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College of Engineering & Computer Science

Technical Advisory Group Meeting

"Interactive Decision Support Tool for Leachate Management"

By D.E. Meeroff and R. Teegavarapu (Florida Atlantic University)

Funded by the Bill Hinkley Center for Solid and Hazardous Waste Management (BHCSHWM)

DATE: **Friday, April 17, 2009**
TIME: **11:00 am**
WHERE: **Florida Atlantic University Boca Raton Campus**
Computer Center Building
CM Building (22), Room 130 (Studio 1)
777 Glades Road, Boca Raton, Florida 33431

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FAU
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MEETING AGENDA
Friday, April 17, 2009
11:30 AM – 12:50 PM

1. 11:45 AM: Opening address by Dr. Meeroff followed by introduction of the group members and participants

2. Introduction of Landfill Leachate Project by Dr. Meeroff
   - Objectives, overview, need for research, conventional/existing leachate management options, the future of leachate management, new web-based methodology.
   - Dr. Meeroff discussed the objectives of the project tasks including the evaluation of alternatives, evaluation of energized processes, and compilation of the best management practices guide/database.

3. Discussion of Study Methodology by Dr. Teegavarapu
   - Dr. Teegavarapu discussed development of the decision support tool, previous decision support tools developed by his research group for other applications, and the framework established for this project.

4. Discussion of Future Work by Dr. Meeroff
   - Dr. Meeroff presented information about the energized processes of photocatalytic oxidation and photochemical iron-mediated aeration.
   - Dr. Meeroff presented the project website and introduced opportunities for TAG member input for the ranking criteria, the technology matrix, the user-interface profile data collection tool, site-specific information (leachate quantities, issues, past experiences, etc.), and the web survey.
   - Dr. Meeroff discussed opportunities to partner with FAU for the upcoming pilot studies planned to test the two new treatment technologies.

5. Discussion of TAG Input Needs (Open Forum)
   - "What are you looking for from vendors?"

    - We are looking to modify reactors that are in place and allow for study…
- "What type of flow [for pilot study]?"
    - The initial thought is 100's of gallons/day…
- "What is the duration of the pilot study?"
    - We would like to do [wet vs. dry] seasons…
- "Leachate changes over time."
    - We can continually test the pilot unit…
- "What exactly is lab scale?"
    - Approximately 100-250 mL per batch…
- "How 'smart' will the system model be?"
    - It will be able to adapt to different landfills, but it will only be as good as the data that users put in…
- "UV light comes from the sun. What is different?"
    - We use the catalyst reaction; PIMA (iron) and TiO_2
- "How much energy will the UV cost?"
    - This is exactly why we need a pilot study. We are not sure how increasing the scale will affect the unit cost…
- Kennedy Space Center did something similar with Chlorine (for Haz waste)."
    - Chlorine alone (or UV alone for that matter) does not work for leachate…
- "What costs are you looking for (cost per gallon)?"
    - We are looking for utility costs, capital costs, O&M, labor costs, etc. to be broken down…
- "Will there be use for constructed wetlands?"
    - We have it listed in our database as natural attenuation…
- "Are you looking for funding or partners?"
    - At this point we have too many variables to answer. Depending on the partners, we will outline the best case relationship…
- "How is permitting used for a pilot?"

    - The FDEP will need to be involved from the beginning…
- "How long for permitting?"
    - Joe Lurix (FDEP) answered: 90 days, but may be more for pre-permitting
- "How large of a pilot are you looking for?"
    - Preferably, 1/3 full scale, but we need to work with a vendor partner for this…
- "Are you looking to work outside of Florida? How would you take this further?"
    - We would use the web decision support tool and hope that entrepreneurs and solid waste managers outside of Florida would participate in the survey. Also, the more information we have, the better the module will perform...
- "Do you just have leachate aeration?"
    - For the energized processes, we know that we need air to activate the reaction. Air alone does not get us to where we need to go for sewer discharge in all cases. For the energized processes, we can combine air stripping and aeration, or they can be two separate unit processes. We would like to know if you would like to have them separate or in one unit...
- "Tallahassee has a pre-treatment study."
    - We would like to investigate those results, can you provide a contact person?
- "Have you captured all the information from all over the country?"
    - We have an evolving study…

