

The EPA Small Business Innovation Research (SBIR) Program presents:

EPA SBIR Innovative Recycling Technologies Webinar



Wednesday March 30, 2022



Webinar Agenda

- 2:00 Introduction
 - April Richards, EPA SBIR
 - Jason Walker, EPA OLEM
- 2:10 Technology presentations (~5 minutes each)
 - 6 small businesses
- 3:00 Q&A

Introduction

EPA Mission

- Protect human health and the environment

EPA Sustainable Materials Management

- Fulfilling human needs and prospering, while using less materials, reducing toxics and recovering more of the materials used

EPA SBIR

- Seed technology innovations to meet Agency's mission
- One of 11 federal agencies with SBIR
- Focus is commercialization



Disclaimer

- The views expressed in this presentation are those of the speaker(s) and do not necessarily represent the views or policies of the Agency. Any mention of trade names or commercial products does not constitute EPA endorsement or recommendation for use.

EPA SBIR Recycling Projects

- **Rebecca Popowsky** [OLIN](#) (Philadelphia, Pennsylvania): An engineered soil product and process that repurposes waste-stream glass into soil suitable for horticultural and green infrastructure projects.
- **Patrick K. Simpson** [PKS Consulting, Inc.](#) (Anchorage, Alaska): A mobile plastic ocean waste recycler. This innovation can be deployed in coastal communities to produce recycled plastic lumber products from locally collected plastic ocean waste.
- **Anna-Marie Cook** [Kamilo, Inc.](#) (San Francisco, California): Utilizing blockchain and GIS-based verification to develop a recycling supply chain measurement system.
- **Nik Balachandran** [Zabble Inc.](#) (Walnut Creek, California): A zero-waste campaign management platform utilizing artificial intelligence.
- **Dani Charles** [Veriflux Corp](#) (Washington, D.C.): A data platform for waste traceability to increase reuse and ensure compliance with regulations.
- **Zak Wehman** [CleanRobotics, Inc](#) (Longmont, Colorado): Automated waste sorting system that utilizes robotic sorting, object detection, artificial intelligence, and machine learning to sort recyclables at point of disposal.



OLIN

Developmental Investigation of Recycled Color Mixed Glass in Engineered Soils



EPA SBIR

AMERICA'S SEED FUND FOR
ENVIRONMENTAL INNOVATION

Project Team

OLIN
Engineering & Land Planning Associates
Pennsylvania Recycling Markets Center
Andela Products
Craul Land Scientist
Bottle Underground & ReMark Glass
Bennett Compost
Circular Philadelphia

