Aluminum Critical Mineral Production via Landfill Mining: Environmental, Community, and Technical Feasibility for Integrated Multi-Material Resource Recovery

FE0032236

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U.S. Department of Energy

National Energy Technology Laboratory

Resource Sustainability Project Review Meeting

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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)

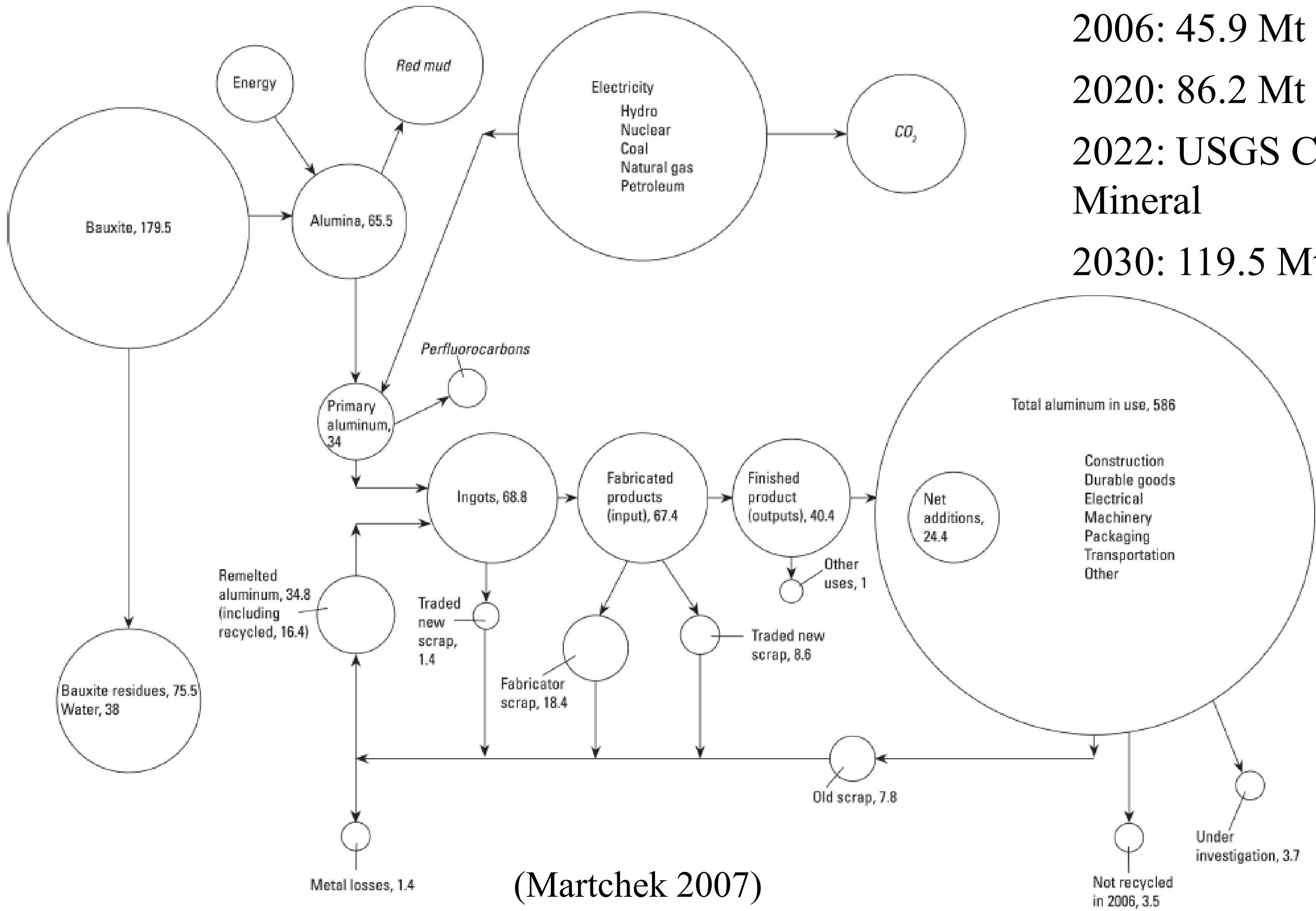
Social Science
Undergrad Student
Emma Strutz