6. Adjourn, thank you for participating (12:48 PM)

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"Interactive Decision Support Tool for Leachate Management"

Daniel E. Meeroff, Ph.D.
Ramesh Teegavarapu, Ph.D., P.E.
Department of Civil Engineering

Agenda

1. Introductions/Opening Remarks — *Dr. Meeroff*
2. Study Methodology — *Dr. Teegavarapu*
3. Future Work/Project Website — *Dr. Meeroff*
4. Open Forum/User Input — *Everyone*

So, Why Am I Here?

- We need industry input
  - Regulators
  - Utilities
  - Operators
  - Consultants
  - Vendors
  - Other stakeholders

Need For Research

- Florida manages 35 million tons of MSW each year
- Almost 65% sanitary landfill disposal
- In 2006, Florida's Class I landfills generated over 750 gpd of leachate per acre
- Variable types/ages of leachate require different management strategies
  - "One size does NOT fit all"

Elevated TDS, BOD, NH_3, VOCs
Odor
EDCs
Color
Pathogens
Heavy metals Pb, As, Cd, Hg
pH toxicity
High COD/BOD ratio

We Can't Simply Store This Stuff

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Conventional Leachate Management

- Sewer discharge
  - Disrupts WWTPs due to high COD and ammonia toxicity if Q > 2%
- Natural attenuation
  - Deep well injection
  - Evaporation ponds
- Hauling off-site
  - >$50 per 1,000 gallons
  - Transportation risk
- On-site treatment
  - Biological treatment
  - Physical/Chemical treatment
  - Advanced oxidation
  - Energized processes
- Leachate recirculation may also be viable
  - Morris (2003) reported promising pollutant removal capacities

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Boca Raton, FL, April 17, 2009

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Future Leachate Management

- Must be sustainable
- Must be site-specific
- Must be capable of adaptation to:
  - Evolving regulations
  - Climate change
  - Population growth
- A likely approach:
  - On-site pretreatment, to reduce the toxicity of the leachate, and then discharge to sanitary sewer

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Florida Must Lead By Improving

1. Measurement and evaluation of current leachate management practices
2. Design and implementation of new or upgraded systems
3. The regulatory framework to deal with changing technologies and lessons learned
4. Access to vital information on leachate management strategies and applications

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How Do We Keep Up to Date with the Latest Innovations?

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- We need a groundbreaking new methodology
- That will allow regulators, consultants, and utilities to keep up to date with the latest practices and operational experiences regarding leachate management, available at their finger tips
- That solution is a web-based interactive decision support tool

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Objectives of the Research

Objective 1	Objective 2	Objective 3
Evaluate Alternatives	**Evaluate EPs**	**Develop Management Tool**
• Review & collect leachate quality data • Identify trends • Rank alternatives (performance, risk, environmental and economic factors)	• Technical data *(with the goal of achieving sewer discharge limits)* • PIMA • Photocatalytic oxidation • Others	• Preliminary cost analysis • Preliminary risk assessment • Web-based BMP guide • Interactive and goal-based

Year 1 → Year 2 → Current Work

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Tasks

- Compile BMP database
- Identify user profile information
- Refine and map user needs to BMP matrix
- Design decision tree
- Identify host institution needs
- Develop user interface
- Beta testing
- Publish user's manual
- Launch and monitor success

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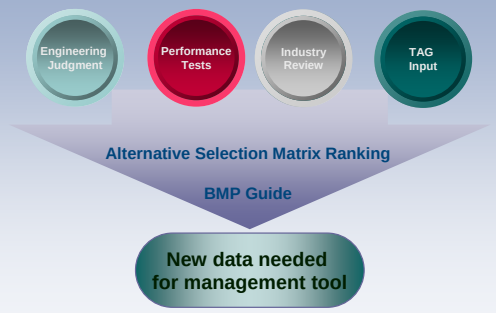

