



Civil & Environmental Consultants, Inc.

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Treatment Methods for Leachate Impacted by Landfill Gas Well Pumping

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Overview

- ➔ Leachate Concerns
- ➔ Comparative Trends in leachate quality
- ➔ Technologies
 - Passive
 - Active
- ➔ Case Examples
- ➔ Cost implications
- ➔ Structured Decision Process



Leachate Problem Constituents

- ➔ **Ammonia/Nitrogen**
 - Ammonia – aquatic toxicity issue
 - High nitrogen is a nutrient issue & Nitrate – drinking water issue
 - O₂ Demand at POTW
- ➔ **Total Dissolved Solids (TDS)**
 - Regulatory - direct discharge, or for some reuse strategies
 - Can be a toxicity issue for surface discharge (acute/chronic)
 - High TDS impacts biological treatment
 - Corrosion
- ➔ **COD/BOD**
 - Potential surface water discharge issue
 - Basis for most pretreatment permit surcharges, Oxygen Demand
- ➔ **VOC; SVOC**
- ➔ **Emerging Compounds – “Microconstituents”**
 - Metals - Mercury is recent example – very low criteria (1.3 ng/L)
 - Pharmaceuticals and Personal Care Products/Endocrine Disruptors



Causes for Leachate Variability

- ➔ **Leachate Characteristics Vary in Volume & Concentration**
 - Landfill Age
 - Ambient Temperature
 - Rainfall
- ➔ **Impacts of Landfill Gas Well Pumping/ Condensate Management**
 - Refuse Permeability
 - Refuse Depth
 - Refuse Temperature
 - Refuse Composition
 - MSW/C&D/Industrial
- ➔ **Causes**
 - Vertical Conduit
 - Wells in use
 - Active v. legacy
 - Balancing

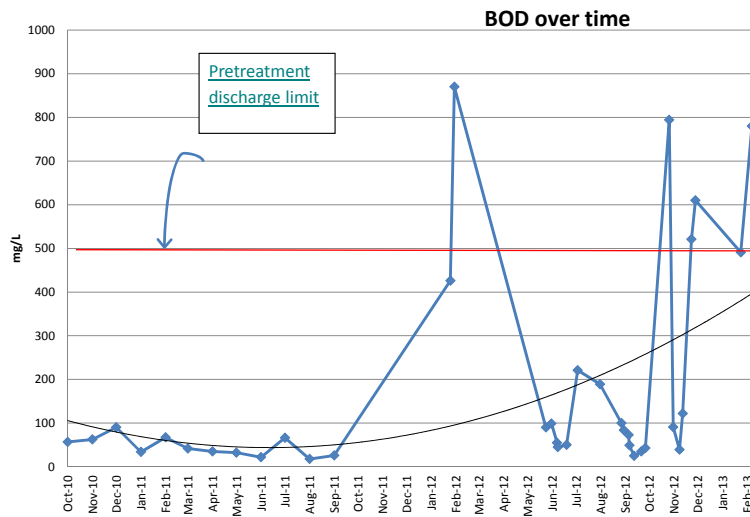


Leachate Characteristics

Characteristics	Leachate Alone mg/l	With Gas Well Pumping/Condensate mg/l
BOD	100 - 500	1,000 – 5,000++
COD	250 – 1,000	750 – 15,000++
Ammonia	100 - 250	500 – 12,000++
Metals		200 – 500% Higher
VOCs		200 – 500% Higher
TDS	500 – 4,000	3,000 – 20,000++

