Characterization of Florida Landfills with Elevated Temperatures

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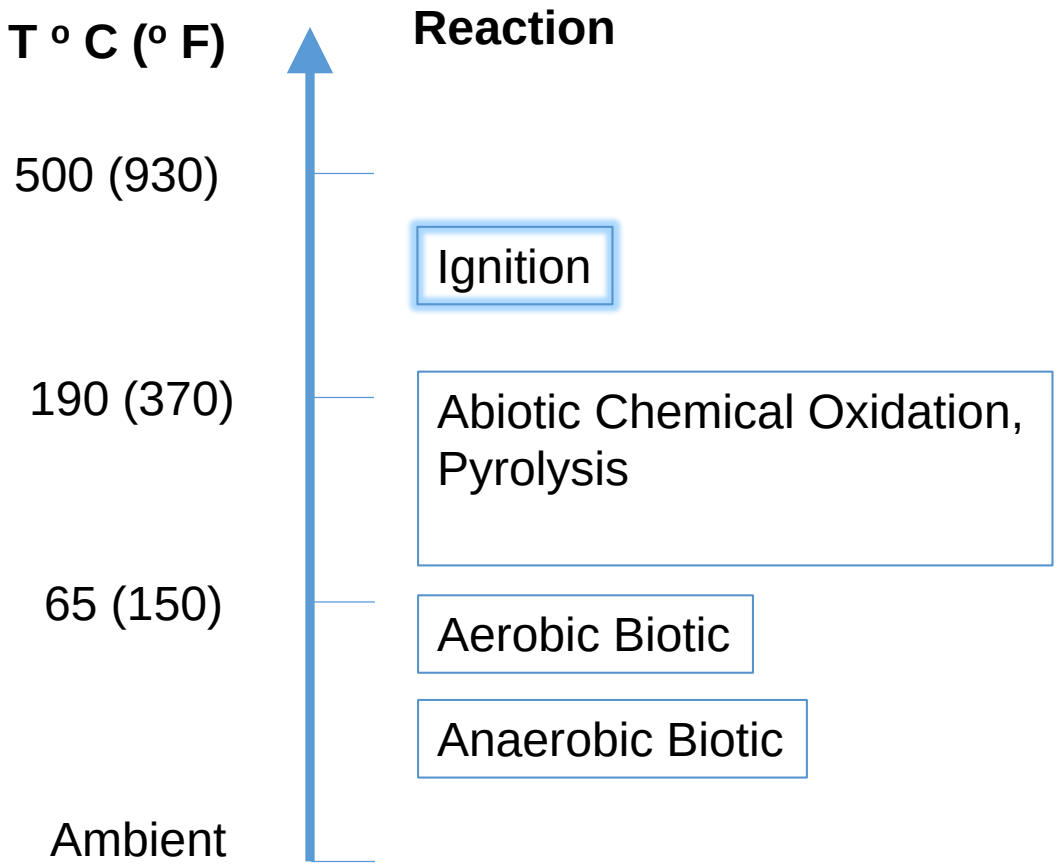
Presentation Overview

- Project Rationale
- Research Goal and Objectives
- Benefit to End Users
- Methodology and Timeline
- Results to Date
- Q & A

Project Rationale and Background

- Following completion of a case-study for an elevated temperature landfill (ETLF) in Florida, it was evident that elevated temperatures are occurring in Florida landfills.
- Between 2004-2010, there were approximately 840 landfill fires in the country (400 at landfills utilizing gas collection).
- Full characterization of ETLF landfills is necessary to determine the impact that certain landfill characteristics have on landfill temperature.

Temperature Ranges



Conditions for Elevated Temperatures

- Requisite conditions for elevated temperatures include the availability of the following:
  - Fuel (waste)
  - Moisture
  - Energy Input

- Energy inputs can be provided by:
  - Aerobic Decomposition
  - Anaerobic Decomposition
  - Aluminum and Iron Deposition
  - Other Metal Deposition

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Conditions for Elevated Temperatures

- Aluminum Deposition
  - Aluminum is deposited in elemental form from MSW and special waste (Hao et al., 2017).
  - Also found in incinerated MSW, industrial waste, and aluminum production facilities (Calder and Stark, 2010)
- Ash disposed in landfills may contain insoluble substances such as: silicon, metal oxides, aluminum, iron, and calcium (Sun et al., 2016).
  - MSW bottom ash was found to be 30-48% silicon oxide and 15-23% calcium oxide (Rendek et al, 2007).
- Hydrolysis reactions with the metal oxides can generate significant energy by producing CO_2 and H_2 gases (Calder and Stark, 2010).
- If certain reduced metals (aluminum, zinc, iron, nickel, etc.) are exposed to acids present in landfill leachate or pooling water, an exothermic reaction can occur in which the metal forms a metallic salt by stripping the hydrogen from the acid (EPA, 2014). Results in significant heat production

