ENGINEERED WETLAND TECHNOLOGY TO ADVANCE STORMWATER QUALITY TREATMENT

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March 28, 2012

TWO BASIC TYPES OF CONSTRUCTED WETLANDS

- **Stormwater (SW) Wetlands**

- **Treatment Wetlands**

STORMWATER WETLANDS

- **May Hold Water in Some Part at All Times**
  - **Dry & wet ponds too**
  - **Marshy areas**
- **Used to Manage Stormwater Runoff**
  - **Uses storage & restricted outlets to do so**
  - **Major purpose is to manage SW quantity**
- **Some Improvement of Stormwater Quality**
  - **Although limited**
- **May Have Aesthetic & Habitat Functions as Well**

TYPICAL SW WETLAND DESIGN

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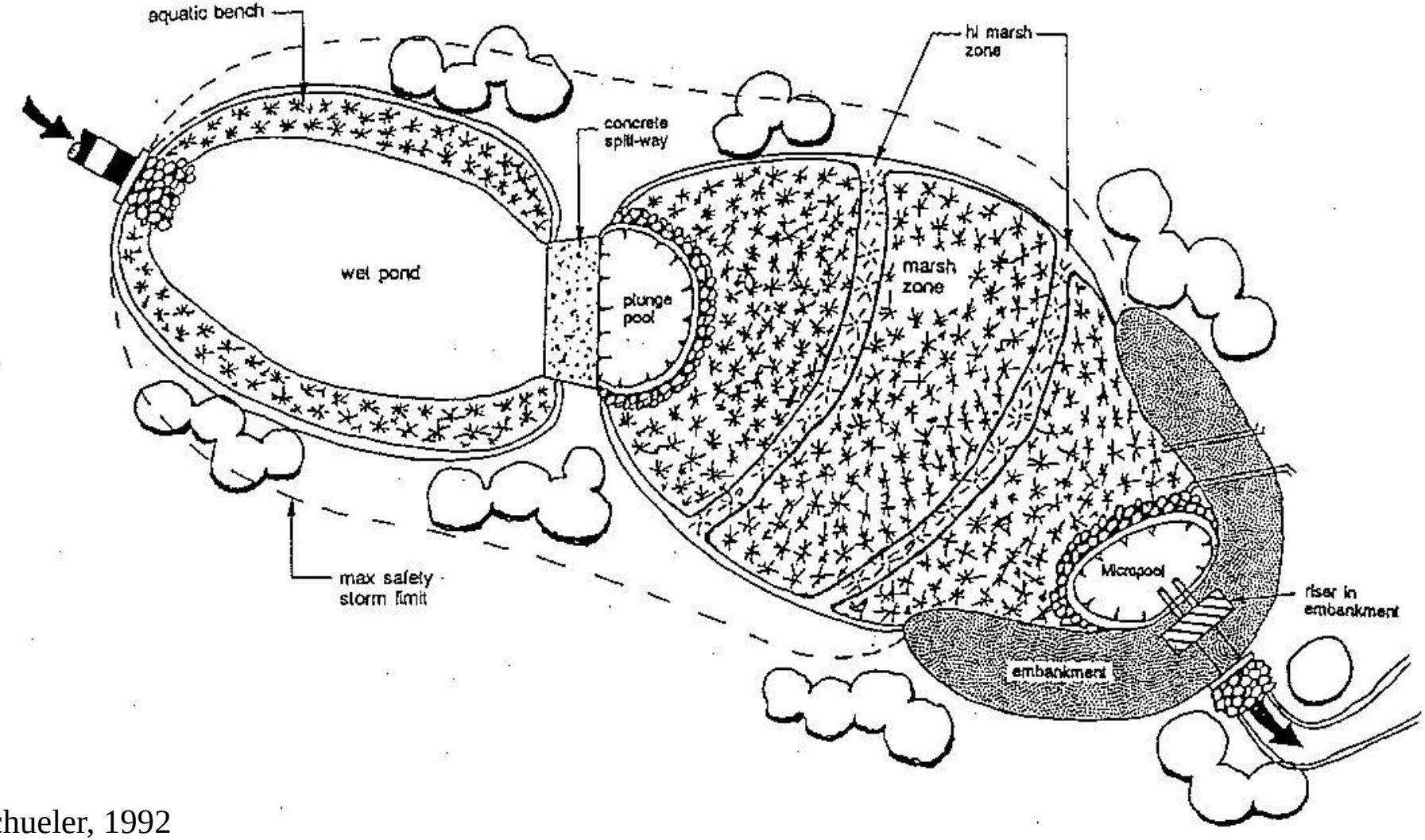

Schueler, 1992

CONVENTIONAL STORMWATER WETLAND CONSTRAINTS

- **Require a Lot of Land**
- **Nuisance Insects & Animals**
- **Limited/No Treatment of Some Pollutants**
- **Most Kinds Have Areas of Deep Permanent Water**

CONSTRUCTED TREATMENT WETLANDS (CWs)

- **Human-Constructed**
- **Built Specifically to Remove Contaminants**
- **Wide Variety of Removal Processes**
- **Generally Not Designed to Fully Re-Create the Structure & Function of Natural Wetlands**
- **Three Basic Kinds**
  - **Pond Wetlands**
  - **Free Water Surface (FWS)**
  - **Sub-Surface Flow (SSF)**