The Problems



SUSTAINABLE SOIL SOURCING



WASTE OF RECYCLABLE GLASS

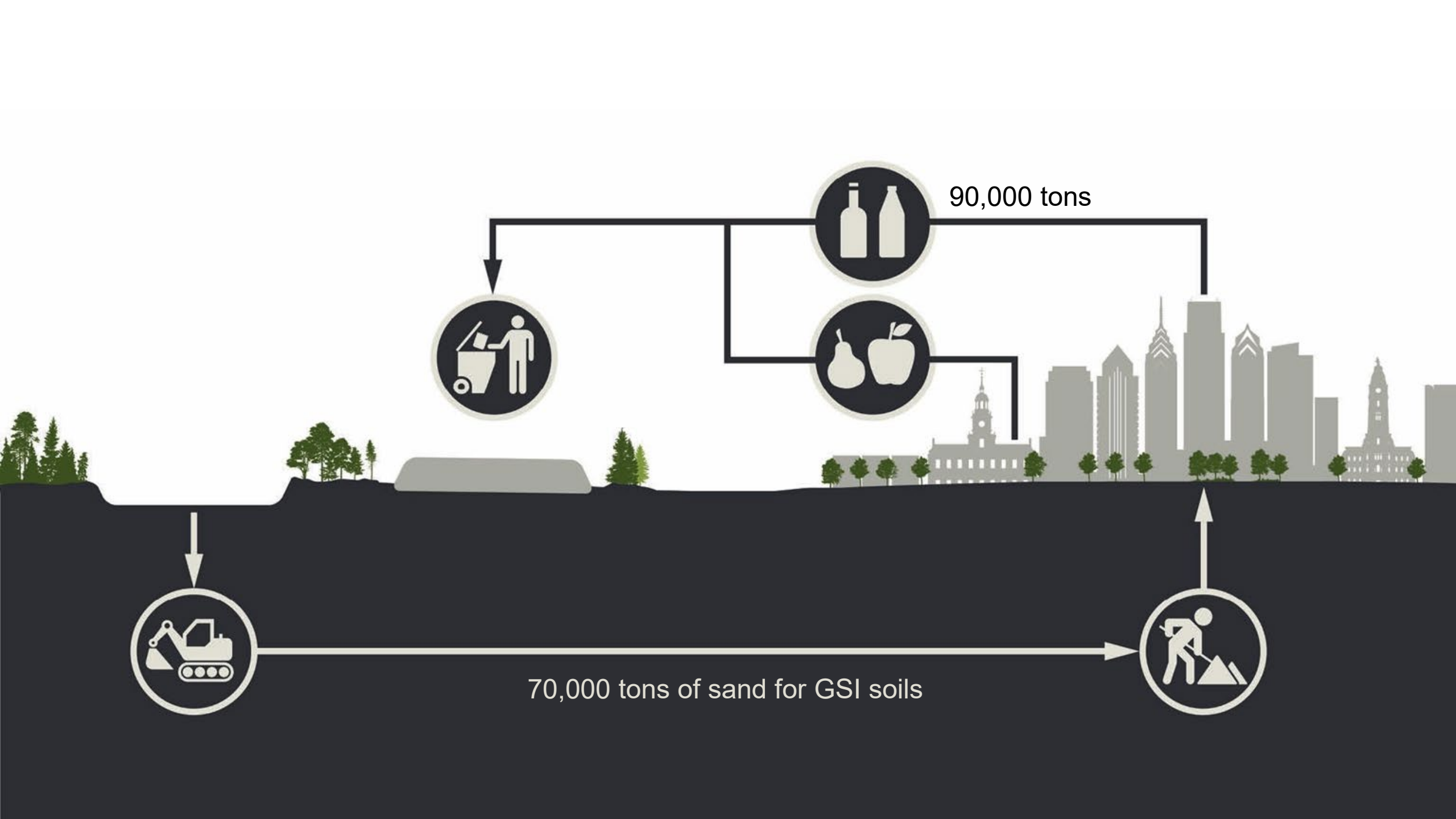
The Opportunity



GLASS + FOOD WASTE

**LOCALLY-SOURCED
HIGH-PERFORMING
SOIL**



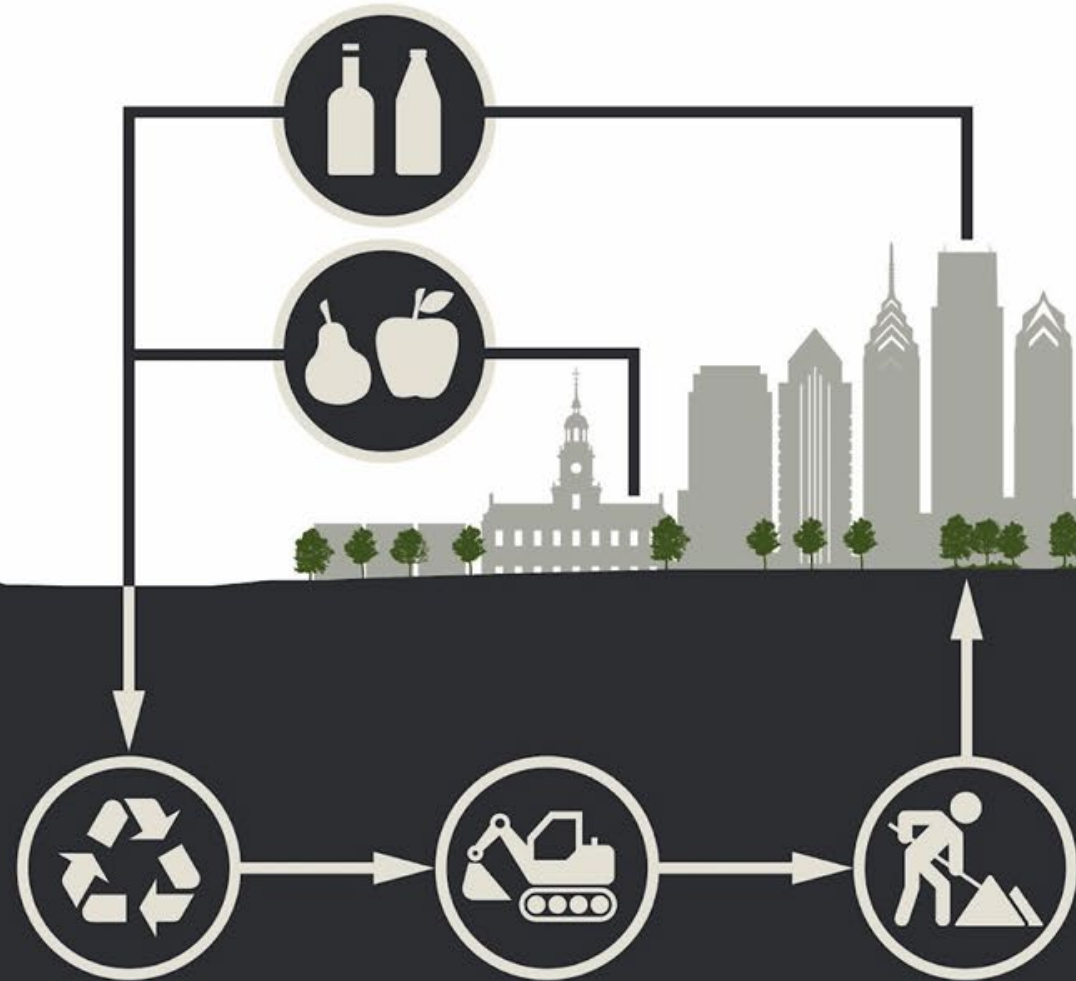


Customers

MRFs and Recycling Processors
Municipalities
Landscape Industry

As a design and planning firm, OLIN provides:

1. Proof of concept
2. Open-sourced process guidance and resources



2019-2020

Results from a previous greenhouse trial and mesocosm study assessed short-term plant growth, leachate quality and water flow.

