BUILDING A WORLD OF DIFFERENCE®

BLACK & VEATCH





Trends in Wastewater Treatment

E30: AAEE/AIDIS/WEF Breakfast

WEFTEC 09
Orlando, Florida
October 10–14, 2009

James L Barnard

Contents

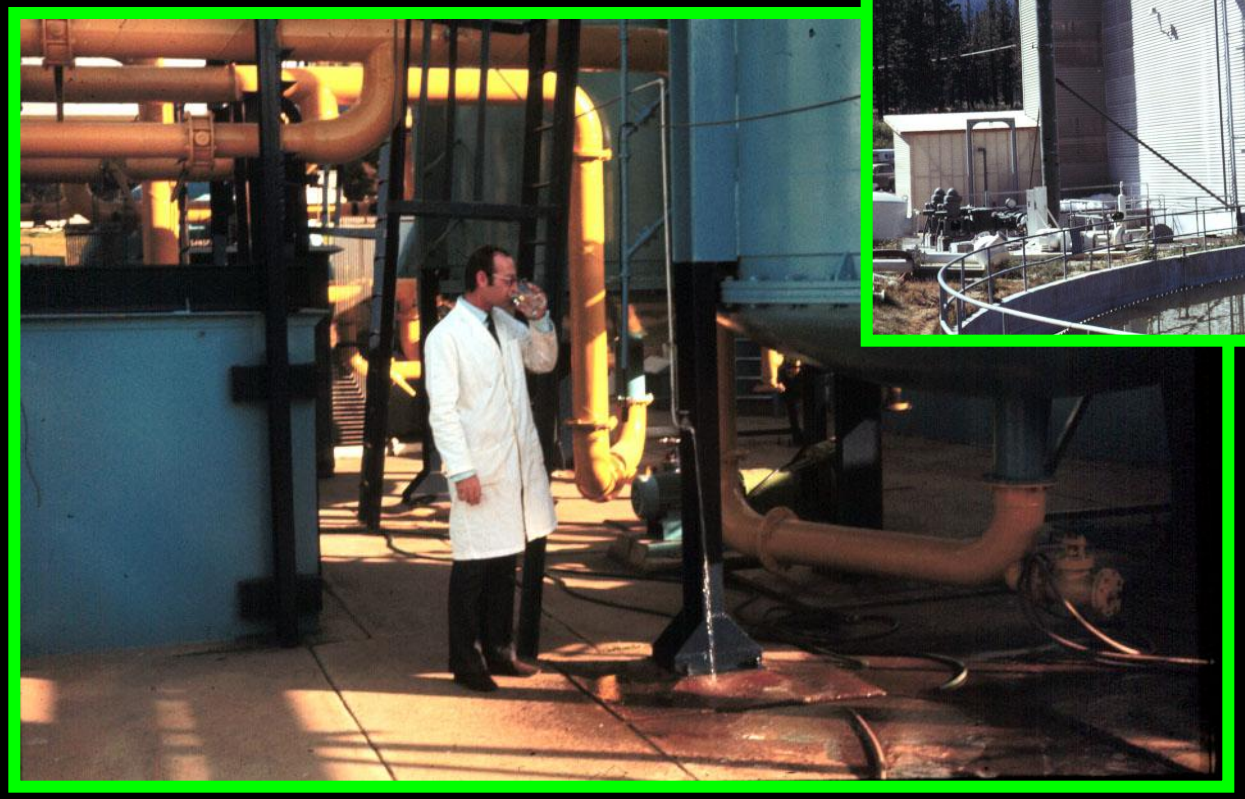
- Discovery of the Activated Sludge Process
- Major trends in wastewater treatment
- Drivers for Research and Development
- Wastewater as a Resource
- Possible Future Scenarios

1914 - Arden & Lockett Publish Activated Sludge Process

The Activated Sludge Process

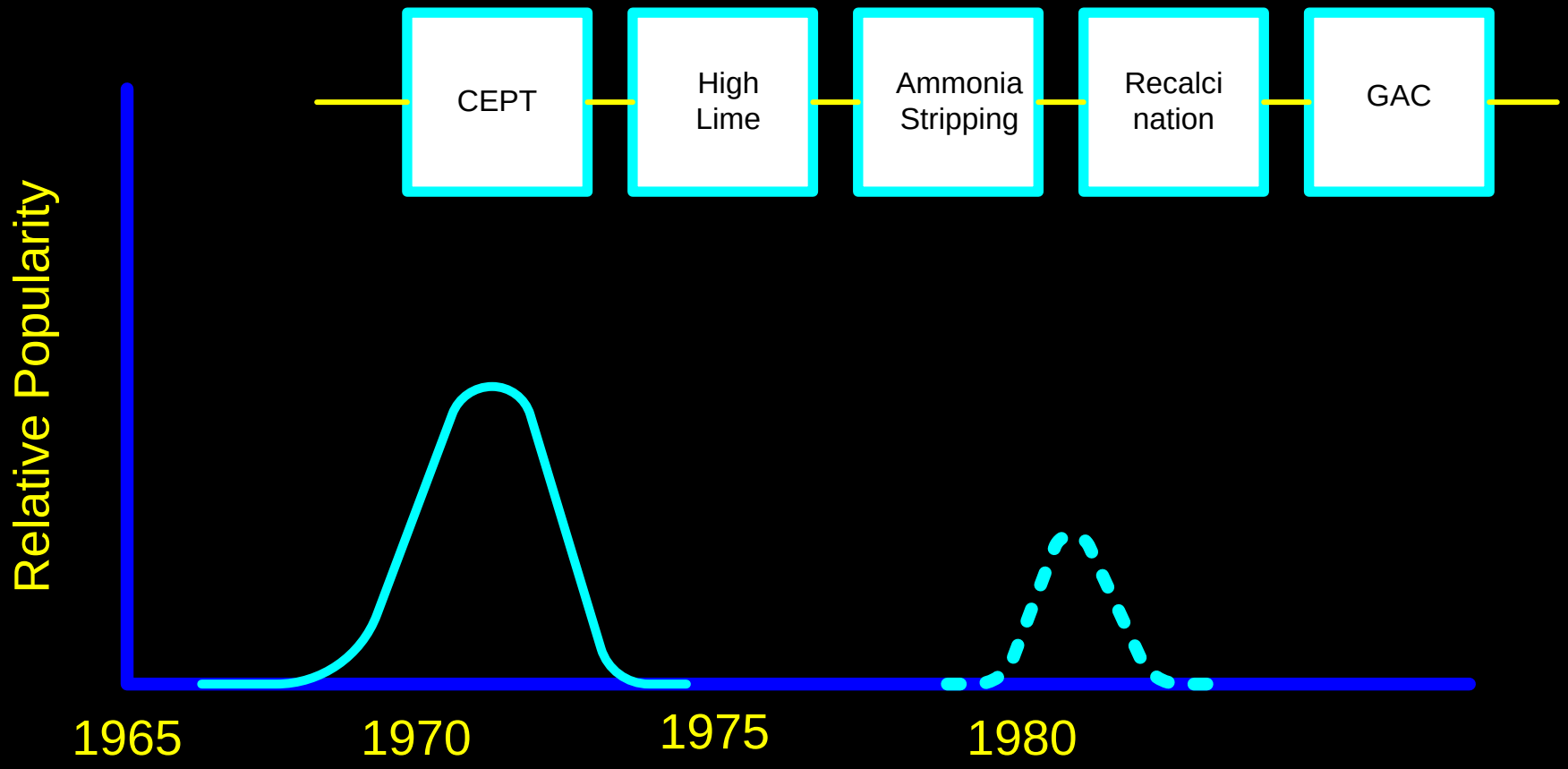
Tertiary High Lime and Ammonia Stripping