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

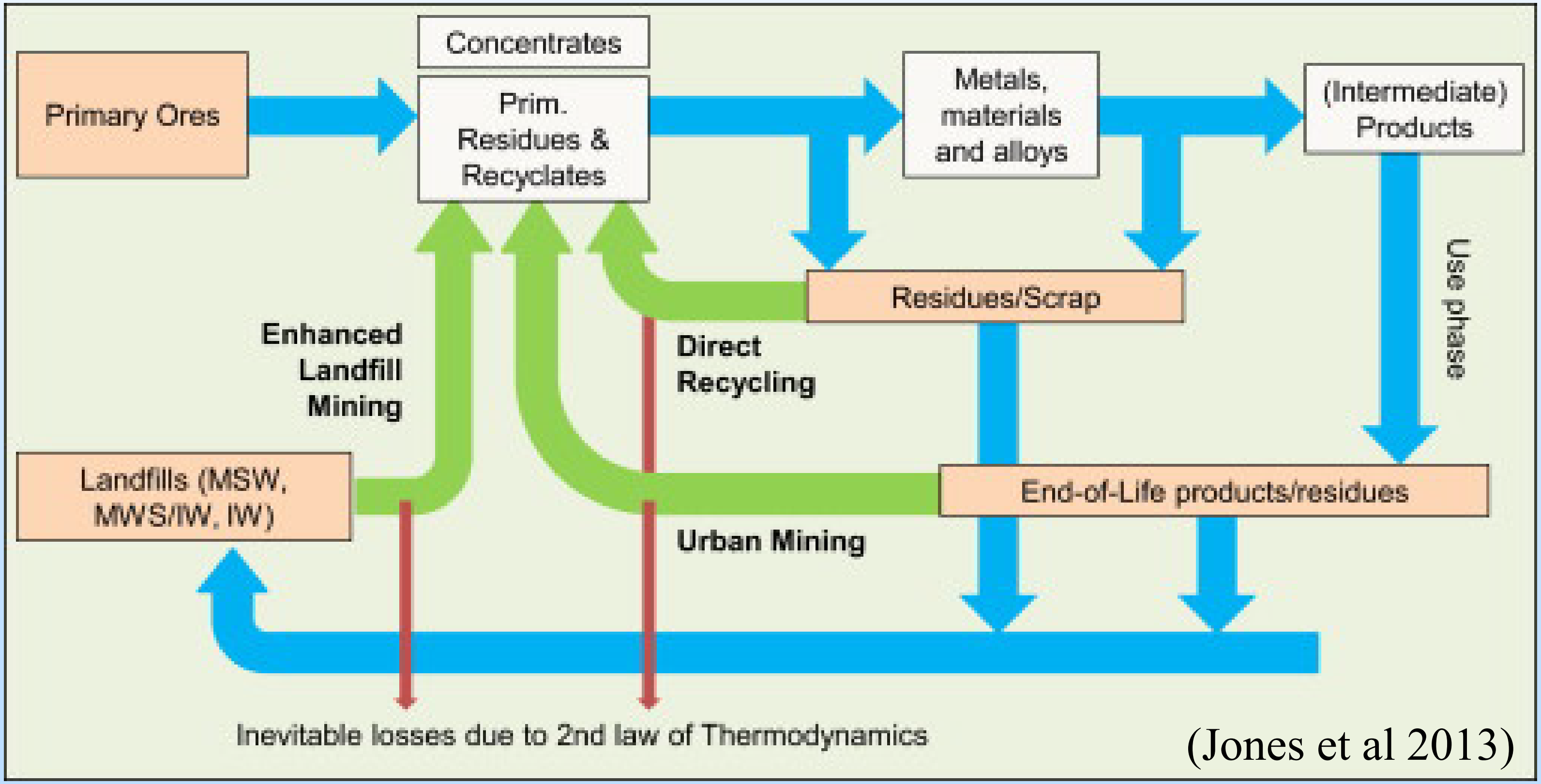
2030: 119.5 Mt

(Martchek 2007)