- Plants performed as well in glass-based soils as in sand-based soils
- Leachate analysis: metals under EPA drinking water requirements (Cu, Zn)
- However, pH of glass-sand is higher than specified soil mixes
- Glass-sand mixes retain water for longer than natural sand.
- Therefore, more research is needed to find and optimal glass-based soil blend



2021: EPA SBIR Phase I

Results:

- Lab & greenhouse tests: no significant differences in plant biomass between glass-based and sand-based mixes.
- Economic analysis showed benefits of diverting glass from municipal single-stream recycling.

Plant Growth Trial: Biomass

Calamagrostis 'Karl Foerster'

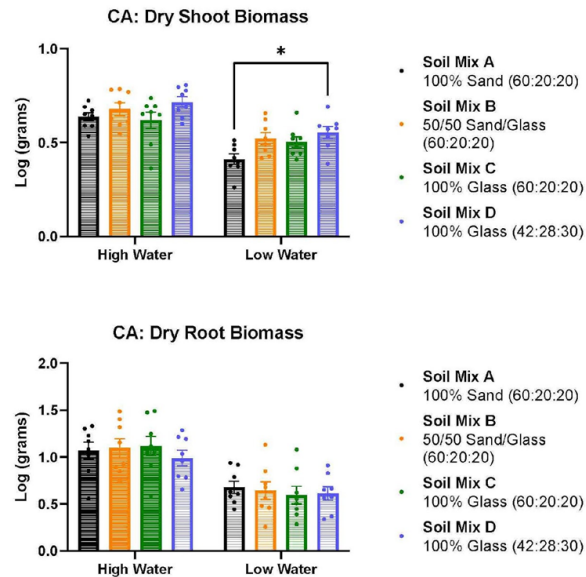
Watering Treatment Impacted Plant Growth

- There were significant differences in biomass between high and low watering treatments for both roots ($p < 0.001$) and shoots ($p < 0.001$).

No Significant Interaction Effect between Watering Treatment and Soil Mix

Performance Difference between Sand and Glass-based Soils

- Soil mix had a significant effect on shoot biomass only ($p = 0.0058$).
- Plants in the low watering treatment exhibited significantly higher shoot biomasses ($p = 0.0120$) when grown in glass-based soil mix D than when grown in sand-based soil mix A.



Notes: A logarithmic transformation was applied to the biomass data since the untransformed data did not fit a normal distribution. Two-way ANOVA was then used to assess differences in biomass between soil mixes and water treatments. When soil mix was found to have a significant effect, a Tukey's multiple comparisons test was used to assess differences between mixes. All error bars indicate standard error of the mean.