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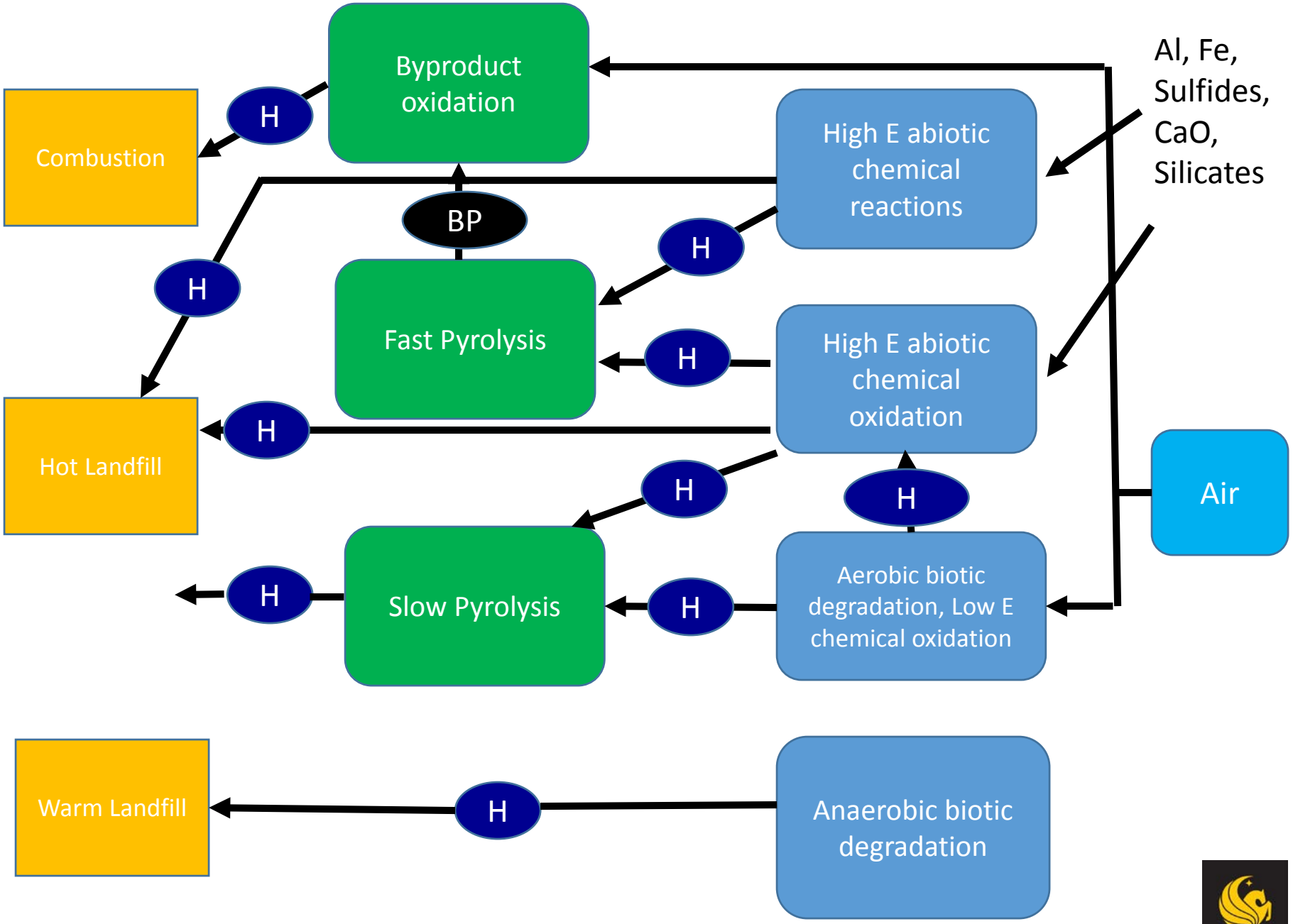

Byproduct oxidation
Combustion
H
High E abiotic chemical reactions
Al, Fe, Sulfides, CaO, Silicates
BP
H
H
Fast Pyrolysis
H
High E abiotic chemical oxidation
Hot Landfill
H
H
H
Air
Slow Pyrolysis
H
H
Aerobic biotic degradation, Low E chemical oxidation
Warm Landfill
H
Anaerobic biotic degradation

Research Goals

- To develop a more complete understanding of the reactions and conditions leading to elevated temperatures in Florida landfills through data analysis and landfill characterization.
- Focus of this research is on subsurface reactions that are more difficult to characterize, understand, or mitigate than site, surface, or near surface fires.

Picture of Mumbai Deonar Landfill fire captured by sensors on the Terra, Aqua, and Suomi NPP satellites

Benefit to End Users

- The solid waste landfill industry in Florida will be able to detect the onset of elevated temperatures in landfills.
- Better estimation of the effectiveness of interventions and the time required to reach normal temperatures.
- Protection of the health of landfill operators, first responders, and landfill neighbors as well as preservation of large landfill infrastructure investments.
- Best practice manual for preventing, detecting, and control of elevated temperature

Year 2 Objectives

1) Expanding analysis of historical leachate and gas data
2) Utilization of the EREF Elevated Temperature Model to create two case study models of Florida landfills
3) Determination of appropriate design and operating parameters to safely manage ash and waste

Methodology - Task 1: Expanded Landfill Analysis

- Historical leachate quality, wellhead gas data, waste disposed, and landfill geometry was examined for 20 landfill cells throughout Florida in Year 1.
- Data for additional landfills will be obtained directly from FDEP or through individual landfill databases.
- Analyzing the historical data will allow us to observe changes in characteristics over time and correlate the findings with operational events (type of waste accepted, installation of gas wells, etc.).

Methodology - Task 2: EREF Elevated Temperature Modeling

- The model is used to understand the impact that certain parameters (moisture content, waste composition, landfill geometry, etc.) have on chemical reactions and heat transfer within landfills.
- Two case study models of Florida landfills will be developed to understand the impact that these characteristics may have on heat generation in Florida landfills.
- The following heat sources will be tested: aerobic and anaerobic biological reactions, anaerobic metal corrosion, acid-base reactions, and ash hydration and carbonation.

