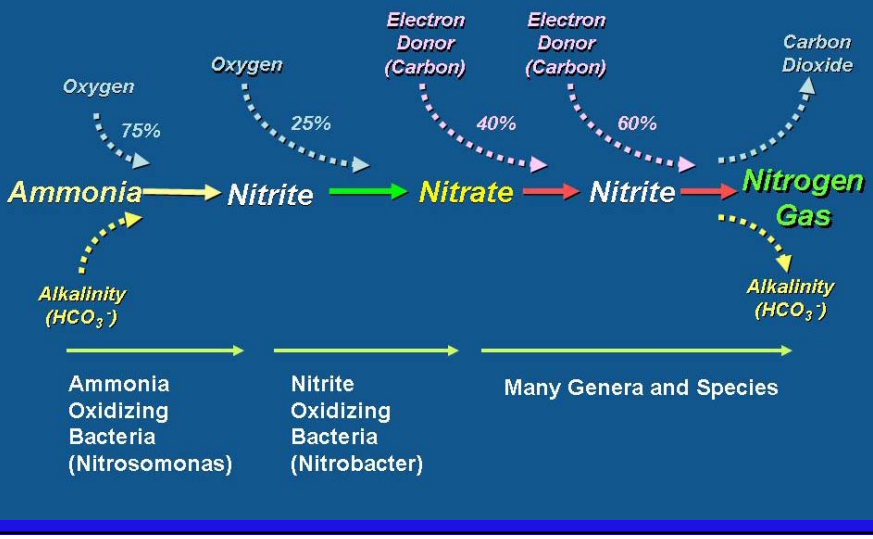
Conventional Nitrification and Denitrification



Process Basis

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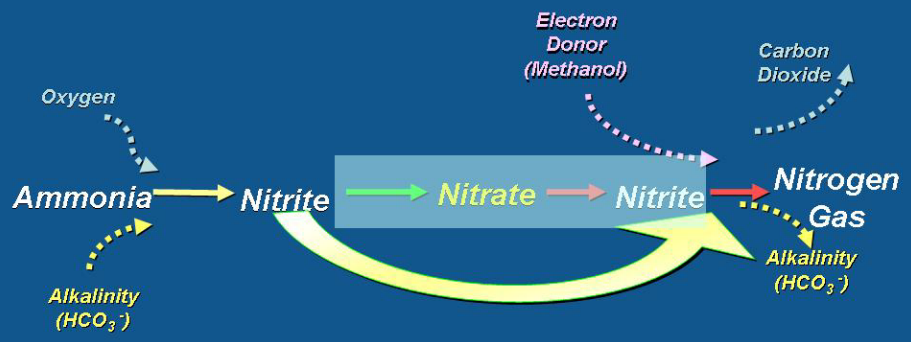
SHARON® Process



Short-Circuited Nitrification/Denitrification Pathway

Process Benefits

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- Reduces oxygen & power demand 25%
- Reduces carbon demand 40%
- Reduces alkalinity demand due to recovery during the denitrification phase
- No continuous biomass seeding required
- Small footprint
- No chemical sludge production
- Insensitive to influent TSS

parameter	units	avg value	max value	min value
flow	MGD	0.925	1.155	0.695
	m^3/day	3,501	4,377	2,626
	m^3/h	146	182	109
TKN	kg/day	2,885	4,144	1,815
NH_4-N	kg/day	2,451	3,501	1,576
TCOD	kg/day	3,326	7,003	1,051
TSS	kg/day	2,100	5,252	263
alkalinity	kmol/day	74	92	55
influent temperature	°F	89.6	93.2	82.4
	°C	32	34	28

Wards Island Demo
Two Reactor Trains combined avg flow → 1.85 MGD

Project Status

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- Construction Commenced (Oct 2006)
- Capital Cost ≈ $60M
- Construction Schedule: 2 years
- Process Startup: 3Q 2008

Summary

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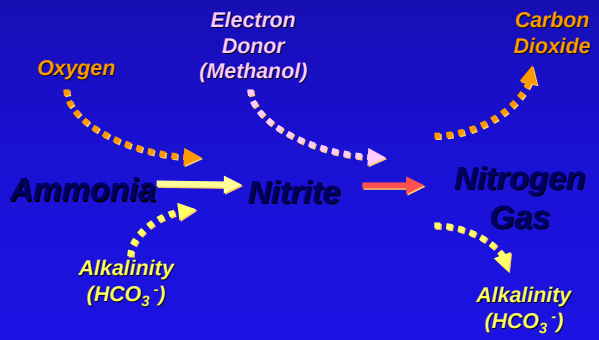
SHARON® Separate Centrate Treatment Process