- Lake Tahoe – Right and Pretoria Left



Ion Exchange for ammonia removal

Trends in Independent Physical/Chemical



Goudkoppies plant completed - 1975

60th Birthday of the activated sludge process

85% N removal

90% P Removal

Anaerobic Zones added 1974

Dublin Bay – View towards City

11.3 m^3/s 260 mgd

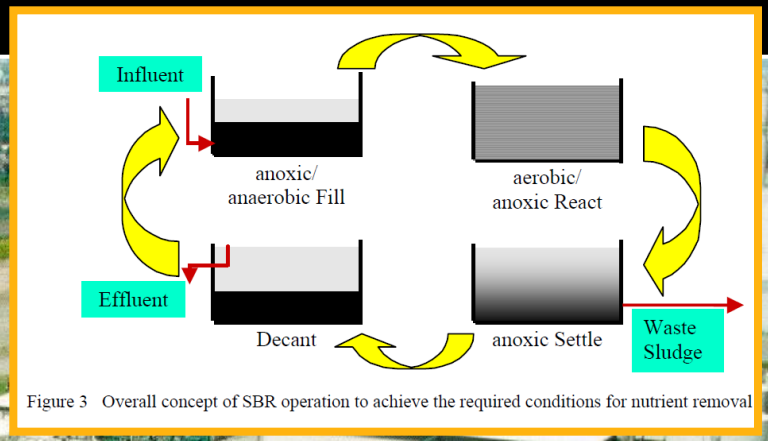
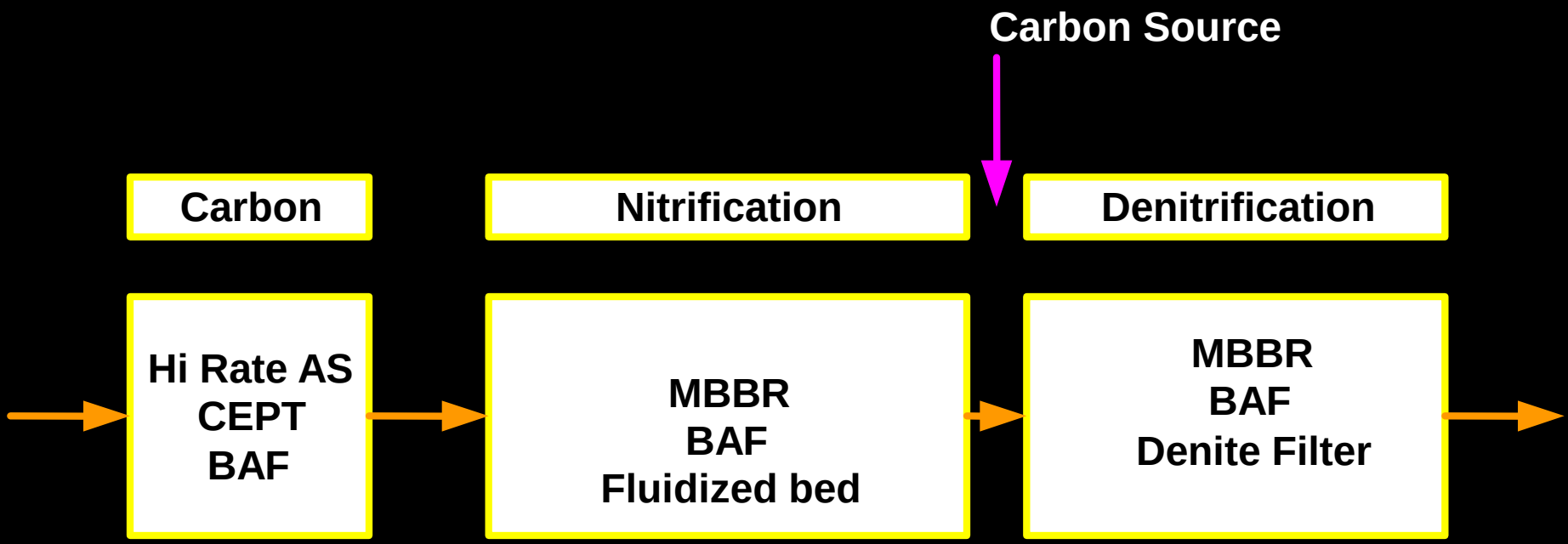
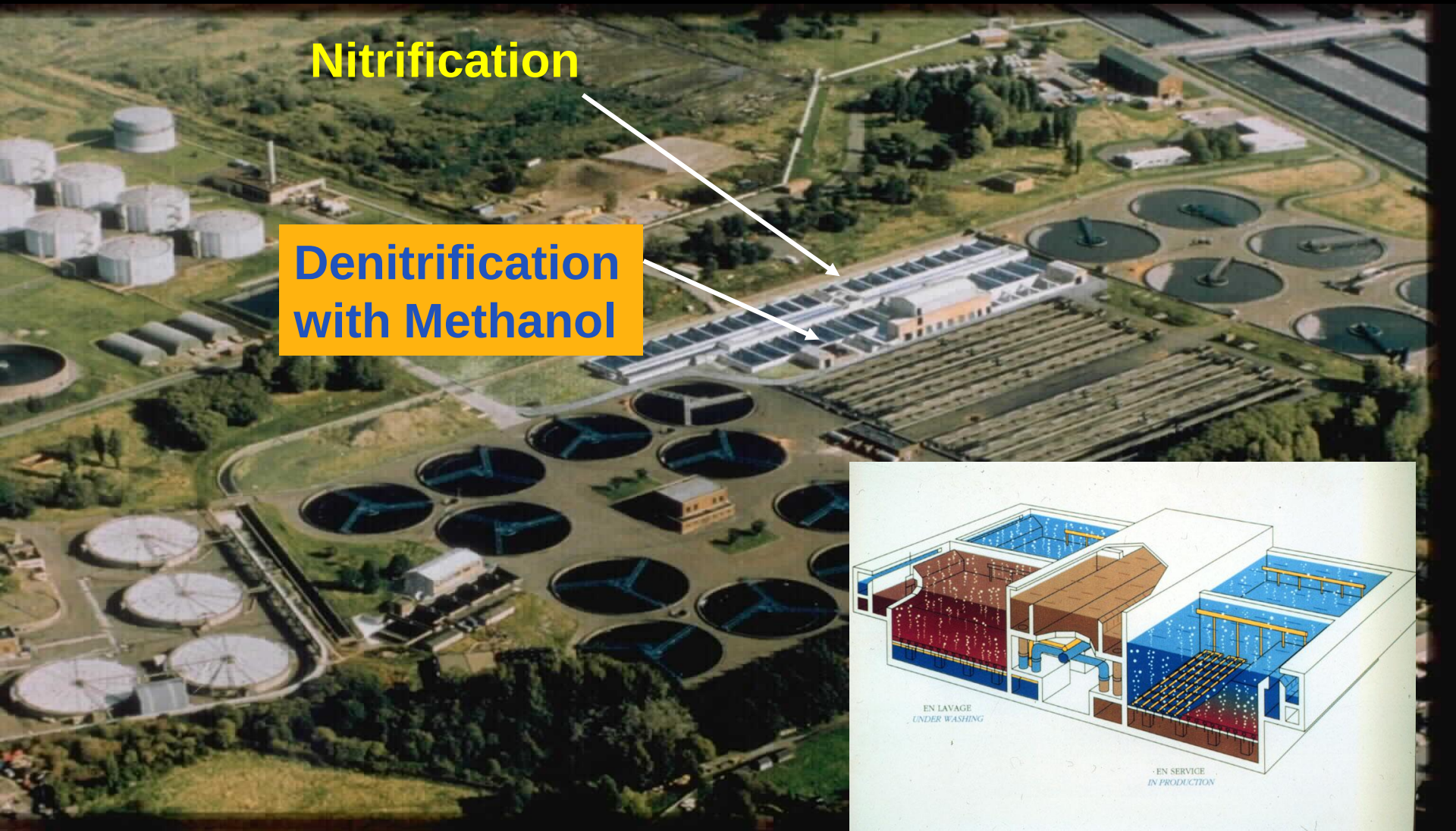


Figure 3 Overall concept of SBR operation to achieve the required conditions for nutrient removal