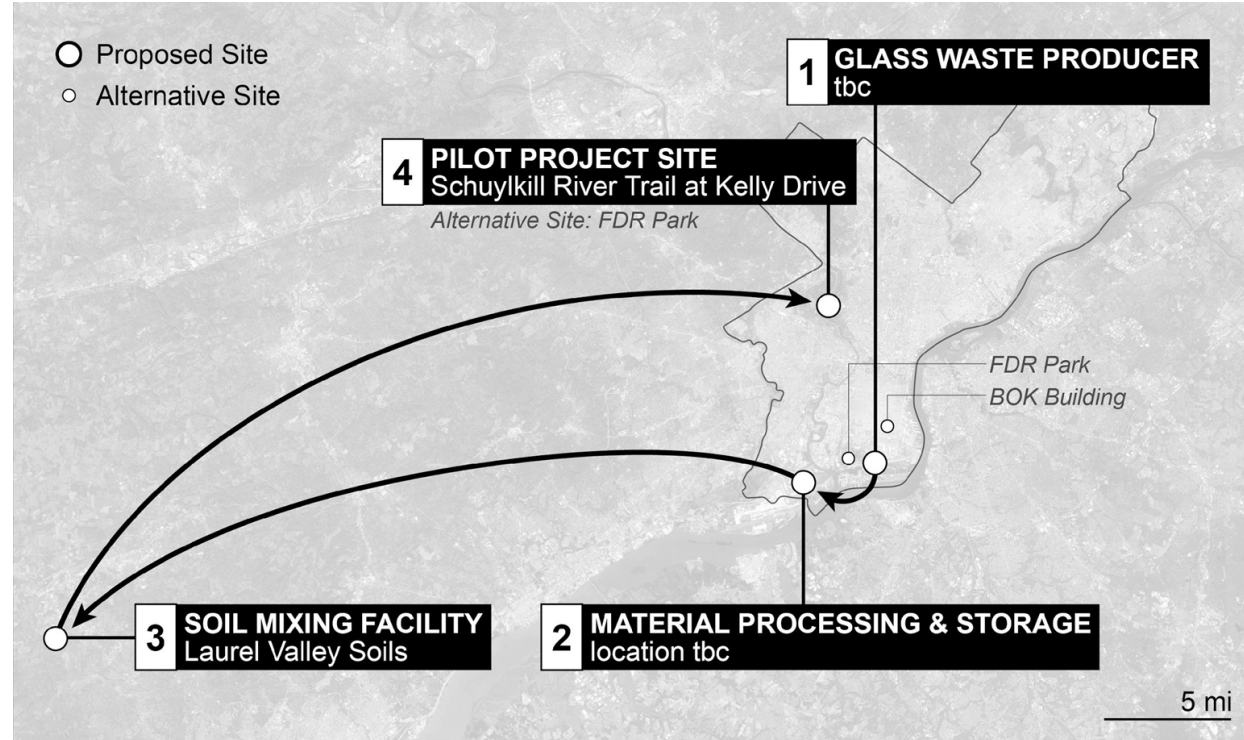


EPA SBIR Phase II

- Pilot glass-sand processing hub
- Monitored GSI installation in partnership with Philadelphia Dept of Parks & Rec and Philadelphia Water Department
- Commercialization



Andela

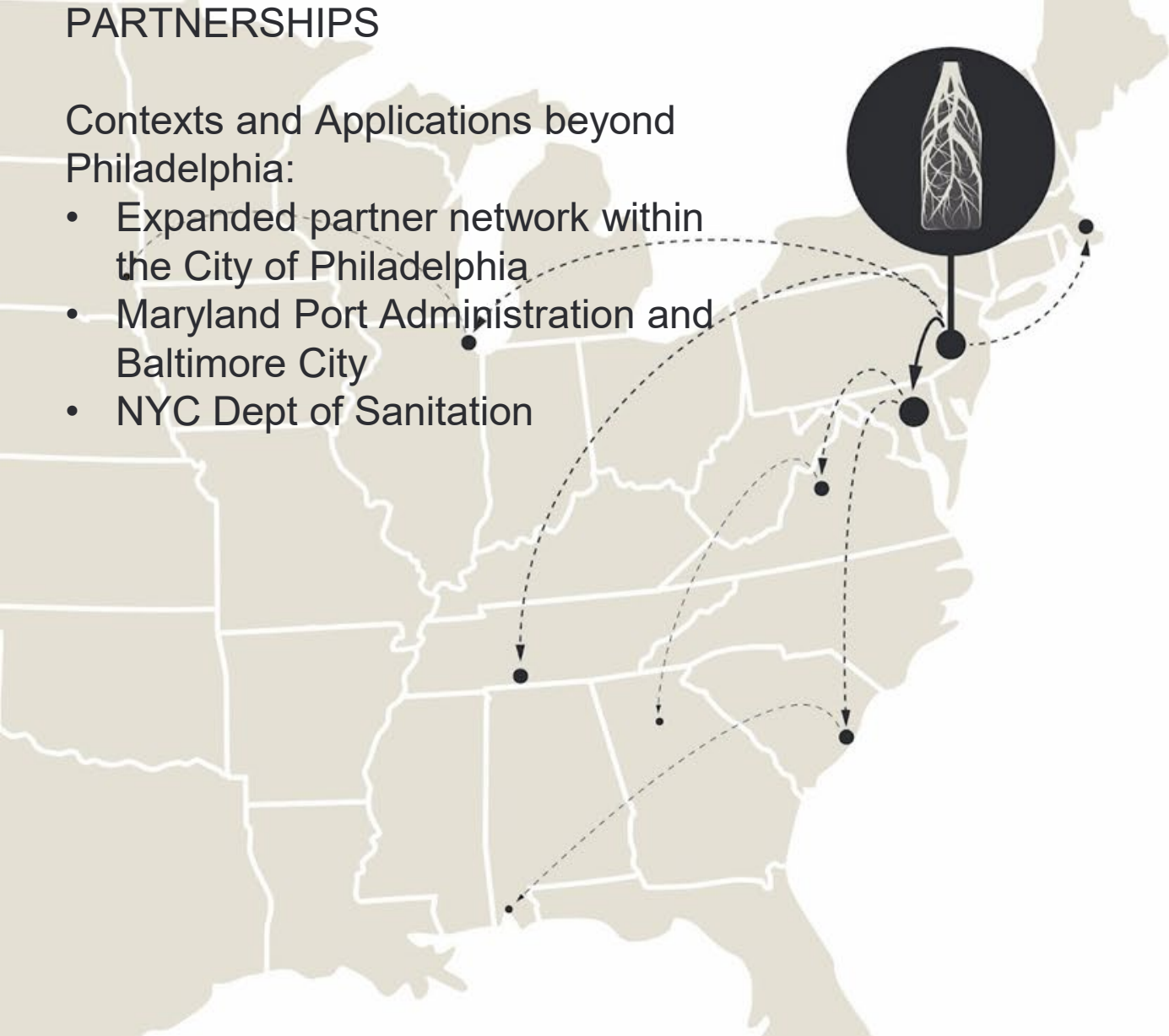


Lab to Implementation

PARTNERSHIPS

Contexts and Applications beyond Philadelphia:

- Expanded partner network within the City of Philadelphia
- Maryland Port Administration and Baltimore City
- NYC Dept of Sanitation



Mobile Plastic Ocean Waste Recycler

Patrick K Simpson
PKS Consulting, Inc.
PO Box 241367
Anchorage AK 99524
(907) 444-5860

www.pksconsulting.biz

The Challenge

2022

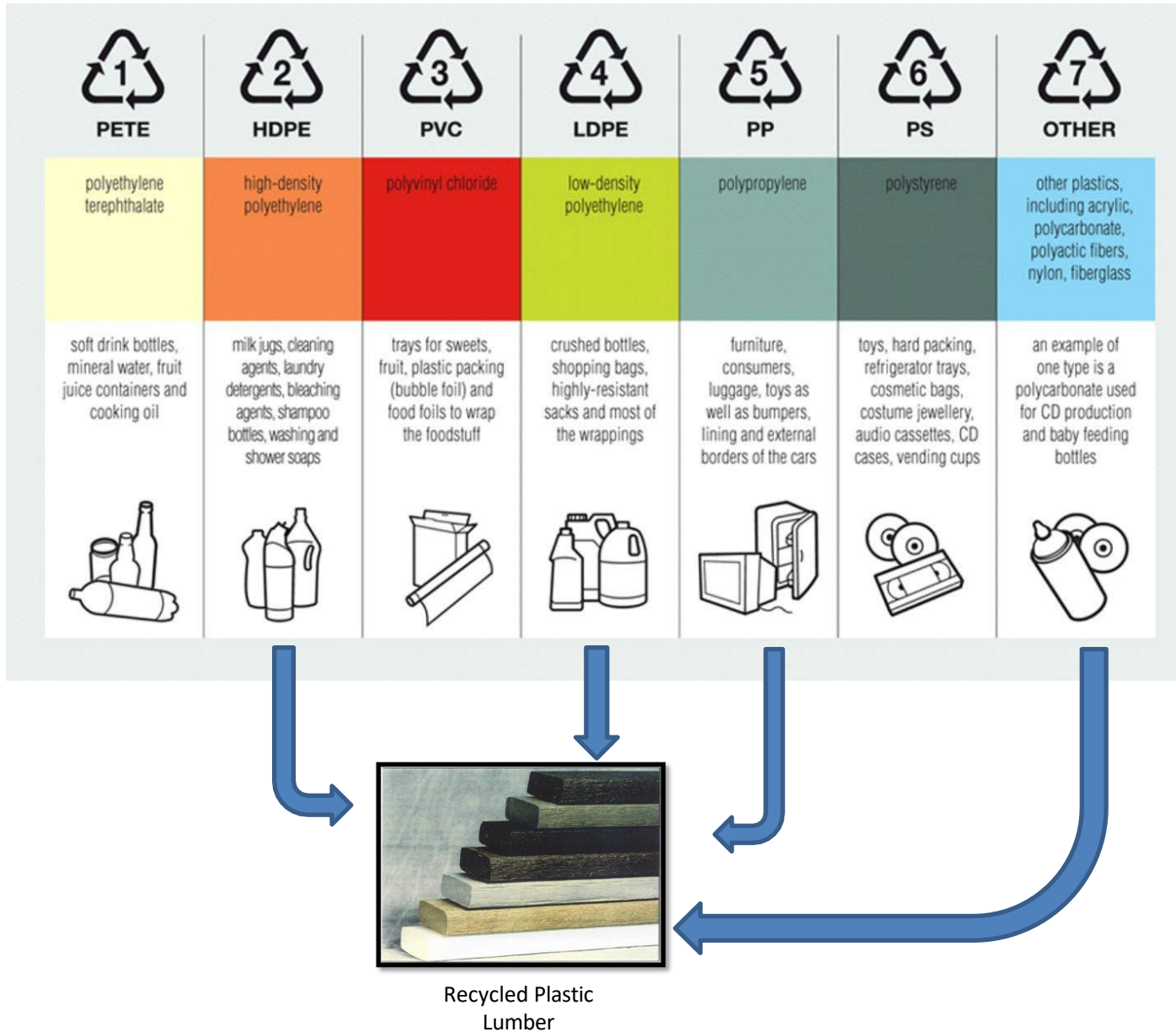
- In Jambeck's seminal ~~2015~~ paper, at least ~~8 million MT~~ of plastics leak into the ocean each year
 - **Now 11 million MT**
- That amount is equivalent to unloading "one garbage truck into the ocean every minute," the MacArthur Foundation calculated
- Pollution could grow to the equivalent of two trucks per minute by 2030 and four per minute by 2050 if mitigation efforts do not intensify



