



**Chamber Pots, Cesspools, Street Gutters** 

Earth Pit Privies, Corn Cobs, Night Soil

Flush Toilets, Sanitary Sewers, Toilet Paper

Septic Tanks, Tile Fields, Sewage Farms

### **Engineering Design and Process Optimization**

Imhoff Tanks, Primary Settling: 50% Solids, BOD Removal

Trickling Filters: 80% BOD Removal

**Activated Sludge: 95% BOD Removal** 

Anaerobic Digestion, Methane Utilization

Disinfection: Chlorine, Ultraviolet Irradiation

Nutrient (N,P) Removal, Tertiary Treatment, Wetlands

**Wastewater Reclamation & Reuse** 

# **Water Use** ⇒ **Wastewater**

**Population Growth x Water Use** (130 gpcd, max. month)

**Urban Sprawl** ⇒ sewer extensons, irrigation of suburbs

Groundwater depletion; drought; consumptive water use

# **Growing Water Shortages**

**New Water Sources?** 

U.S.: 22,000 POTW (98% municipally-owned) ⇒ 35 billion g/d

1 billion g/d (3%) of treated WW ⇒ parks, golf courses, ...

ENGINEERING



Population, millions Life Expectancy, years

1933: 125

2010: 310

2025: 357

2050: 439

zno zxpootanoj, joa

**78** 

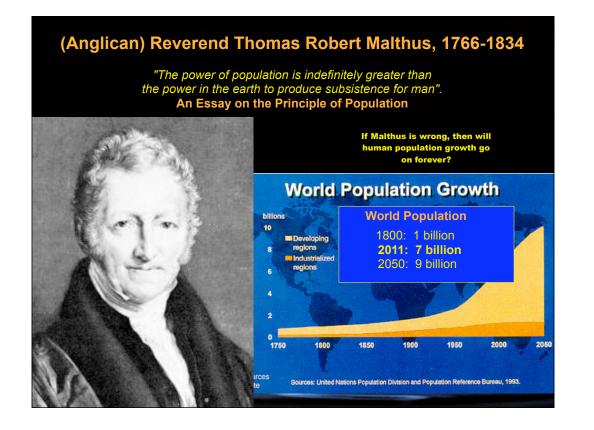
80

83

U.S. Population Increase: 3 million/year

**New Missouri every 2 years** 

FLO'C ENGINEERING

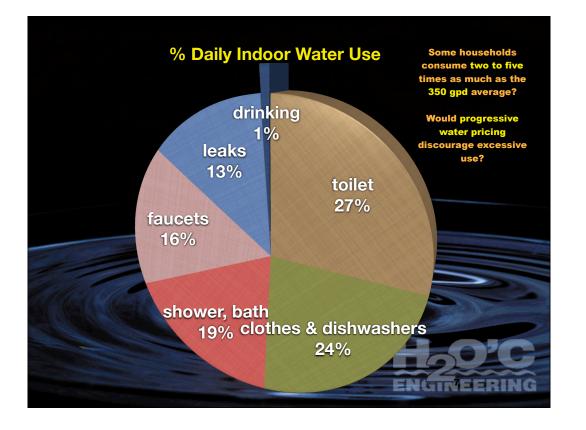


# **Suburban homeowners are 'grass farmers'**

60% of water use is outdoors;

only 40% indoors





# **Managing Wastewater Costs**

### 1. Administrative Strategies

What might utility management do to contain costs?