Background: Landfill Mining

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

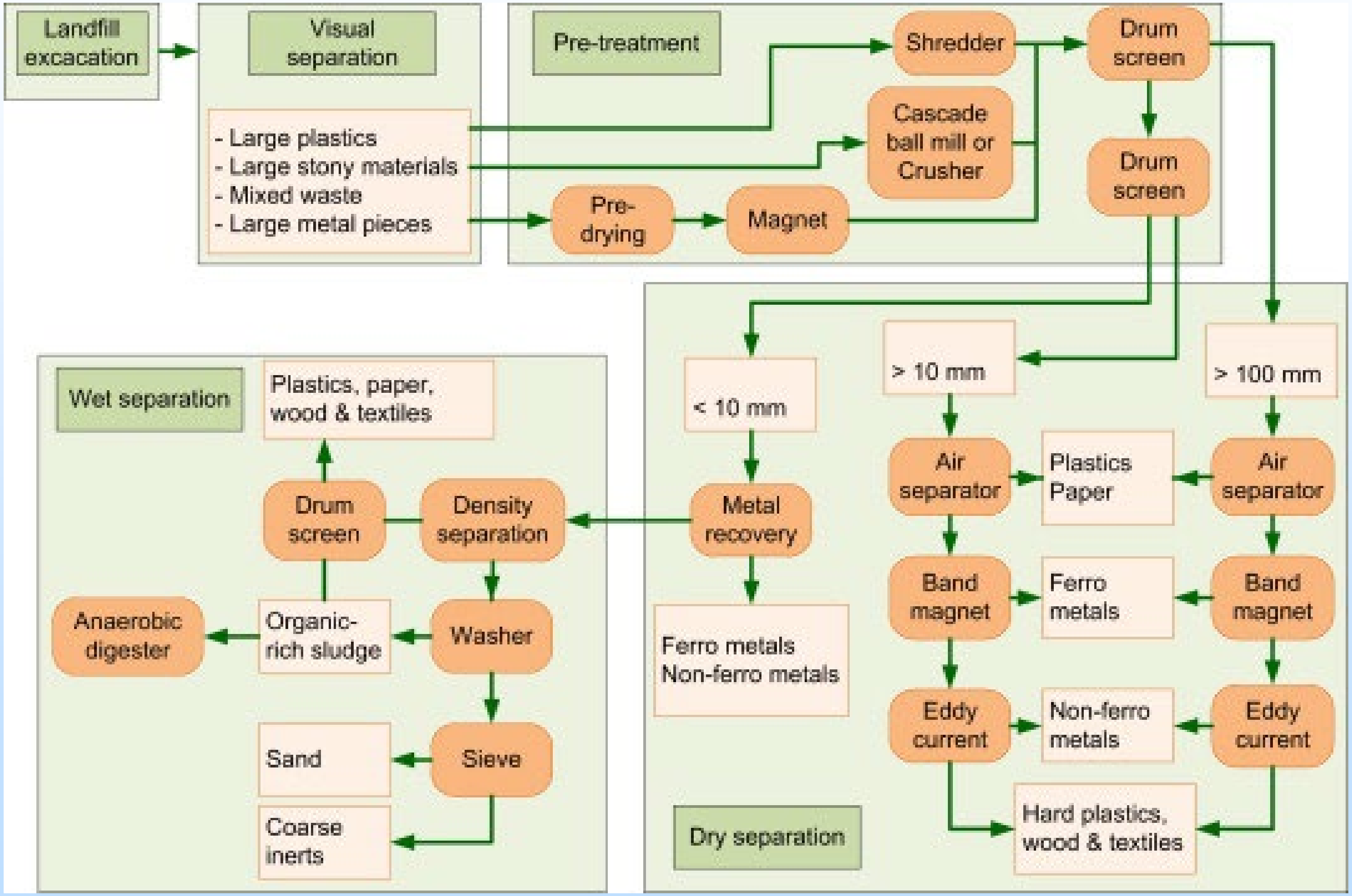
Other Purposes: airspace reclamation, landfill expansion, land redevelopment, improved landfill liner technology, reducing greenhouse gas emissions, or using reclaimed materials as combustibles for energy generation.



(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

Current Project Tasks

Task 4.0 - Assess, Optimize, & Quantify Recovered Aluminum

Task 5.0 - Interdisciplinary Capstone Senior Design

Project success criteria:

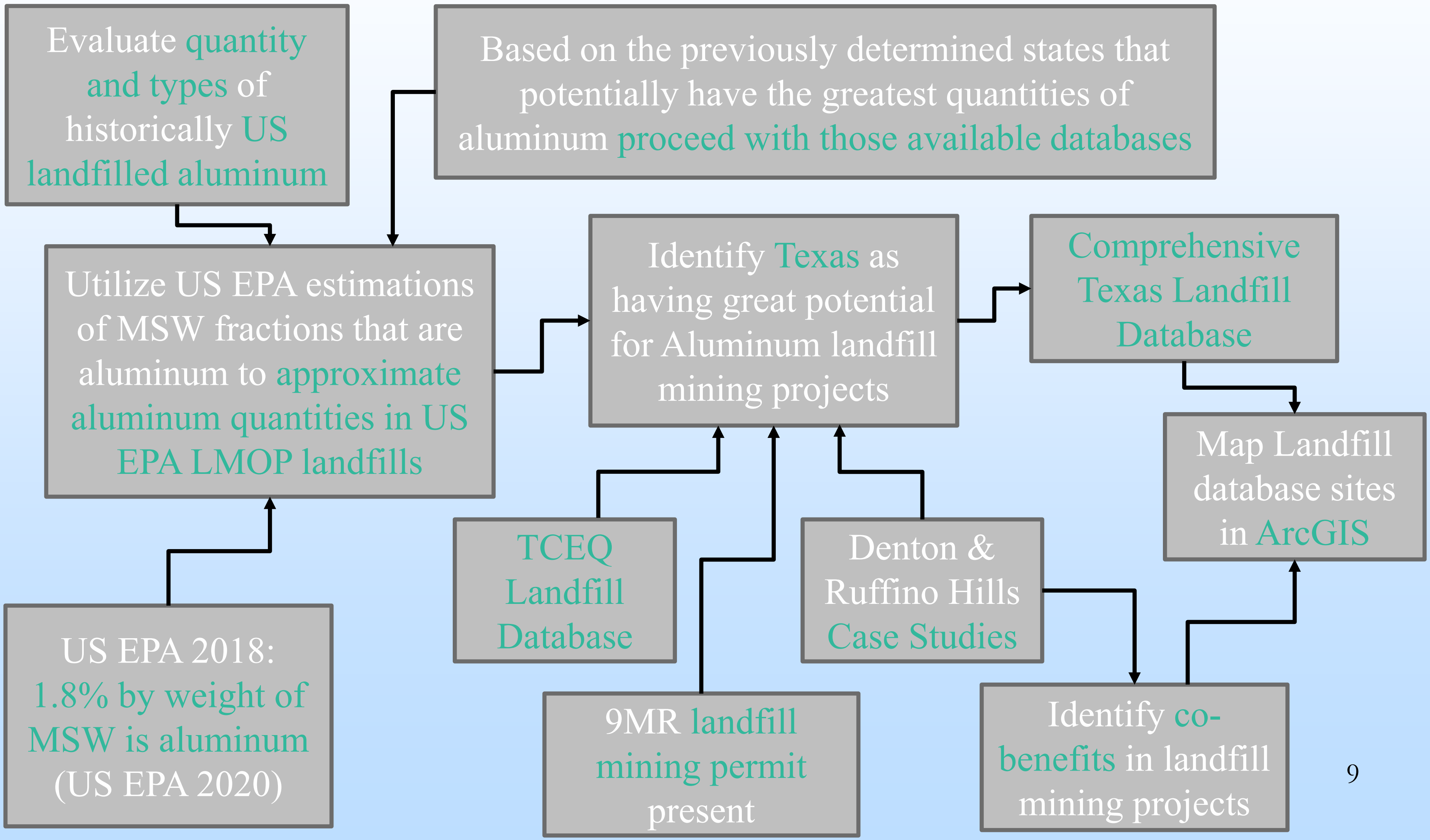
- Quantify risks to landfill mining utilizing social science strategies by assessing the content and layout of landfills, and the attitudes and desires of the community.
- Justify the environmental and economic benefits of landfill mining with LCA and TEA analysis.
- Develop flowsheet, pilot-scale separation,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

Project Risks & Mitigation

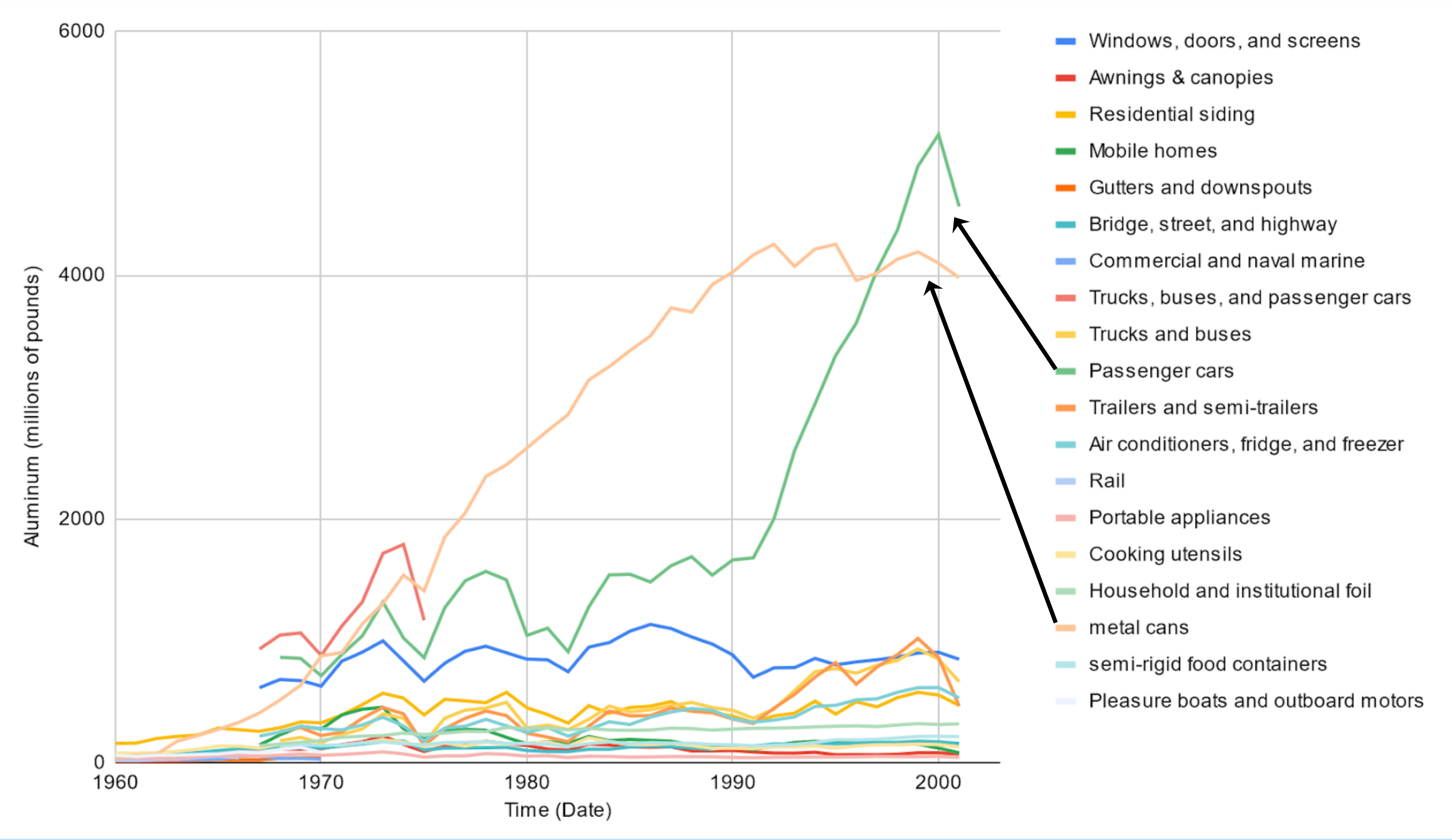
- **Policy restrictions or policy gaps for landfill mining** → No Federal restrictions, but state/local regulations and policies may restrict activities on landfill sites. A review of applicable policies and early contact with regulators and policymakers where policy gaps or uncertain interpretations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

