Understanding sources, management, and impact of Endocrine Disrupting Compounds (EDCs) in the Potomac

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DC Water

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Outline

- Background/ Context
- What are the typical estrogenic compounds in watewater?
- What are the treatment impacts?
- Where do we go from here?

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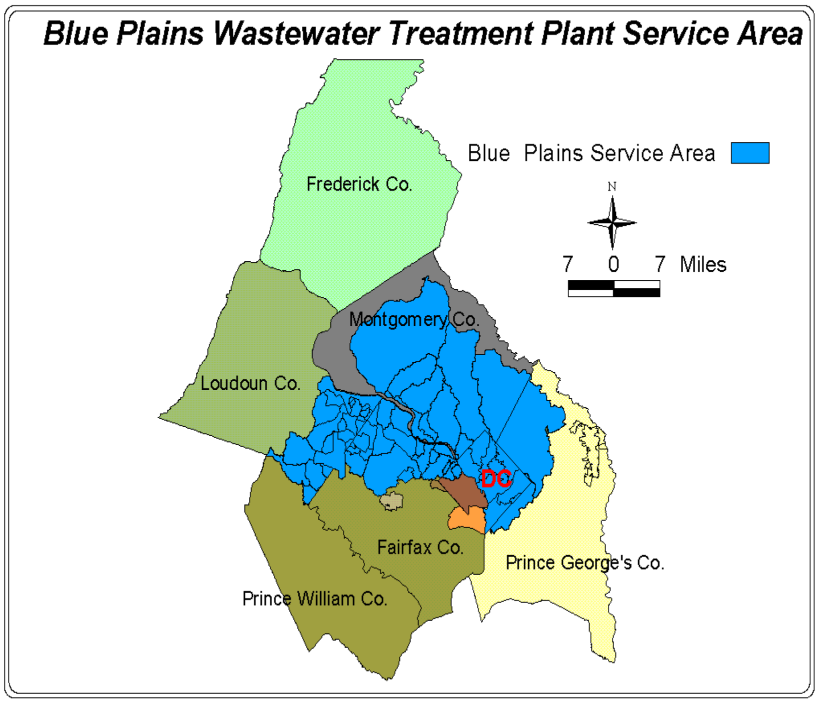
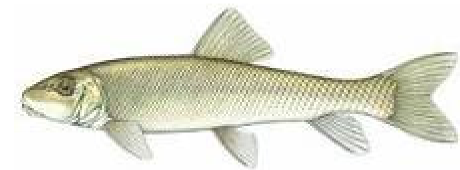


General Information

- 370 mgd ADF
- 1,076 mgd Peak
- CSO Flows
- 2 Million Customers
- 725 sq mile Service Area

Evidence of Reproductive Disruption in Fish Downstream WWTP Discharges

1. Sex Ratio: skewed toward females downstream of WWTP Discharges



2. Vitellogenin (estrogen-dependent female yolk protein) elevated in males downstream of WWTP.

3. USGS have conducted research in the Potomac Fish but no causal link to Blue Plains

USGS Study

"The proximity to wastewater treatment plants may influence the reproductive health of bass in the Potomac watershed, but inputs from other sources likely contribute to the widespread, high incidence of testicular oocytes".

Iwanowicz, L. R. et al. (2009)
Reproductive Health of Bass in the Potomac, USA, Drainage: Part 1. Exploring the Effects of Proximity to Wastewater Treatment Plant Discharge. *Environmental Toxicology and Chemistry*. **28,** 1072-1083

USGS Study

"The Potomac River in Washington, D.C. is showing multiple benefits from restoration efforts. Reduced nutrients and improved water clarity have increased the abundance and diversity of submerged aquatic vegetation (SAV)
in the Potomac, according to direct measurements taken during the 18-year field study".

Ruhl, H. A. and Rybicki, N. B. (2010)
Long-term reductions in anthropogenic nutrients link to improvements in Chesapeake Bay habitat
PNAS. **107,** 16566-16570.