- Short Circuits Conventional Nit / Denit Process
- Removes >90% TN Load
- Reduces Oxygen and Power Demands (25% Reduction)
- Reduces Carbon Demands (40% Reduction)
- Significant Space Savings



Applied Research Program

Applied Research Program

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Highlights:

- Separate Centrate Treatment Pilots
- ANAMMOX Pilot Study
- Carbon Control
- Glycerol/Biodiesel by-product as a Carbon Source
- Biolysis® O Pilot Study

Separate Centrate Treatment

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- Side stream pre-treatment of dewatering centrate prior to introduction to the Step Feed BNR process.
- **Objectives:**
  - Nitrification-denitrification of centrate
  - Seeding of nitrifiers and denitrifiers into the Step Feed BNR process
- **Online:** 2005, on-going

Immediate Benefits of AT-3 Process

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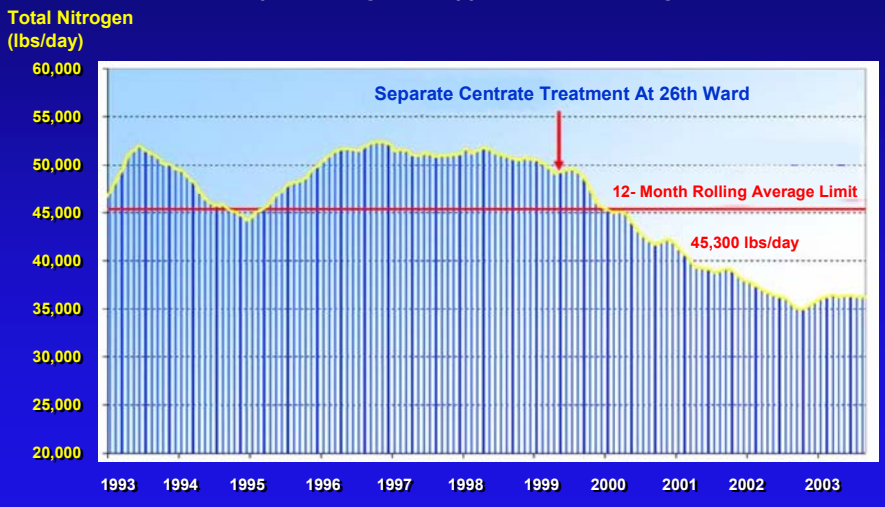
Separate Centrate TN Removal Process (AT-3 Process)
Developed Through The Applied Research Program



ANAMMOX

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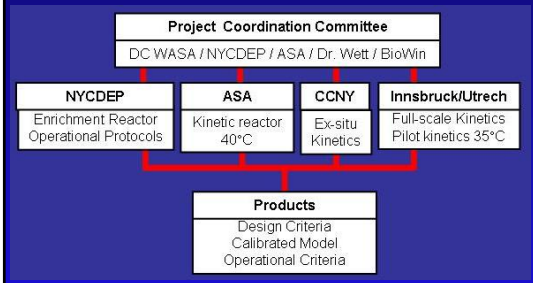
ANaerobic AMMonium OXidation

- Collaborative Research



- Timeline:
  - Enrichment Reactor (100 gallons)
    Construction: January 2006
  - Demonstration Unit (2,000 gallons)
    Construction: on-going
    Online: November 2006
- 1st Demonstration Unit in US

ANAMMOX

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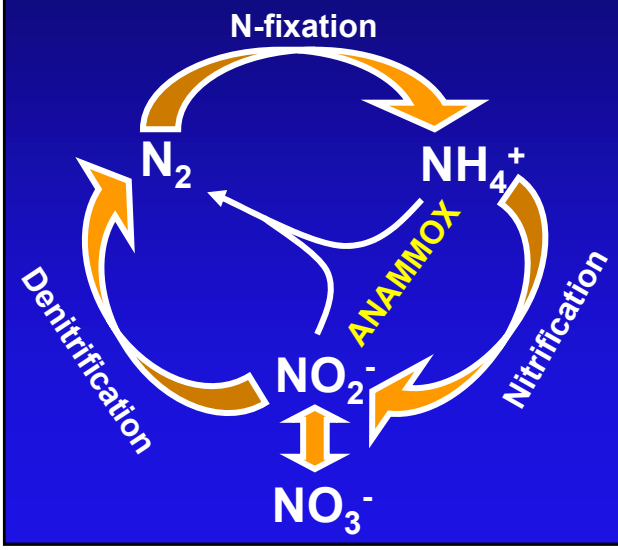
Nitritation/Deammonification Process