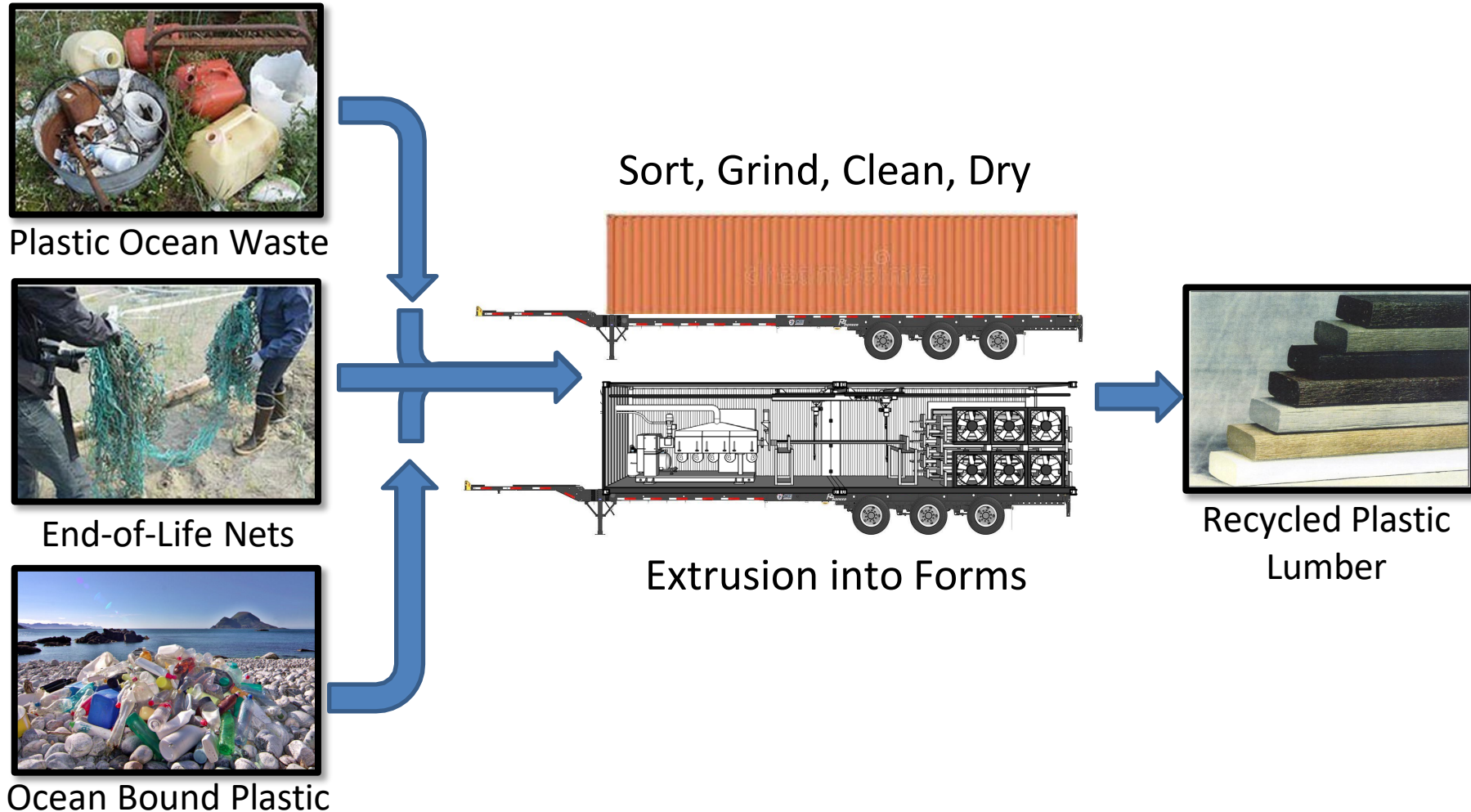
The Vision

- Understand the flux of Plastic Ocean Waste onto our shorelines
- Find more affordable methods for removing Plastic Ocean Waste from the shorelines
- Convert Plastic Ocean Waste into useful products that are produced and sold locally
- Alaska first, then expand