Methodology - Task 3: Defining Operating Parameters for the EREF Elevated Temperature Model

- The EREF Elevated Temperature model will be used to determine appropriate design and operating parameters required to safely manage ash and unburned waste.
- Impact of certain variables (gas flow rate, moisture content, ratio of methane/carbon dioxide, etc.) on internal temperatures will be studied.
- Ash and unburned waste reactions will be modeled in landfills to determine if they produce elevated temperatures in the modeled landfills.

Project Timeline

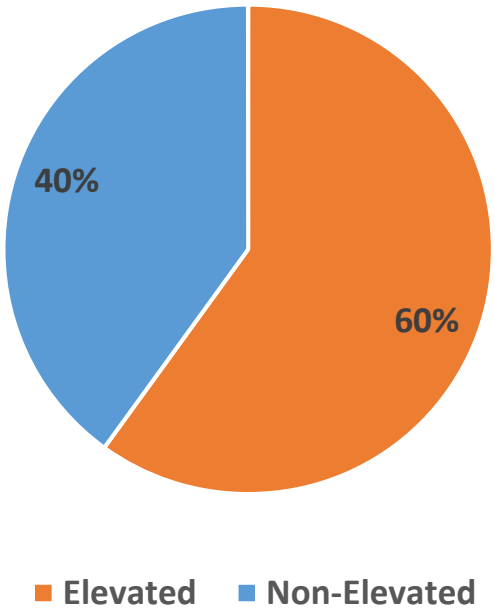
Tasks	Month					
	1-2	3-4	5-6	7-8	9-10	11-12
Task 1. Expanded Landfill Analysis						
Task 2. EREF Elevated Temperature Modeling						
Task 3. Defining Operating Parameters for the EREF Elevated Temperature Model						
Annual and Quarterly Reports						
TAG Meetings						

Results to Date

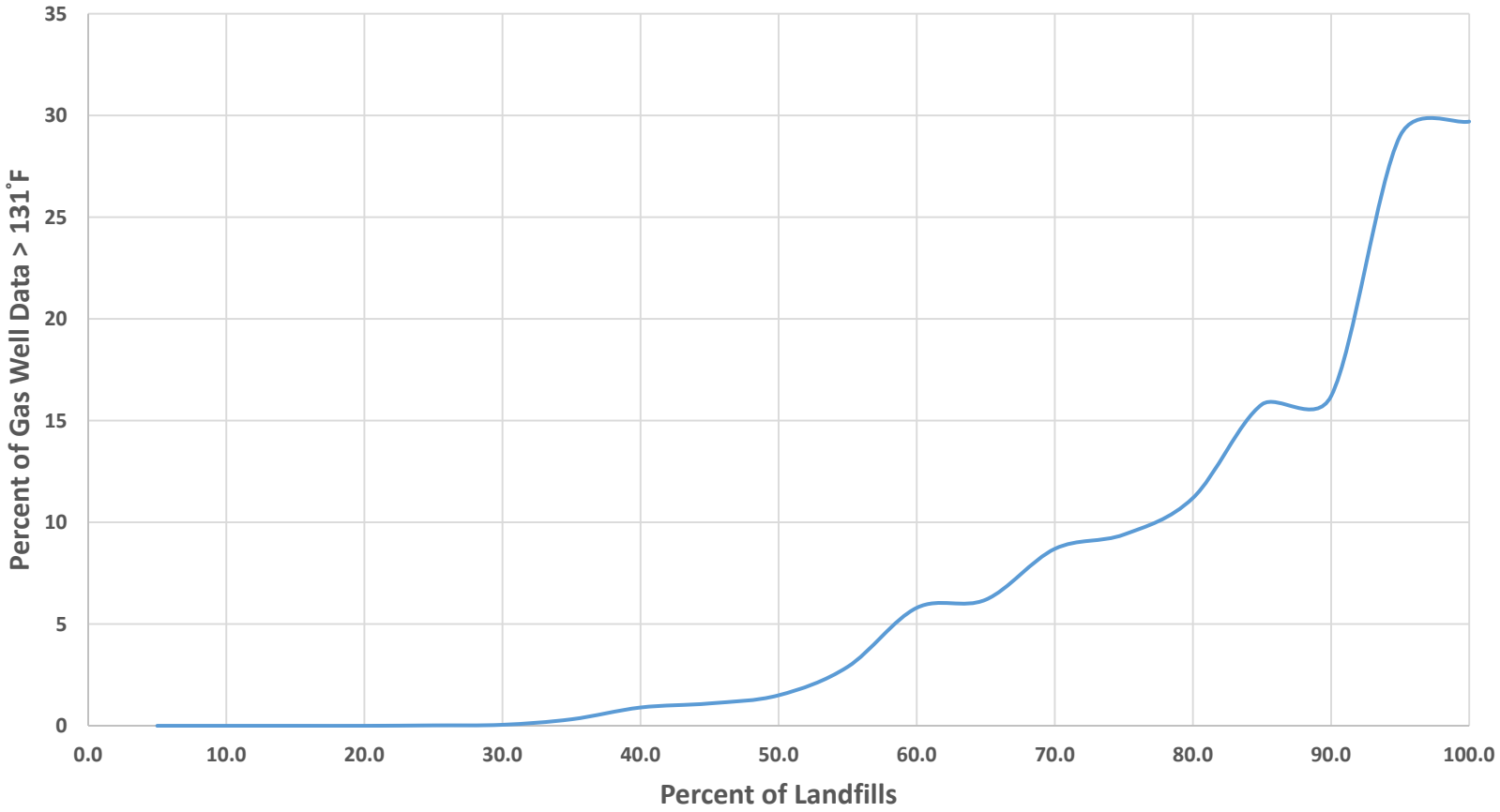
Task 1. Historical Gas Temperature Data Analysis

- Of the 20 landfill cells, 60% had elevated temperatures.