EVOLUTION OF CW DESIGN

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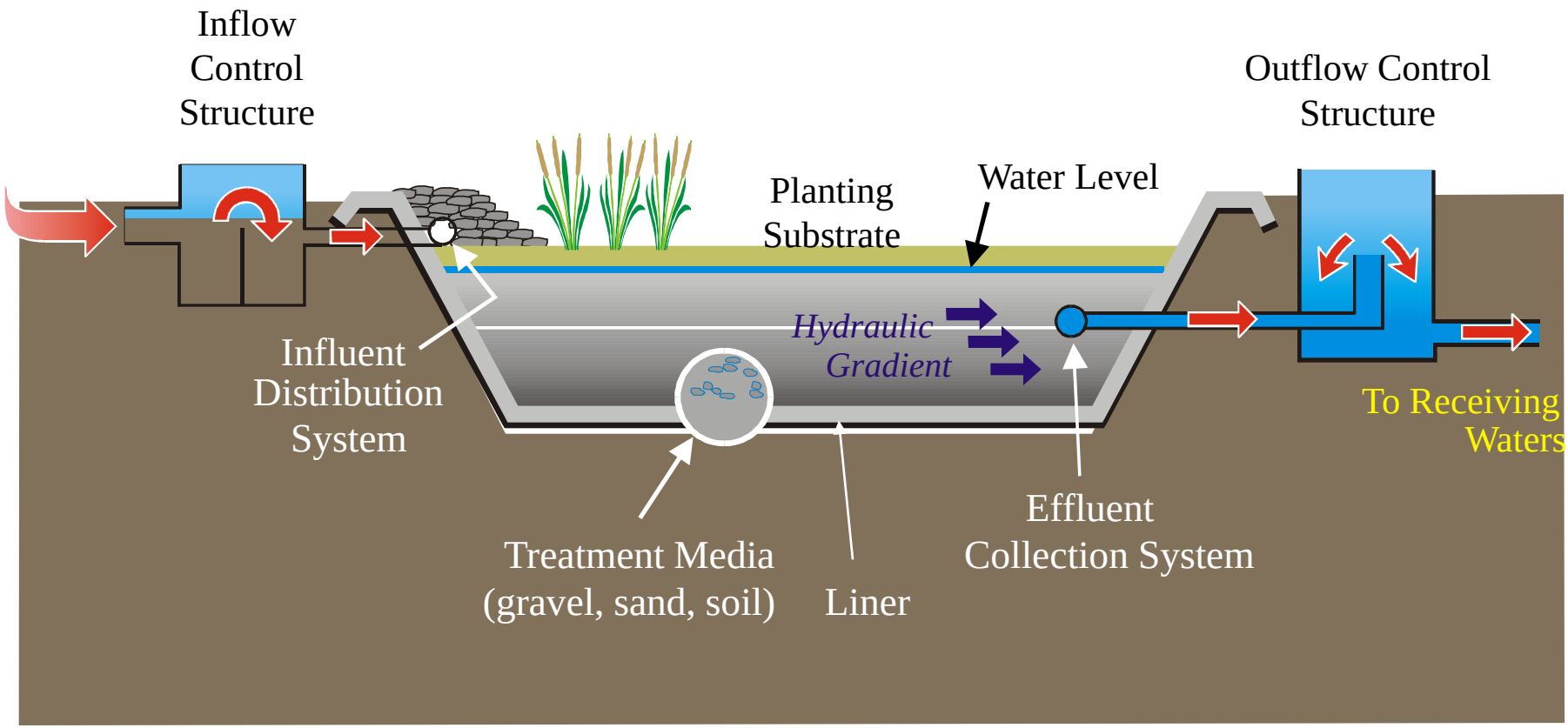
- **Kinds of Basins (Cells)**
  - **Pond → FWS →SSF**
  - **Single cell → multi-cell, multi-train**
- **Morphology**
  - **Irregular cells → rectilinear cells**
  - **High aspect ratios → lower aspect ratios**
- **Sizing methods**
  - **Empirical → reaction kinetics based**
- **Engineering Design**
  - ***Ad hoc* → formal civil & chemical engineering methods**

SUB-SURFACE FLOW (SSF) CONSTRUCTED WETLANDS



Water flow may be horizontal (HSSF) or vertical (VSSF)

ITRC 2003

CONVENTIONAL CWs ARE GOOD AT REMOVING:

- **BOD**
- **Suspended Solids**
- **Particulate Heavy Metals**
- **Bacteria, Viruses**
- **Oil & Grease**
- **Many Lighter Organics**

CONVENTIONAL CWs ARE NOT GOOD AT REMOVING:

- **Removing Nutrients & Many Dissolved Ions**
  - **NH_3: 40 – 60%, TP: 30 – 60%**
- **Coping with Highly Variable Flow Rates**
- **Coping with Very High Flow Rates**
  - **Especially with low pollution concentrations or very high ones**
- **Cleaning Up Recalcitrant Wastewaters**

ENGINEERED WETLANDS (EWs)

- New, Advanced Secondary, Wastewater Treatment Natural Systems Technology for Year-Round Operation
- BREW Project Pilot- & Demo-Scale Testing, Late 1990s
  - Indoor Pilot-Scale (1m^2) & Outdoor Demo-Scale HSSF Wetland Cells (25 m^2)
  - Targeted ammonia and phosphorus removals
- Also Treated Recalcitrant Wastewaters
  - Especially landfill leachates
- Substrate Aeration in Some Cells
- "Engineered" Substrates in Some Cells
- Successful Project
  - Led to patented, proprietary technologies

ENGINEERED WETLANDS

- **Advanced Types of Constructed Treatment Wetlands**
- **Many Cells Operated as Field Scale (Bio)Reactors**
- **Conditions Manipulated & Controlled**
- **Very Much Higher Pollutant Removals Than CWs or Most Mechanical WWTPs**

AVERAGE CW/EW PERFORMANCE *(% Removals)*

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	CW	EW
BOD	50 – 90%	70 – 99%+
TSS	60 – 95%	70 – 95%+
TKN	40 – 60%	90 - 99%
TP	30 – 60%	95 – 99%+
Soluble Organics	80 – 95%+	95 – 99%+
Dissolved Metals	40 – 90%	90 – 99%+
Pathogens	2 – 3 log	3 – 9 log