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DC Council Bill

Wastewater study and testing:

-the Authority shall initiate a study that tests for the presence of endocrine disruptor compounds in wastewater effluent

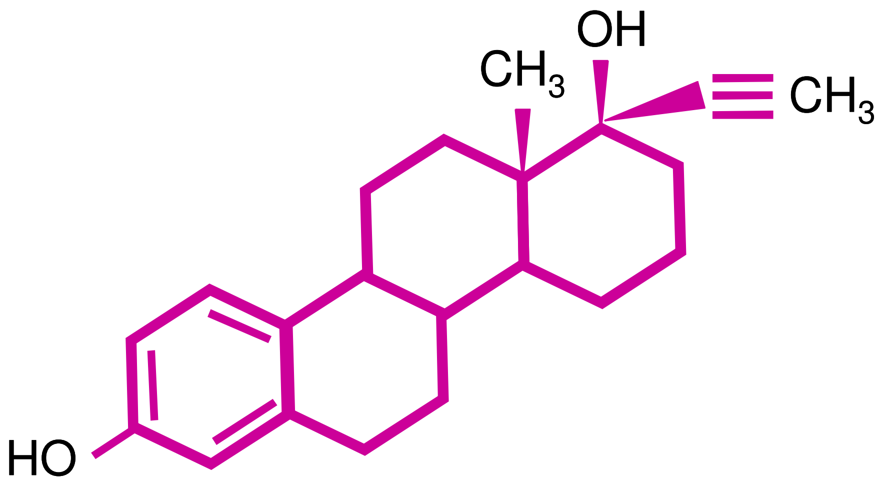
-the Authority shall present the findings of the study to an advisory Panel, the General Manager, the Mayor, and the Council within 30 days of the study's completion

-this section shall be subjection to appropriation

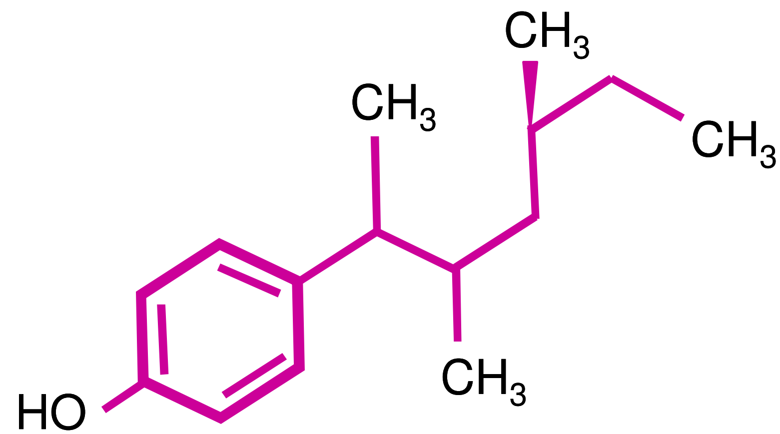
Estrogenic Compounds Found in Wastewater Effluents

- Natural estrogens- estrone (E1) and estradiol (E2)
- Synthetic estrogen- Ethinylestradiol (EE2)
- Alkylphenol Ethoxylate Degradation Products (Octylphenol/Nonylphenol)

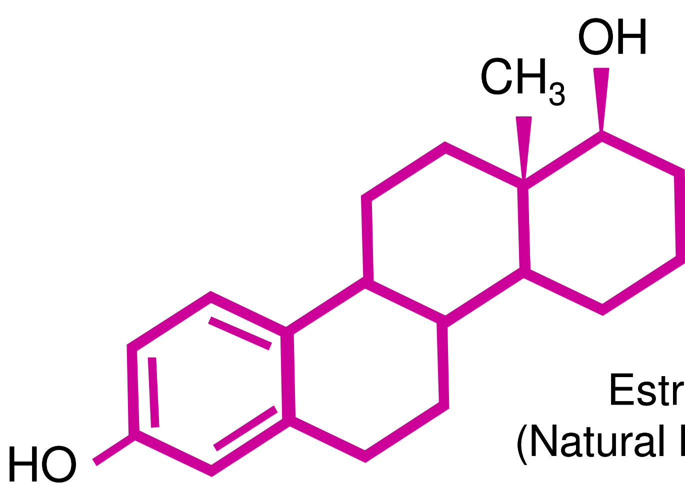
Major Estrogenic Compounds



Ethinyl Estradiol (Synthetic Hormone)



Nonylphenol Isomer



Estradiol (Natural Hormone)