Nitrogen Removal in Attached Growth systems

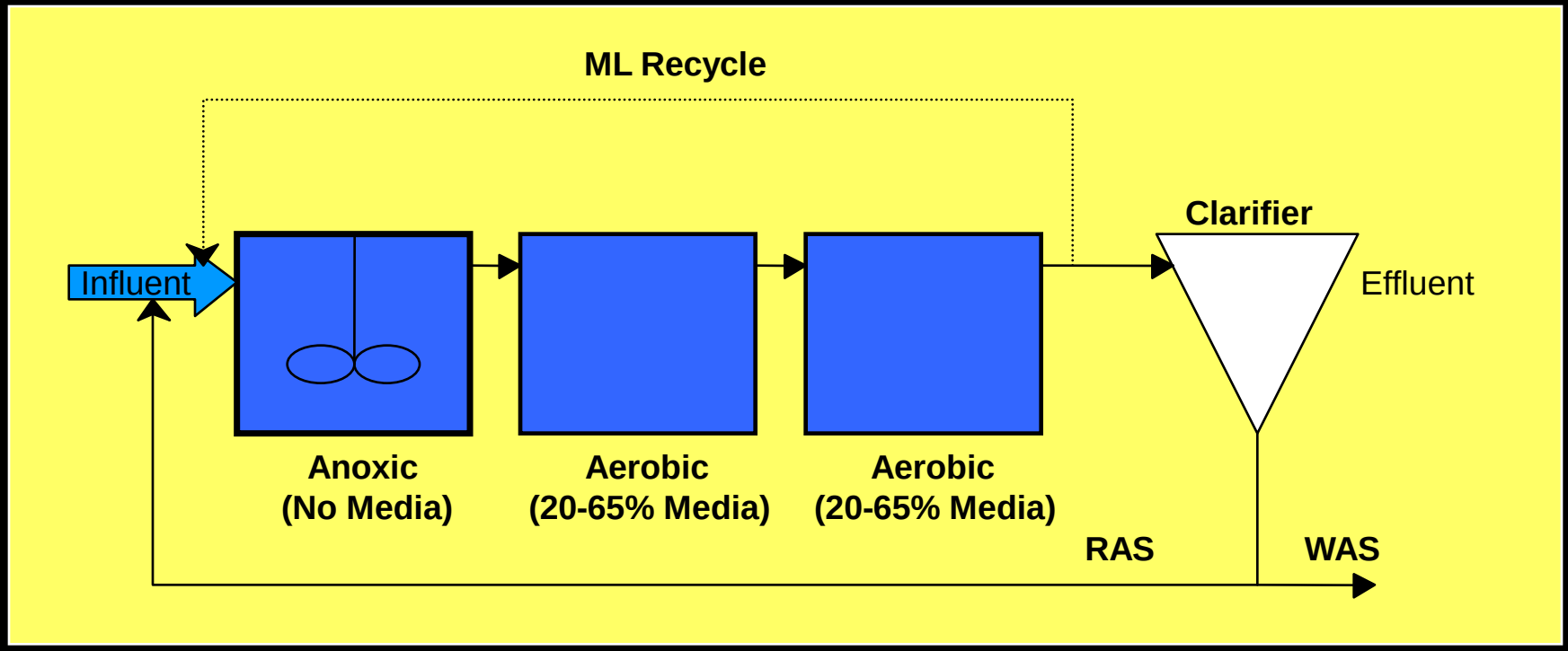


Davyhulme plant, Manchester – Biological Aerated Filters

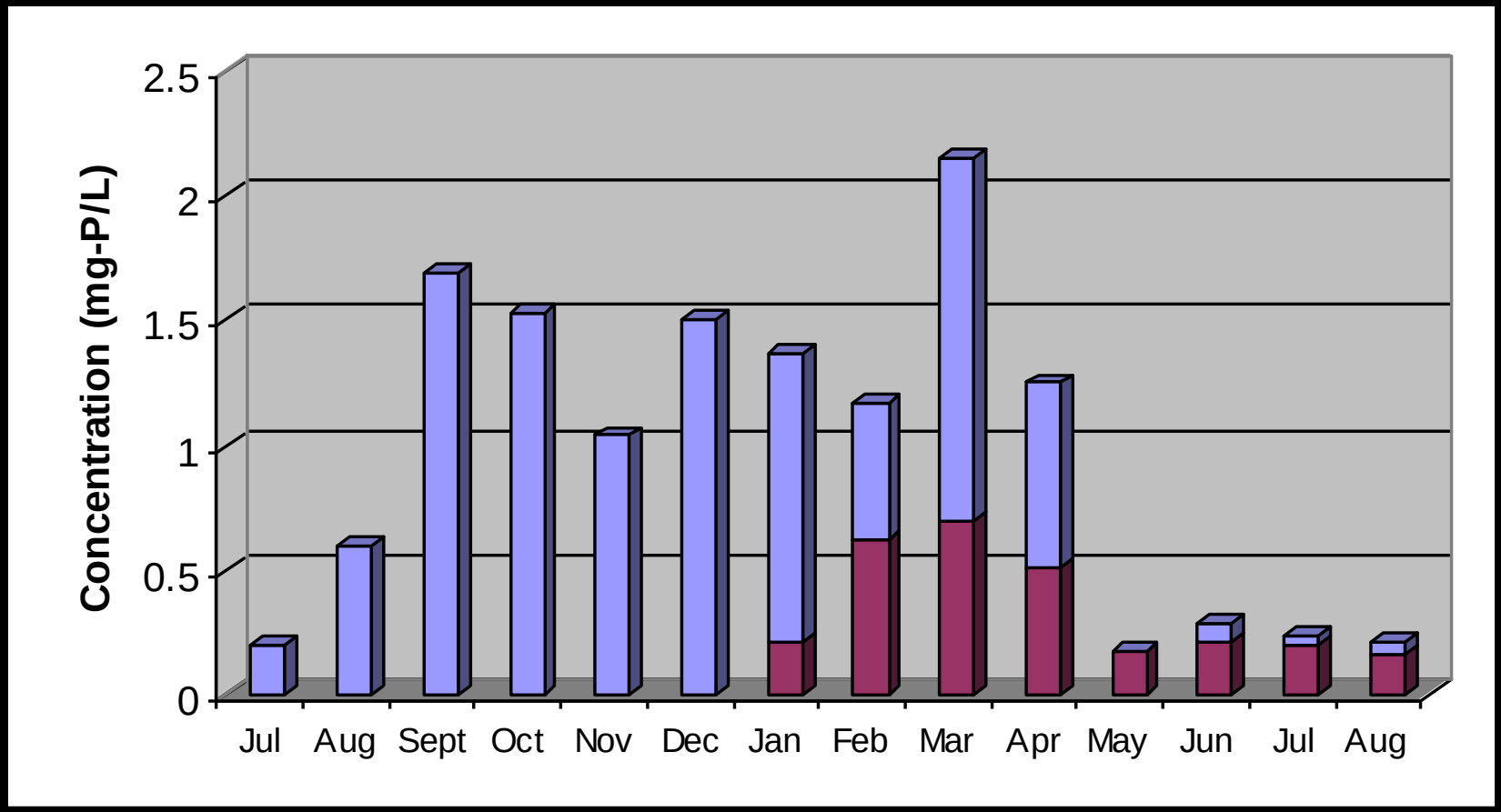


The Activated Sludge Process #2

IFAS Example Schematic

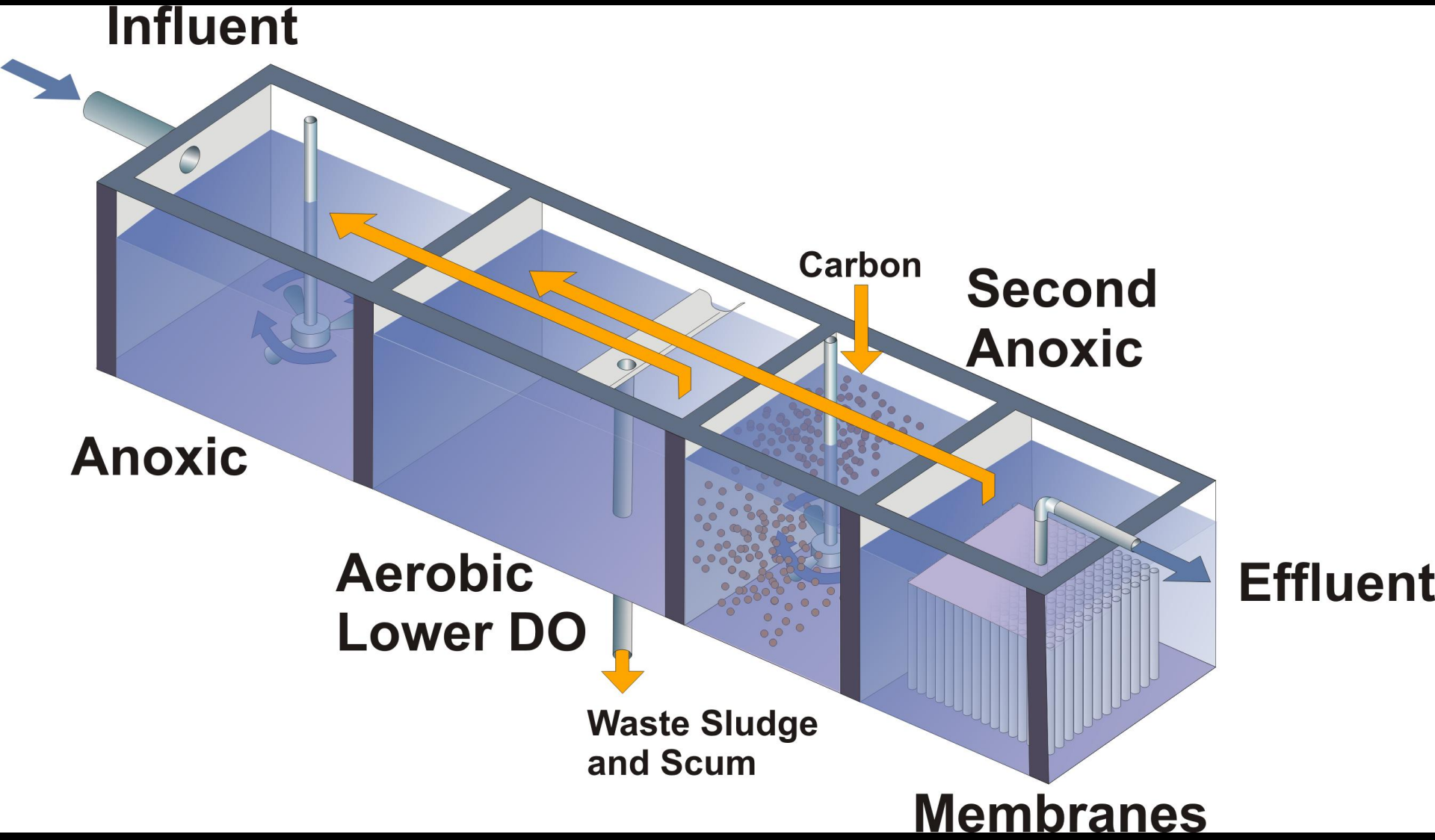


Biological phosphorus removal still possible



Application of Membranes to Wastewater - 1968

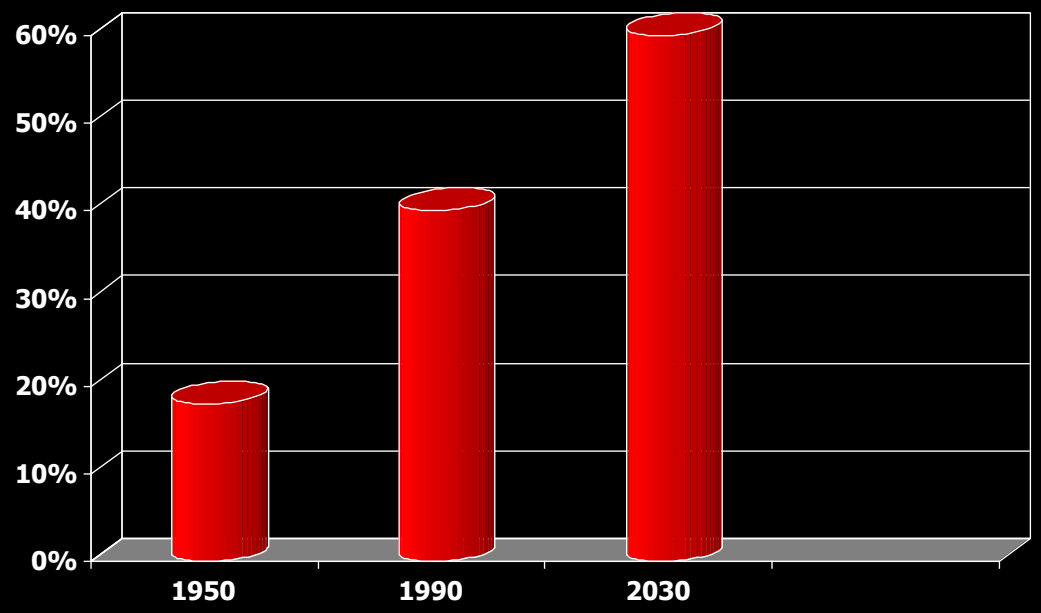
MBR Lay-out with media in 2nd AX Zone

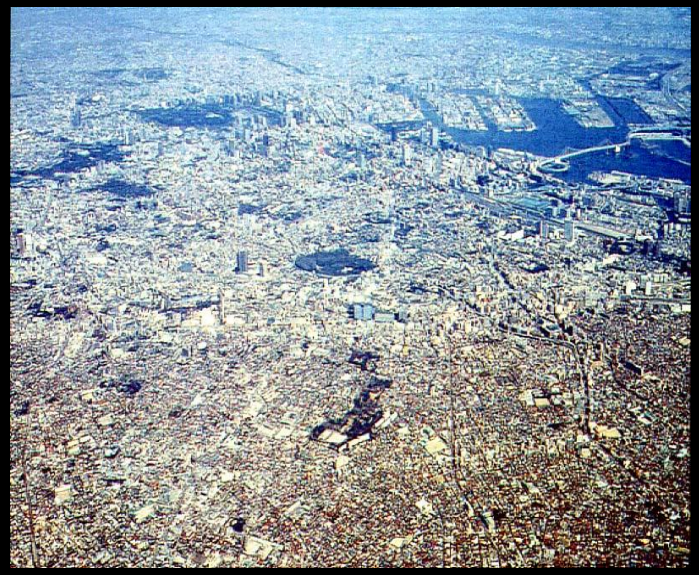


Drivers for Development of New Technology

- Population Growth
- Eutrophication – Reduce N and P to lowest possible level
- Reduce energy cost and recovery of energy
- Reduce EDC and PCP
- Reduce GHG
- Recovery of resources