EW SYSTEMS CAN INCORPORATE

- **Pre-Treatment**
  - **Screens**
- **Primary Treatment**
  - **Sedimentation ponds, oil/grit separator vessels, septic tanks, sand filters**
- **Secondary Treatment**
  - **Usually one or more SSF EW cells**
  - **Cells in series, one or more trains**
- **Tertiary Treatment**
  - **Enhanced nutrient removal**
  - **Polishing**
- **Disinfection**

EW CELL OPTIONS

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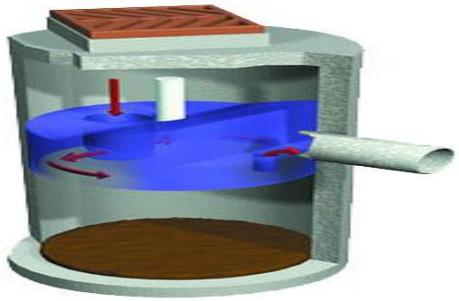
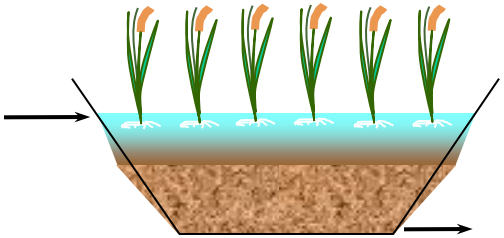
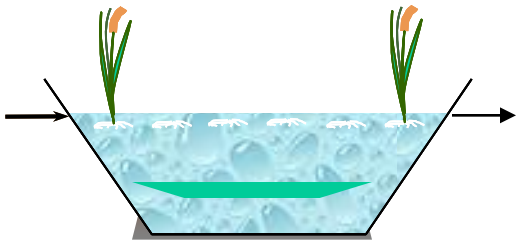


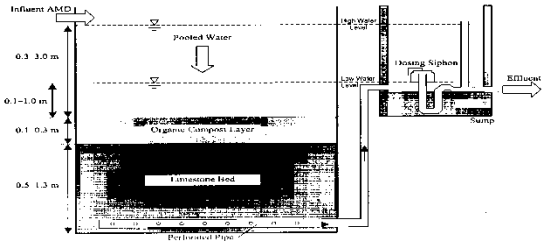
OGS Vessel



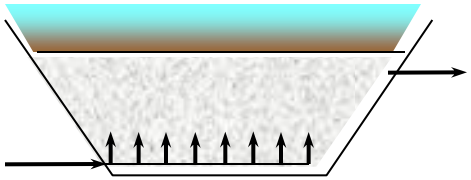
FWS CW CELL



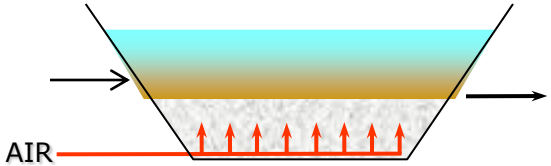
POND CW CELL



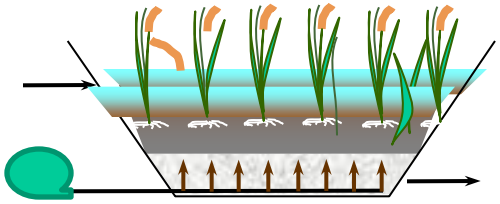
SAPS With a Dosing Siphon



ANOXIC LIMESTONE DRAIN CELL

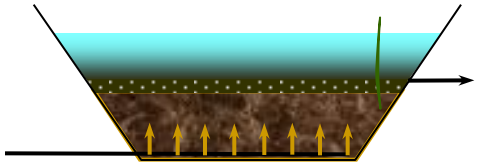


AEROBIC BIOREACTOR CELL

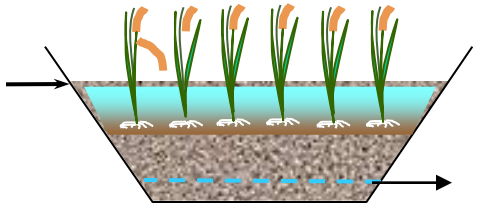


Blower

AERATED VSSF EW CELL



ANAEROBIC BIOCHEMICAL REACTOR CELL



PEAT OR COMPOST ANAEROBIC CELL

WHAT CAN BE TREATED IN AN EW SYSTEM?