Landfill Letter	No. of Data Points	Mean Temperature of Gas Wells	% of data points > 131 oF
A	2435	84.1	0
B	16708	99.2	9.4
C	927	92.2	0.32
D	2823	102.3	0
E	6102	88.3	0.02
F	5817	107.8	16.2
G	11553	118.9	29.7
H	3948	89.7	0.05
I	5129	98.3	6.2
J	22778	89.9	2.9
J	23822	97.8	0.9
K	3412	94.2	5.8
L	4952	92	1.5
M	4284	113.3	15.8
N	9413	114.3	29.0
O	629	114.5	8.7
P	170	91.6	0
Q	3727	92.1	0
R	22911	98.8	11.2
S	2538	98.1	1.1

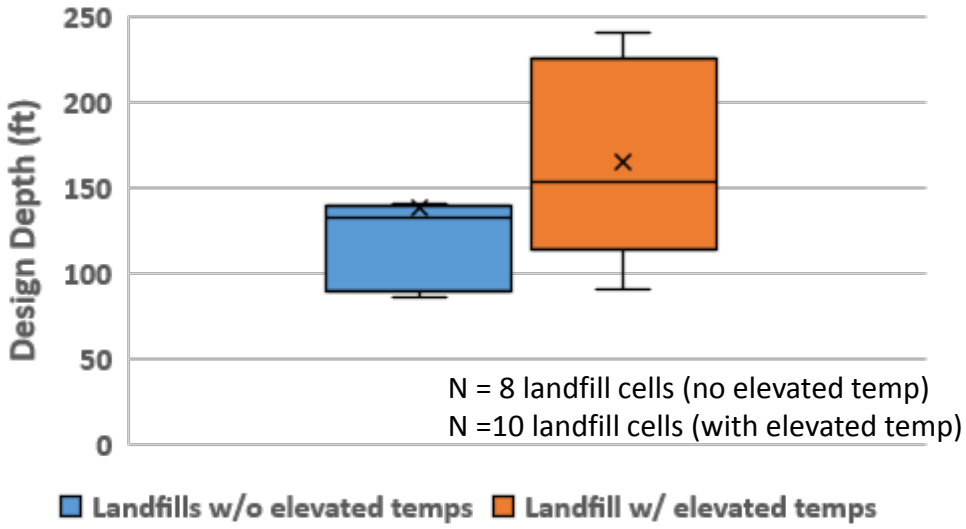


Task 1. Historical Gas Temperature Data Analysis

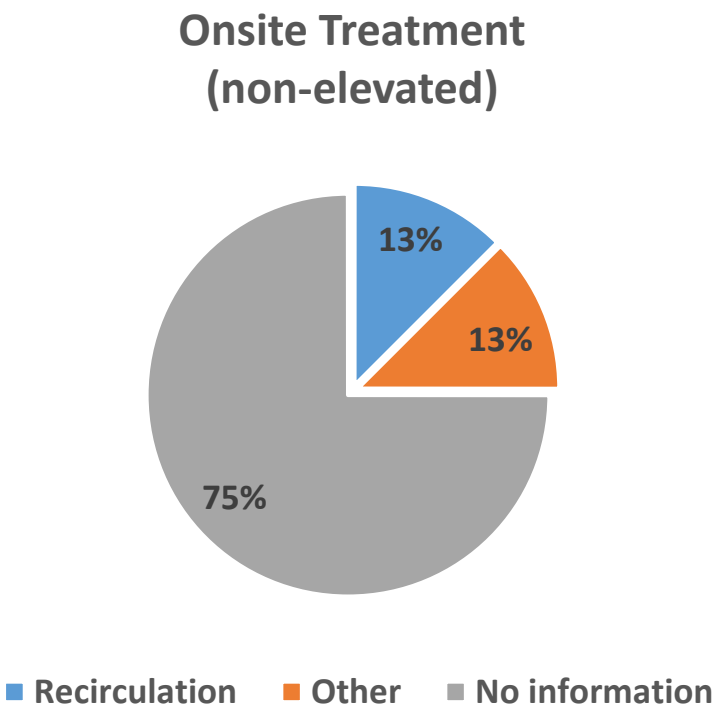


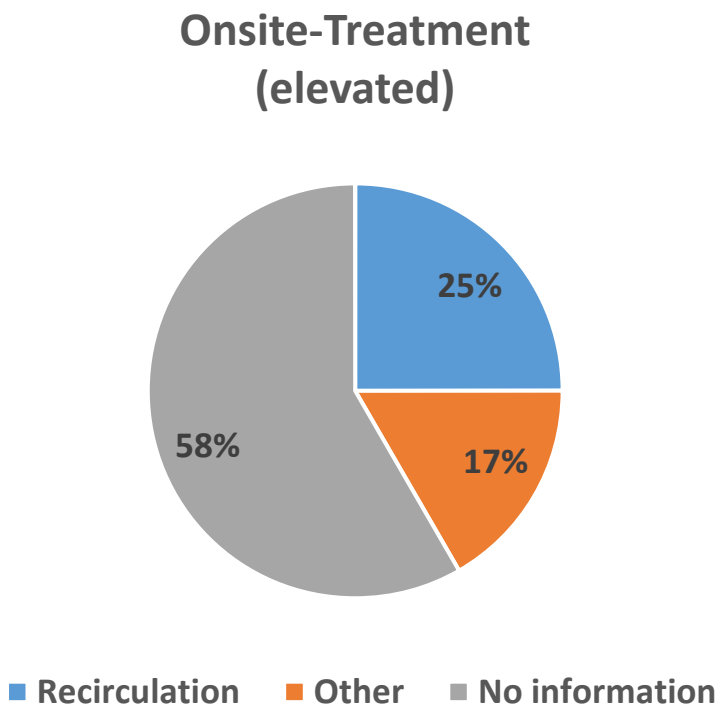
Task 2. Characterization of Florida Landfills – Landfill Geometry