Benefits:

- **60% Reduction in Oxygen Demand**
- **No supplemental carbon required**
- **> 40% Reduction in Biomass Production**

ANAMMOX

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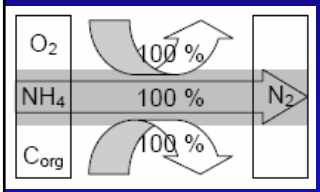
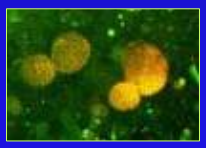
Relative Demand for Resources

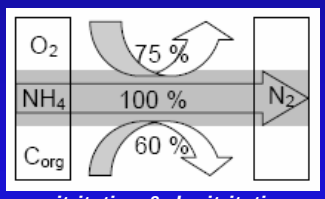
Conventional



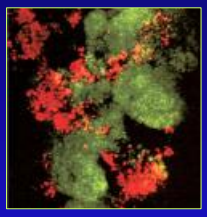
nitrification & denitrification



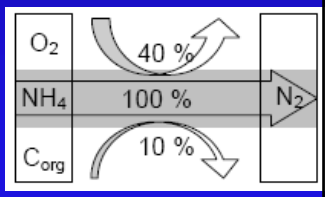
SHARON®



nitritation & denitritation



ANAMMOX



deammonification

Figures courtesy of Bernhard Wett

Carbon Control Study

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Objectives for Full Scale Application:

- Control carbon dosing in response to diurnal variations,
- Optimize carbon dosage to maintain TN removal using automated ORP and nitrate monitoring,
- ORP - evaluate as a simple and inexpensive monitoring tool,
- Automated carbon dose control system - examine applicability to full scale,
- Carbon source – Methanol (summer)
  Ethanol (winter)

Expected Benefits:

- Potential to save significant cost by eliminating carbon overdose,
- ORP: less cost/labor intensive and reliable monitoring tool for the BNR system
- Stable and reliable operation

Glycerol as Supplemental Carbon

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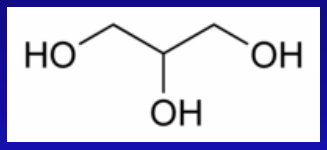
- Glycerol is a byproduct of biodiesel production
  - 1 gallon of biodiesel produces approximately 15% glycerine byproduct
- Local Mfg'ring – Newark, New Jersey
- Cost Comparison with MeOH & EtOH:
  - Methanol: $1.33 - $1.50 per gallon
  - Ethanol: $2.50 - $3.00 per gallon
  - Biodiesel by-product: $0.30 per gallon
- Safety/Storage
  - Transportation
- Research Objectives:
  - Kinetic testing
  - Screening
  - Long-term plan



$C_3H_5(OH)_3$

Biolysis® O Pilot Study

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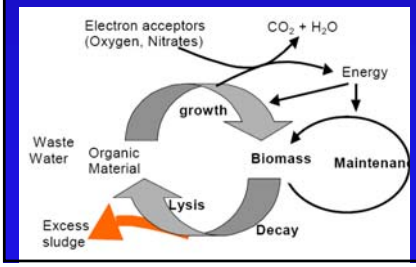
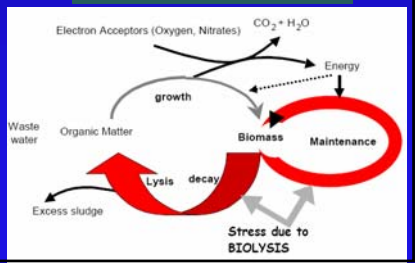
- Research Objectives: *to evaluate the effects of the ozonation system on:*
  - froth reduction
- Designed & built by IDI
- 1st US installation
  - successfully implemented in pilot studies in France & the UK
- 1 year study starting 2Q 2007





Applied Research Program

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Nitrogen Technical Advisory Committee (NTAC)