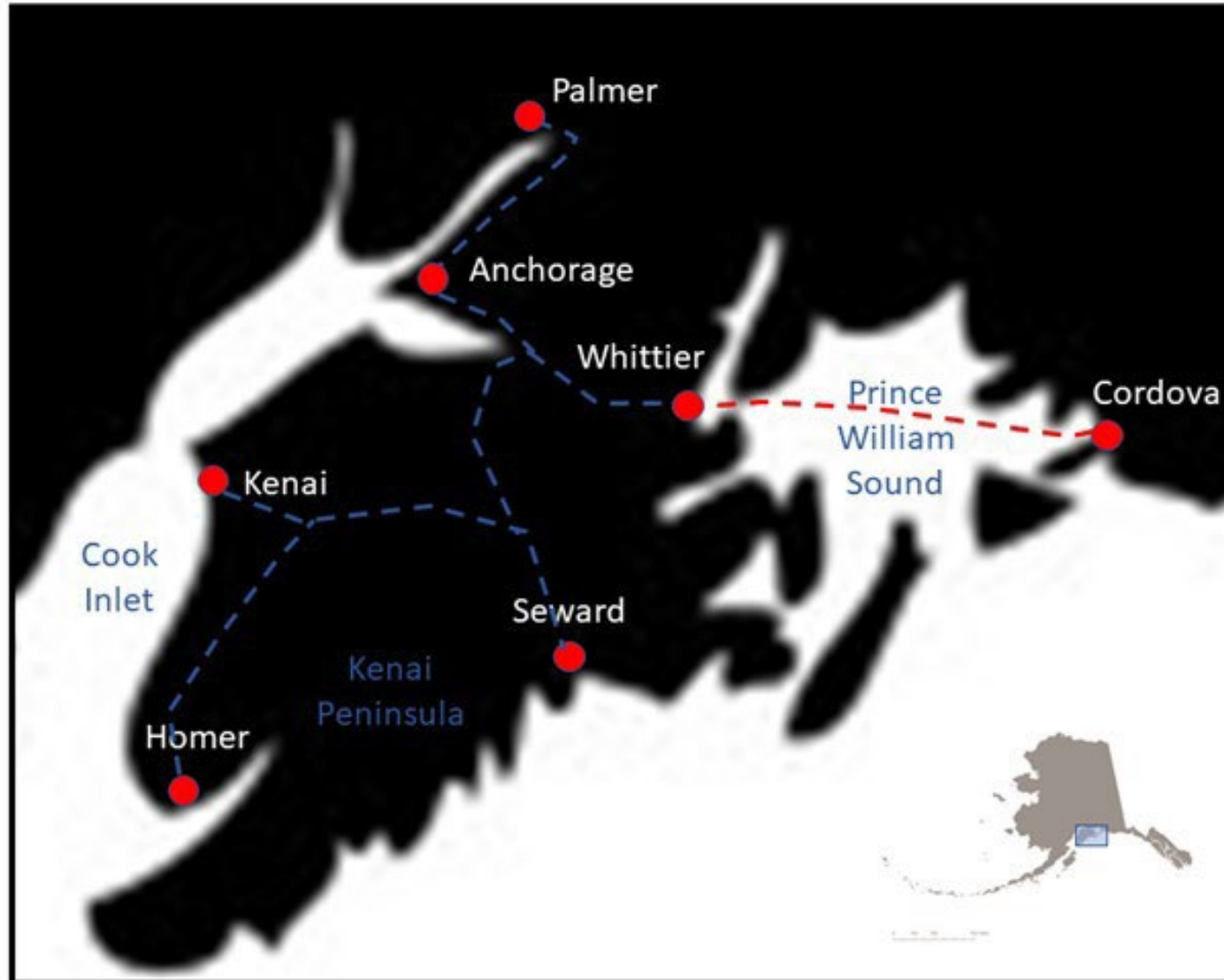
Mobile Processing



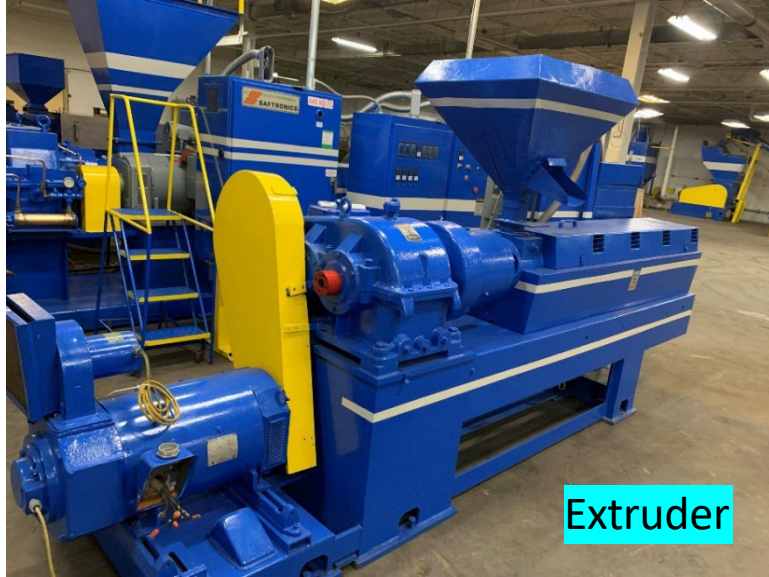
Mobile Plastic Ocean Waste Recycler (HDPE, LDPE, PP, PA \Rightarrow RPL)