Urbanization in the world





Within 2035 60 % of the global population will live in cities

World Watch Institute 2007: > 50 % is already living in urban areas

Town of Brits

Johannesburg North Receiving Water

Image © 2008 DigitalGlobe

©2007 Google

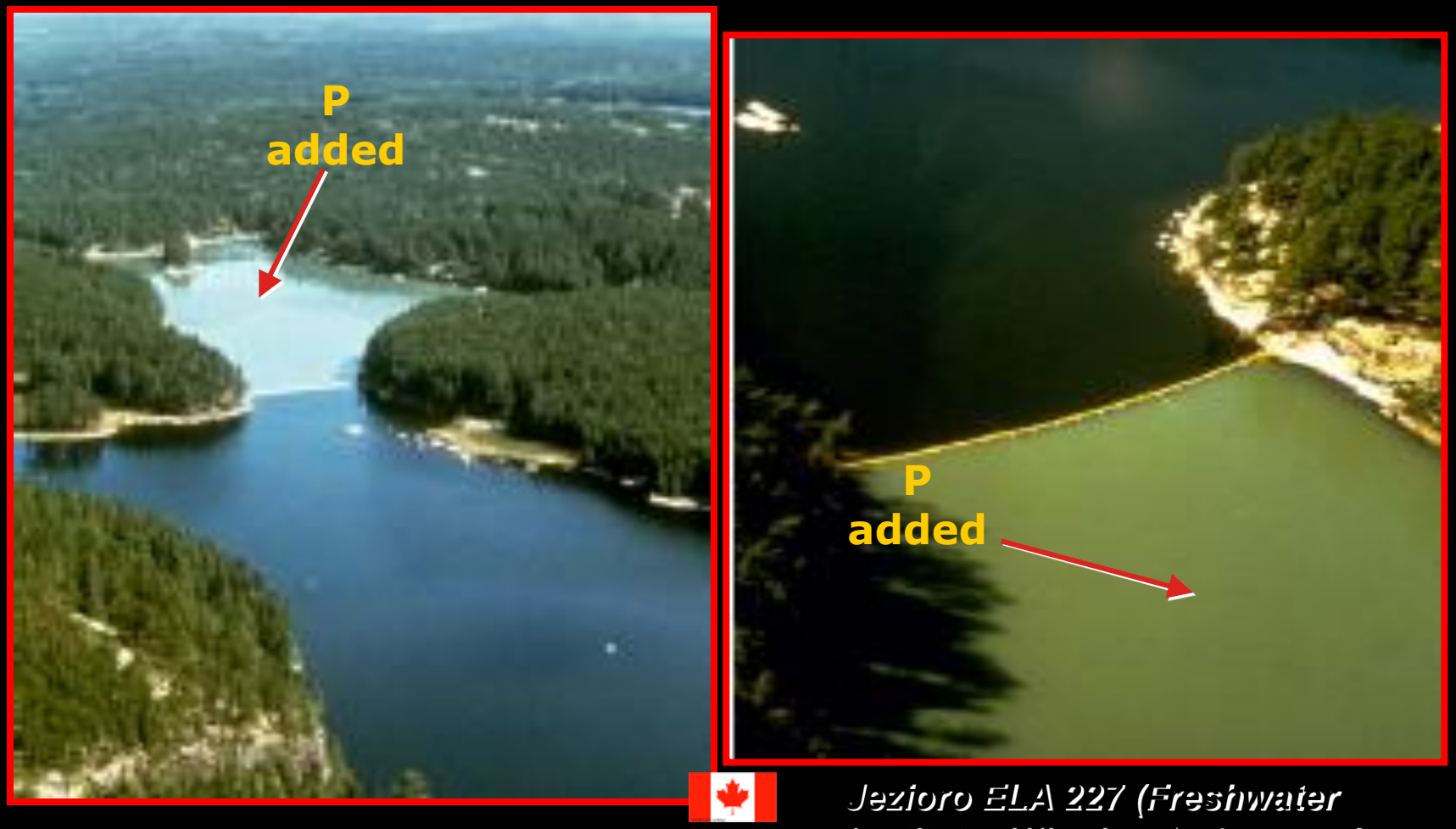
Pointer 25°42'20.13" S 27°51'12.67" E elev 3961 ft Streaming 100%

Eye alt 43814 ft

Drive for Limits of Technology (LOT)

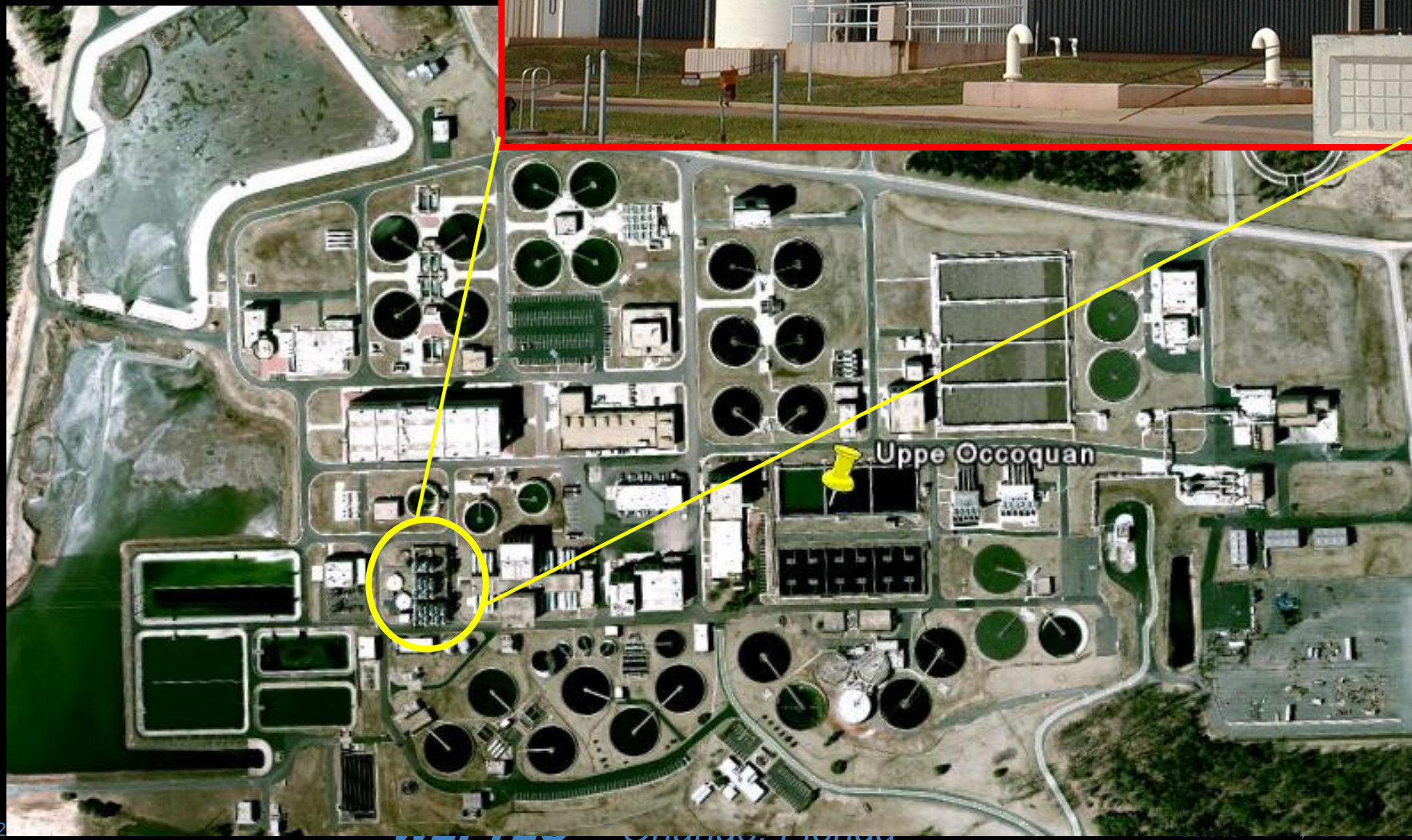
- LOT is meaningless and should not be used
- What is Sustainable
- What is economically justifiable
- LCA studies
- Nitrogen limits 2.5 mg/L? What is the role of the rDON? How is it removed?
- Phosphorus limits down to 0.01 mg/L.
- Should we apply strict nutrient limits when the impact is negligent or it is evident that it may harm the receiving water

In inland freshwater, it was proven that phosphorus leads to algal growth



Jezioro ELA 227 (Freshwater Institute, Winnipeg). Przegroda oddziela sekcje z dodatkiem P

Upper Occoquan Plant



Occoquan Reservoir, Virginia

Unaddressed Violations Damage Waterways and Send the Wrong Message to Citizens, Developers and Neighboring Localities

Up to 85% of the flow to the reservoir comes from Water Purification plants

In 1989, 60% all streams in the Occoquan Watershed were classified as high-quality streams

Energy

Global Cooling or Global Warming

1968

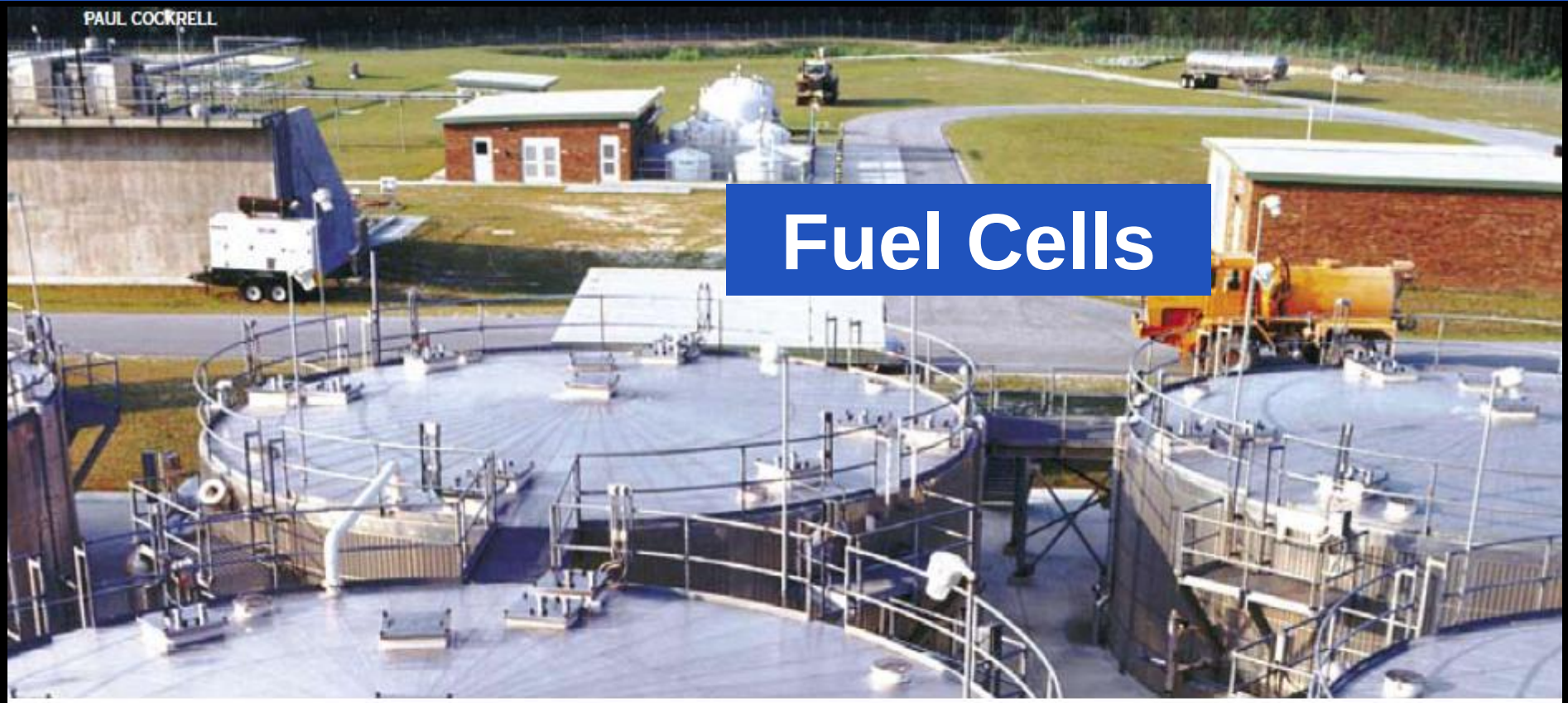
2009

Comparative Energy Costs

Energy used for	kWh/c/a
BNR Wastewater Treatment	40
Switching one lamp to low energy fixtures	102
Pumping water from north to south of California	355
Household per person (2 persons)	14,000

Most of the Energy in WWTP required for Nitrification

Fuel Cells



FAD OR FUTURE?