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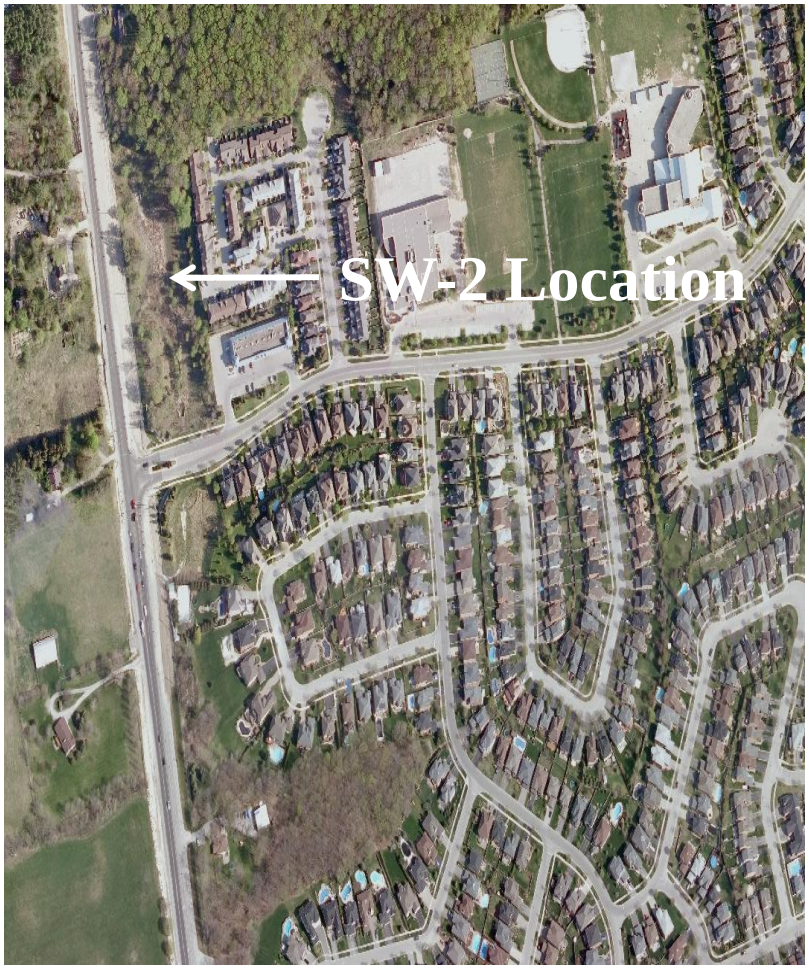
- **Dissolved Metal(loid) Cations & Anions**
  - **Pb, Ni, Cd, Co, Cu, Zn, Mo, Cr, As**
- **Other Biologically Reducable Contaminants**
  - **Nitrates, sulphates, chlorinated organics**
- **Biologically Oxidizable Contaminants**
  - **Ammonia, CN, organics, PAHs, phenols**
- **Chemically Precipitatable/Sorbable Contaminants**
  - **P, CN**

THE OPPORTUNITY

- A Stormwater Dry Pond (SW-2) in the Town of Aurora, Ontario, Canada requires retrofit
- Previously Proposed Retrofit Was Not Executed
  - Convert to Wet Pond
- Could Pond SW-2 Be Upgraded to Improve Water Quality?
  - Demonstration project
  - Lake Simcoe Region Conservation Authority (LSRCA) initiative
  - Lake Simcoe Clean Up Fund (LSCUF)



AERIAL VIEW

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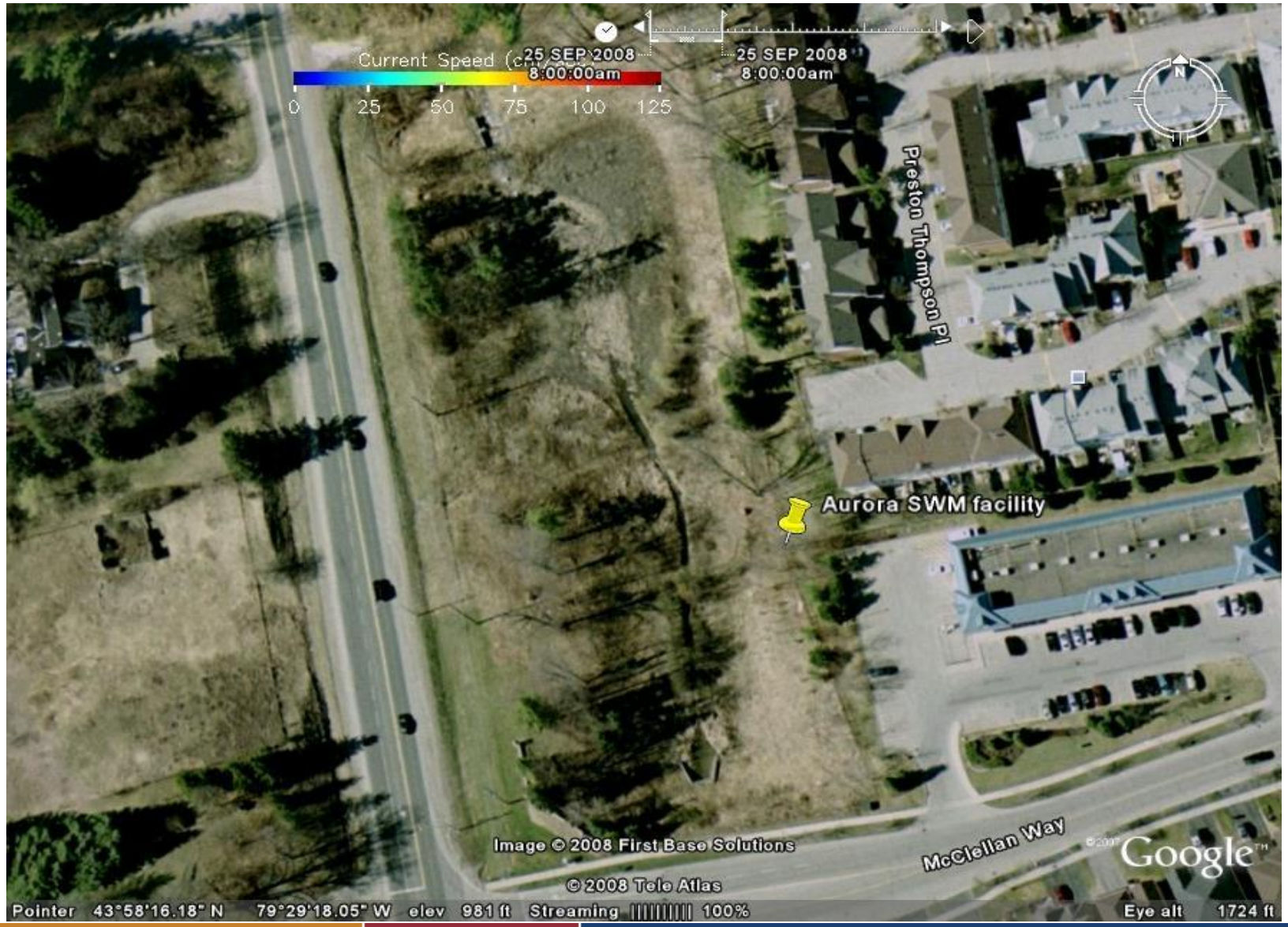