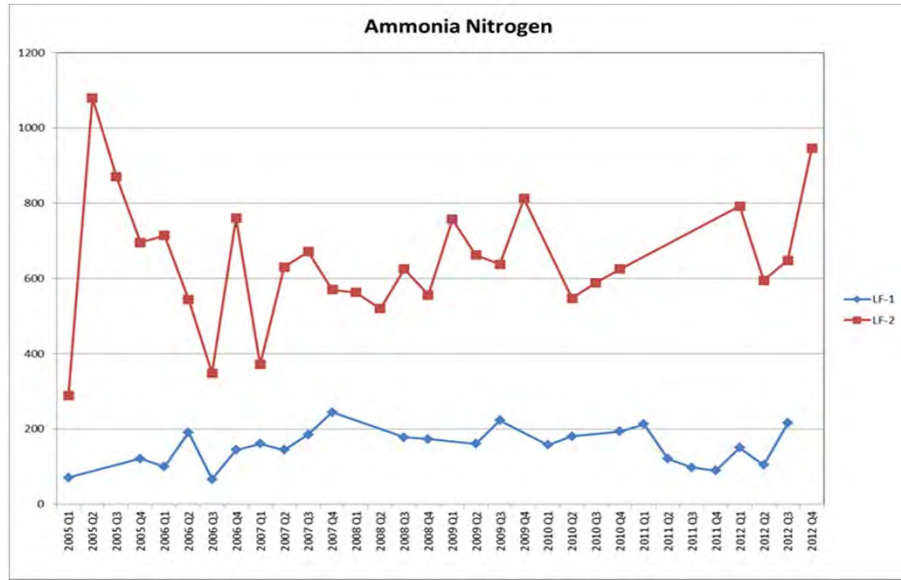


Leachate Characteristics

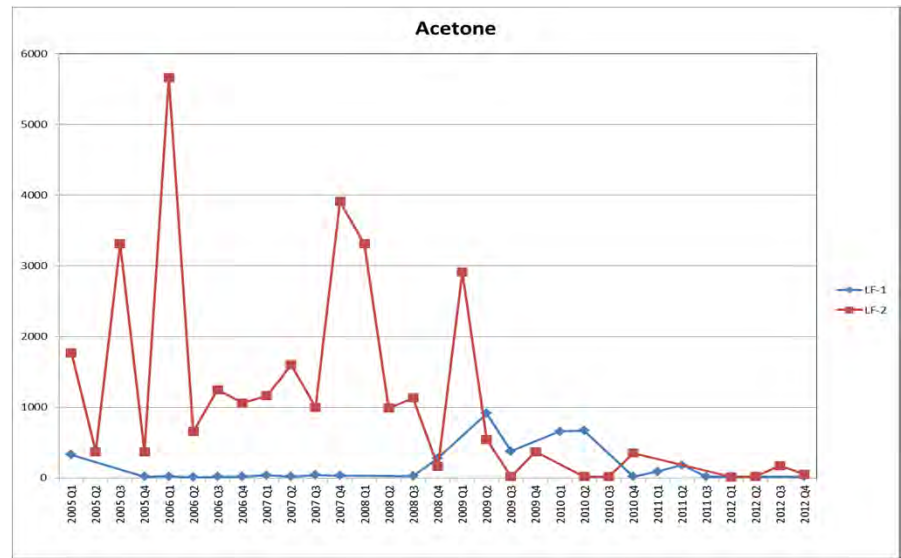




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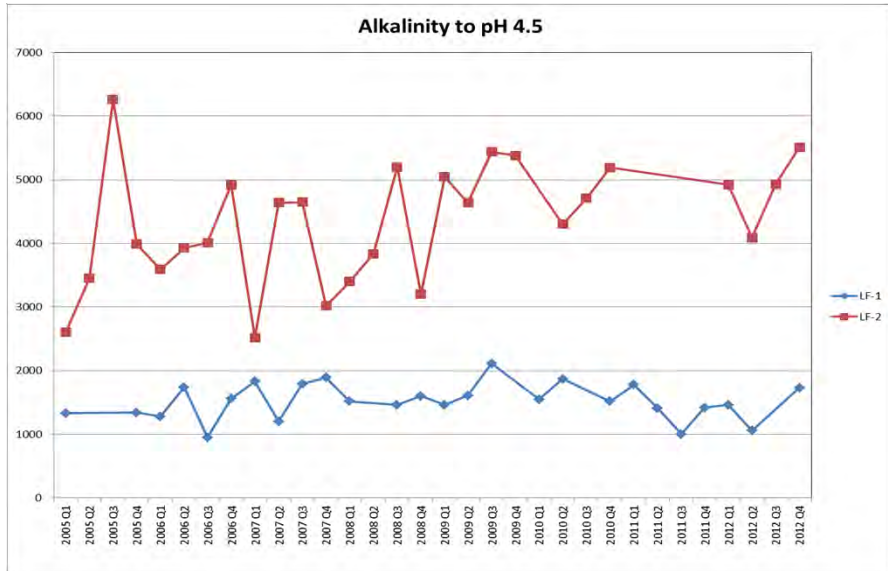