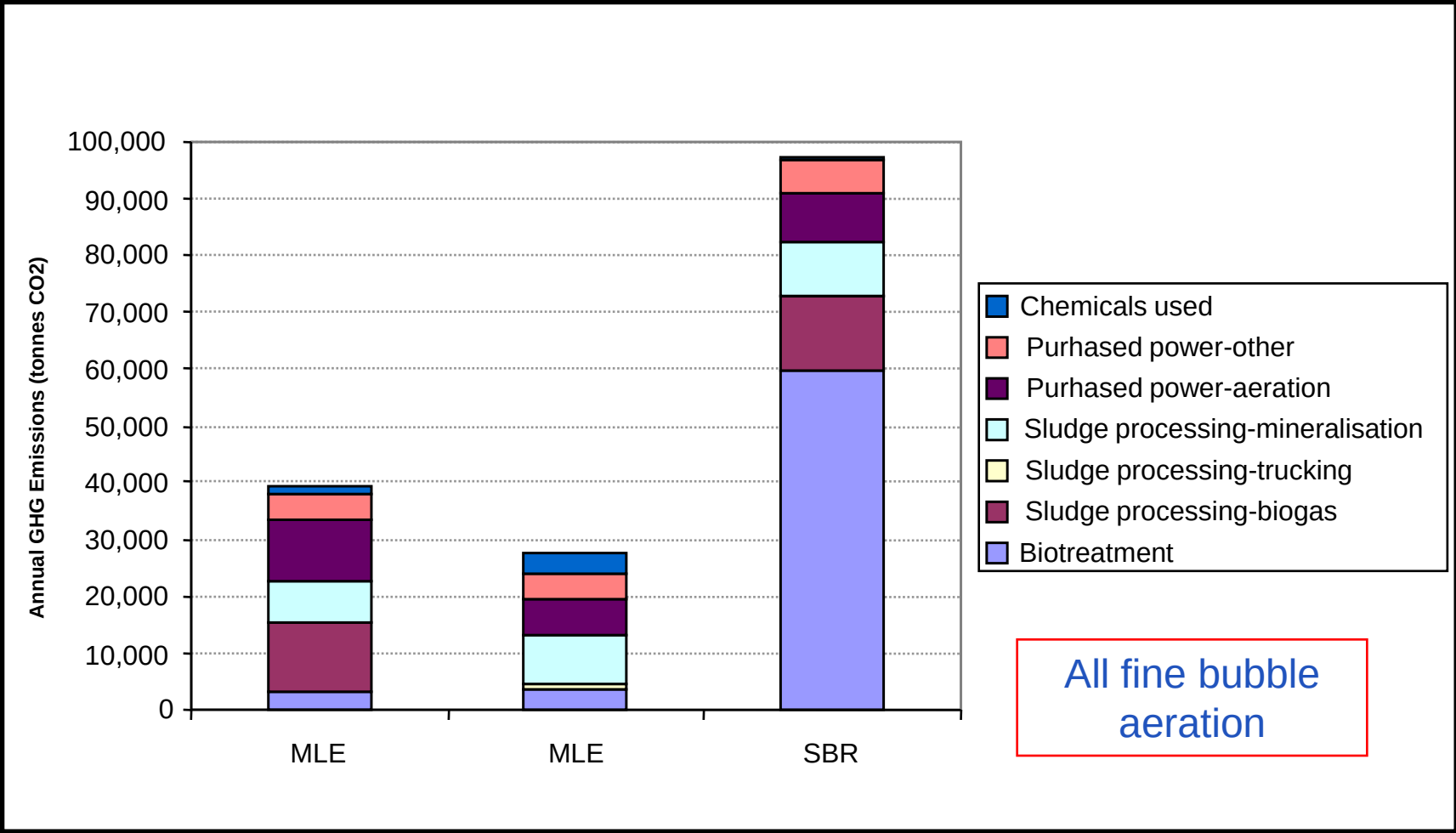
An expert evaluates whether digester-gas-fed fuel cells and microturbines are cost-effective sources of power

Nicholas Mignone WE&T November 2008

Green-House Gases

GHG Emissions from three plants –

(Dr Katie Third – W2W Alliance Perth)



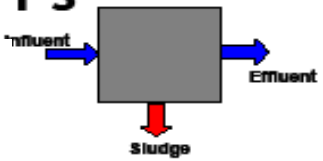
Sources of green house gases

- 85 - 95% from water vapor
- 13% of remaining GHG caused by nitrous oxide (by effect)
- 12% of N_2O from anthropogenic sources
- 65% of that from domesticated animals
- 20% from industry including vehicles
- That leaves 15% for others including agriculture which would put wastewater treatment plants at most (guess) 0.1% of the remaining 15%. (from Foley et al 2008)
- The net effect of reducing N_2O at all WWTP may be a reduction of 0.000006% of GHG

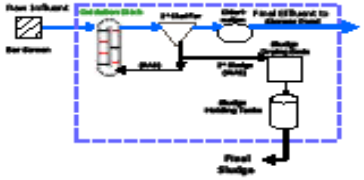
Endocrine Disruptors Personal Care Products

Treatment of Emerging Contaminants Biological Treatment

Preliminary Comparison of six Arizona WWTPs

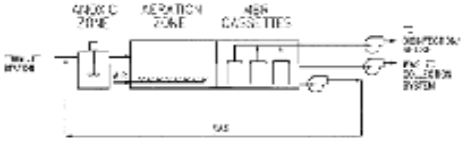


Overall estrogenic activity removal (%)



