Civil & Environmental Consultants, Inc.

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Treatment Methods for Leachate Impacted by Landfill Gas Well Pumping

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Palmetto Chapter

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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
  - O_2 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

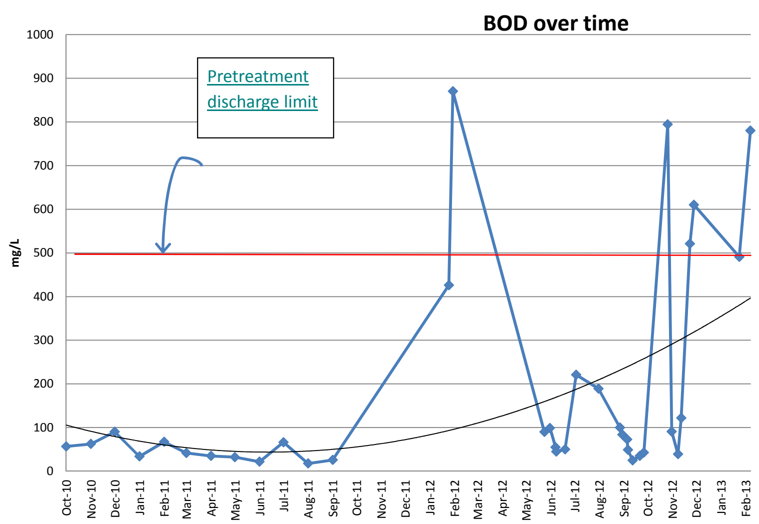
- **Leachate Characteristics Vary in Volume & Concentration**
- **Impacts of Landfill Gas Well Pumping/ Condensate Management**
- **Causes**
  - Vertical Conduit
  - Wells in use
  - Active v. legacy
  - Balancing

- Landfill Age
- Ambient Temperature
- Rainfall
- Refuse Permeability
- Refuse Depth
- Refuse Temperature
- Refuse Composition
  - MSW/C&D/Industrial

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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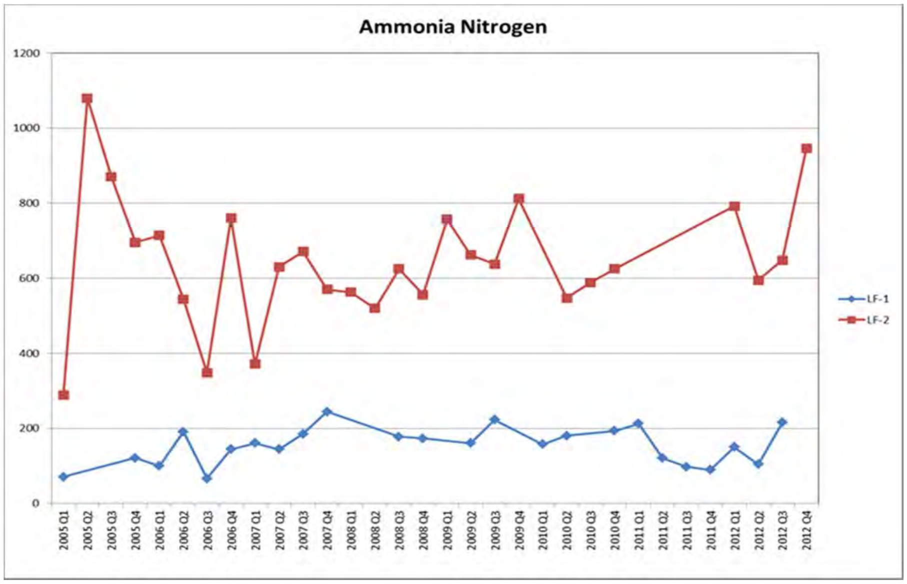