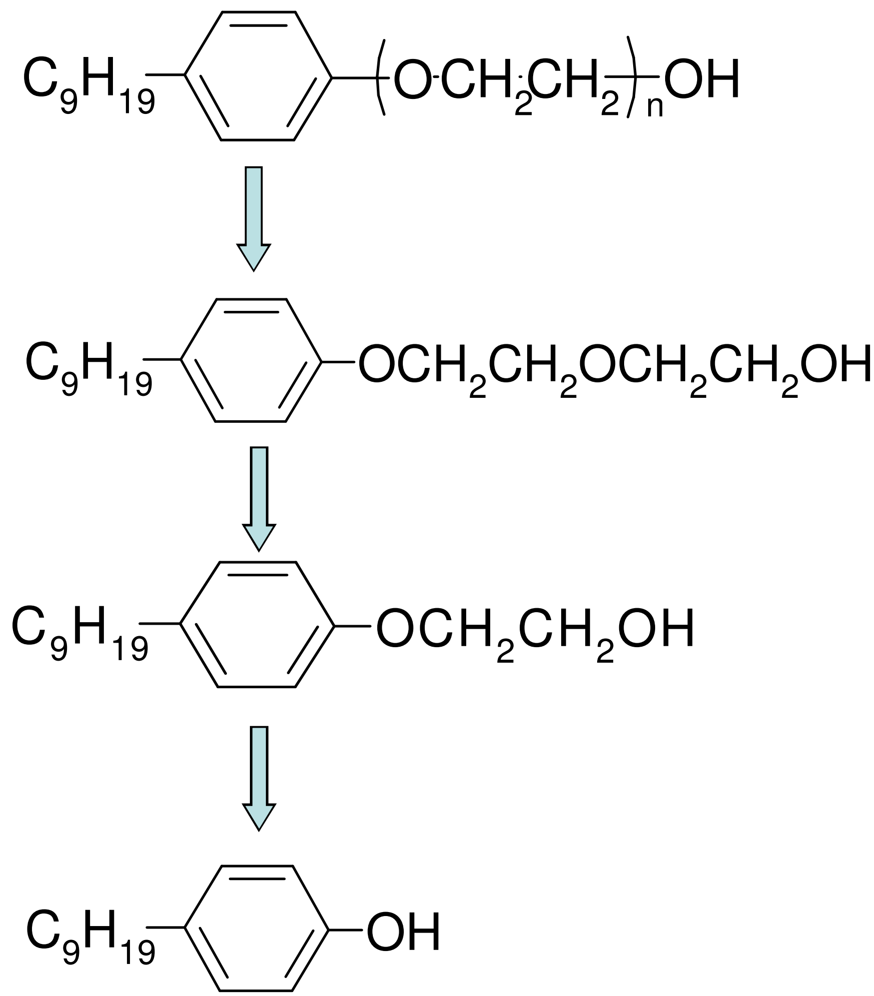
Metabolites of Nonylphenol Ethoxylates (from Ahel *et al.*, 1994; Naylor, 1992)