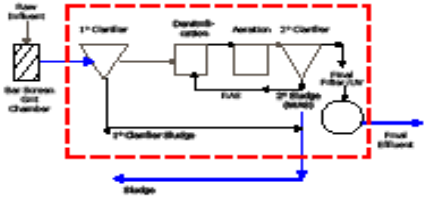
Oxidation ditch

97



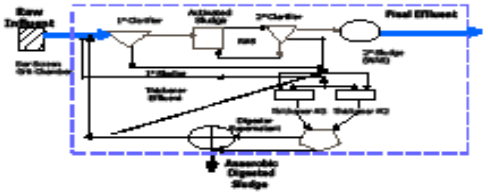
Membrane bioreactor

97



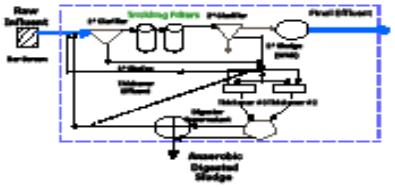
Nitrification/denitrification

99



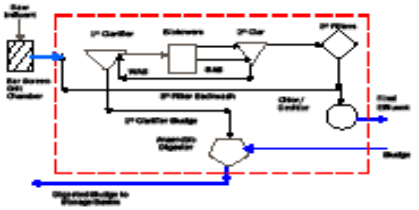
Activated sludge

65



Biotower #1

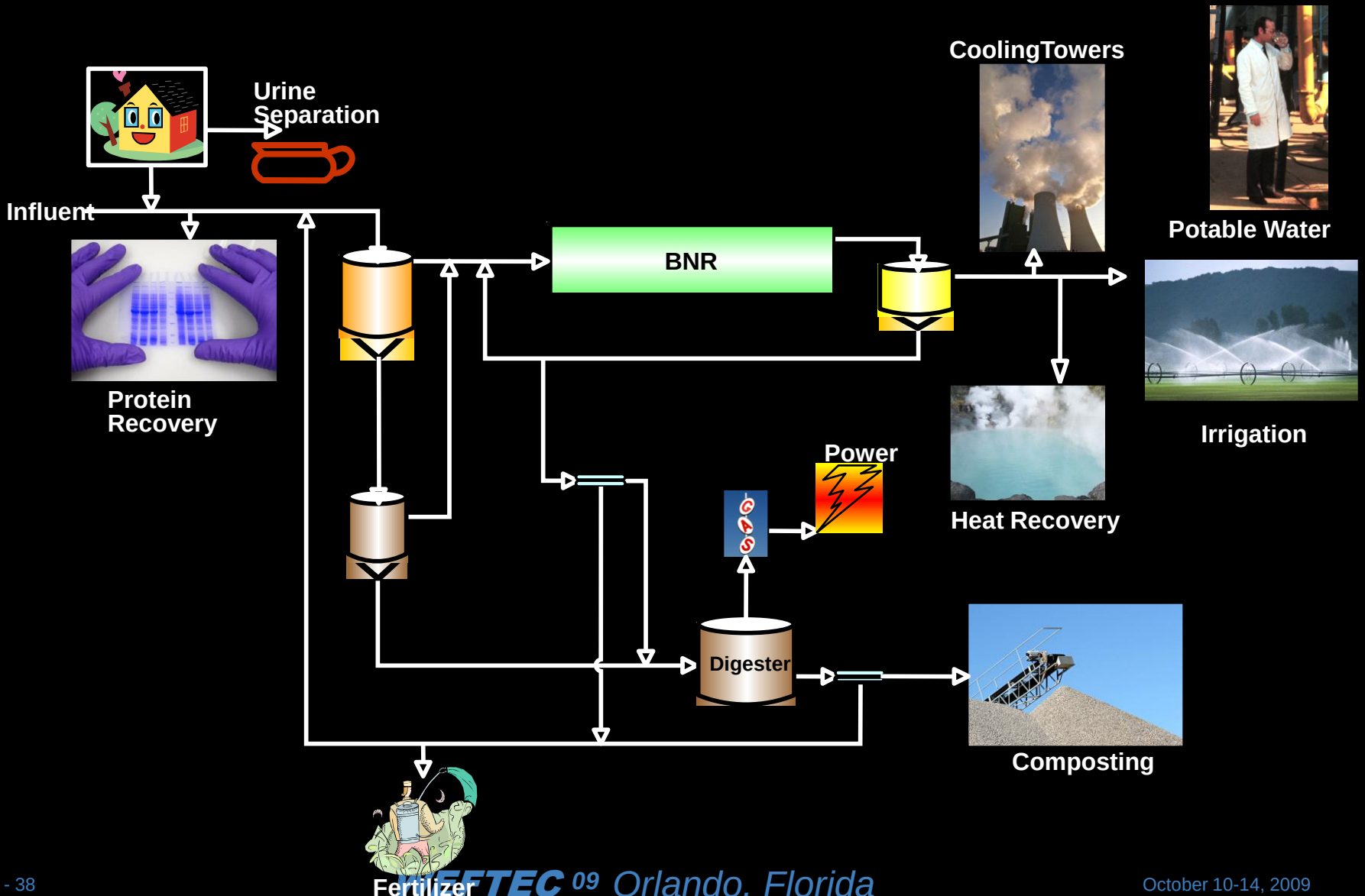
26



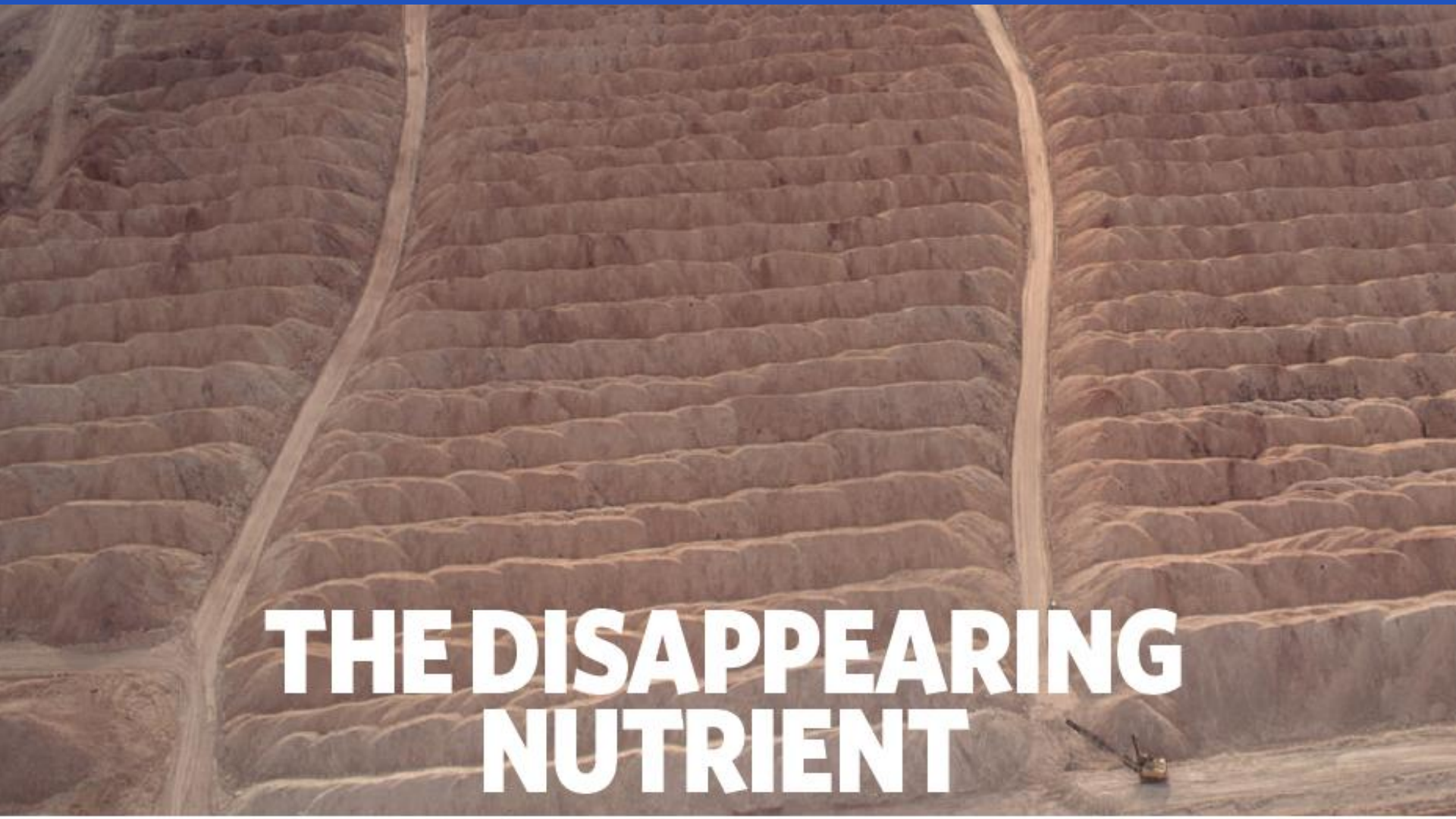
Biotower #2

54

Possible Resource Recovery



Phosphorus Removal and Recovery



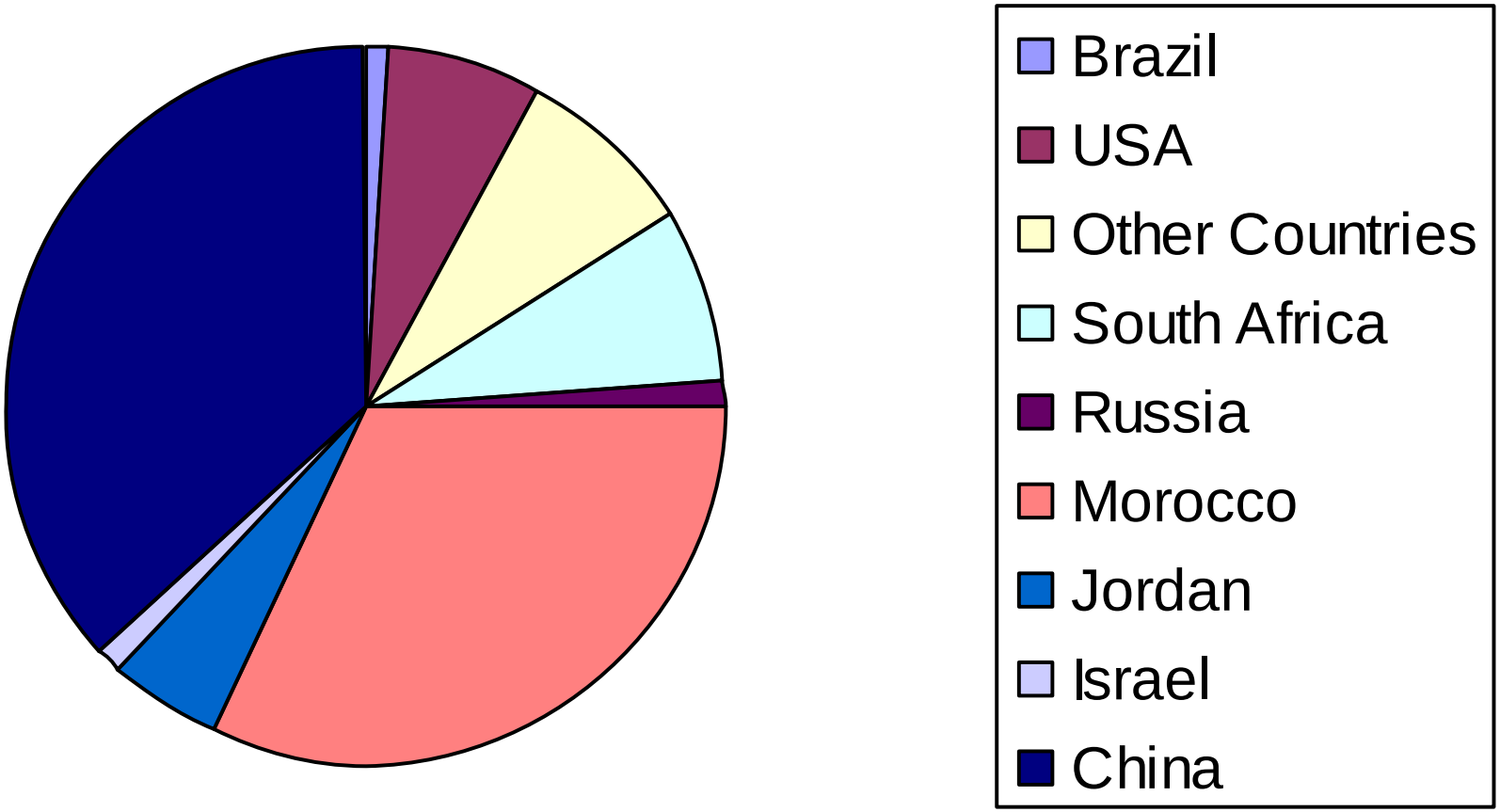
THE DISAPPEARING NUTRIENT

Phosphate-based fertilizers have helped spur agricultural gains in the past century, but the world may soon run out of them. **Natasha Gilbert** investigates the potential phosphate crisis.