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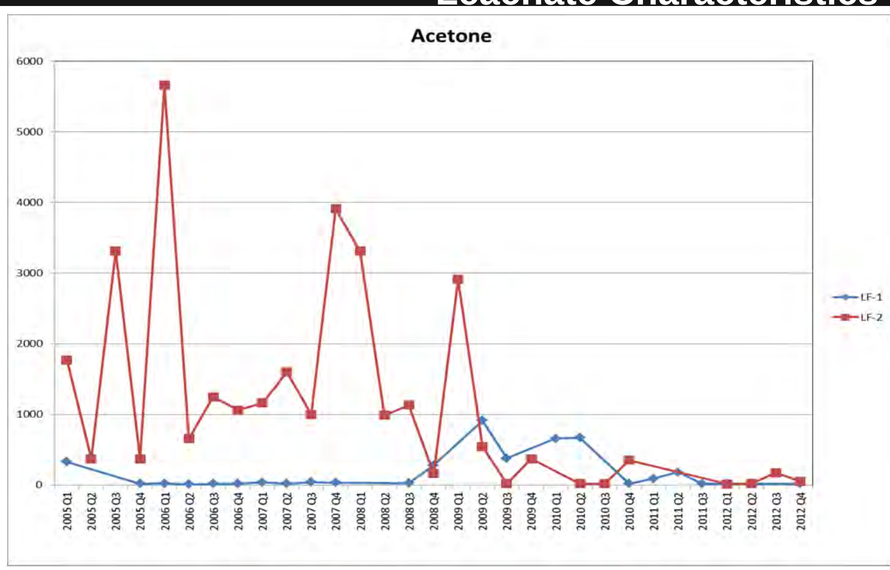

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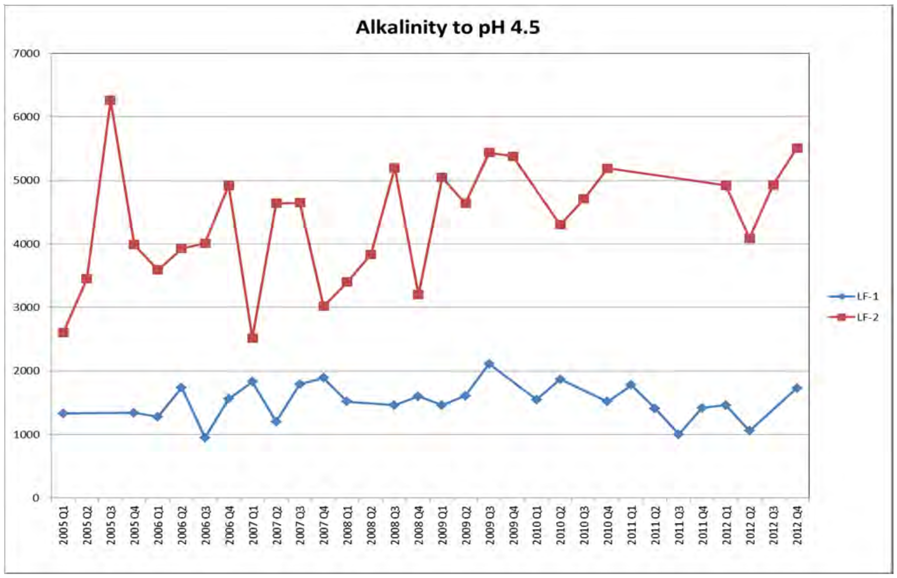

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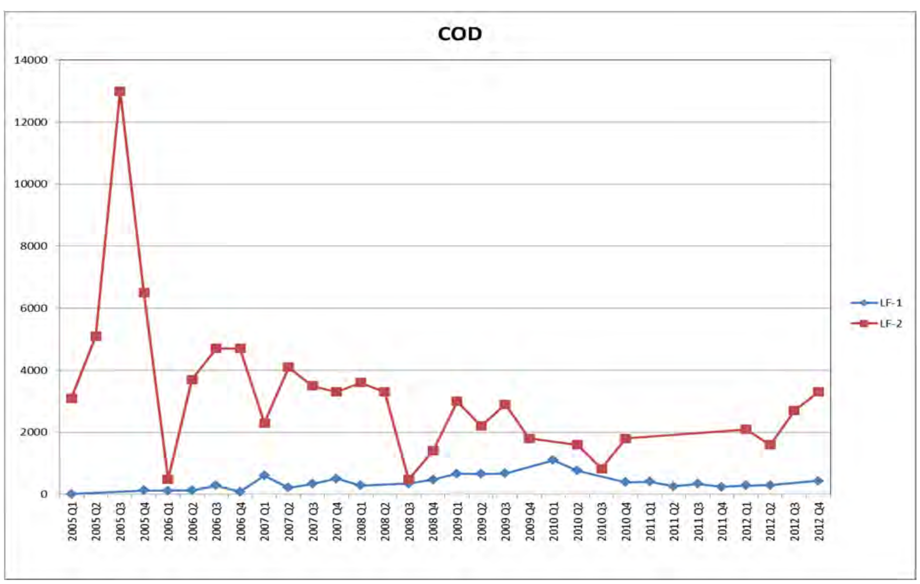