NP ethoxylate
n ~ 9-17

NP2EO

NP1EO

NP



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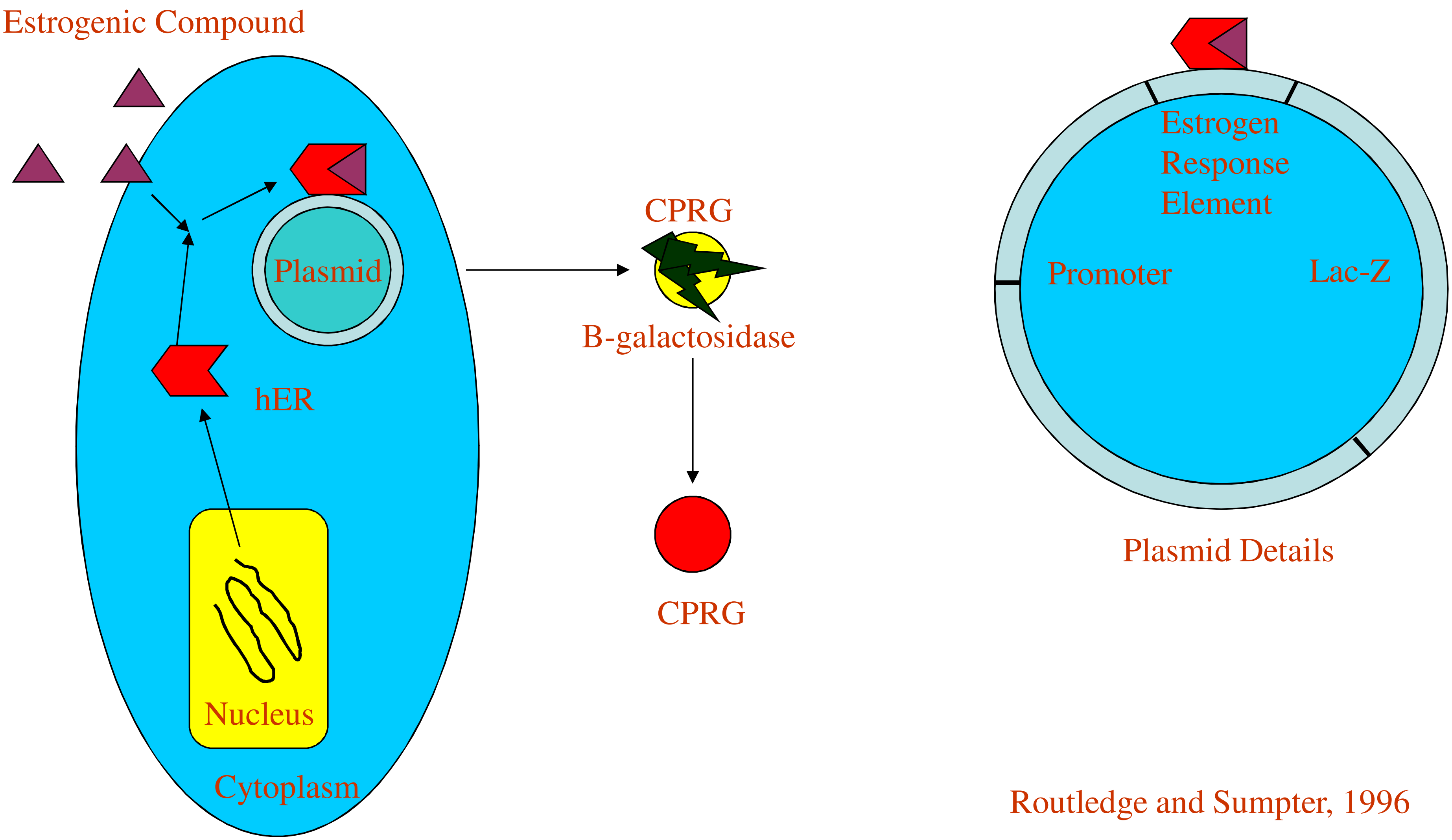
Bans and Restrictions on Use of NPE in European Union and Canada

Yeast Estrogen Screen



Routledge and Sumpter, 1996

Microtiter Plates

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YES Standards Data

Analyte	Eeq [1]	Literature Ranges
E2	1.0	1
EE2	1.5	0.17 – 1.4
E1	0.97	0.02 – 0.5
E3	0.011	0.002 – 0.3
NPs	0.00038	$10^{-5} – 10^{-3}$

[1] Eeq data courtesy of Dr. Benjamin Stanford, Hazen and Sawyer (Data originally published in 2007).