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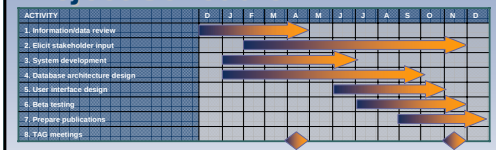
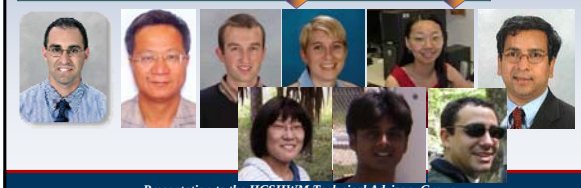
Project Schedule





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Future Work

1. Work with expanded TAG to update the BMP Guide
2. Develop management tool
   - BMP guide database
   - Decision support tree
   - User profile
   - Beta testing
   - Launch
3. Complete scoping tests for futuristic technologies
4. Update performance assessments with pilot test data

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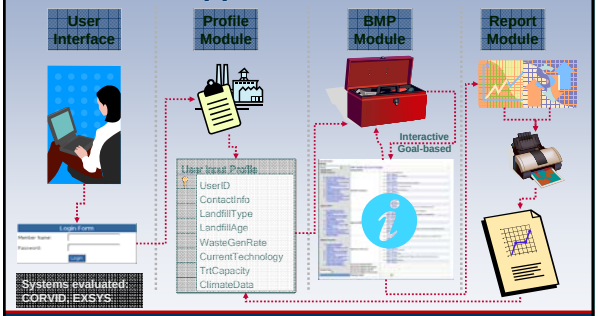
Decision Support Tool Architecture



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Decision Support Systems

- Past experience in the development and implementation of two specialized decision support systems (DSS)
- Two Decision Support Systems (Teegavarapu et al., 2005, 2006)
  - STREAMS (STReam Environment Assessment and Monitoring System)
  - MIST (Model Identification and Selection Tool)

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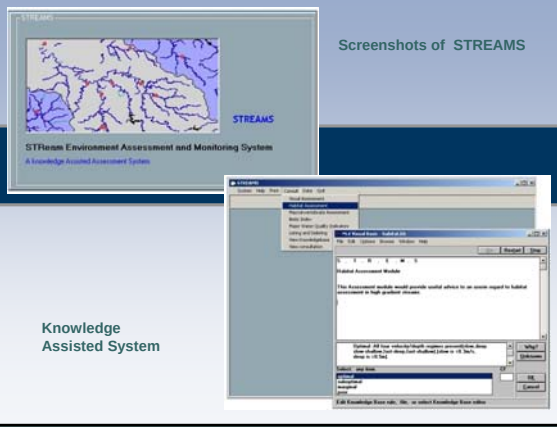
STREAMS

- STREAMS
  - Was primarily intended to provide a knowledge-based decision support system based on visual assessment protocols for stream health monitoring.
  - Several visual assessment criteria were used to assess the health of impaired streams and to make recommendations for further monitoring.

Screenshots of STREAMS



Knowledge Assisted System

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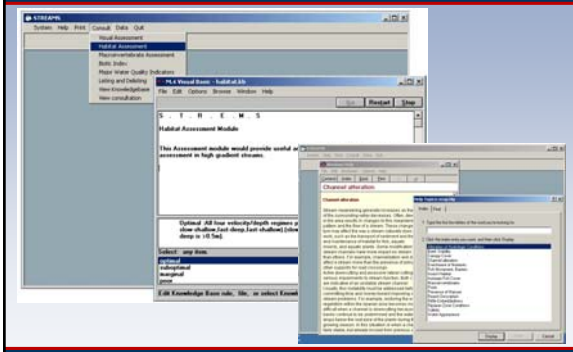

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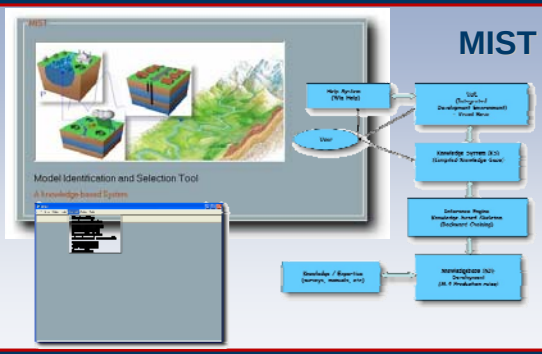
MIST



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MIST

- MIST is a knowledge-based assessment system for selection of water quality modeling environments and models. The system developed is modular in nature thus allowing the user to have control over the nature and level of consultation that is required At a later stage, the integrated development environment (IDE) can also be used to link the models and also provide help to the user in selecting the appropriate parameters for the model.