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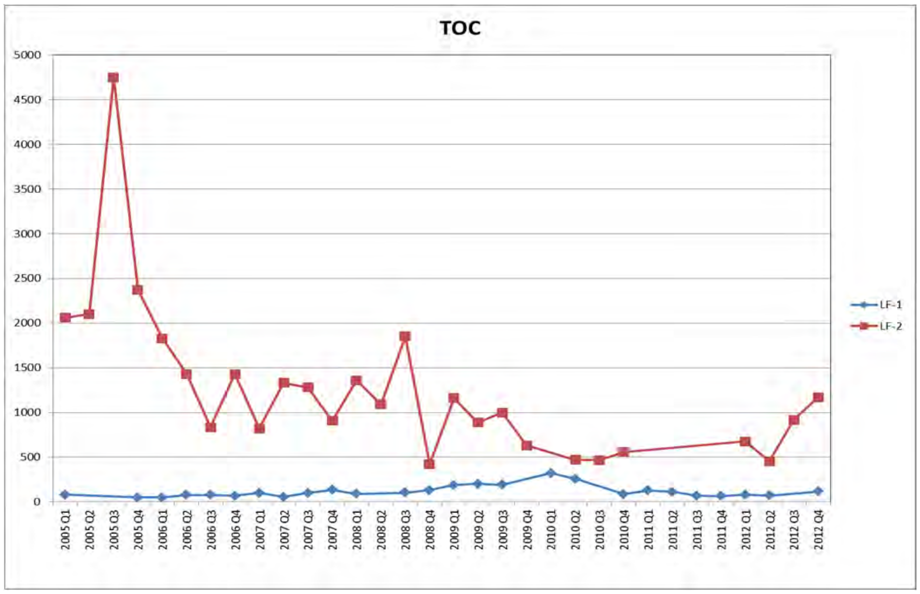

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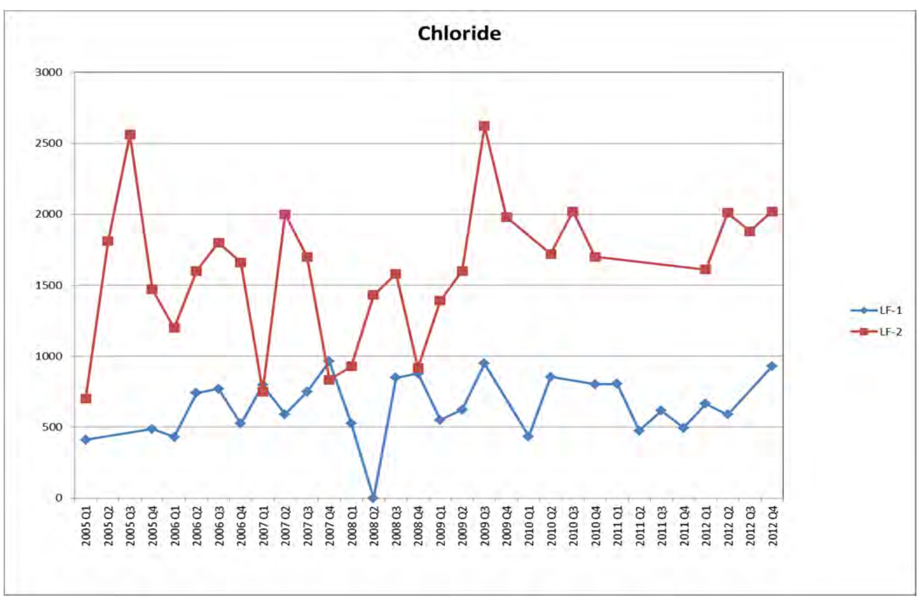