COMPARISON OF TYPICAL SW-2 INLET WATER QUALITY WITH ONTARIO PWQOs (mg/L)

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	Observed	PWQO
Suspended Solids	43 – 194	-
Biochemical Oxygen Demand	2.1 – 5.3	-
Total Kjedahl Nitrogen	1.0 – 2.1	-
Ammonia Nitrogen	0.08 – 0.5	non-toxic
Total Phosphorus	0.2 – 0.4	0.03
Ortho-Phosphorus	~0.1	-
Copper	0.008 – 0.011	0.005
Zinc, Zn	0.23 – 0.49	0.020
Iron, Fe	0.5 – 0.8	0.3

SWAMP, 2003

THE CONCEPT

- **Extend EW Concept into Stormwater Wetlands**
  - **Create *Engineered Stormwater Wetlands* (ESWs)**
- **Why?: The World Is Changing**
  - **Site Specific Sensitivities (Lake Simcoe)**
  - **Tightening regulations**
  - **New technologies**
  - **Economic drivers**
- **ESWs Would Have Potential To Address Specific Contaminants in Stormwaters as Well as Water Quantity**
  - **Much more Suspended Solids**
  - **Nutrients (N, P)**
  - **Metals**
  - **Pathogens**

THE AURORA SW-2 POND RETROFIT PROJECT

- **Three-Phase Project to Demonstrate the ESW Concept**
  - **Phase 1: design & tender ESW**
  - **Phase 2: construction (2011)**
  - **Phase 3: monitoring may set standard for new SW management criteria in future**
- **Various Partners**
  - **Environment Canada, LSRCA, Town of Aurora, Stantec, OGS Supplier, MOE, Others**
- **Funding by Conservation Authority, Federal Government and Town of Aurora**

THE DESIGN

- **Replace Existing Dry Pond with an ESW System**
  - **Water quality improvement as well as water quantity management**
- **Three Components**
  - **Inlet Oil/Grit/Sediment (OGS) Removal Vessel and small Forebay (1º Treatment)**
  - **High headspace Horizontal/Vertical Sub-Surface Flow (HSSF/VSSF) EW Cell (2º Treatment)**
  - **Free Water Surface (FWS) CW Cell (3º Treatment)**

AURORA ESW LAYOUT

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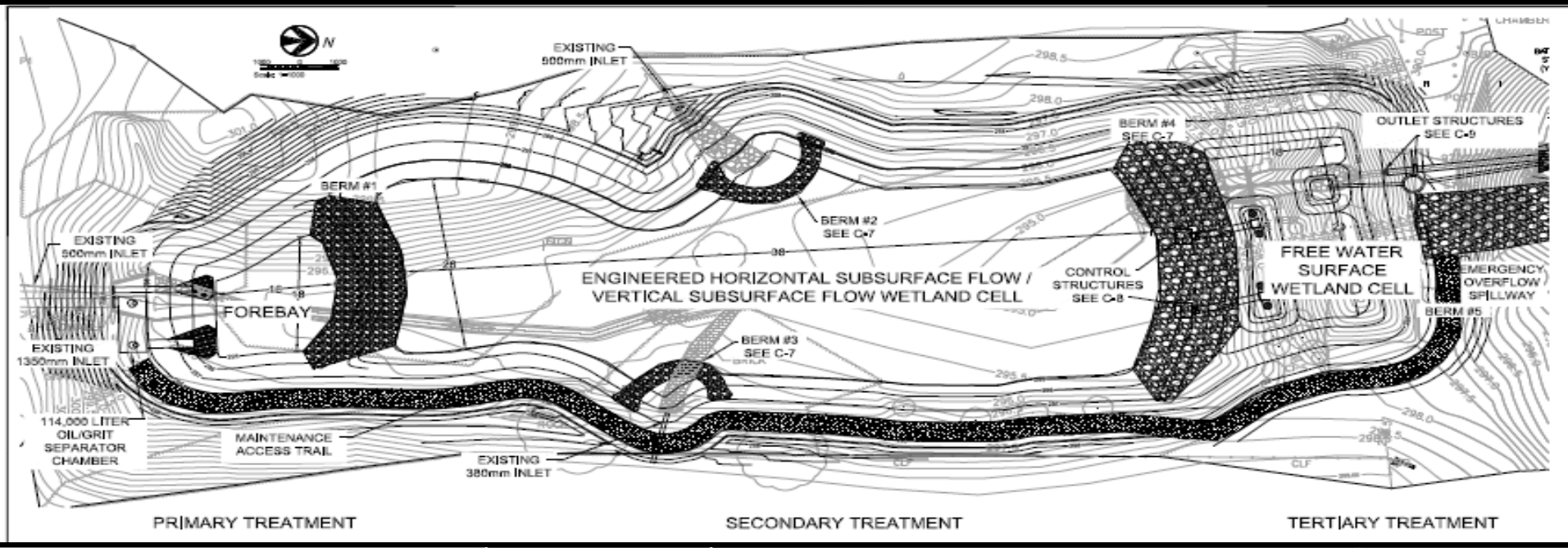

Stantec

DESIGN BASIS

- **Design for Water Quality Event**
  - **Enhanced Water Quality Improvement to the 2- yr storm event**
  - **32.3 mm pptn, 71.5 ha catchment area**
  - **Peak flow 2.76 m^3/s, Volume: 4900 m^3**
- **Design to Accommodate 100 Year Storm**
- **Design for Worse Influent Quality**
- **Effluent Quality Targets**