Renewed Interest in Biological Phosphorus Removal

- Cost of chemicals.
- Sludge production: S-T estimates saving of £4 million p.a.
- Better understanding of the mechanism
- Better overall economics in getting to really low levels
- Phosphorus recovery while still applying chemicals for polishing

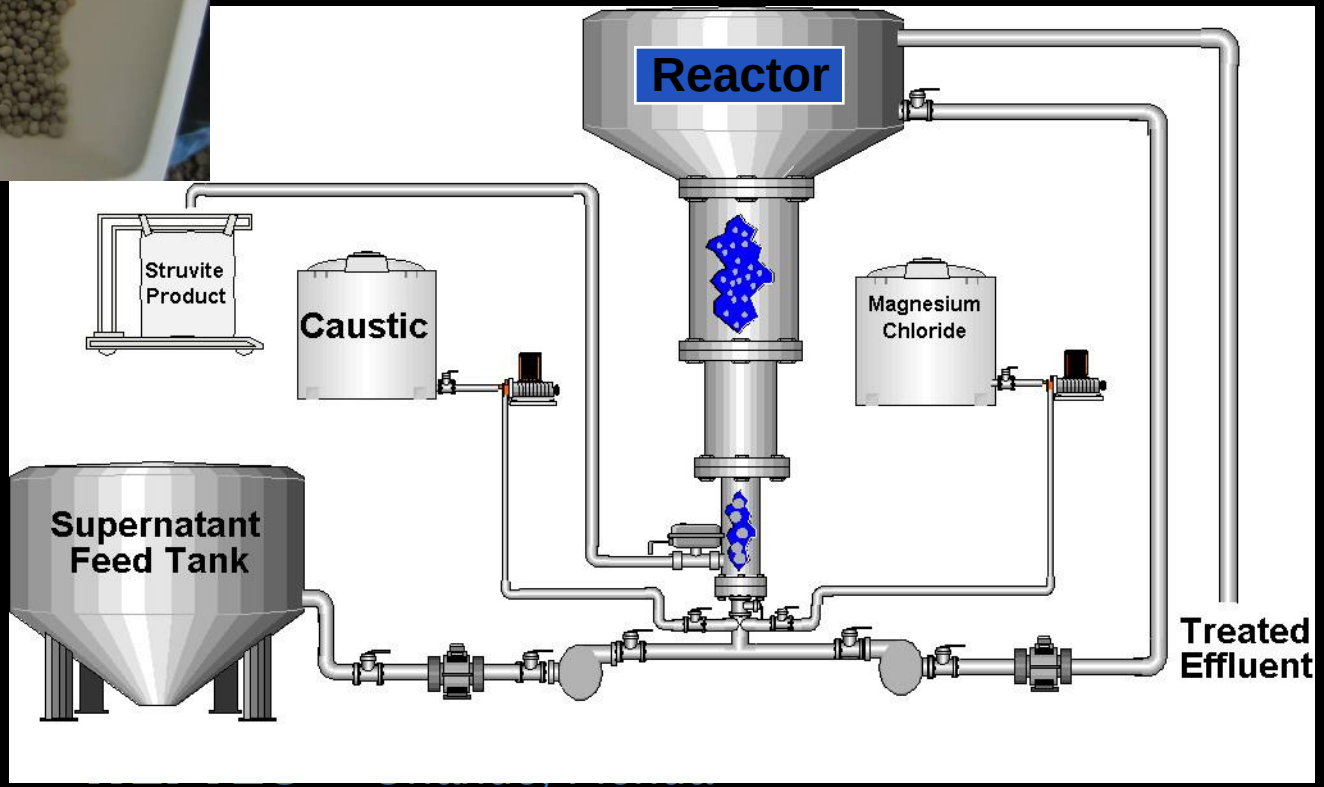
Global Reserves of Phosphorus



Phosphorus recovery

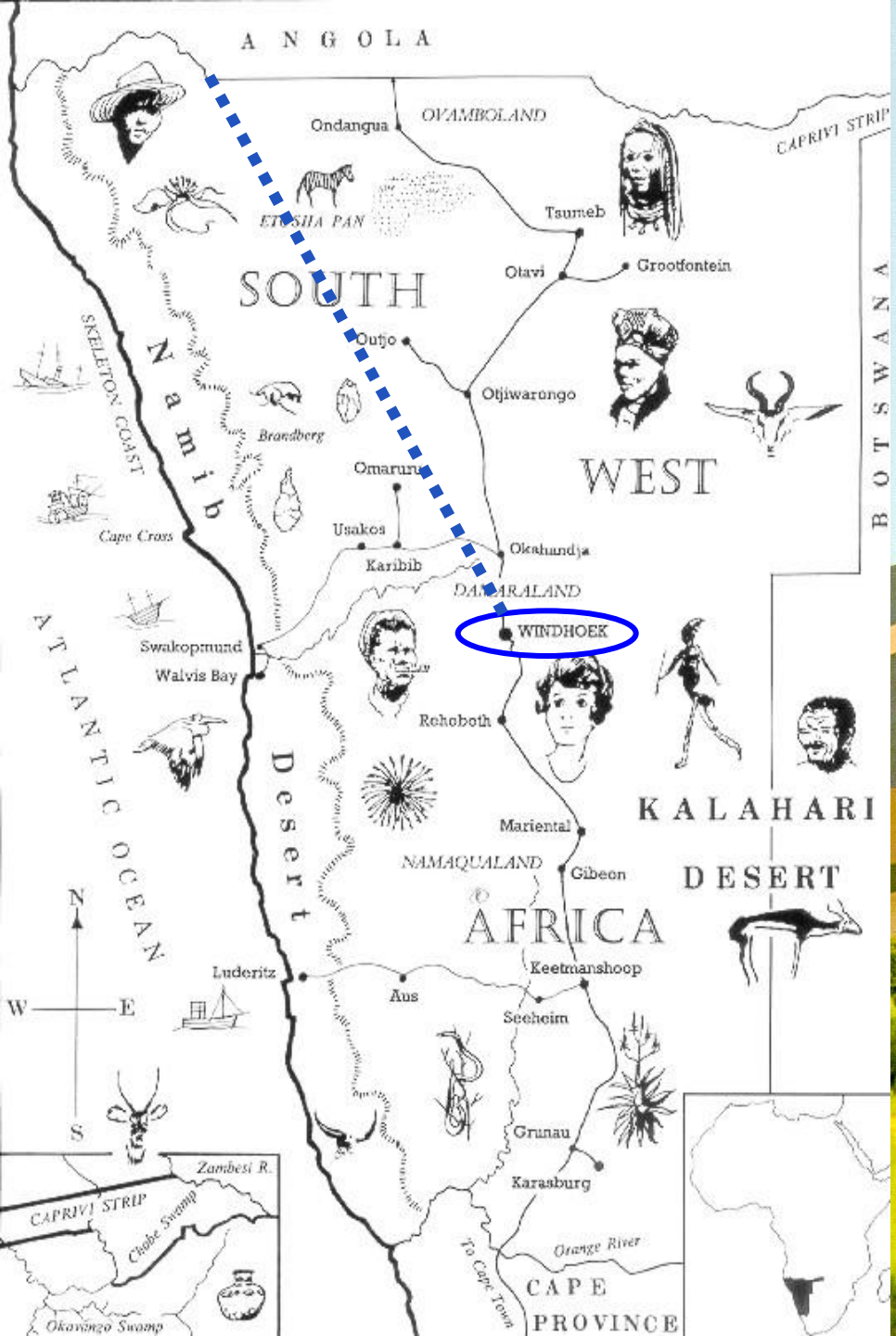
Struvite

$Mg.NH_4.PO_4 \cdot 6\ H_2O$



Also recovers up to 20% of nitrogen

Water Re-use


ANGOLA
Ondangua
OVAMBOLAND
CAPRIVI STRIP
ETOSHA PAN
Tsumeb
Otavi
Grootfontein
SOUTH
WEST
Outjo
Otjiwarongo
BOTSWANA
SKELETON COAST
Namib
Brandberg
Omaruru
Usakos
Karibib
Okahandja
Cape Cross
DAMARALAND
WINDHOEK
Swakopmund
Walvis Bay
Rehoboth
ATLANTIC OCEAN
Desert
KALAHARI
DESERT
Mariental
NAMAQUALAND
Gibeon
AFRICA
Luderitz
Keetmanshoop
Aus
Seeheim
N
W
E
S
Grunau
Karasburg
Zambesi R.
CAPRIVI STRIP
Chobe Swamp
Orange River
To Cape Town
CAPE
PROVINCE
Okavango Swamp

Water reclamation for Potable use

Windhoek Water Reclamation

LEGEND:

Old Process Train

Additions to old train to collectively compose the process train

PAC (Standby Process)

Pre-ozonation

Flocculation

Dissolved Air Flotation

Sedimentation

Rapid Sand Filtration
(Filter to Waste Facility)