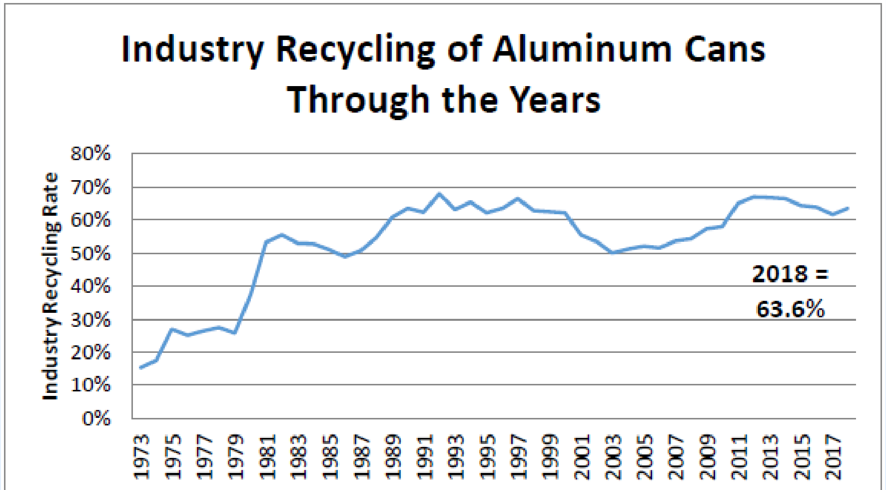


Progress & Current Status of Project



Estimate of Historical Aluminum Landfilling by Product (Garnio 2014)

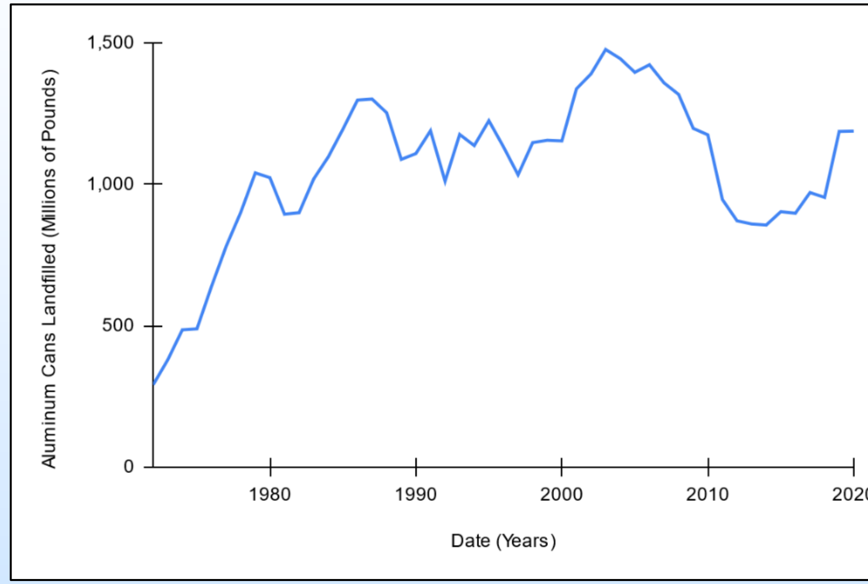
Progress & Current Status of Project



The aluminum industry recycling 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.