Parameter	Influent	O/G Separator Effluent		EW Effluent		FSW Effluent	
	mg/L	%	mg/L	%	mg/L	%	mg/L
TSS (mg/L)	200	60	80	75	20	50	10

EFFLUENT WATER QUALITY TARGETS (mg/L)

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TSS	**<10**
BOD	**<0.5**
TP	**0.03**
o-PO_4	**0.01**
TKN	**<0.3**
NH_3-N	**<0.03**
Metals	**< PWQO**
Oil & Grease	**0**
E. coli	**< 2 log**

REDUCED FOREBAY CONTAINING OGS VESSEL

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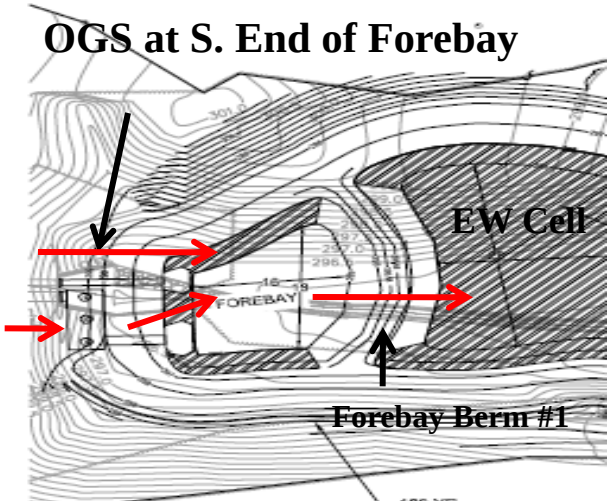
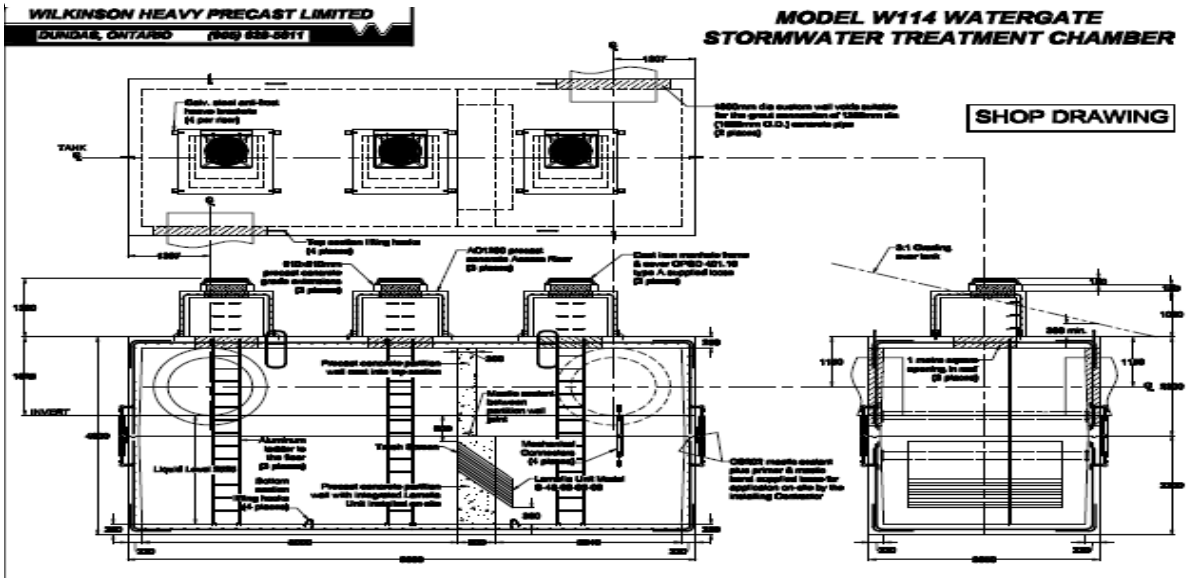
OGS at S. End of Forebay

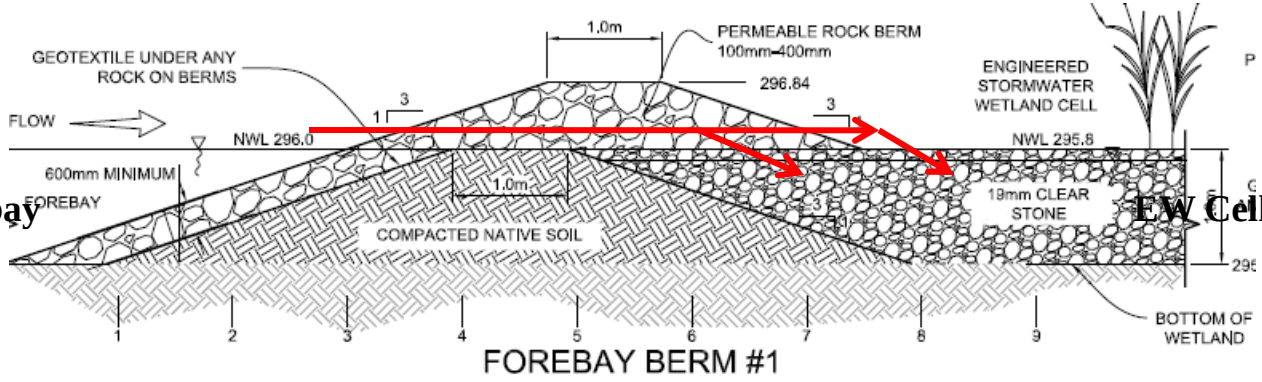


Greatly Reduced Forebay With OGS Vessel
Target: >60% TSS Removal

WILKINSON HEAVY PRECAST LTD.