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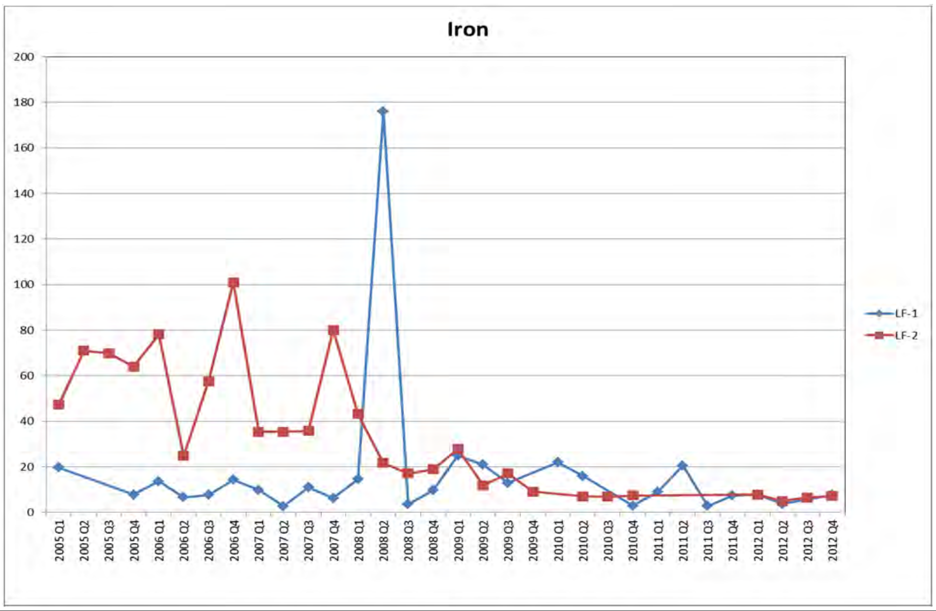

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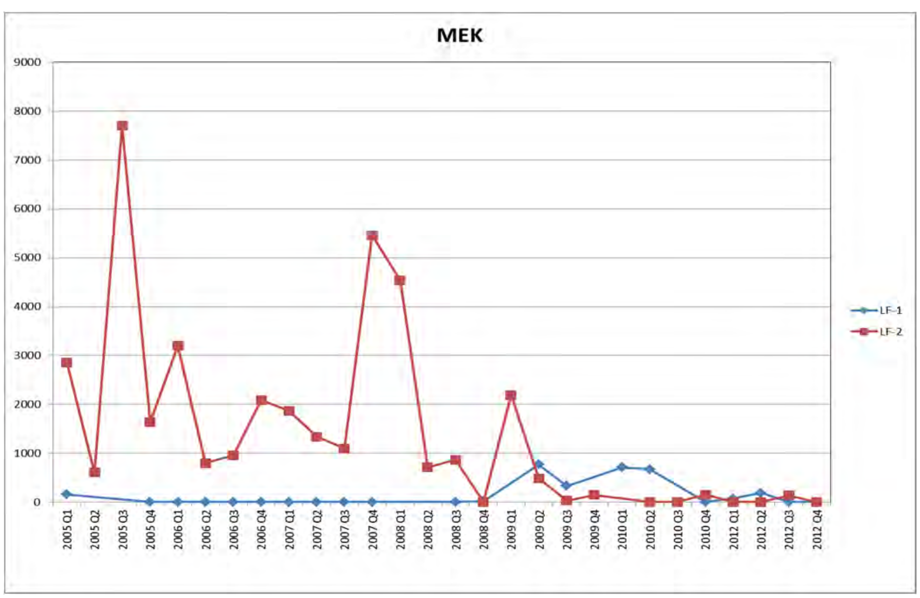