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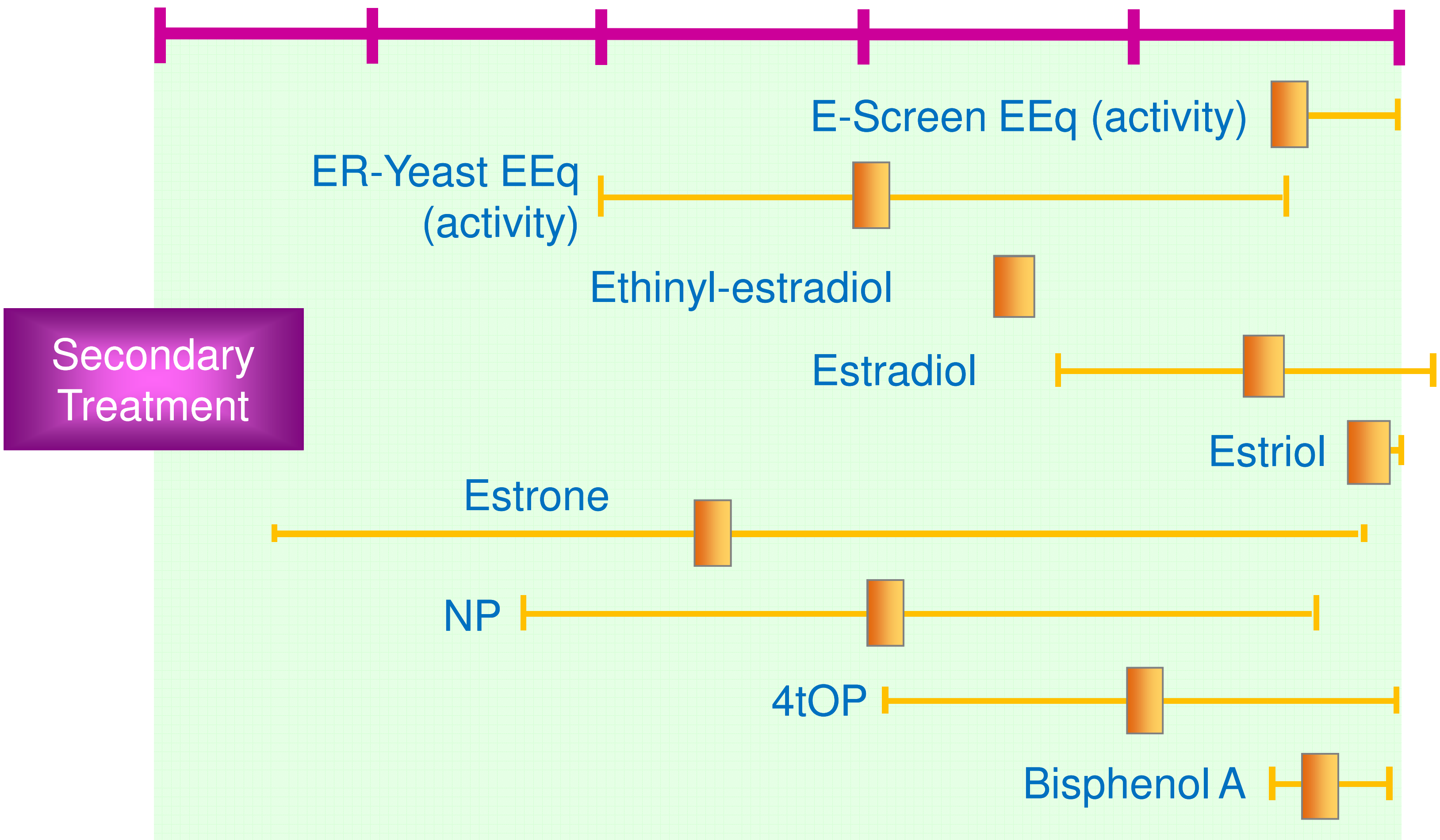
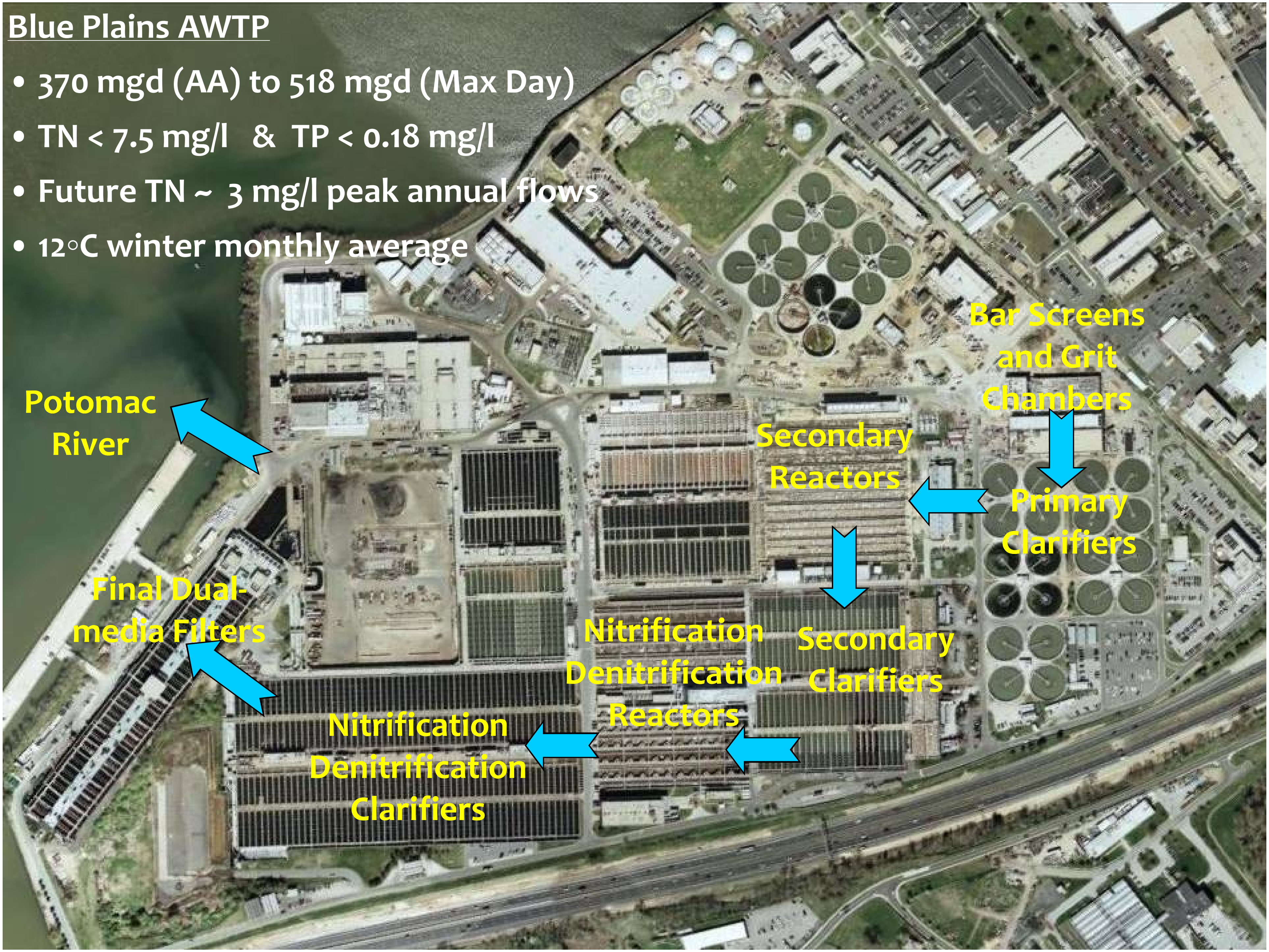