- **✓** Asset Management delay new *capital* construction
- **Stormwater Inflow & Infiltration (20%) reduction**
- Automation reduce labor requirements
- Reduce overtime; utilize part-time employees
- **☑** Eliminate retirement benefits; outsource





### 2. Reduce Hydraulic Loadings

Mandate efficiency of toilets, showers, faucets Advocate Gray Water use for lawn, gardens, toilets

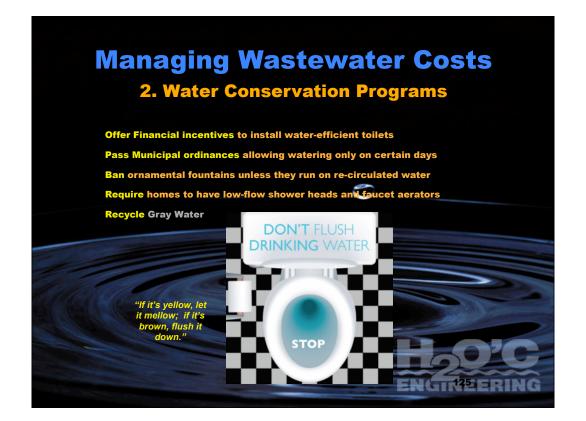
U.S. Suburban Household Water Use

Average Day: 350 gallons Toilet flushing: 100 gallons

Gallons per flush: 3.5, 1.6, 1.28, 1.6

**Federal Water Efficiency Standards (1992)** 

Showerheads: 2.5 gallons per minute Faucets: 2.5 gallons per minute



When freshwater gets scarce ... utilize 'toilet to tap', a.k.a.

Wastewater Reclamation & Reuse

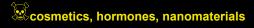
California State Department of Health
permits use of reclaimed wastewater for:

agricultural irrigation of over 20 food crops:
landscape parks, playgrounds and golf courses,
restricted recreational impoundments,
groundwater recharge to domestic water supply areas

\*Apples, Grapes, Asparagus, Lettuce, Avocados,
Maize, Barley, Peaches, Beans, Peppers, Broccoli,
Pistachios, Cabbage, Plums, Cauliflower, Squash,
Celery, Sugar Beets, Citrus, Wheat

# **Emerging Health Concerns**

pharmaceuticals: N-nitrosodimethylamine (NDMA), 1,4-dioxane, bisphenol A, alkylphenol polyethoxy carboxylates (APECs), dioxin, disinfection by-products, ...

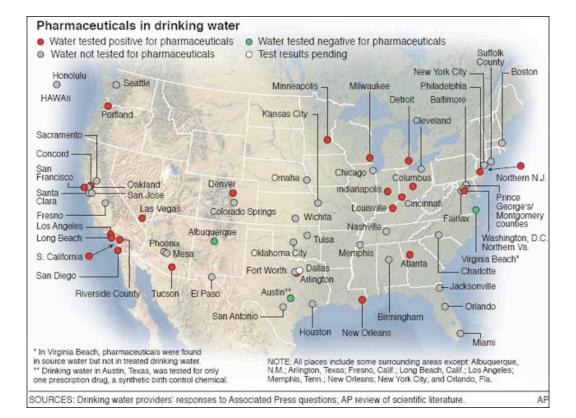


endocrine disruptors, a class of compounds that perturb the normal functioning of endocrine systems including those that affect growth, reproduction and behavior.

Partial removal requires capital, energy-intensive processes:

(GAC adsorption; ozonation; micro-, ultra-, nano-filtration; reverse osmosis; membrane bioreactors; advanced oxidation (hydrogen peroxide - UV)

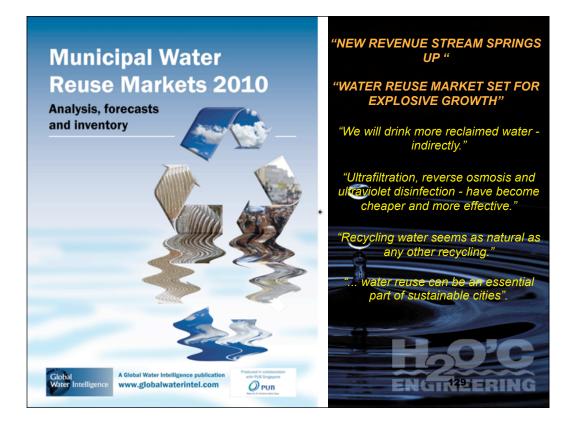




# **Orange County, CA Water District**

*'Indirect Potable Water Reuse'*70 mgd - Groundwater Replenishment System











### Padlock your manholes?

Membrane Bioreactors (MBR)
membranes immersed into highly concentrated mixed liquor suspended solids