Sections of Watergate™ OGS Vessel

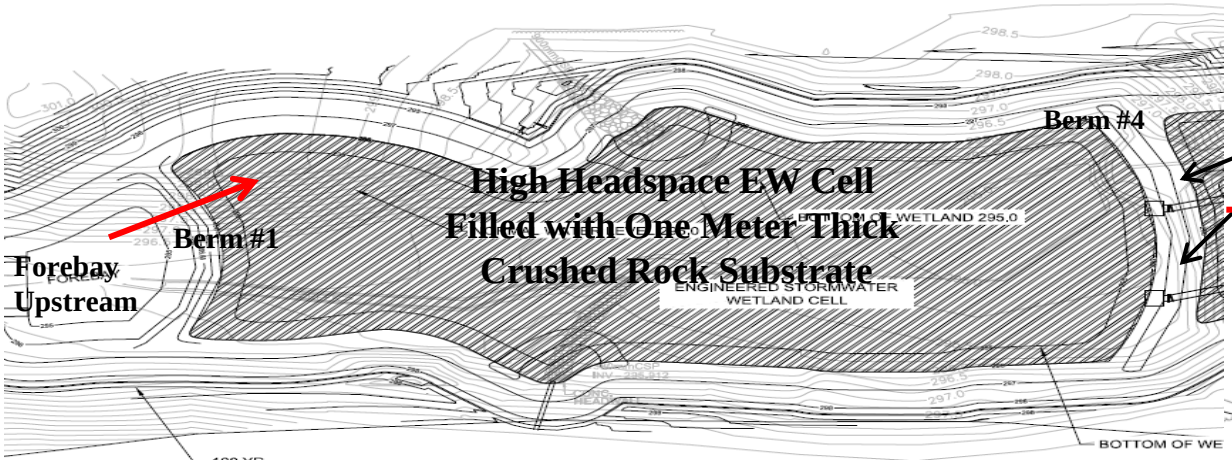


Forebay **EW Cell**

FOREBAY BERM #1

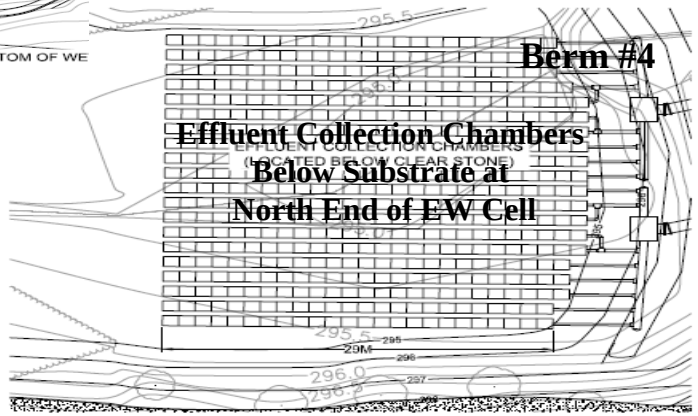
Stantec

HSSF/VSSF EW CELL

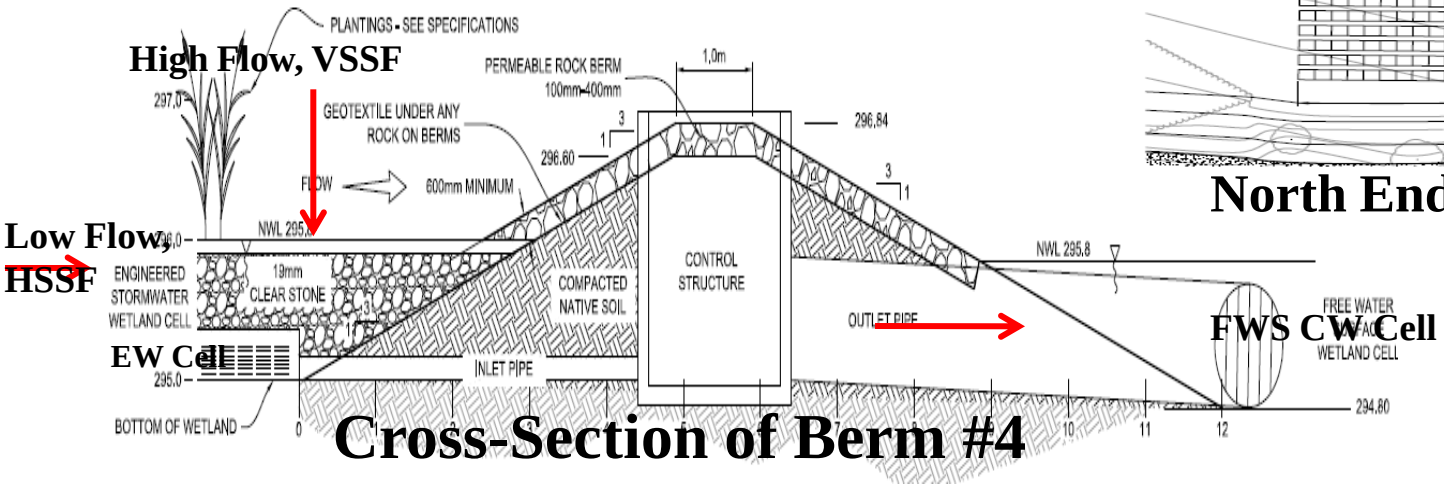


ENGINEERED WETLAND CELL

Target: A further 75% TSS removal
+ removal of BOD and NH_3-N



North End of EW Cell



FWS CW Cell

Cross-Section of Berm #4

FWS CW CELL AT NORTH END OF ESW

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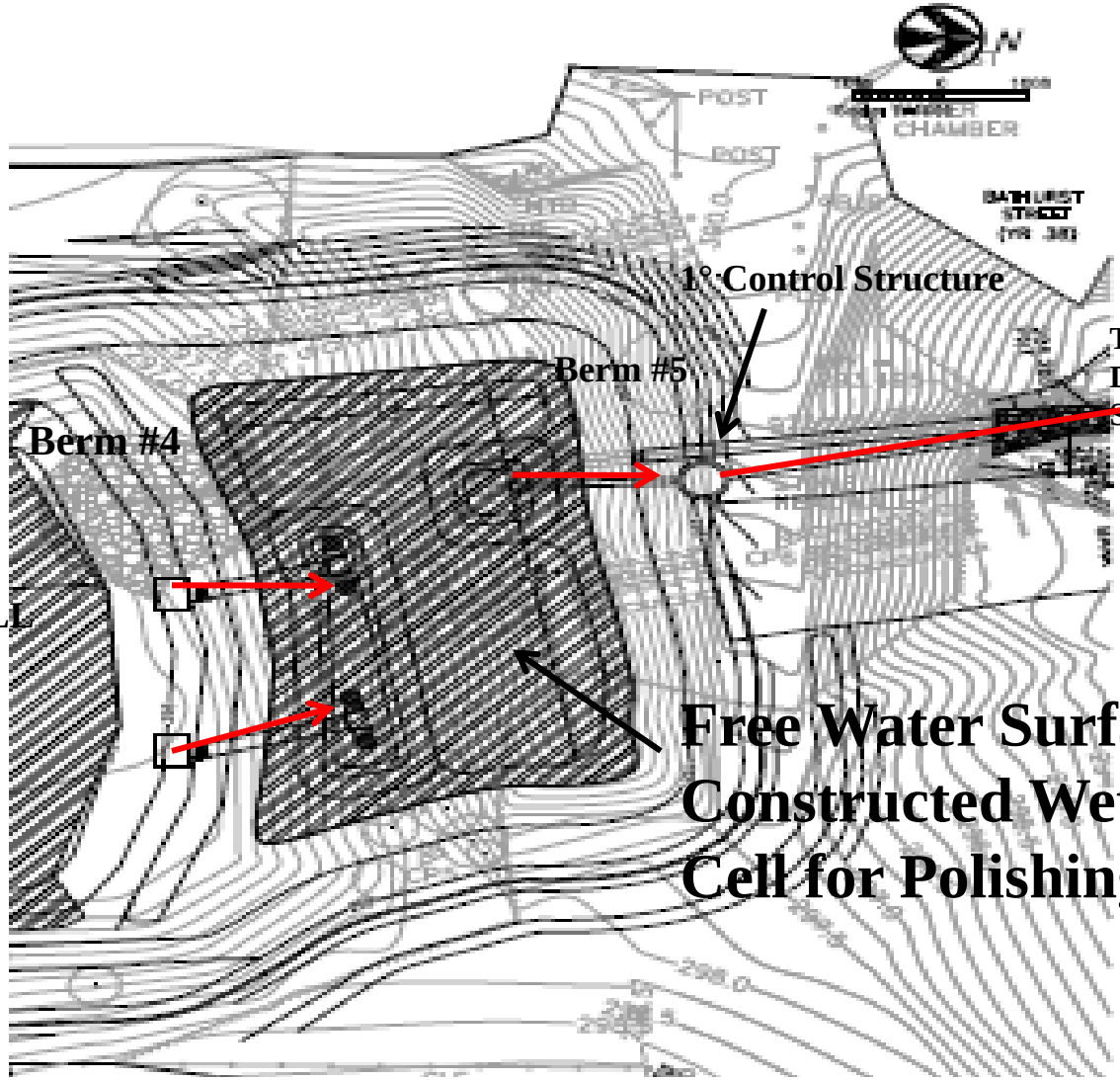

AURORA ESW DESIGN CRITERIA COMPARISON

Pond Criteria/Guidelines (Enhanced Level of Protection)	Constructed Wetland Requirements	Proposed ESW Design
Quality Control Criteria	80% SS removal	na
Wetland Permanent Pool	66 m^3/ha	20.2 m^3/ha
Extended Detention[1]	≥ 40 m^3/ha (2860 m^3)	2-yr event runoff (68.9 m^3/h or 4929 m^3)
Flood Control Volume	100-yr event runoff	100-yr event runoff (12560 m^3)
Active Storage Detention Time	24 hrs	30 hrs
Forebay: Minimum Depth	1 m	1 m
Forebay: Maximum Area	20% of total permanent pool	22% of total permanent pool
Permanent Pool Depth	150 mm to 300 mm	800 mm
Active Storage Depth	Maximum 1.0 m for storms < 10 year event	1.3 m
Outlet: Pipe diameter	Minimum 450 mm	450 mm
Outlet: Pipe slope	>1%	1%

Notes:
na – not applicable
1 – The minimum required extended detention volume is 40 m^3/ha (MOE, 2003). The extended detention volume must ensure a minimum 24 hours of drawdown to the 25-mm precipitation event. 40 m^3/ha equates to 2860 m^3.

CONSTRUCTION

AS - CONSTRUCTED

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ADVANTAGES OF ENGINEERED STORMWATER WETLANDS

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- **Manage Water Quantity & Water Quality**
- **Inexpensive to Construct & Operate**
- **Permanently Removes Pollutants**
- **Can Handle Varying Influent Quality**
- **Tolerant of Fluctuating Influent Flows**
- **Favorable Public Perception, Increased Aesthetics**




WHERE TO FROM HERE

- **Have completed MEA Class EA and Preliminary Design for Retrofit of Existing Wet Pond (Lincoln Pond) to ESW in Uxbridge**



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Thank You!