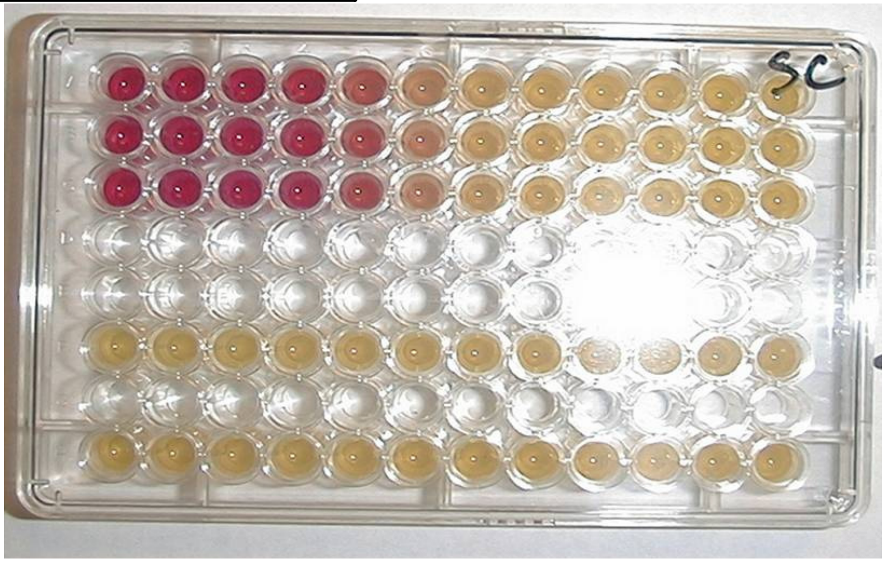
Drewes et al. 2006. Removal of Endocrine Disrupting Compounds in Water Reclamation Processes. Water Environment Research Foundation (01-HHE-20T).
Graphic courtesy of Hazen and Sawyer.


Blue Plains AWTP
• 370 mgd (AA) to 518 mgd (Max Day)
• TN < 7.5 mg/l & TP < 0.18 mg/l
• Future TN ~ 3 mg/l peak annual flows
• 12◦C winter monthly average
Bar Screens and Grit Chambers
Potomac River
Secondary Reactors
Primary Clarifiers
Final Dual-media Filters
Nitrification Denitrification Reactors
Secondary Clarifiers
Nitrification Denitrification Clarifiers