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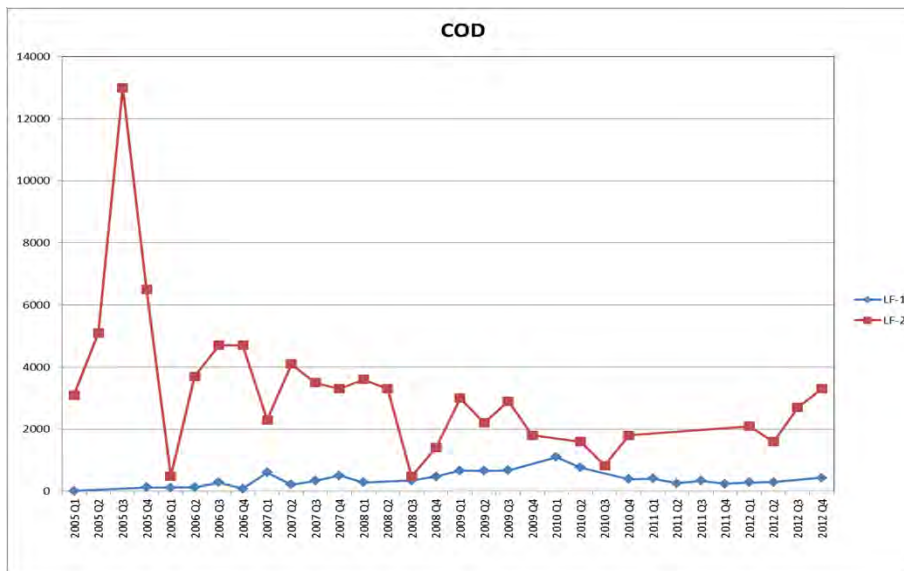




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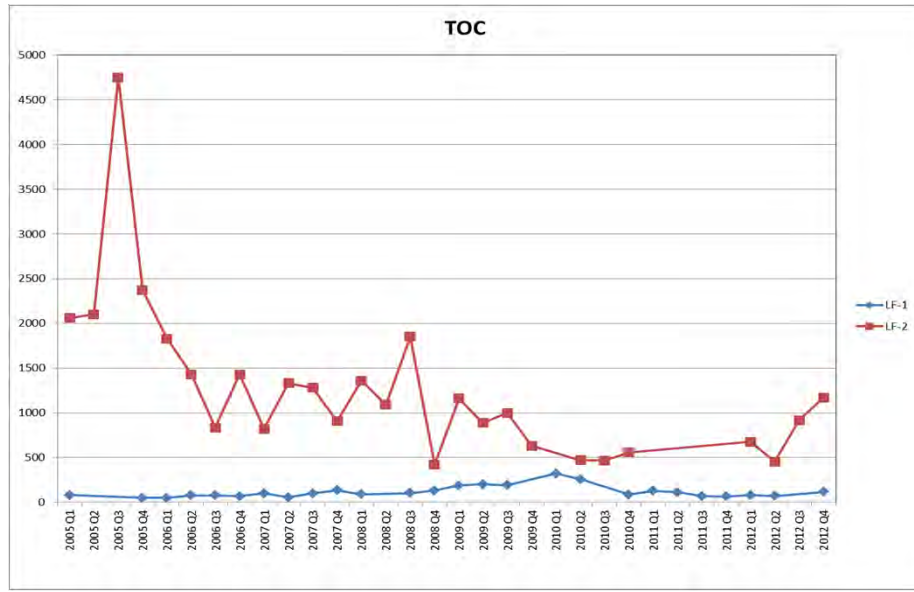


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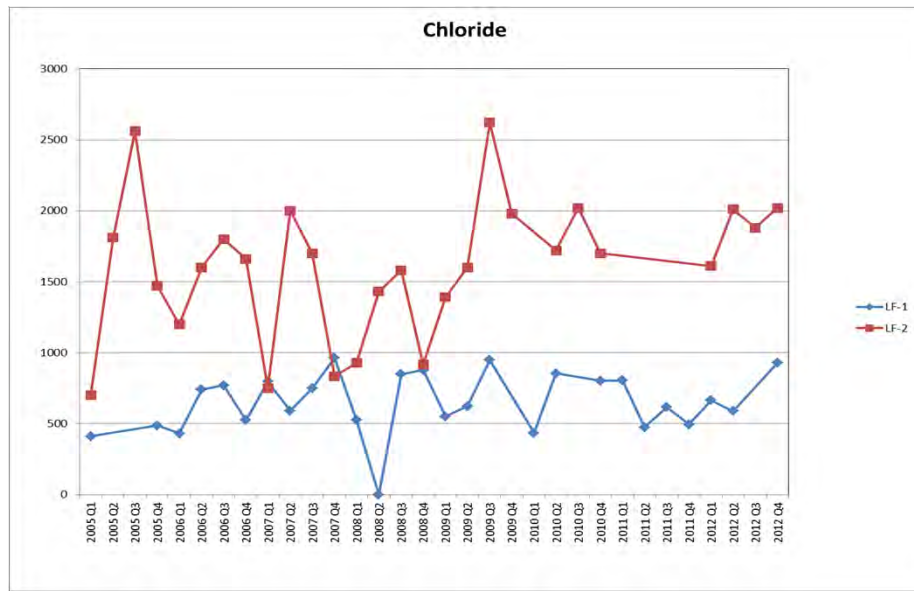