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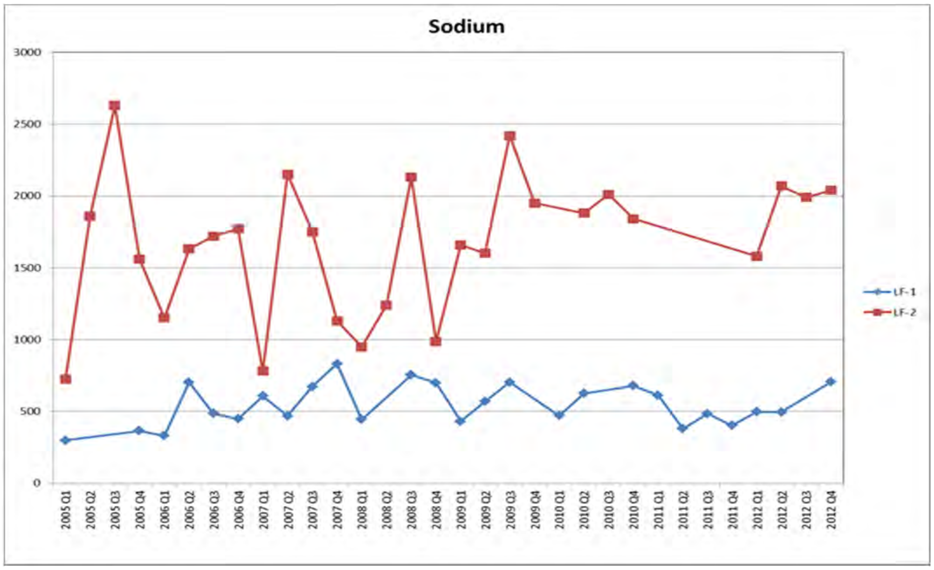

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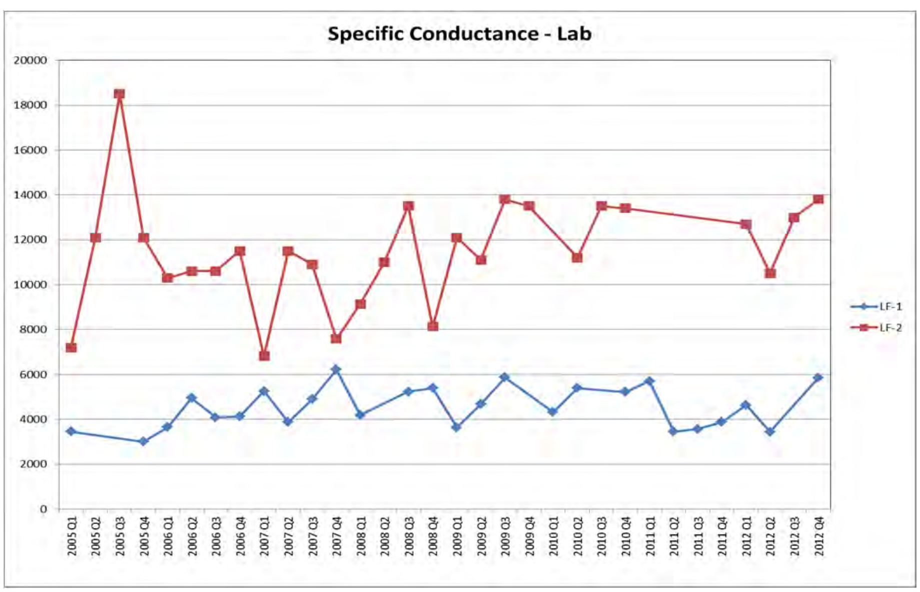

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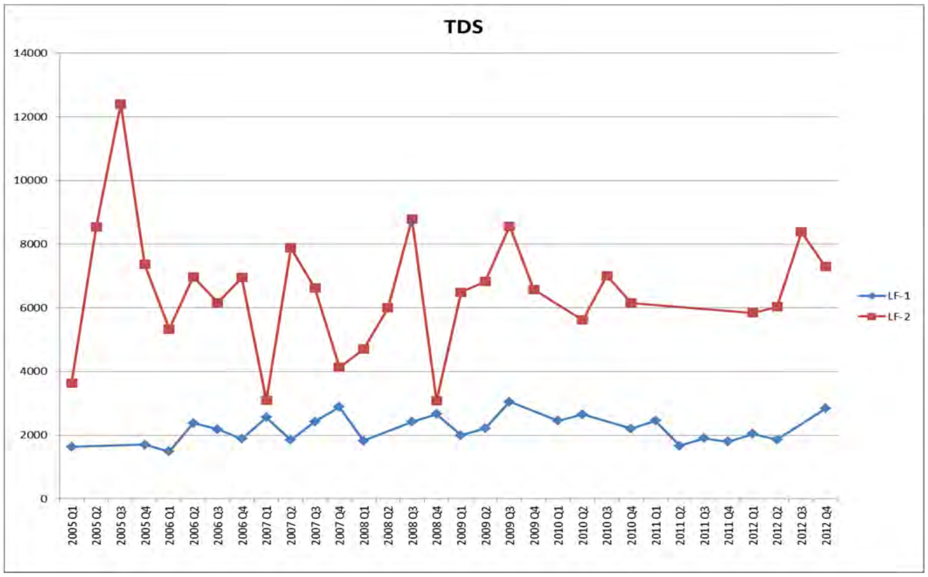