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DSS Development & Interaction

- The tool will be will be a standalone system initially and then ported to web based portal.
- User profile needs to be developed before the consultation.
  - The user will be prompted to answer detailed questions about critical characteristics needed to assess alternatives.
- Questions will be related to: climate conditions, generation rates, waste characteristics, customer characteristics, age of facilities, size, type of landfill, regulatory requirements, costs of operation, and current disposal practices.
- It will also ask for subjective inputs such as desired range of costs and technologies to exclude, for instance.

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DSS Development …

- During this consultation phase, the tool elicits the user's objectives, resources, preferences, constraints, etc. that must be factored into the selection of the appropriate strategies for a particular application.
- As a knowledge-based system, the tool balances the multiple criteria that need to be weighted and prioritized to choose the best strategies from the BMP guide.
- The user profile will interface with the BMP database and match the best fit technologies to generate a recommended set of alternatives.
- Once the appropriate technology has been selected by the user and implemented, its performance must be tracked against the initial goals set by the user profile.

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DSS Interaction…

- The user will continue to update the profile with specific measures to provide the feedback necessary to keep the BMP database and ranking system current, thus closing the loop.
- Performance measures can then be assessed against other participating utilities, which will allow the database to be continually refined and adjusted to be as realistic and as useful as possible.

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Decision Trees

On Site Management Options	COD	BOD	Ammonia	Inorganics	Food Prod Size	Odor Control	TDS	TSS	Pre-Treatment	Conductivity	VOC	Disinfectant Action	Improves Biodegradability	Metals	Post Treatment	Increase DO Level	
Municipal Sewer Discharge without Pre-Treatment	0	0	0	0	NA	0	NA		0	0	0	0	0	0	0	0	No = 0
Leachate Recirculation Bioreactor	1	1	1	1	Small	NA	NA		0	0	0	0	0	0	0	0	Yes = 1
Evaporation	1	0	0	1	Large	NA	NA		0	0	0	0	0	0	0	0	
Heating Off Gas	0	0	0	0	0	0	NA		0	0	0	0	0	0	0	0	
Deep Well Injection (Natural Attenuation)	0	0	0	0	0	0	NA		0	0	0	0	0	0	0	0	
On Site Treatment Options																	
Photocatalytic Oxidation (UV)	1	1	1	0	Small	0	0	0	0	0	0	1	1	0	0	0	
Membrane Filtration	1	1	0	0	Large	0	0	1	1	0	0	1	0	0	1	0	
Iron Mediated Aeration (Mediated Aeration (UV))	1	1	0	0	Small	0	0	0	1	0	0	1	1	0	0	0	
Hydrogen Peroxide (AOP)	1	0	0	1	Medium	0	0	0	1	0	0	1	0	0	0	0	
Ion Exchange	0	0	1	1	Small	0	1		1	1	0	0	0	0	0	0	
Coagulation	1	0	0	1	Large	0	NA	1	1	NA	0	1	0	0	0	0	
Flocculation	1	0	0	1	Large	0	NA	1	1	NA	0	1	0	0	0	0	
Precipitation	1	0	0	1	Large	0	NA	1	1	NA	0	1	0	0	0	0	
Sedimentation	1	0	0	1	Large	0	NA	1	1	NA	0	1	0	0	0	0	
UV and Ozone (AOP)	1	1	0	0	Small	0	0	0	1	0	0	1	1	0	1	1	
UV and Hydrogen Peroxide (UV)	1	1	0	0	Small	0	0	0	1	0	0	1	1	0	0	0	
Carbon Adsorption	1	1	1	1	small	0	0		1	0	0	0	0	0	0	0	
UV, Ozone, and Hydrogen Peroxide (UV)	1	1	0	0	Small	0	0	0	1	0	0	1	1	0	1	1	
UV and Ozone (UV)	1	1	0	0	Small	0	0	0	1	0	0	1	1	0	1	1	
Ozone (AOP)	1	1	0	0	Small	0	0	0	1	0	0	1	1	0	1	1	
Aerobic and Anaerobic Biological Process	0	1	0	0	Large	0	1		0	0	1	0	0	0	0	0	
Air Stripping	0	0	1	0	Small	0	0		1	0	1	0	0	0	0	0	
Ozone and Hydrogen Peroxide (AOP)	1	1	0	0	Small	0	0	0	1	0	0	1	1	0	1	1	
Iron Mediated Aeration (AOP)	1	0	1	1	Small	0	0	0	0	0	0	1	1	1	1	0	
UV (UV)	1	1	0	0	Small	0	0	0	1	0	0	1	1	0	1	0	