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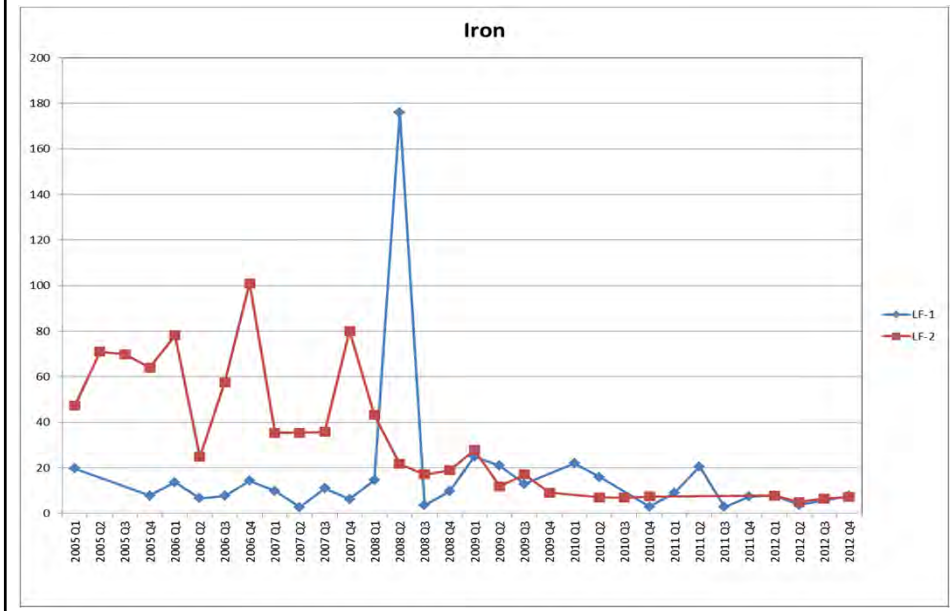


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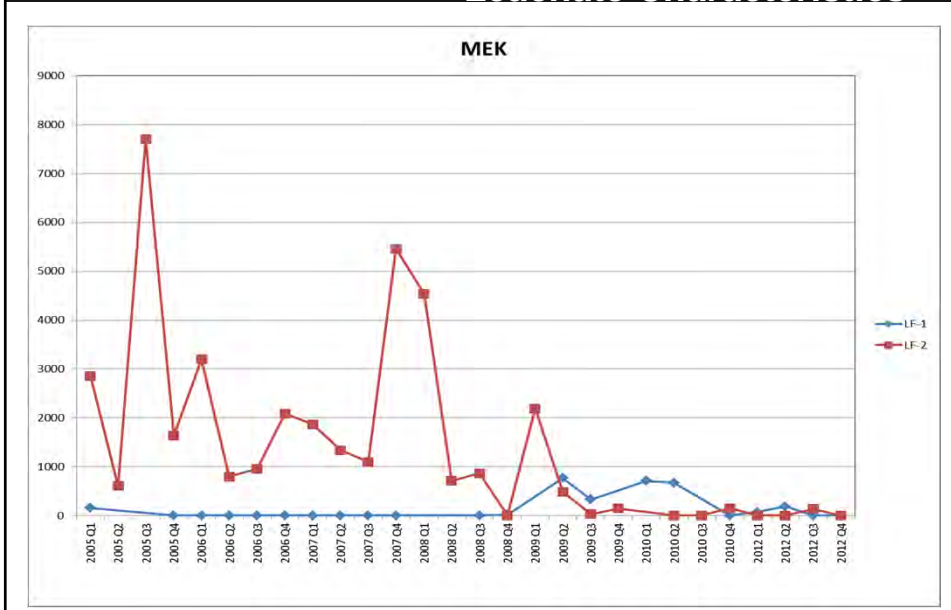




