
FE0032236

Anabel Needham

U.S. Department of Energy
National Energy Technology Laboratory
Resource Sustainability Project Review Meeting
April 2-4, 2024
Project Overview

- DOE Funding: $749,980
- Overall Project Performance Dates: 4/01/2023 to 3/31/2026
- Overall Project Objectives:
  - Reduce US dependence on imported bauxite for aluminum production.
  - Reduce energy and greenhouse gas emissions by recycling aluminum.
  - Reclaim landfill materials such as iron, other nonferrous metals (e.g., copper), plastics, and glass.
  - Reduce landfill volume by processing organics and removing metallics.
  - Interdisciplinary approach.
Project Participants

Metallurgist
Dr. Paul Sanders (PI)

Contract Contact
Allison Hein

Technical Contact/
Environmental Engineer
Dr. Robert Handler (Co-PI)

Social Scientist
Dr. Jon Robins (Co-PI)

Metallurgy
Grad Student

Mineral Processing
Engineer
Dr. Tim Eisele (Co-PI)

Social Science
Undergrad Student
Emma Strutz

Interdisciplinary
Undergrad Teams

Mineral Processing PhD
Student
Daniel Amponsah-Berko

Environmental
Engineering Grad Student
Anabel Needham
Background: Aluminum Production

2006: 45.9 Mt
2020: 86.2 Mt
2022: USGS Critical Mineral
2030: 119.5 Mt

(Martchek 2007)
Background: Landfill Mining

First documentation of landfill mining: 1953 Tel Aviv, Israel – soil reclamation.

Other Purposes: **airspace reclamation**, landfill expansion, land redevelopment, improved landfill liner technology, reducing greenhouse gas emissions, or using reclaimed materials as combustibles for energy generation.

(Jones et al 2013)
Background: Landfill Mining

Co-Benefits? Economic viability? Community input?

(Jones et al 2013)
Technical Approach & Scope

Project steps and work plan:

Task 1.0 - Site History & Community Impacts
Task 2.0 - LCA & TEA
Task 3.0 - Separation of Landfilled Resources, Pilot Scale Process
Task 4.0 - Assess, Optimize, & Quantify Recovered Aluminum
Task 5.0 - Interdisciplinary Capstone Senior Design

Project success criteria:

- Quantify risks to landfill mining utilizing social science strategies by assessing the content and layout of landfills, and the attitudes and desires of the community.
- Justify the environmental and economic benefits of landfill mining with LCA and TEA analysis.
- Develop flowsheet, pilot-scale separation, and final aluminum processing method to quantify aluminum quality possible in a pilot-scale operation.
Project Risks & Mitigation

- **Policy restrictions or policy gaps for landfill mining** → No Federal restrictions, but state/local regulations and policies may restrict activities on landfill sites. A review of applicable policies and early contact with regulators and policymakers where policy gaps or uncertain interpretations of policy may apply.

- **Community opposition to landfill mining** → Community research may reveal opposition to proposed landfill mining. Solutions include proactive engagement with stakeholders in project design, public information sessions, modification of project design, and identification of co-benefits.

- **Incomplete or otherwise inadequate LCA and TEA input data** → The detailed scenario analysis plan will create a range of outcomes based on several input data assumptions, bounding the potential impact of these data gaps and illustrates their importance for future worksites.

- **Inability to achieve necessary aluminum separation/purity** → Formability metrics will be implemented in the material utility function. Existing relationships with wire suppliers and cored wire vendors will be utilized to process custom compositions.
Progress & Current Status of Project

Site History & Community Impacts: Dr. Jon Robins, Dr. Robert Handler & Anabel Needham

Evaluate quantity and types of historically US landfilled aluminum

Utilize US EPA estimations of MSW fractions that are aluminum to approximate aluminum quantities in US EPA LMOP landfills

Based on the previously determined states that potentially have the greatest quantities of aluminum proceed with those available databases