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http://labees.civil.fau.edu

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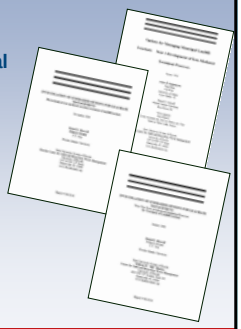
Previous Work

- "Options for Managing Municipal Landfill Leachate"
  - Englehardt and Meeroff (2005)
- "Investigation of Energized Options for Leachate Management Year One"
  - Meeroff and Tsai (2006)
- "Investigation of Energized Options for Leachate Management Year Two"
  - Meeroff and Tsai (2008)



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Ranking Criteria

Efficiency of Treatment (5)	Pollutant removal performance for the major contaminants of interest in leachate
Other Issues (4)	Includes environmental impacts, odors, dependency on climate conditions, etc.
Preliminary Costs (3)	Preliminary capital and O&M costs for the proposed treatment process
Residuals (2)	Adverse by-products generated during treatment or as a consequence of treatment
Footprint (1)	Physical size requirements of the proposed treatment process

Maximum score = 75 (incl. costs) or 60 (without costs)

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Results from Alternative Analysis

Technology	Efficiency (5)	Residuals (2)	Footprint (1)	Other (4)	Costs (3)	Total Weighted Score (out of 60)
Municipal Sewer Discharge	2	4	5	4	?	39
Leachate Recirculation Bioreactor	4	2	3	3	?	39
Evaporation	2	2	1	3	?	27
Hauling Off-Site	0	5	5	0	?	15
Deep Well Injection	0	5	3	0	?	13

- Evaluated 23 Engineering Alternatives
  - Efficiency, economics, risk, footprint, and residuals disposal
- Energized processes scored high
  - Ex. Advanced oxidation, PIMA, Photocatalytic oxidation, etc.

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Technology	Efficiency (5)	Residuals (2)	Footprint (1)	Other (4)	Total Weighted Score (out of 60)
Photocatalytic Oxidation	4	4	3	4	47
Membrane Filtration	5	1	3	2	38
Iron-Mediated Aeration	4	1	3	3	37
Photochemical Iron Mediated Aeration	4	1	2	3	36 (29 with actual leachate)
Hydrogen Peroxide	3	3	2	3	35
Ion Exchange	3	2	3	3	34
Physical/Chemical Processes	3	2	2	3	33
Fenton Process	3	1	2	3	31
UV and Hydrogen Peroxide	3	3	2	2	31
Photo-Fenton Processes	3	1	2	3	31
Carbon Adsorption	3	2	3	2	30
Ultraviolet Processes	2	4	3	2	29
UV and Ozone and Hydrogen Peroxide	3	3	3	2	29
Air Stripping	1	3	3	2	22

Preliminary Rankings

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Summary of Alternative Analysis Comparison Results