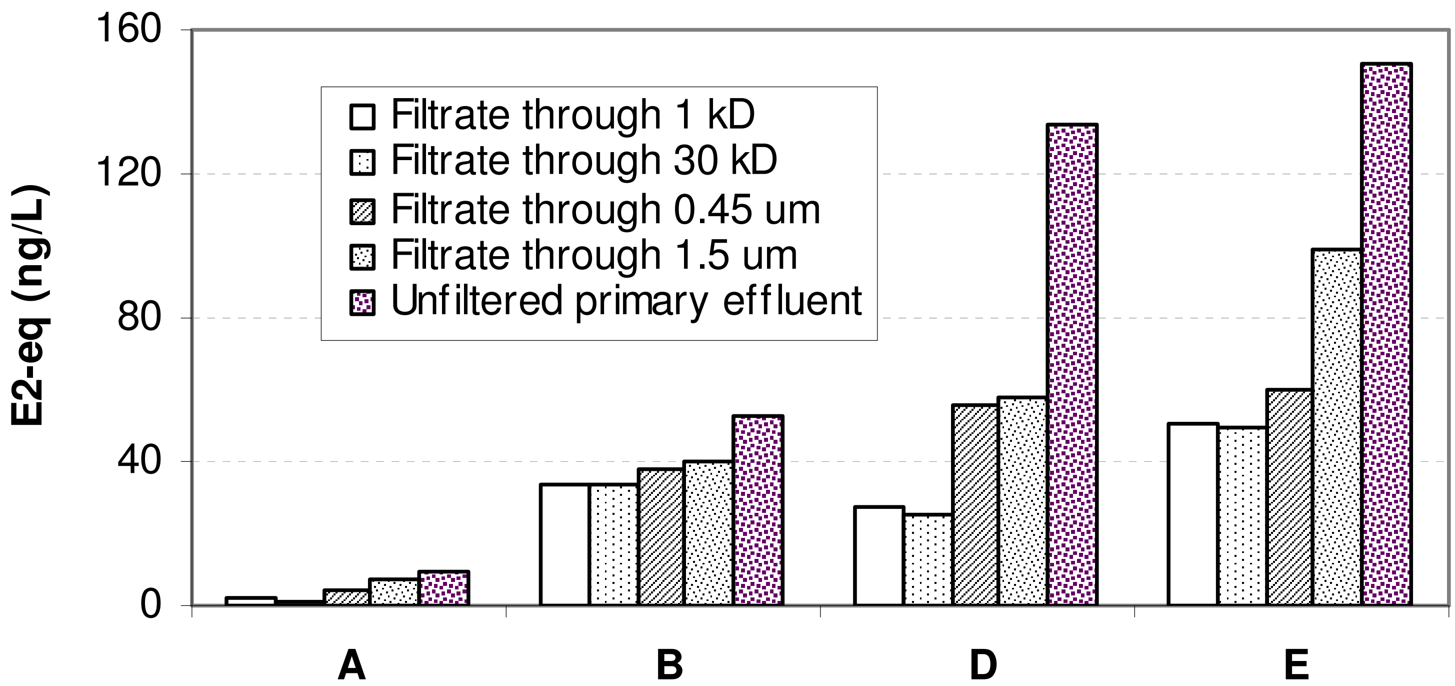
YES Assay

E2* (ng/L)	Primary Effluent	Secondary Effluent	Nitrification Effluent	Final Effluent
05/21/2004	8.2	<2.5	<2.5	<2.5
07/02/2004	10.6	37	<2.5	<2.5
12/27/2004	64.4	60	<2.5	<2.5

*expressed as 17β-estradiol equivalent



YES Assay



*Primary Treatment Effluent of 4 plants

Water Quality

EPA recommended water quality criterion for nonylphenol.

Constituent (µg/L)	Class-C CCC	Class – C CMC	New constituent and criterion added. EPA recommended final aquatic life ambient water quality criterion. EPA-822-R-05-005, December 2005.
Nonylphenol CAS number 84852153	6.6	28	

CCC- Criterion Continuous Concentration- Chronic
CMC- Criterion Maximum Concentration- Acute

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Nonylphenol

Influent	Nonylphenol
Summer	µg/L
July	15.1
Aug	36.4
Winter	
Feb	35.2
Mar	22.5

Effluent	NP
Summer	µg/L
July	0.637
Aug	0.155
Winter	
Feb	1.35

Loyo- Rosales et al. (2007) Fate of Octyl- and Nonylphenol Ethoxylates and Some Carboxylated Derivatives in Three American Wastewater Treatment Plants. *Environ. Sci. Technol.*, **41**, 6815.