Identify Texas as having great potential for Aluminum landfill mining projects

Comprehensive Texas Landfill Database

Map Landfill database sites in ArcGIS

TCEQ Landfill Database

Denton & Ruffino Hills Case Studies

9MR landfill mining permit present

US EPA 2018: 1.8% by weight of MSW is aluminum (US EPA 2020)

Identify co-benefits in landfill mining projects
Progress & Current Status of Project

Estimate of Historical Aluminum Landfilling by Product (Garnio 2014)
Progress & Current Status of Project

Industry Recycling of Aluminum Cans Through the Years

![Graph showing the industry recycling rate of aluminum cans in the US from 1973 to 2018. The rate has risen steadily over the last 40 years. The rate was 15.4 percent when first reported in 1972. The industry recycling rate remains above 63 percent—exceeding the 20-year average of 59.1 percent.](image)

(The Aluminum Association 2019)

Weight of Aluminum Cans landfilled in the US (Aluminum Statistical Review 2021)

![Graph showing the weight of aluminum cans landfilled in the US from 1980 to 2020.](image)

States with the Greatest Total Estimated Landfilled Aluminum Cans (Waste360 2023).

<table>
<thead>
<tr>
<th>State</th>
<th>Al Can Recycling Rate (%)</th>
<th>Al Can Deposit</th>
<th>Year Bottle Bill was passed</th>
<th>Al lbs/ Capita generated</th>
<th>Al lbs/ capita disposed</th>
<th>Al lbs/ capita recycled</th>
<th>Population (April 2020-July 2021)</th>
<th>Total Al disposed (lbs)</th>
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<tbody>
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### Progress & Current Status of Project

<table>
<thead>
<tr>
<th>Landfill Name</th>
<th>City</th>
<th>County (CTY)</th>
<th>Ownership Type</th>
<th>LF Owner Org.(s)</th>
<th>Year Open</th>
<th>Year Close</th>
<th>Waste in Place (tons)</th>
<th>Relative Al. (million tons)</th>
<th>Sum of Relative Al. by CTY (million tons)</th>
<th>Sum of Relative Al. by Org. (million tons)</th>
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<td>Atascocita RDF</td>
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<td>Harris</td>
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<td>2033</td>
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# Progress & Current Status of Project

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<thead>
<tr>
<th>Landfill Name</th>
<th>City</th>
<th>County (CTY)</th>
<th>Ownership</th>
<th>LF Owner Org.(s)</th>
<th>Year Open</th>
<th>Year Close</th>
<th>Waste in Place (tons)</th>
<th>Relative Runway Al (million tons)</th>
<th>Relative Al (million tons)</th>
<th>Sum of Runway AI/LF Org. by CTY (million tons)</th>
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<td>Private</td>
<td>Republic Services, Inc.</td>
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<td>Collin</td>
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</table>

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Progress & Current Status of Project

Ruffino Hills Case Study: Proposed Landfill Mining Project in Houston, Texas

City of Bellaire (West),
1954 – 1988, MSW, SUBT

City of West University Place (East),
1959 – 1992, MSW, SUBT

Co-Benefits:

- Stormwater & Flood Mitigation Potential: Keegans Bayou
- Community Green Space & Parks
- Economic Development: Job Creation & Business Space

(Houston One Voice 2022)
US EPA LMOP & TCEQ Database Compilation (123 sites) for 9 counties containing Houston (Austin, Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, and Waller)

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<thead>
<tr>
<th>Type</th>
<th>Type Description</th>
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</tr>
<tr>
<td>2</td>
<td>Closed</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>Brush, construction, &amp; demolition</td>
<td>20</td>
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<tr>
<td>9MR</td>
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<td>CP</td>
<td>Construction over Closed MSW LFs, Permitted</td>
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<td>CR</td>
<td>Construction over Closed MSW LFs, Registered</td>
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<tr>
<td>SUBT</td>
<td>Construction over Closed MSW LFs, Non-enclosed</td>
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<td>UNUM</td>
<td>Closed, Operated before permits were required</td>
<td>40</td>
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<tr>
<td><strong>Total:</strong></td>
<td></td>
<td><strong>91</strong></td>
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</table>
Progress & Current Status of Project