Technology	Efficiency Score	Efficiency Weighted Score	Preliminary Costs Score	Preliminary Costs Weighted Score	Residuals Score	Residuals Weighted Score	Footprint Score	Footprint Weighted Score	Other Score	Other Weighted Score	Total Score	Total Weighted Score
On-Site Management Options:												
Municipal Sewer Discharge without Pre-Treatment	2	12			4	8	5	5	4	16	15	39
Leachate Recirculation Bioreactor	4	24			2	4	3	3	3	12	12	39
Evaporation	2	12			2	4	1	1	3	12	8	27
Hauling Off-Site	0	0			5	10	5	5	0	0	10	15
Deep Well Injection (Natural Attenuation)	0	0			5	10	3	3	0	0	8	13
On-Site Treatment Options:												
Photocatalytic Oxidation	4	24			4	8	3	3	4	16	15	47
Membrane Filtration	5	30			1	2	3	3	2	8	11	38
Iron-Mediated Aeration	4	24			1	2	3	3	3	12	11	37
Photochemical Iron Mediated Aeration	4	24			1	2	2	2	3	12	10	36
Hydrogen Peroxide	3	18			3	6	2	2	3	12	11	38
Ion Exchange	3	18			2	4	3	3	3	12	11	37
Physical/Chemical Processes (Coagulation, Flocculation, Precipitation, Sedimentation)												
Fenton Process	3	18			1	2	2	2	3	12	10	34
UV and Hydrogen Peroxide	3	18			3	6	2	2	2	8	10	34
Photo-Fenton Processes	3	18			1	2	2	2	3	12	10	34
Carbon Adsorption	3	18			2	4	3	3	2	8	10	33
Ultraviolet Processes	2	12			4	8	3	3	2	8	11	31
UV and Ozone and Hydrogen Peroxide	3	18			3	6	3	3	2	8	11	35
UV and Ozone	2	12			2	4	3	3	2	8	9	27
Ozone	2	12			2	4	3	3	2	8	9	27
Aerobic and Anaerobic Biological Processes	2	12			2	4	3	3	2	8	9	27
Ozone and Hydrogen Peroxide	2	12			2	4	3	3	2	8	9	27
Air Stripping	1	6			3	6	3	3	2	8	9	23

Weighting Scale	Ranking Scale	Weighting Scale
Efficiency	None	Air Stripping
Residuals	Minimal	
Footprint	Moderate	
Other	Significant	
Costs	Not	

Costs: Costs are not included in the analysis at this time.
Other: Other includes environmental impacts, odor generation, dependency on climate conditions, etc.

Latest Version of the Rankings

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TAG Opportunity #1

TAG Input Opportunity #1

- Refine the BMP guide
- Step 1. Take a look at the alternative selection matrix, the selection criteria, the weighting scale, and the technologies evaluated
- Step 2. Provide the research team with comments to refine the values and provide data to support your reasoning

http://labees.civil.fau.edu/LeachateMatrix.pdf

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User Profile Data Collection

- We selected 52 landfill sites from all districts in Florida to provide data for mapping to the BMP guide
- 26 categories of user provided information
  - Ex. Class, Size, Age, Costs, Disposal, etc.
- We have an online survey
  - http://labees.civil.fau.edu/DST-tool.pdf

- We have some incomplete responses so far

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User Provided Information

- Current database is incomplete

Region	County	Facility ID#	Facility Name	Class Website	Facility	Disposal	Inclusion of Service Area?	Landfill Capacity Remaining (tons)	Estimated Landfill Life in Years
SWD	BAY	0300004	STERLINGROOF	100.00000000					
SD	BREVARD	0305.026	SOUTHWEST	100.00000000					
SED	BROWARD	0305.005	CENTRAL SANITARY LANDFILL & RECYCLING	831.00000000		Hollywood WWTP			
SED	BROWARD	0305.1024	WOOD RIDGE CNTL REMEDIAL CONTAINMENT LF (RIC)	831.00000000		Hollywood WWTP			
SED	BROWARD	0305.1007	WOOD RIDGE CO. SOUTH RESOURCE RECOVERY	831.00000000		Hollywood WWTP		199.5	
SD	CHARLOTTE	0307.1714	CHARLOTTE COUNTY REGIONAL LANDFILL	100.00000000				150	
NED	CITRUS	0309.5811	TRIPLE CENTRAL	100.00000000					50
SD	COLLIER	0307.0604	NAPLES SLF CELL #8	100.00000000					
SD	COLLIER	0307.0114	IMMOKALEE LF (17 - RECEIVER)	100.00000000				0.5	
NWD	COLUMBIA	0323.1.001	MOFIELD SW FACILITY	300.00000000					
NWD	DESOTO	0315.0512	DESOTO SW LF	100.00000000					
NWD	GADSDEN	0315.0624	TRAIL RIDGE LANDFILL	200.00000000					
NWD	ESCAMBIA	0300.1.001	PERDIDO LANDFILL	730.00000000				50	
SD	GLADES	0307.0608	GLADES CO. SAN. LANDFILL	200.00000000					
NWD	HARDEE	0315.0612	HARDEE COUNTY	100.00000000					
SD	HENDRY	0307.0711	HENDRY COUNTY LANDFILL	200.00000000					
SD	HENDRY	0307.0703	SW HENDRY CO REGIONAL SW DISP	200.00000000					
NWD	HERNANDO	0309.0721	HERNANDO COUNTY	100.00000000				50	
SD	HIGHLANDS	0307.0803	HIGHLANDS COUNTY	100.00000000					
NWD	HILLSBOROUGH	0320.1.001	SOUTHEAST COUNTY	100.00000000					