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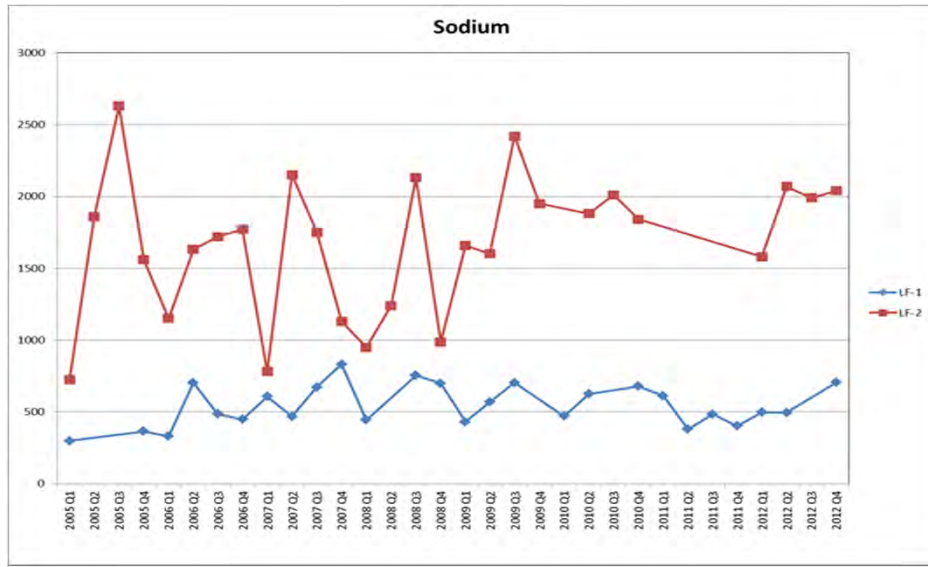


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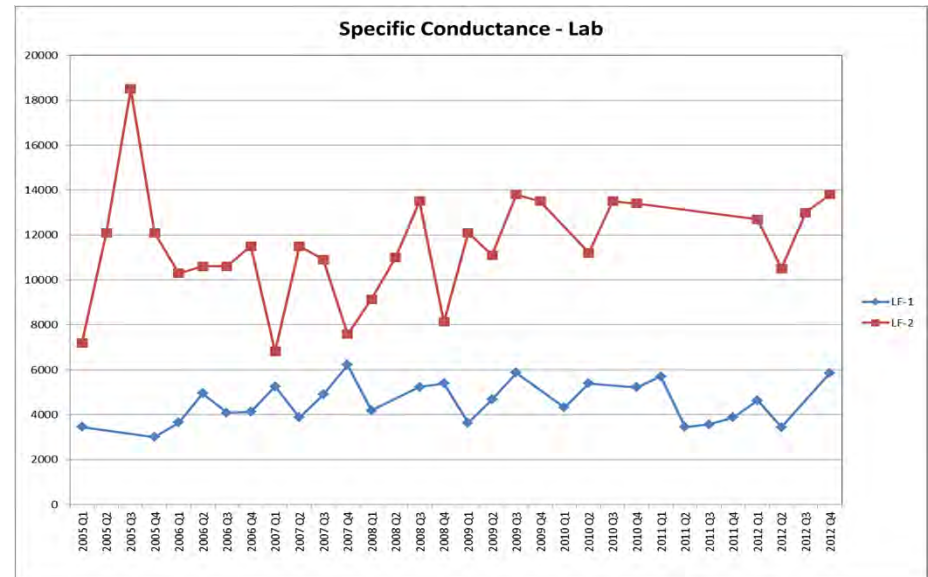




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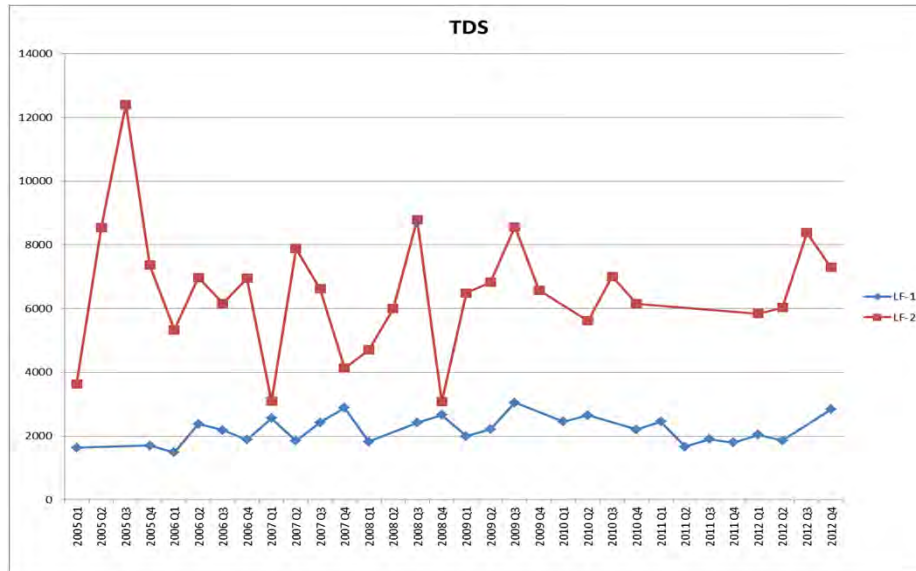