Ozonation

Biological Activated Carbon

Granular Activated Carbon

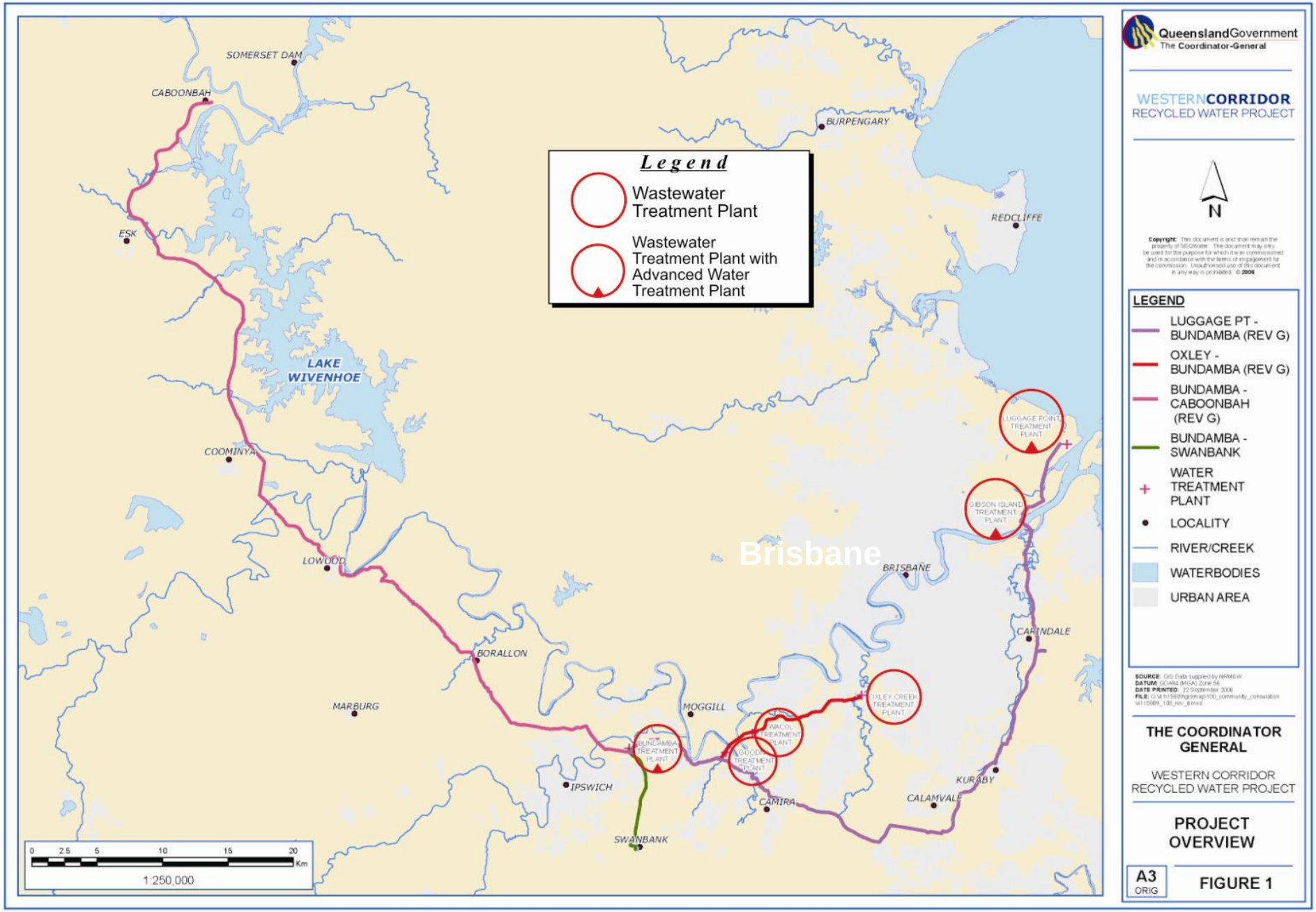
Membrane Filtration

Chlorine Disinfection

Stabilisation

Secondary Chlorination

Singapore - New Water


Legend
Wastewater Treatment Plant
Wastewater Treatment Plant with Advanced Water Treatment Plant
SOMERSET DAM
CABOONBAH
ESK
LAKE WIVENHOE
COOMINYA
LOWOOD
BORALLON
MARBURG
IPSWICH
SWANBANK
MOGGILL
CAMIRA
BURPENGARY
REDCLIFFE
BRISBANE
Brisbane
CARINDALE
KURABY
CALAMVALE
LUGGAGE POINT TREATMENT PLANT
GIBSON ISLAND TREATMENT PLANT
OXLEY CREEK TREATMENT PLANT
WACOL TREATMENT PLANT
LOGOOD TREATMENT PLANT
BUNDAMBA TREATMENT PLANT
0 2.5 5 10 15 20 Km
1:250,000
QueenslandGovernment
The Coordinator-General
WESTERN CORRIDOR
RECYCLED WATER PROJECT
N
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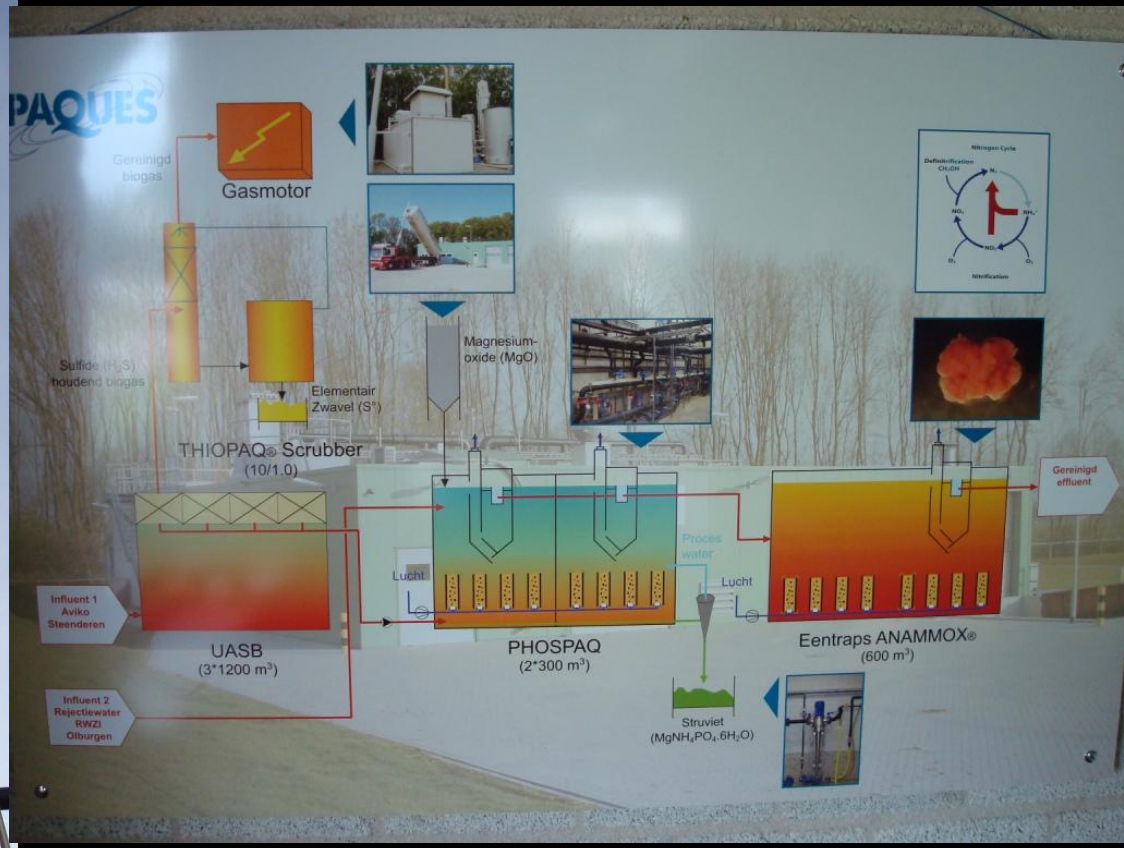
LEGEND
LUGGAGE PT - BUNDAMBA (REV G)
OXLEY - BUNDAMBA (REV G)
BUNDAMBA - CABOONBAH (REV G)
BUNDAMBA - SWANBANK
WATER TREATMENT PLANT
LOCALITY
RIVER/CREEK
WATERBODIES
URBAN AREA
SOURCE: GIS Data supplied by NRMEW
DATUM: GDA94 (MGA) Zone 56
DATE PRINTED: 23 September 2006
FILE: G:\4115\GIS\gismap\100_community_consultation\4115089_100_rev_0.mxd
THE COORDINATOR GENERAL
WESTERN CORRIDOR RECYCLED WATER PROJECT
PROJECT OVERVIEW
A3 ORIG
FIGURE 1

Will the activated sludge plant be around for another 30 years? 50 years? 100 years?

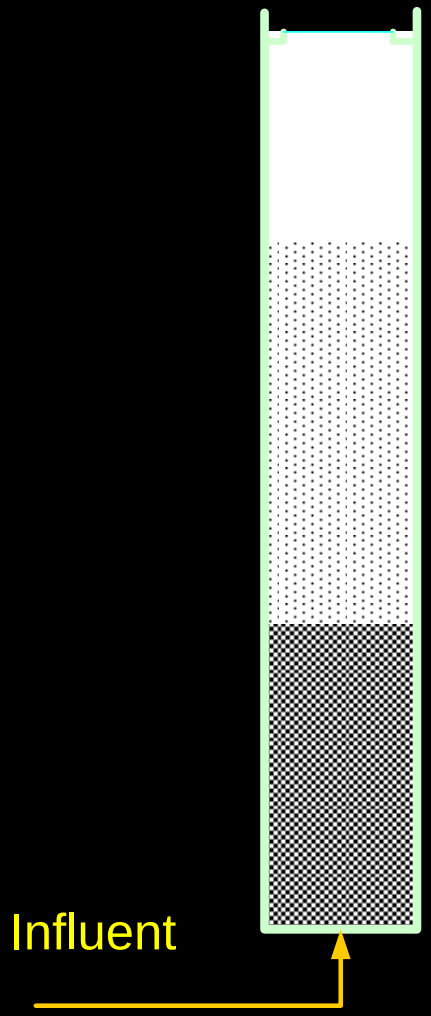
Very Likely

- As MBR for low footprint
- With Membrane Filtration - Nanotechnology
- With maximum power recovery
- High removal rate of ammonia
- Relatively low GHG
- High removal rate of PCP&EDC
- Opportunity to recover phosphorus

Or in other forms - Anammox

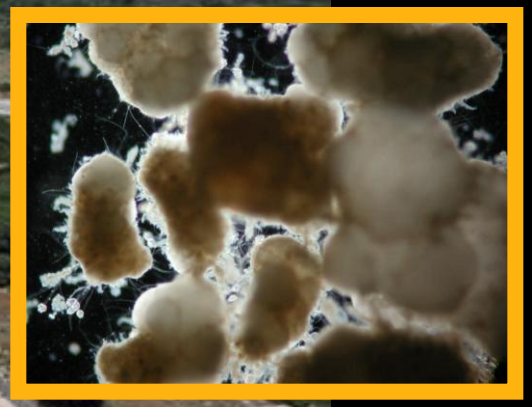


Granular Activated Sludge



Granular Activated sludge - Gansbaai RSA

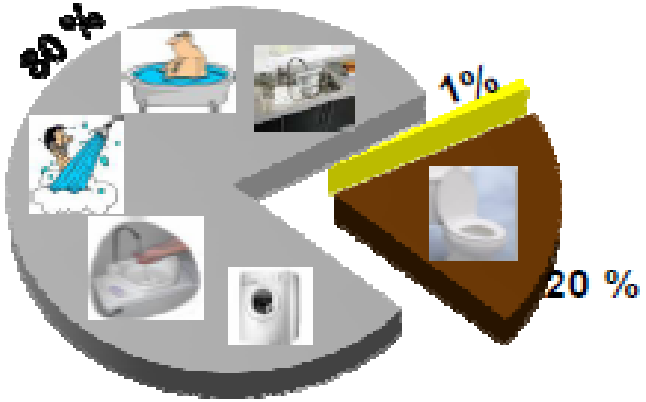
COD in 800-10,000 ppm → COD out < 100 ppm / N in 150-200 ppm → N out < 10ppm
P(dissolved) in 15-25 ppm → P out < 1.0 ppm / SS out < 20 ppm



NEREDA®

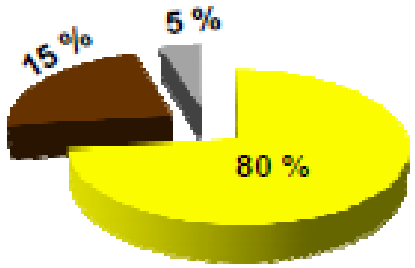
Urine in Wastewater

Volume of Wastewater

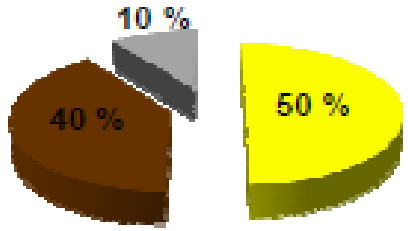


Yellow-water (Urine+flushwater)
Brownwater (Faeces+flushwater)
Greywater (shower, kitchen, etc)

"N" Content



"P" Content



WRC WATER RESEARCH COMMISSION

UNIVERSITEIT STELLENBOSCH UNIVERSITY

Reference

Andre Mbya UCT

Summary

- Expect to see the activated sludge process around for some time in some form – as, IFAS, MBR or with membrane filtration for water re-use
- More emphasis on resource recovery N and P
- More emphasis on saving water as the main driver for reducing energy cost – indigenous living
- Urine separation as a means of sustainability in countries that are catching up and in new developments
- Greatly improved membranes for solids liquid separation and water recovery

If you are still awake
Thank you for coming