Leachate Treatment

- **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

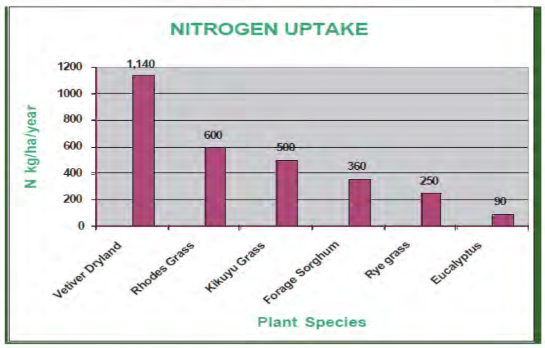
- → Constructed Wetlands
  - Peat Filters (Boron removal)
  - Aerobic / Free Water Surface (FWS) Cells
  - Vertical Flow Wetlands
  - Subsurface Flow Wetlands
- → Land Disposal
- → Anaerobic NRBR's/SRBR's or VSB's
- → Phytoremediation
- → Lagoons

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

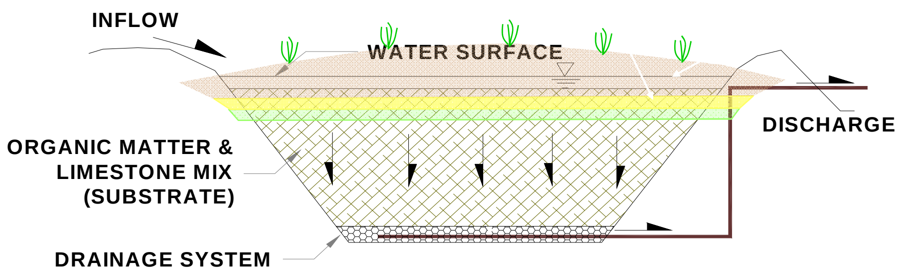
- Spray Irrigation
- Drip Irrigation – Surface/Subsurface
- Northern v Southern Plants
  - Reeds, bulrush, cattails
  - Vetiver Grass – no freeze conditions
  - BOD, Salinity, metals, VOCs



Phytoremediation

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

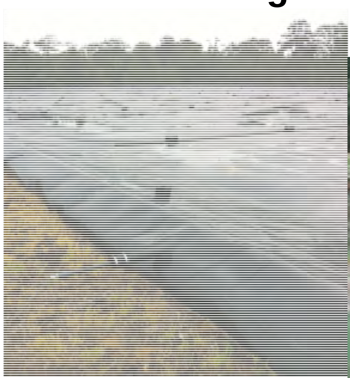
Alternative to Vegetated Submerged Beds



Covered Sulfate Reducing or De-nitrification Cell

Lagoons

- Facultative Lagoon
- Anaerobic Lagoon
- Aerated Lagoons

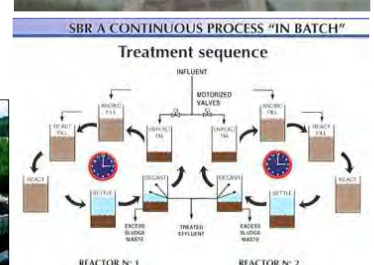


Physical Treatment Technology

- **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**



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 Bioportz™ 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 Paralle**
- **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 to1
  - 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?