Leachate Characteristics





Leachate Characteristics



Leachate Treatment

➔ Typical Leachate Management Practices

- Hauling to a waste water treatment plant (POTW)
- Discharge to POTW via Force Main
- Off-site irrigation
- On-site irrigation
- discharge to surface water (e.g., NPDES to nearby creek)
- Recirculation to landfill

➔ Passive Treatment Systems

➔ Active Treatment Systems

- Physical Treatment
 - Sedimentation
 - Precipitation
 - Evaporation
 - Concentration
- Biological Treatment-Aerobic/Anaerobic
 - Attached Growth
 - Suspended Growth

➔ Advanced Systems

- Zero Liquid Discharge
 - Evaporation
 - Deep Well Injection
 - Mechanical Systems
- AOP
- Sulfate Radical AOP
- Plasma



Landfill Leachate Passive Treatment System Components

➔ Several Types of Natural Based Systems

- Constructed Wetlands
 - Peat Filters (Boron removal)
 - Aerobic / Free Water Surface (FWS) Cells
 - Vertical Flow Wetlands
 - Subsurface Flow Wetlands
- Land Disposal
- Anaerobic NRBR's/SRBR's or VSB's
- Phytoremediation
- Lagoons



Constructed Wetlands

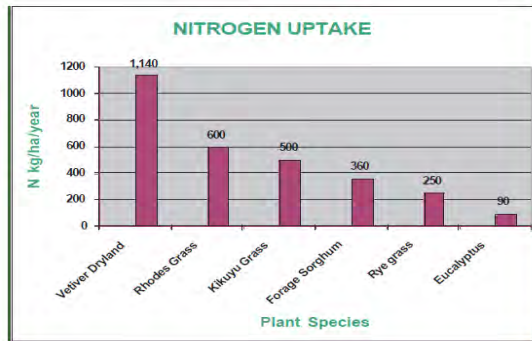
- ➔ Imitate the environment
- ➔ Aerobic, anoxic & anaerobic zones
- ➔ FWS/ Vertical Flow/ Subsurface Flow
- ➔ Oxidize ammonia to nitrate
- ➔ Plant uptake of ammonia/nitrate in photosynthesis
- ➔ Reduce nitrate to atmospheric nitrogen
- ➔ Removes BOD, COD, metals
- ➔ Effective at mercury removal to v. low levels (0.04-0.09 to <0.008 µg/L)
- ➔ Settling/filtering of suspended materials and precipitates manganese, boron, selenium





Land Disposal

- ➔ Spray Irrigation
- ➔ Drip Irrigation – Surface/Subsurface
- ➔ Northern v Southern Plants
 - Reeds, bulrush, cattails
 - Vetiver Grass – no freeze conditions
 - BOD, Salinity, metals, VOCs



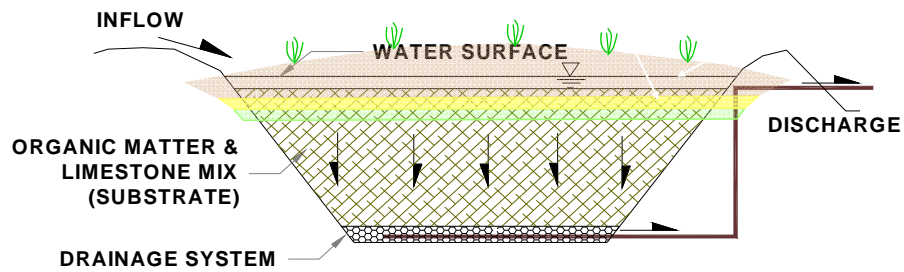
Phytoremediation

- ➔ Hybrid Poplars
- ➔ Fast Growth
- ➔ Max 300 mg/l ammonia??
- ➔ High water consumption
- ➔ High constituent uptake
- ➔ Artificial soils help – biosolids?