Hydraulic Retention Time: 4-8 hours; 25% conventional footprint

Solids Retention Time: 10- 365 days; 20% conventional sludge yield

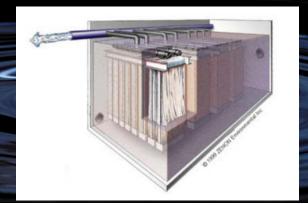
MLSS: 10,000 - 15,000 mg/l

Modular: small scale

Effective organism removals

Removal of nutrients

Reuse of product water



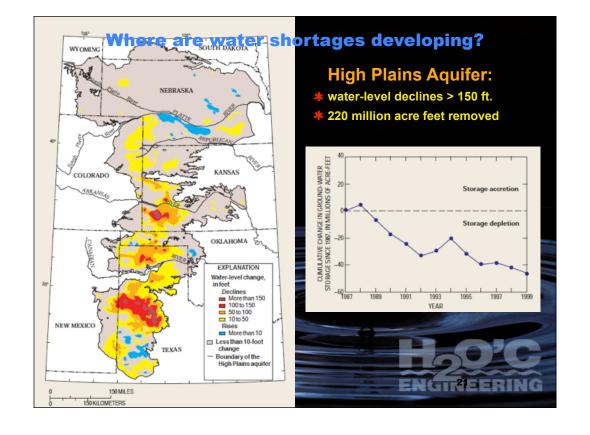
### **Operational Issues Membrane Bioreactors (MBR)** Fine Screening (1 mm) required; disposal of untreated waste Fouling results in low membrane flux rates; large membrane surfaces Air Scour, MLSS recirculation: high energy consumption Large Equalization Tank Volume: to offset low peak flow tolerance Low Oxygen Transfer Efficiency due to high MLSS **Membrane Replacement Frequency and Costs** SIMPLIFIED MBR SCHEMATIC Membrane Module Treated Water Waste Sludge to ♣ Disposal Raw\_\_\_ Wastewater ML Recycle Mixed Liquor Recirculation

Blower

Bioreactor

Air Scour



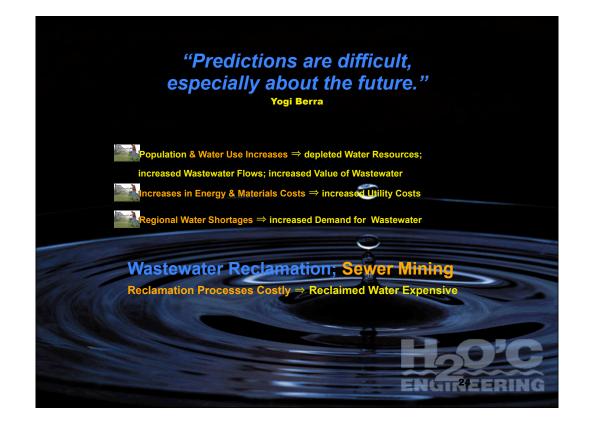




# **Future WW Management?**

- Conservation reduce energy, material, capital consumption
  U.S. households may draw 350 gpd of water; drink < 2 gallons
- Pollution Prevention reduce water use; employ dry sanitation
- Recovery & Reuse agriculture, parks, gardens, lawns
- Full Cost Pricing fair accounting practices; doing without subsidies





# Integrated Water & Wastewater Systems? coordinated development & system management integrated cost accounting; service charges; billing cross-training of water & wastewater staff w & www staff not one big, happy family? integrated staff reductions (Finland): 456 + 270 = 400 pipes for both services laid in same excavation