Landfill Type	Average Site Area (acres)	Average Current Landfilled Area	Average Design Landfill Depth (feet)	Average Current Landfill Depth (feet)	Average Well Depth (feet)
Non-elevated	228	88	137	123	73
Elevated	501	149	165	134	91

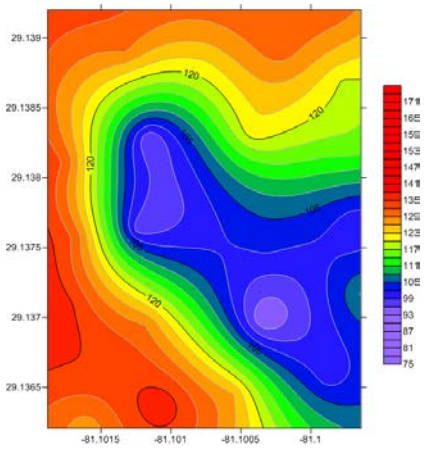


Task 2. Characterization of Florida Landfills with Elevated Temperatures - Leachate Treatment

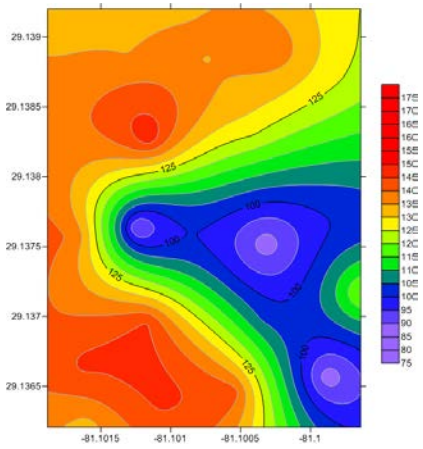




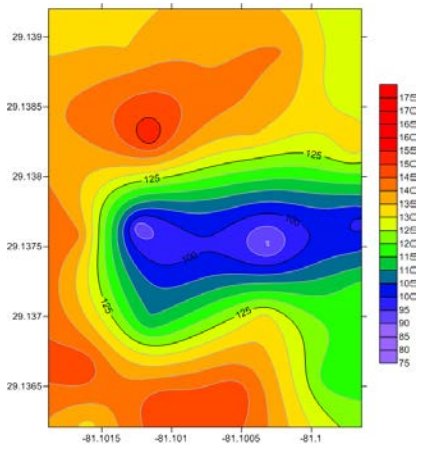
Task 2. Characterization of Florida Landfills - Temperature contour map (annual average)