Alternative to Vegetated Submerged Beds



Covered Sulfate Reducing or De-nitrification Cell



Lagoons

- ➔ Facultative Lagoon
- ➔ Anaerobic Lagoon
- ➔ Aerated Lagoons





Physical Treatment Technology

➔ Ammonia

- Air Stripping
- PPT: Mg salts
- Breakpoint Chlorination

➔ Chemical Precipitation

➔ TDS & Other Constituents

- Ion Exchange
- Reverse Osmosis
- Evaporation/Crystallization
- Deep Well Injection



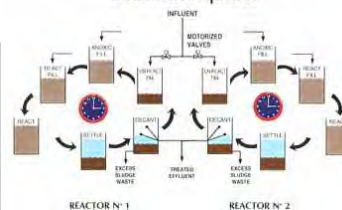
Types of Biological Treatment Process

- ➔ Aerated Lagoon
- ➔ Activated Sludge
- ➔ SBR
- ➔ Trickling Filter
- ➔ MBBR
- ➔ Membrane Bioreactor
- ➔ Fixed Film
- ➔ Immobilized Cell Bioreactor
- ➔ Anaerobic & Anaerobic/Aerobic



SBR A CONTINUOUS PROCESS "IN BATCH"

Treatment sequence





Case Study – Active Treatment

Case Study 1

- ➔ **Gas well dewatering liquid/condensate are a high strength wastestream**
 - Significantly different characteristics, compared to leachate
 - Prior Leachate approximately 200 to 500 mg/L ammonia
- ➔ **Existing Treatment - Three 20,000 gallon MBBR biotowers in series**
- ➔ **Projected Design Flow > 100,000 GPD**
- ➔ **Actual Flow = 20,000 to 30,000 GPD**
- ➔ **Gas well dewatering liquid/condensate ranges from 2,000 to 4,000 mg/L ammonia**
- ➔ **Plant experiences spikes up to 3,500 mg/L ammonia**
 - Upgrade not adequate to treat ammonia loading
 - Effluent limit achieved by recycling
 - Hauling off-site at significant cost
- ➔ **Proposed Expansion: Increase MBBR capacity by 4 to 6 times, 415,000 gallon MBBR**
 - Provide for flexibility
 - Provide for future expansion



Figure 1 - Entex Bioport2™ media element and screen used in Seneca Landfill.



Case Study – Active Treatment

Case Study 2

- ➔ **High variability – Gas Wells/Condensate**
- ➔ **Two Membrane Bioreactors (MBR) Operated in Parallel**
- ➔ **Existing 4 tank leachate “storage” system**
 - No mixing or equalization provided
- ➔ **Design: 2,200 mg/l ammonia, 6,000 mg/L COD**
 - COD/ammonia ratio: 3 to 1
- ➔ **Gas well dewatering liquid/condensate**
 - Multiple wells have 100,000 mg/L to 150,000 mg/L COD
 - High concentrations of ammonia, metals
- ➔ **COD spikes 12,000 mg/L to 16,000 mg/L**
 - Organic overloading, over double design
 - Current COD/ammonia ratio over 6 to 1
 - Ammonia bacteria are “crowded out”
 - Less ammonia removal capacity
- ➔ **Potential metal “inhibition” issues**
- ➔ **Proposed Modifications:**
 - Convert two leachate “storage” tanks to “equalization” tanks
 - Convert the MBR from “parallel” to “in-series” – Two sludge system





Cost Implications

System Costs

Alternatives built on combination of technologies

CONSTRUCTION

Lagoons	\$0.01 – \$0.03/gal
Constructed Wetlands	\$0.01 - \$0.03/gal
Chemical Treatment	\$0.02 - \$0.05/gal
Biological Treatment	\$0.025 - \$0.06/gal
RO	\$0.02 - \$0.06/gal
AOP	\$0.06 - \$0.07/gal
Hauling	\$0.05 - \$0.18/gal



How to Select Technologies/Alternatives

- ➔ Fatal Flaw Analysis
- ➔ Identify Key Attributes
- ➔ Structured Decision Process
- ➔ Lab, Bench tests, Pilot tests