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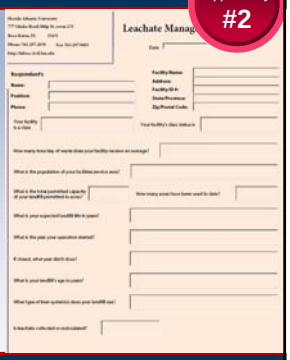
TAG Opportunity #2

Online Survey

- TAG Input Opportunity #2
- We need your input
- Please take a moment today to fill out as much as you can

http://labees.civil.fau.edu/DST-tool.pdf



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Futuristic Leachate Technologies

- We need to know about your experiences with innovative treatment processes
- We need to continue to develop futuristic technologies
  - PIMA
  - Photocatalytic oxidation
  - Others
- These processes are capable of:
  - Conversion of refractory COD into more biodegradable BOD
  - Removal of heavy metals (Pb, As, Cd, Hg) through co-precipitation, adsorption, and redox
  - Conversion of ammonia to nitrate through aeration, and stripping of $NH_3(g)$
  - Destruction of recalcitrant organics and stripping of VOCs
  - Disinfection
  - Color/odor treatment

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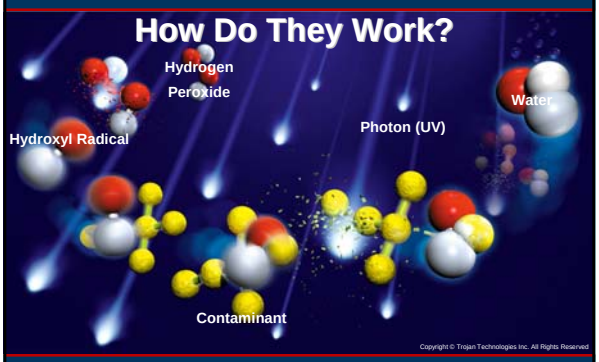

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TAG Opportunity #3

Future Studies

- *"Energized options for onsite leachate management"*
- We are looking to pilot test futuristic advanced oxidation technologies developed in Year 1 and Year 2

- We need a partner landfill site for pilot testing
- We need a partner vendor for a pilot platform to mount the technology

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Presentation to the HCSHWM Technical Advisory Group
Boca Raton, FL, April 17, 2009

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Agenda

1. Introductions/Opening Remarks — *Dr. Meeroff*
2. Study Methodology — *Dr. Teegavarapu*
3. Future Work/Project Website — *Dr. Meeroff*
4. Open Forum/User Input — *Everyone*

Presentation to the HCSHWM Technical Advisory Group
Boca Raton, FL, April 17, 2009

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TAG Opportunity #4

Presentation to the HCSHWM Technical Advisory Group
Boca Raton, FL, April 17, 2009

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Presentation to the HCSHWM Technical Advisory Group
Boca Raton, FL, April 17, 2009

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Acknowledgments

Presentation to the HCSHWM Technical Advisory Group
Boca Raton, FL, April 17, 2009

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