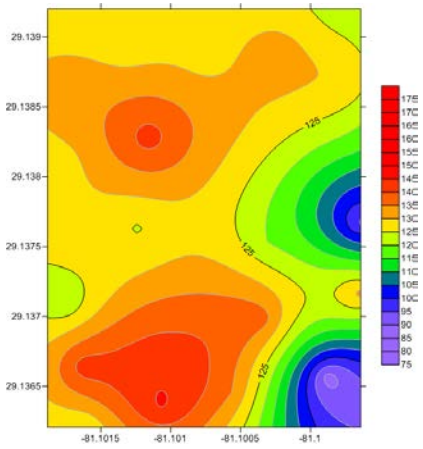
2007



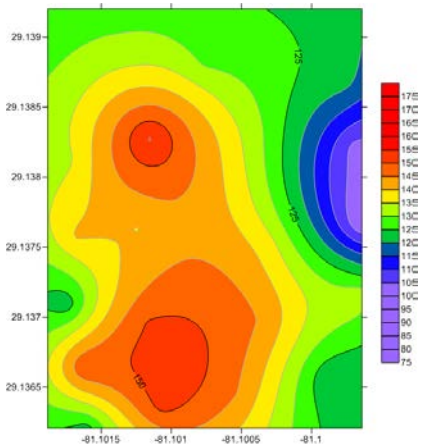
2008



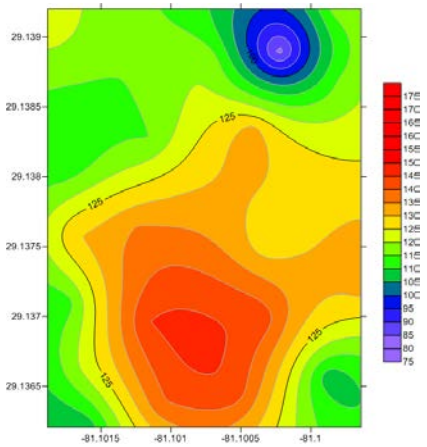
2009



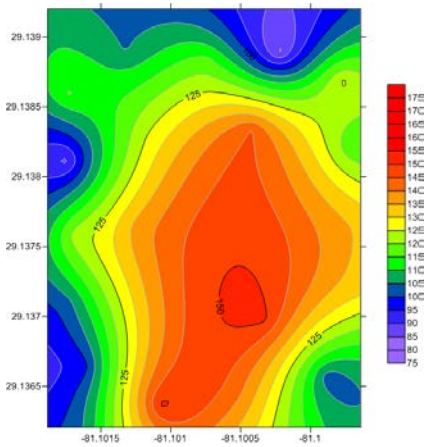
2010



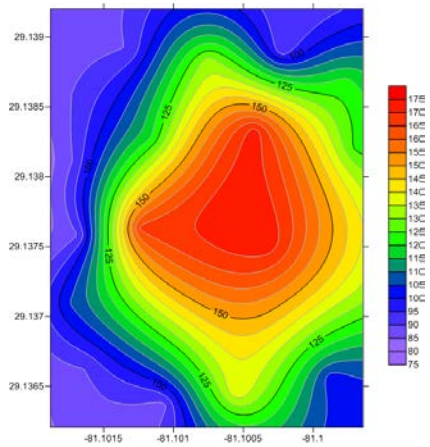
2011



2012



2013



2016

Task 2. Characterization Of Florida Landfills With Elevated Temperatures

Landfill Letter	No. of Data Points	Mean Temperature of Gas Wells	% of data points > 131 oF	Ash Accepted
A	2435	84.1	0	No
B	16708	99.2	9.4	No
C	927	92.2	0.32	No
D	2823	102.3	0	Yes
E	6102	88.3	0.02	No
F	5817	107.8	16.2	Yes
G	11553	118.9	29.7	Yes
H	3948	89.7	0.05	No
I	5129	98.3	6.2	Yes
J	22778	89.9	2.9	No
J	23822	97.8	0.9	No