(The Aluminum Association 2019)

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



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

State	Al Can Recycling Rate (%)	Al Can Deposit	Year Bottle Bill was passed	Al lbs/ Capita generated	Al lbs/ capita disposed	Al lbs/ capita recycled	Population (April 2020-July 2021)	Total Al disposed (lbs)
Texas	16	No		9.7	8.2	1.5	29,527,941	242,129,116
Florida	25	No		12.5	9.4	3.1	21,781,128	204,742,603
Illinois	24	No		10.7	8.1	2.6	12,671,469	102,638,899
Georgia	20	No		9.7	7.8	1.9	10,799,566	84,236,615
Ohio	16	No		8.4	7.1	1.3	11,780,017	83,638,121
California	78	Yes (CRV, 5c)	1987	8	1.8	6.2	39,237,836	70,628,105

Progress & Current Status of Project

Landfill Name	City	County (CTY)	Ownership Type	LF Owner Org.(s)	Year Open	Year Close	Waste in Place (tons)	Relative Al. (million tons)	Sum of Relative Al. by CTY (million tons)	Sum of Relative Al. by Org. (million tons)
Atascocita RDF	Humble	Harris	Private	Waste Management, Inc.	1983	2041	39,042,964	0.70	2.90	5.46
Blue Bonnet LF	Houston	Harris	Private	Waste Management, Inc.	1979	1998	2,564,239	0.05	2.90	5.46
Whispering Pines LF	Houston	Harris	Private	Republic Services, Inc.	1978	2044	10,248,912	0.18	2.90	5.62
McCarty Road LF	Houston	Harris	Private	Republic Services, Inc.	1972	2033	99,568,809	1.79	2.90	5.62
Bellfort Boulevard Landfill	Houston	Harris	Public	City of Houston, TX	1954	1970	9,731,720	0.18	2.90	0.18
Charles M Hinton Jr Regional Landfill	Rowlett	Dallas	Public	City of Garland, TX	2002	2053	7,838,433	0.14	2.06	0.24
Laidlaw/ Wilmer LF	Wilmer	Dallas	Private	Landfill Owner of Laidlaw/ Wilmer LF	1992	2001	686,400	0.01	2.06	0.01
Hunter Ferrell Landfill	Irving	Dallas	Public	City of Irving, TX	1982	2077	4,315,320	0.08	2.06	0.08
McCommas Bluff Landfill	Dallas	Dallas	Public	City of Dallas, TX	1981	2053	55,343,799	1.00	2.06	1.00
Hutchins Landfill	Hutchins	Dallas	Private	Republic Services, Inc.	1978	1992	1,000,000	0.02	2.06	5.62
City of Garland Castle Drive Landfill	Garland	Dallas	Public	City of Garland, TX	1978	2003	5,507,951	0.10	2.06	0.24

Progress & Current Status of Project

Landfill Name	City	County (CTY)	Ownership Type	LF Owner Org.(s)	Year Open	Year Close	Waste in Place (tons)	Relative Runway Al (million tons)	Relative Al (million tons)	Sum of Runway Al/LF Org. by CTY (million tons)
Whispering Pines LF	Houston	Harris	Private	Republic Services, Inc.	1978	2044	10,248,912	0.29	0.18	2.57
McCarty Road LF	Houston	Harris	Private	Republic Services, Inc.	1972	2033	99,568,809	2.28	1.79	2.57
McCommas Bluff Landfill	Dallas	Dallas	Public	City of Dallas, TX	1981	2050	55,343,799	1.76	1.00	1.76
Covel Gardens RDF	San Antonio	Bexar	Private	Waste Management, Inc.	1993	2050	36,416,119	1.38	0.66	1.38
DFW Recycling & Disposal Facility	Lewisville	Denton	Private	Waste Management, Inc.	1972	2023	71,642,714	1.37	1.29	1.37
Atascocita RDF	Humble	Harris	Private	Waste Management, Inc.	1983	2041	39,042,964	1.10	0.70	1.15
Blue Bonnet LF	Houston	Harris	Private	Waste Management, Inc.	1979	1998	2,564,239	0.05	0.05	1.15
Tessman Road Landfill	San Antonio	Bexar	Private	Republic Services, Inc.	1982	2050	34,839,121	1.12	0.63	1.12
Blue Ridge LF	Fresno	Fort Bend	Private	Republic Services, Inc.	1993	2050	24,633,014	0.94	0.44	0.94
121 Regional Disposal Facility	Melissa	Collin	Public	North TX Municipal Water District	2004	2050	12,621,353	0.65	0.23	0.85