- **H. David Stensel, Ph.D., P.E., DEE.**
  University of Washington
- **Glen T. Daigger, Ph.D., P.E., DEE.**
  Senior Vice President, CH2MHill
- **James L. Barnard, Ph.D.**
  Senior Specialist, Black & Veatch
- **Denny S. Parker, Ph.D., P.E., DEE.**
  Senior Vice President, Brown & Caldwell
- **Clifford W. Randall, Ph.D.**
  Virginia Polytechnic Institute
- **Bruce A. Bell, Ph.D., P.E., DEE.**
  President, Carpenter Environmental
- **Jeffrey Featherstone, Ph.D.**
  Temple University

- ***Independently Appointed***
- ***Review Experimental Results***

Applied Research Program

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"In total, these programs go beyond the specifics of the SPDES permits in their scope of activities; the experimental and full-scale testing undertaken has been extremely comprehensive in scope and relatively costly to undertake. **In the opinion of the NTAC, this is the largest and most ambitious nutrient removal development program ever undertaken by a municipal agency.** Nonetheless, the City can justify its investment in technology development on the basis of savings in the very large capital program it will have to implement to meet projected nitrogen control levels. Moreover, the cost of potential long-term requirements (e.g., effluent TN levels of 4 mg/l) and the **very high costs of current tertiary technologies justify continued support by the City of a problem to develop lower cost technologies."**

- December 1999 NTAC Report on NCFP

Cutting-Edge Research

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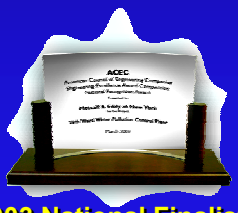
2002 Grand Award
American Council of Engineering Companies

2003 Diamond Award
New York Association of Consulting Engineers



2003 National Finalist
American Council of Engineering Companies

2003 National Research Technology Award
Association of Metropolitan Sewerage Agencies

Recent Publication: ENR

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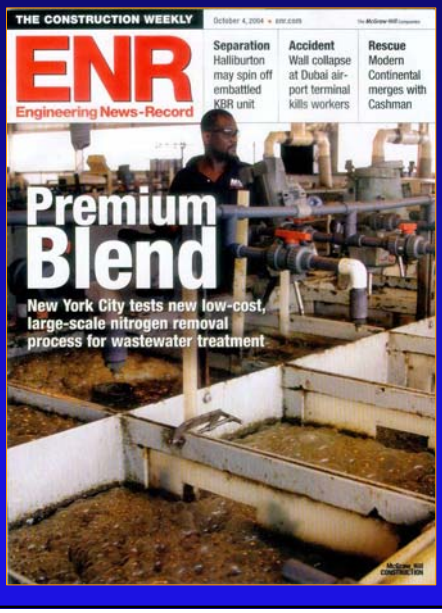

Featured in the cover story of Engineering News Record (ENR)* October 4, 2004

* ENR Is The Premier News Magazine For The Construction Industry, Reaching Over 70,000 Decision Makers Each Week.

Recent Publication: ENR

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SPECIAL ADVERTISING SECTION

WATER&WASTEWATER

10 to watch

SHARJAH DESALINATION PLANTS

United Arab Emirates
In design
Completion: 2007

The Sharjah Electricity and Water Authority is constructing two reverse osmosis desalination plants in Layyah and Khorfakkan. Each of these seawater reverse osmosis desalination plants will have the capability to produce 6-mgd of potable water. In order to treat the warm and organically high Arabian Gulf seawater, the Layyah plant will utilize dissolved air floatation in conjunction with two-stage media filtration as pretreatment technologies prior to the reverse osmosis.

SHARON BIOLOGICAL NUTRIENT REMOVAL PROJECT

Wards Island, New York, NY
Under construction
Completion: 2008

New York City Dept of Environmental Protection will use the Single Reactor System for High Ammonia Removal Over Nitrite (SHARON) biological nutrient removal process (developed in the Netherlands) for wastewater treatment. A first in the U.S., this process is expected to allow greater nitrogen removal within a smaller footprint than traditional systems and with significantly lower energy costs.

JIE YUAN WATER TREATMENT PLANT RENOVATION

Tianjin, China
Under construction
Completion: 2006

Renovations to the Jie Yuan Water Treatment plant will enable the 100-year-old plant to treat high algae levels from two rivers that are vulnerable to pollution in summer and are critical sources of drinking water for about three million people living in Tianjin. When complete, the improved plant will be one of the largest dissolved air flotation facilities in the world, treating up to 500 million liters per day.

Featured in Engineering News Record (ENR) March 20, 2006

DISCUSSION