K	3412	94.2	5.8	No
L	4952	92	1.5	Yes
M	4284	113.3	15.8	No
N	9413	114.3	29.0	Yes
O	629	114.5	8.7	N/A
P	170	91.6	0	No
Q	3727	92.1	0	No
R	22911	98.8	11.2	Yes
S	2538	98.1	1.1	No

- Data from 20 landfill cells analyzed; 12 (60%) landfills had elevated temperatures.
- Hydrolysis reactions with the metal oxides can generate significant energy by producing CO_2 and H_2 gases

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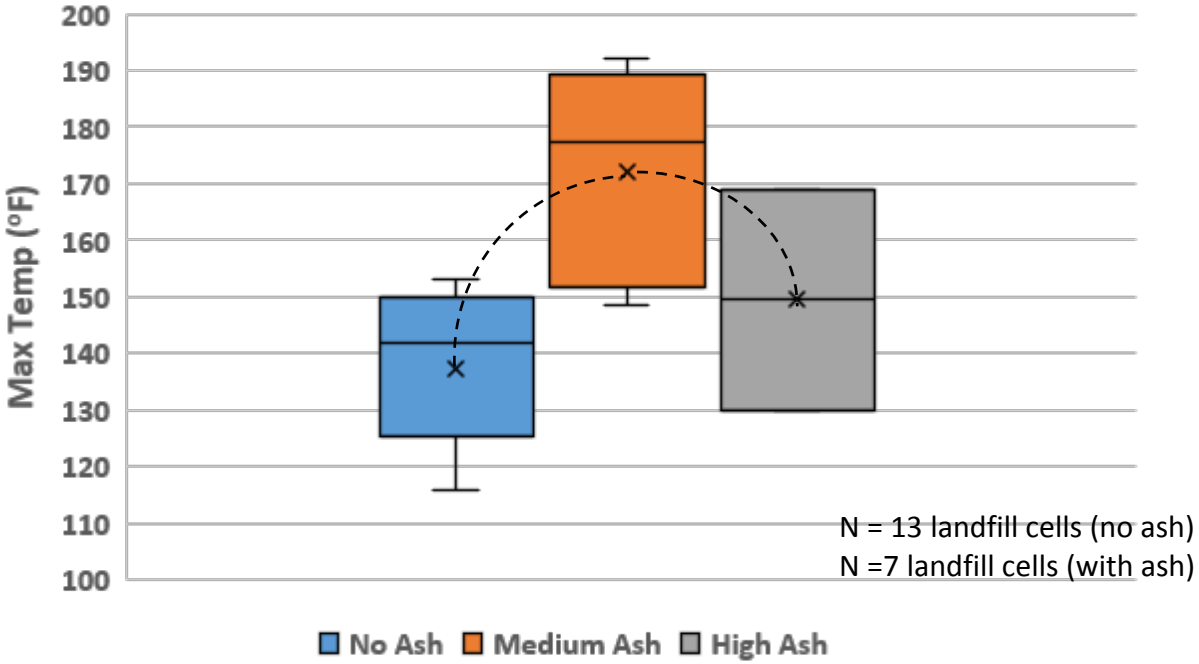
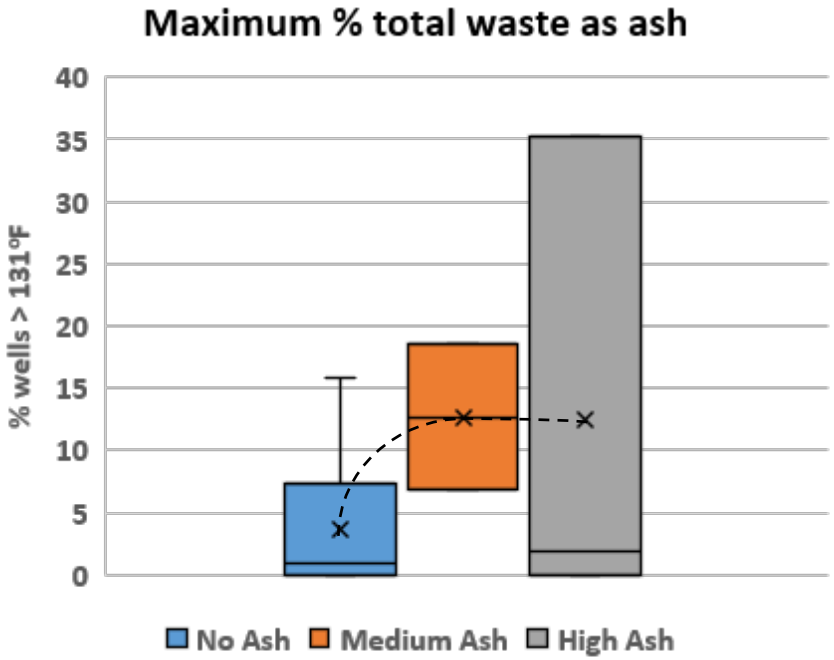
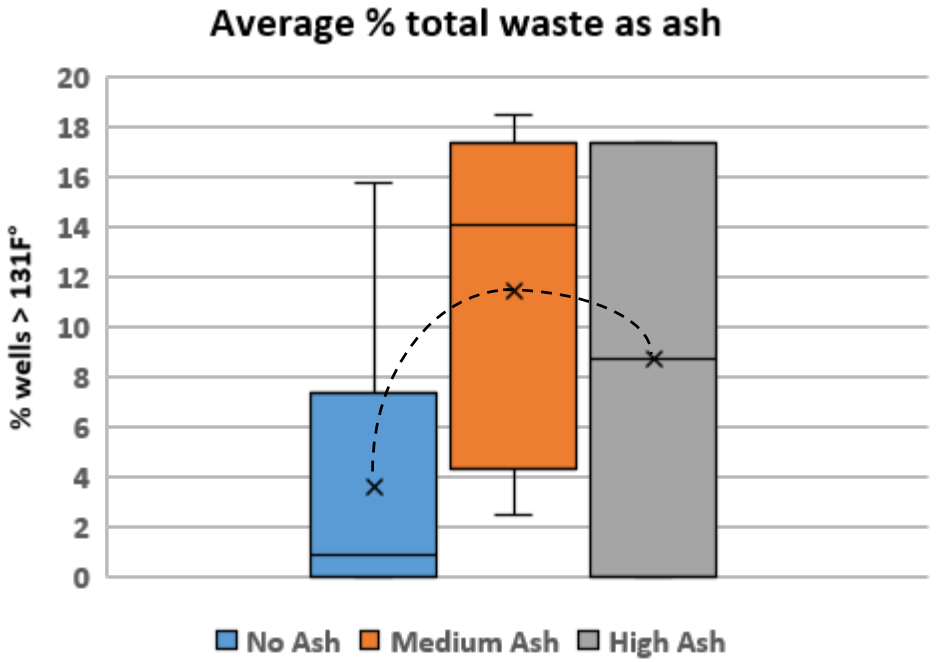
Task 2. Characterization Of Florida Landfills With Elevated Temperatures- Effect of Ash Disposal On Maximum Temperature