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

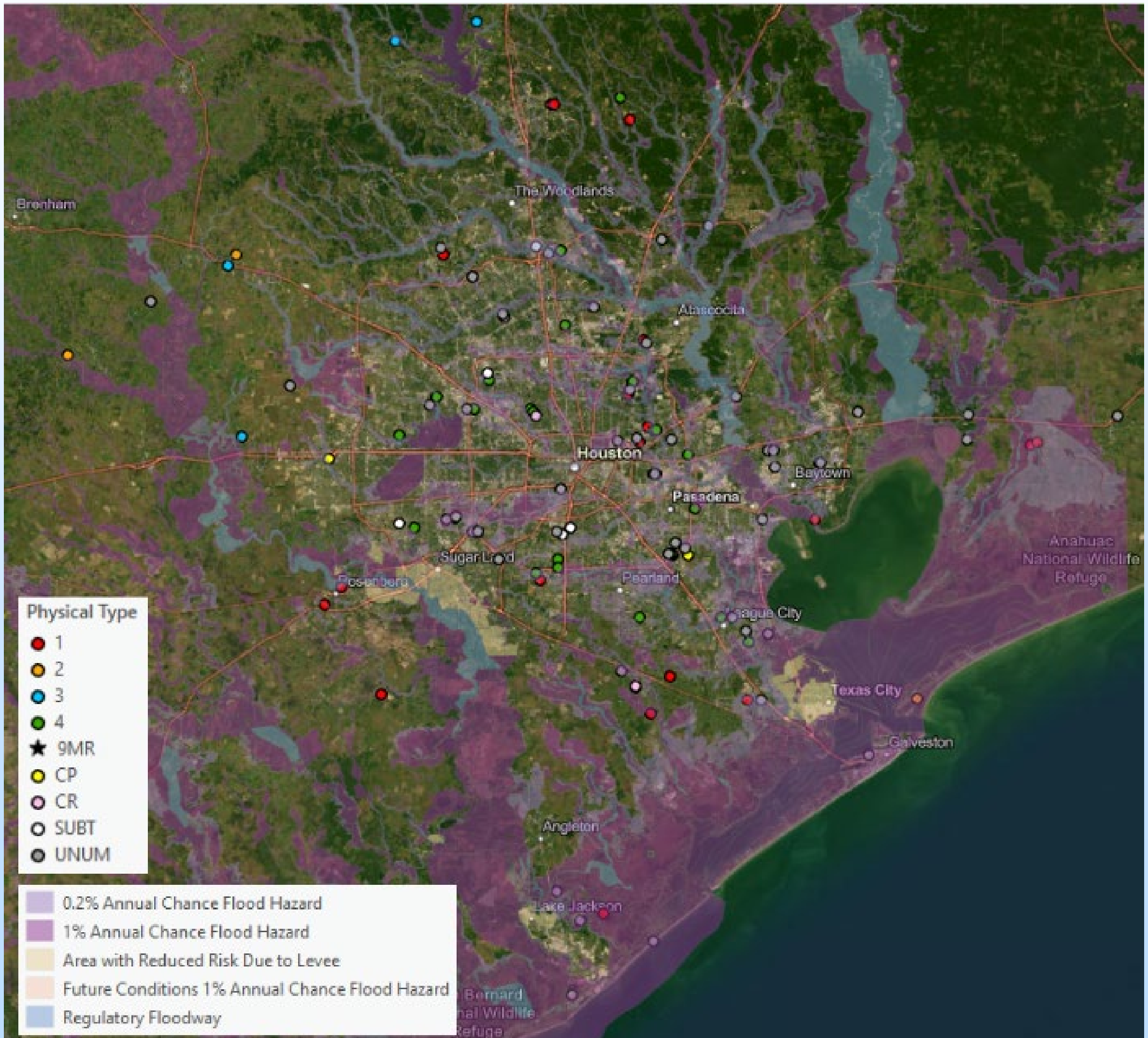
Community Green Space & Parks

Economic Development: Job Creation & Business Space

(Houston One Voice 2022)