Fatal Flaw Technology Comparisons

	Effluent Reliability/Consistency	Operability	Construction Cost	Maintenance Cost	Operator Friendliness	Hydraulic Sensitivity	Waste Load Sensitivity	Flexibility	Odor/Offsite Enviro. Impacts	Noise	Visual Impacts	Hydrological Impact	Footprint	Expandability	Construction Timing
No Action	F	L	L	L	L	L	H	L	H	L	L	L	L	L	L
New Storage Tank Construction	M	L	M	M	M	M	H	L	L	L	M	M	M	H	M
pH Adjust, Air Stripping, Package Biological	M	M	H	H	M	M	H	L	H	M	H	M	M	H	M
Lagoon	M	M	M	L	L	L	M	H	H	L	M	H	F	M	M
SBR/Equalization Tank	H	H	H	M	H	M	H	M	M	M	M	M	M	H	M
Breakpoint Chlorination	F	H	M	M	M	M	H	H	M	L	M	M	M	H	M
Package Biological/Nitrification/EQ Tank	H	H	M	L	M	M	H	L	M	L	H	M	M	M	M
Reverse Osmosis	H	H	H	H	M	F	M	L	L	M	M	F	L	H	M
Evaporation	M	M	F	L	H	M	H	M	H	L	M	F	H	M	M
Constructed Wetlands	M	M	M	L	H	L	M	H	H	L	H	H	F	L	M
Phytoremediation	M	M	M	L	H	L	M	H	H	L	H	H	F	L	M



Technology Comparisons

Heading	Multiplier	Comment
Commercially Proven	10	Fundamental
Operability (ease of)	8	
Hydraulic Variability	5	Feed tank should buffer this
Waste Loading Variability	9	Feed tank should buffer this
Chemical Storage & Delivery (extent, hazard, compliance requirements, complexity)	4	Impacts footprint and distances to premises boundaries; System security.
Secondary Waste	6	(created? difficulty/cost to manage?)
Footprint (small)	10	Critical for this site
Power Requirement (low)	4	Small flows - all relatively low
Capital Cost (low)	5	
O&M Cost (low)	7	Can override capital over a long period of operation
Start-up Period (low)	3	"initial commissioning" or "start up after a process trip"?



Summary of the Consideration Ranking Definitions and Weighting Used for Technology Review

Considerations	Rankings	Multiplier	Definition
Commercially Available	5	10	Frequently Used
	3		Often, but not Frequently Used
	1		Infrequent, but commercially available
Operability	5	8	Moderate operator attention and expertise
	3		Requires full operator attention and expertise
	1		Requires full operator attention and expertise
Hydraulic Variability	5	5	Capable of handling wide flow variations
	3		Moderate upset due to flow variations
	1		Process unable to perform with flow variation
Waste Loading Variability	5	9	Handling large water quality variations
	3		Moderate upset from water quality variations
	1		Process upset without large equalization to address water quality variation
Chemical Storage & Delivery	5	4	Chemical storage and delivery not required
	3		Chemical storage and delivery required
	1		Hazardous chemical storage and delivery



Summary of the Consideration Ranking Definitions and Weighting Used for Technology Review (Con't)

Considerations	Rankings	Multiplier	Definition
Secondary Waste	5	6	Produces no waste that needs further treatment/disposal
	3		Produces waste that needs disposal
	1		Produces waste that needs further treatment prior to disposal
Footprint	5	10	Requires small footprint
	3		Require moderate footprint
	1		Require large footprint
Power Requirement	5	4	Requires little energy
	3		Requires moderate energy
	1		Requires high energy
Capital Cost	5	5	Low capital cost
	3		Moderate capital cost
	1		High capital cost
O&M Cost	5	7	Low O&M cost
	3		Moderate O&M cost
	1		High O&M cost
Start-up Period	5	3	No start-up period required
	3		Moderate start-up period required
	1		Long start-up period required



Pairwise Comparisons of Alternatives

	No Action	SBR & AOP Process	EQ/ Package Biological /pH Adjust/ Air Stripping/ pH adjust	Equalization Tank/SBR	EQ Tank/ Package Biological/ Nitrification	Total Score
No Action		0	0	0	0	0
SBR & AOP Process	1		0	0	0	1
EQ/ Package Biological /pH Adjust/ Air Stripping/ pH adjust	1	1		0	0	2
Equalization Tank/SBR	1	1	1		1	4
EQ Tank/ Package Biological/ Nitrification	1	1	1	0		3



Conclusions

- ➔ Lots of Reasons for Variability
- ➔ Waste Strength Variability
- ➔ Need Historical Data
 - ➔ Theater of seasons
- ➔ Lab, Bench Tests, Pilot Tests
- ➔ Structured Decision Process





Questions?