Task 2. Characterization of Florida Landfills with Elevated Temperatures - Effect Of Ash Disposal On Percent Of Elevated Temperature Readings

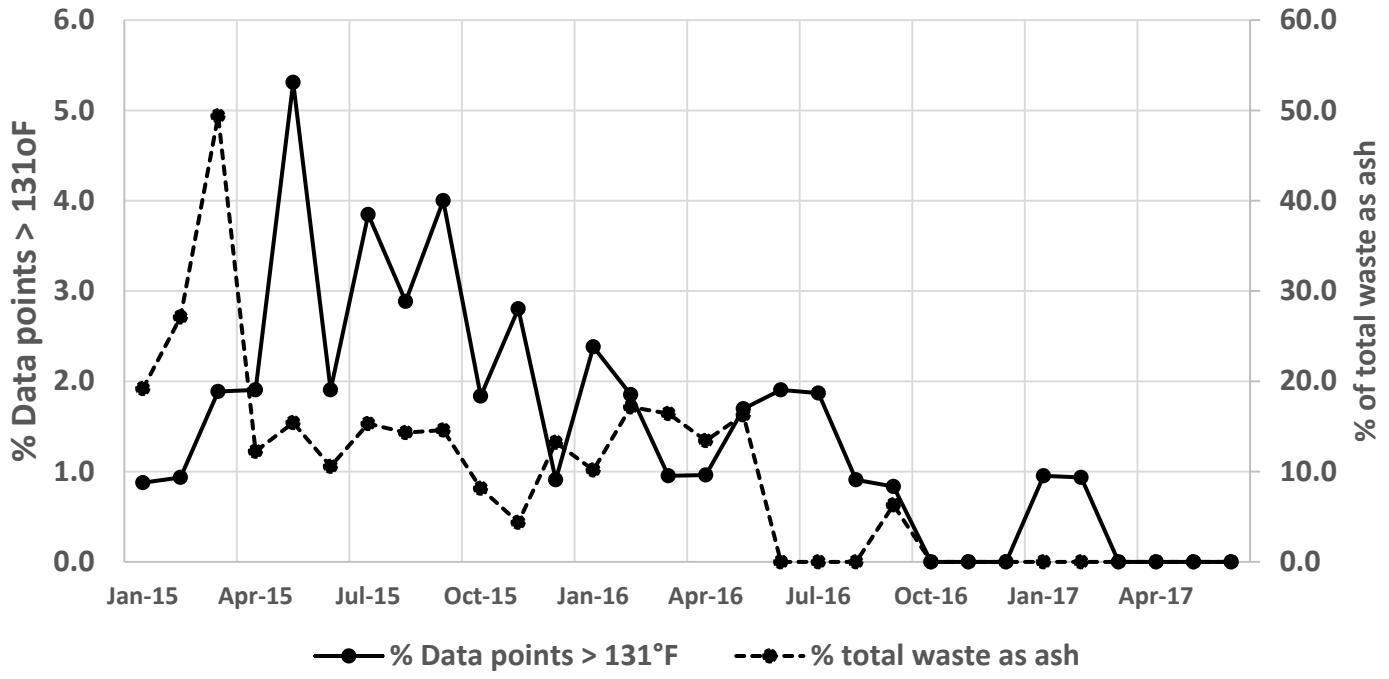




N = 13 landfill cells (no ash)
N =7 landfill cells (with ash)

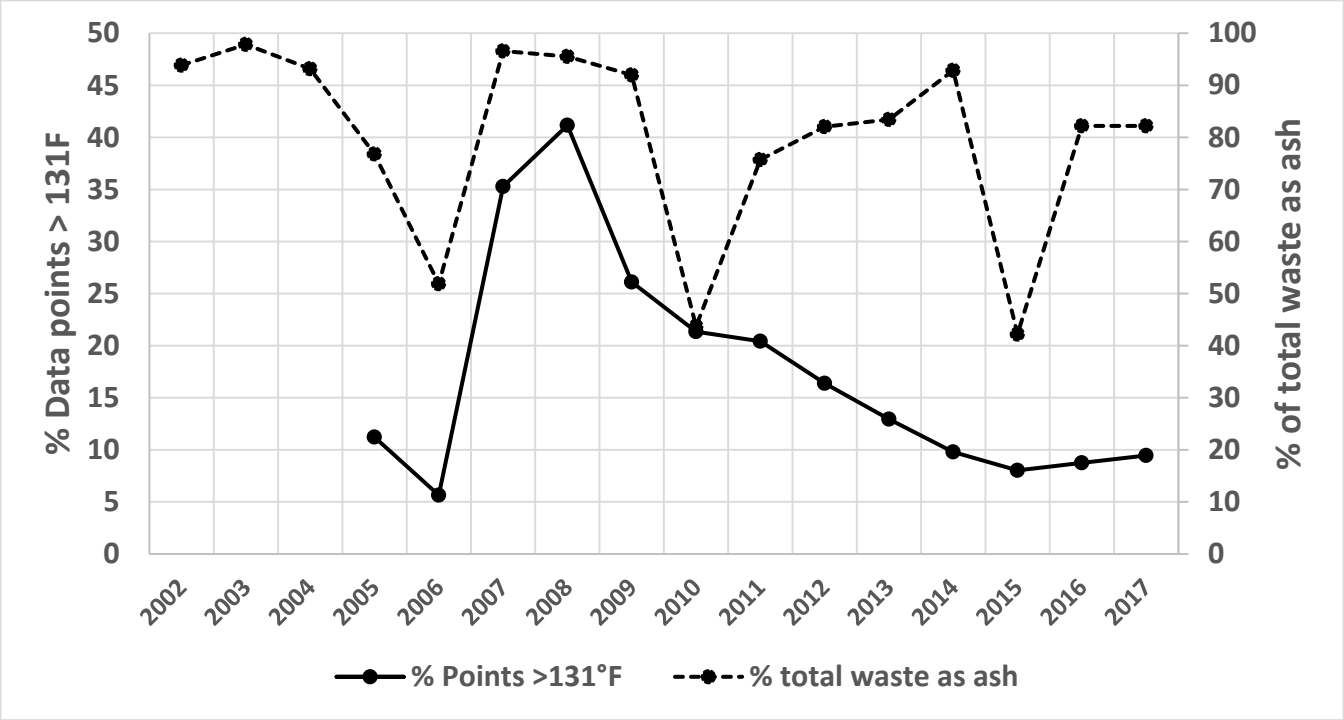
Task 2. Characterization of Florida Landfills with Elevated Temperatures

- Effect of ash disposal on temperature over time:
  - Landfill with medium ash concentration



Task 2. Characterization of Florida Landfills with Elevated Temperatures

- Effect of ash disposal on temperature over time:
  - Landfill with high ash concentration



Presentations

- Florida Water Resources Conference, Palm Beach, FL. April 23, 2017.
- World Environmental & Water Resources Congress 2017, Sacremento, Ca. May 21-25, 2017.
- SWANA Summer Conference, Fort Myers, FL. July 23-25, 2017.
- Sardinia Symposim, Forte Village, Italy. October 2-6, 2017.
- Global Waste Management Symposium, Indian Wells, Ca. February 11-14, 2018.

http://www.cece.ucf.edu/people/reinhart/research/Elevated-Temperature/index.html

Future Work

- Define operating parameters for the EREF elevated temperature model by determining the conditions that favor elevated temperatures.
- Investigate further ETLFs without ash
- Update landfill propagation using GIS software on two case study ETLFs.
- Complete landfill gas/temperature data analysis for additional landfills.

Acknowledgement

- Hinkley Center for Solid and Hazardous Waste Management
- Environmental Research and Education Foundation

Questions?

Image Courtesy of Google Images