Separation of Landfilled Resources, Pilot Scale Process: Dr. Tim Eisele & Daniel Amponsah-Berko

Dry waste → 125mm screen
- Screener 1
  - 50mm screen
    - Large size recovered (ferrous metals)
    - Medium size recovered (ferrous metals)
    - Small size recovered (ferrous metals)

Crusher/Shredder → 25mm screen
- Screener 2
  - 10mm screen
    - Large size recovered (ferrous metals)
    - Small size recovered (ferrous metals)

Hand picking

Eddy current
- Fines re-landfilled
- Nonferrous metals recovered
- Small size recovered (ferrous metals)

Drum magnet
Cross belt magnet
Progress & Current Status of Project

Separation of Landfilled Resources, Pilot Scale Process: Dr. Tim Eisele & Daniel Daniel Amponsah-Berko

There are well established technologies to process waste materials above 20mm. Below are some of the companies that sell such technologies:

- Magnetic separators
- Eddy current separator
- Air separators
- Shredder
- Screens

Nest Steps:
Data from literature review suggests that focusing on the <20mm size range could be advantageous due to the high aluminum content. Plan to develop an economical technology to process fines to recover Aluminum fines from MSW.
Next Steps

Project steps and work plan:

Task 1.0 - Site History & Community Impacts
   - Continue community outreach and interviews
   - Expand stormwater ArcGIS analysis across entire US

Task 2.0 - LCA & TEA
   - Investigate other potential co-benefits and determine their allocation

Task 3.0 - Separation of Landfilled Resources, Pilot Scale Process
   - Create pilot scale process for separating aluminum fines
   - Determine landfill condition effects on aluminum quality

Task 4.0 - Assess, Optimize, & Quantify Recovered Aluminum
   - Utilize alloys from separation

Task 5.0 - Interdisciplinary Capstone Senior Design

Eventual full-scale landfill mining operation
Outreach and Workforce Development Efforts

- Community interviews (Dr. Jon Robins)
  - Social science approach to landfill mining feasibility
- Potential future partner with Hydro
- Michigan Technological University Interdisciplinary Capstone Senior Design
- Additional Metallurgy Grad Student
Aluminum demand is projected to increase, and landfill mining to recycle aluminum products is a potentially viable solution.

Landfill mining projects often face economic barriers, and identifying co-benefits to material recovery is highly recommended.
Thank you! Questions?
Appendix


Organization Chart

Project Landing Page
Michigan Technological University:
Dr. Paul Sanders – PI
  Future Metallurgy Grad Student
Dr. Robert Handler – Co-PI
Dr. Tim Eisle – Co-PI
  Mineral Processing PhD Student, Daniel Amponsah-Berko
Dr. Jonathan Robins – Co-PI
  Environmental Engineering Grad Student, Anabel Needham
  Undergraduate Sustainability Science and Society Student, Emma Strutz
Allison Hein – Contract Contact
Future Interdisciplinary Senior Design Capstone project for Undergraduate Students
## Gantt Chart

<table>
<thead>
<tr>
<th>Milestone</th>
<th>Task/Subtask</th>
<th>Milestone Description</th>
<th>Due Date</th>
<th>Verification Method</th>
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<td>MS-1.1</td>
<td>Subtask 1.1</td>
<td>Landfill downselect</td>
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<td>Data quality and specificity</td>
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| Task | Month => | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 |
|------|----------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| 0.   | Project Mgt | M0.1 | M0.3 | M0.3 |
| 1.   | Site Analysis | M0.1 | M1.1 | M1.2 |
| 2.   | LCA & TEA | M2.1 | M2.2 | M3.2 |
| 3.   | Flowsheet/pilot | M3.1 | M3.2 | M4.2 |
| 4.   | Al final process | M4.2 | M5a  | M5b  |
| 5.   | UG Design Teams | M5b  | M5a  | M5b  |