Nonylphenol

Influent	**NPE**
<u>Summer</u>	µg/L
July	157
Aug	192
<u>Winter</u>	
Feb	210
Mar	134

Effluent	**NPE**
<u>Summer</u>	µg/L
July	4.74
Aug	1.62
<u>Winter</u>	
Feb	25
Mar	17

NPE= Nonylphenol Ethoxylates- 0-5 Ethoxylates

Loyo- Rosales et al. (2007) Fate of Octyl- and Nonylphenol Ethoxylates and Some Carboxylated Derivatives in Three American Wastewater Treatment Plants. *Environ. Sci. Technol.*, **41**, 6815.

What do we know about these compounds?

- They like to attach to solids
- They can be degraded or altered to reduce estrogenic effects
  - Mechanisms for degradation are a topic of intense scrutiny

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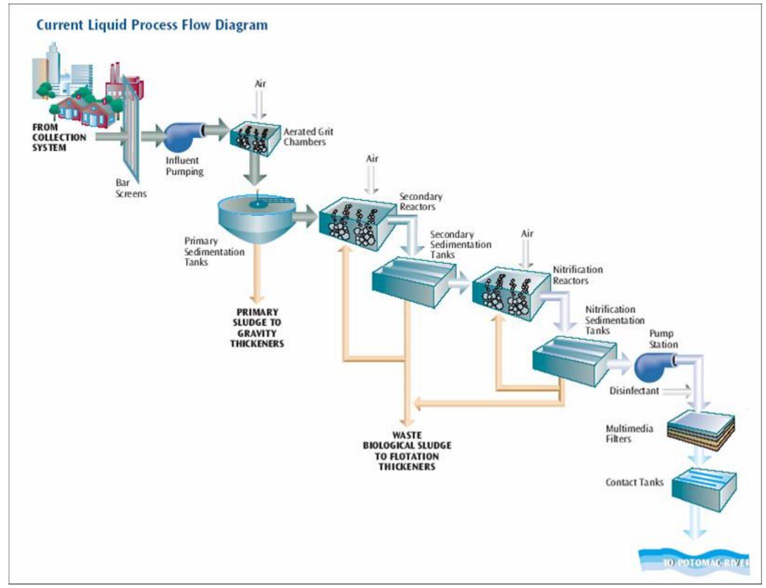
Estrogen Removal at Blue Plains

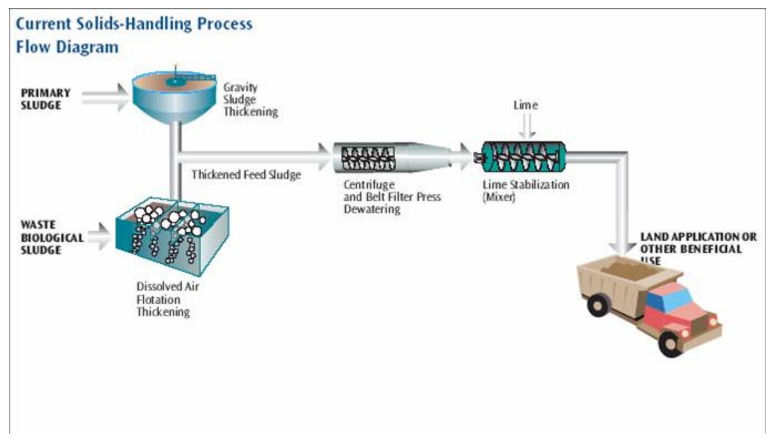
Preliminary work indicates;

- Estrogenic Activity can be removed by processes that separate solids
  - Estrogenic activity associates with solids
- Estrogenic activity can be degraded in ENR process
  - Higher SRTs and longer detention times have been linked to removal
- It can accumulate in the solids treatment processes

Ongoing Work

- We plan to continue our collaboration on this work and stay informed





The Proposal Team

- **Erik Rosenfeldt** has over 10 years of EDC/PPCP occurrence and treatment experience. He is a prinicpal engineer at Hazen and Sawyer, an Industry Leader in Emerging Contaminants Applied Research
- **Luke Iwanowicz**, USGS is a fish health scientist with expertise in the fields of virology, molecular biology, immunology, endocrine physiology, endocrine disruption and environmental health monitoring
- **Clifford Rice**, USDA is a scientist at the Animal and Natural Resources Institute, Agricultural Research Service and specializes in the detection of trace organic chemicals in the environment
- **Sujay Kaushal**, UMD focuses on understanding the interactive effects of land use on ecosystem ecology
- **Sudhir Murthy**, DC Water is Manager, Research and Laboratory and leads technology development associated with $1 billion Blue Plains CIP