Progress & Current Status of Project

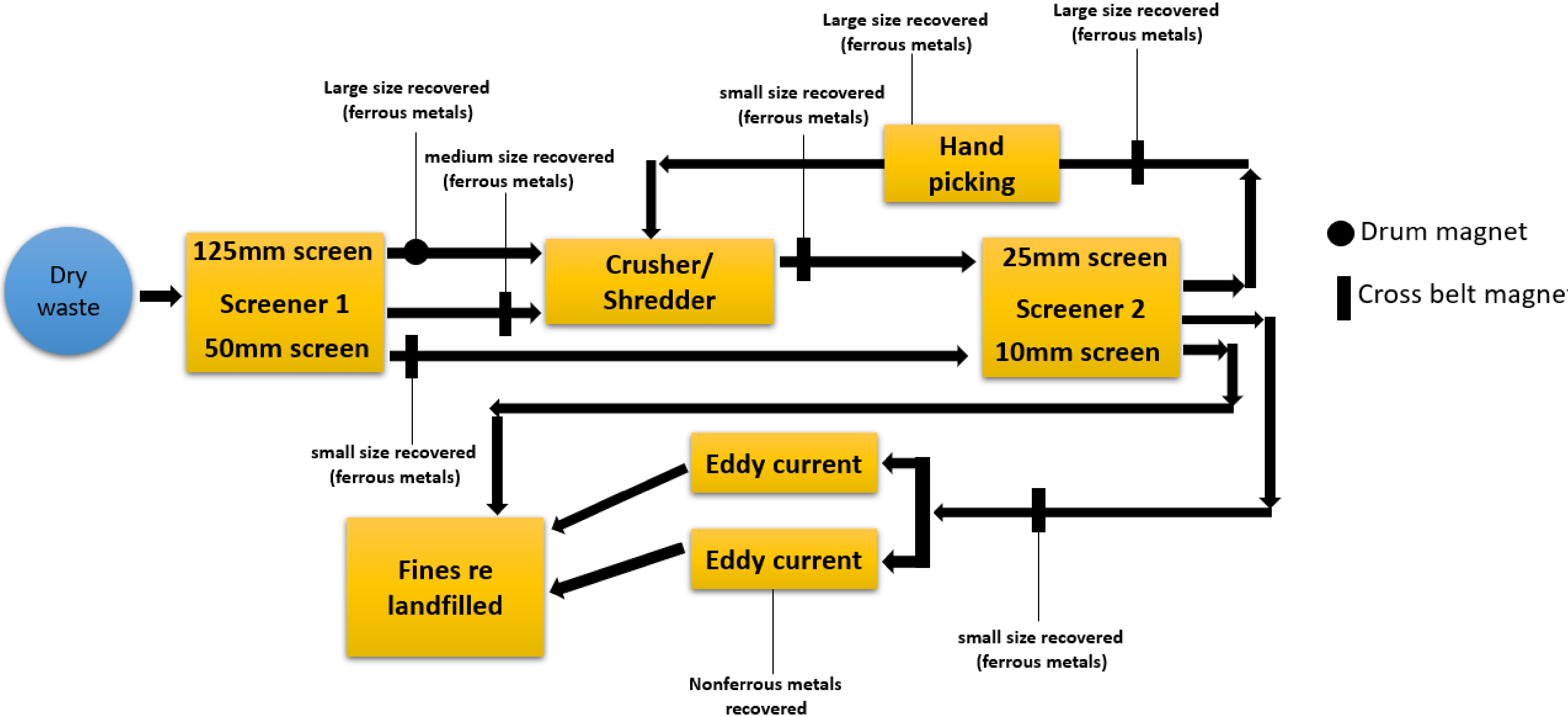
US EPA LMOP & TCEQ Database Compilation (123 sites) for 9 counties containing Houston (Austin, Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, and Waller)



Type	Type Description	Count
1	MSW	17
2	Closed	2
4	Brush, construction, & demolition	20
9MR	Landfill Mining, Permitted	1
CP	Construction over Closed MSW LFs, Permitted	1
CR	Construction over Closed MSW LFs, Registered	1
SUBT	Construction over Closed MSW LFs, Non-enclosed	6
UNUM	Closed, Operated before permits were required	40
Total:		**91**

Progress & Current Status of Project

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



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:

Vecoplan®

336-861-6070

Magnetic separators

Eddy current separator

Air separators

Shredder

Screens

INDUSTRIAL MAGNETICS. EST 1961

800-662-4638

Eddy current separators

Magnetic separators

REDWAVE®

470-699-1688

Single stream waste processing equipment

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

Hydro

Michigan Technological University

1885

U.S. DEPARTMENT OF ENERGY

Summary Slide

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

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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

Milestone	Task/ Subtask	Milestone Description	Due Date	Verification Method
MS-1.1	Subtask 1.1	Landfill downselect	M12	Data quality and specificity
MS-3.1	Subtask 3.1	Flowsheet design	M12	Separates known landfill contents
MS-2.1	Subtask 2.1	Initial LCA & TEA	M18	Addresses landfill contents process
MS-5a	Task 5	Senior design report	M24	Interdisciplinary undergrad project
MS-1.2	Subtask 1.2	Community impact	M36	Peer review/literature comparison
MS-2.2	Subtask 2.2	Revised LCA & TEA	M36	Update based on mine and pilot-scale learning
MS-3.2	Subtask 3.2	Pilot scale report	M36	Separates known landfill contents
MS-4.2	Subtask 4.2	Al quality report	M36	Meets primary aluminum specs
MS-5b	Task 5	Senior design report	M36	Interdisciplinary undergrad project

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												M0.3
1. Site Analsis												M1.1																								M1.2
2. LCA & TEA																		M2.1																		M2.2
3. Flowsheet/pilot												M3.1																								M3.2
4. Al final process																																				M4.2
5. UG Design Teams																								M5a												M5b