Pilot Demonstration Communities



The Equipment



Mobile Processing

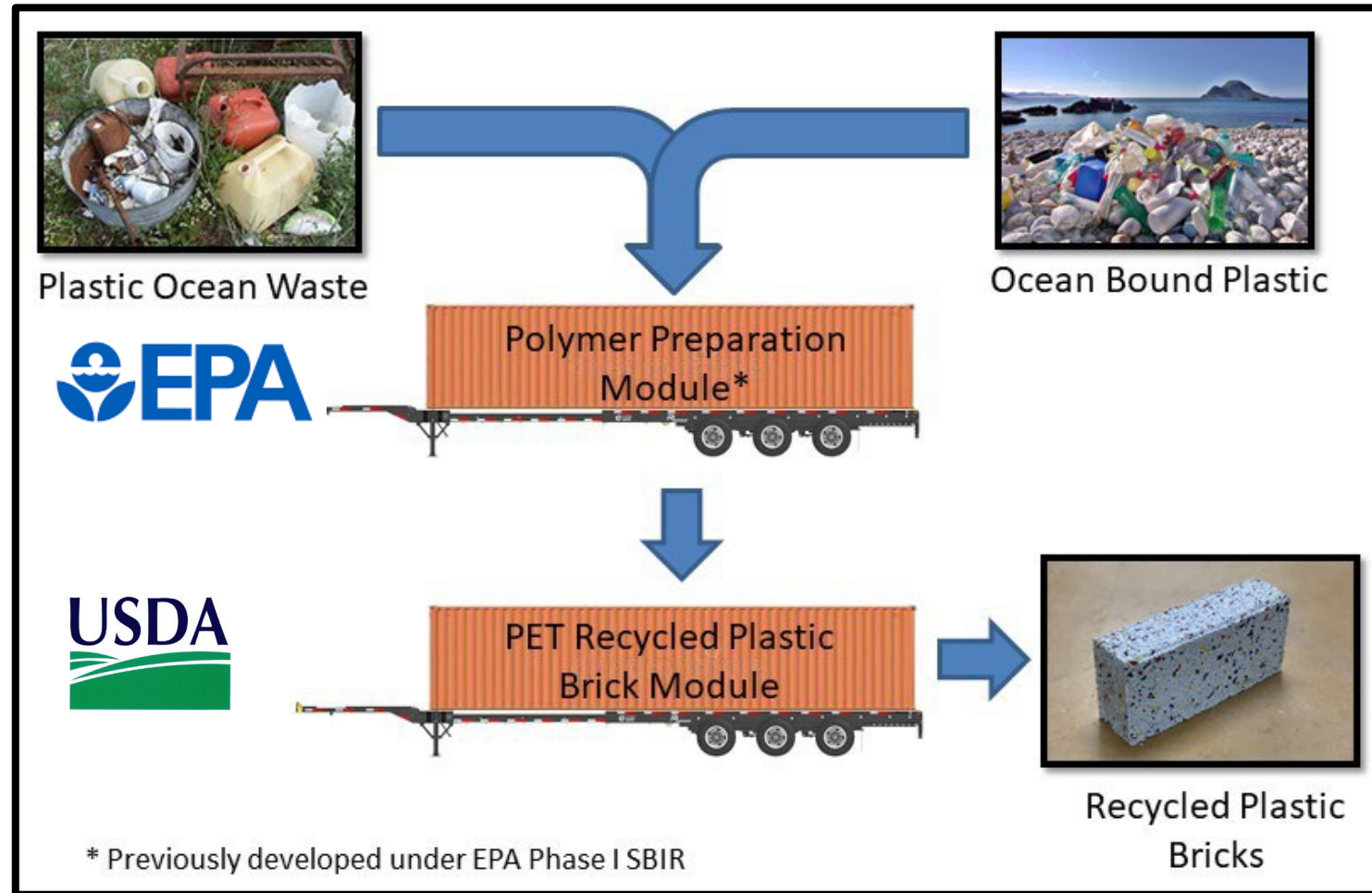
1	2	3	4	5	6	7
PETE	HDPE	PVC	LDPE	PP	PS	OTHER
polyethylene terephthalate	high-density polyethylene	polyvinyl chloride	low-density polyethylene	polypropylene	polystyrene	other plastics, including acrylic, polycarbonate, polyactic fibers, nylon, fiberglass
soft drink bottles, mineral water, fruit juice containers and cooking oil	milk jugs, cleaning agents, laundry detergents, bleaching agents, shampoo bottles, washing and shower soaps	trays for sweets, fruit, plastic packing (bubble foil) and food foils to wrap the foodstuff	crushed bottles, shopping bags, highly-resistant sacks and most of the wrappings	furniture, consumers, luggage, toys as well as bumpers, lining and external borders of the cars	toys, hard packing, refrigerator trays, cosmetic bags, costume jewellery, audio cassettes, CD cases, vending cups	an example of one type is a polycarbonate used for CD production and baby feeding bottles
						



PET Recycled Plastic Bricks



The Mobile PET Plastic Ocean Waste Recycler (POWER) Modular Concept: USDA Phase I SBIR



Commercialization

- Recycled Plastic Construction Materials will generate initial revenue, system sales follow
 - Dunnage, pavers, retaining structure, fencing, decking
- Expansion throughout Alaska
 - Integration with existing recycling and marine debris cleanup programs
- Expansion to Asia-Pacific Countries
 - USAID RFI's, International Outreach

Summary

- There is a LOT of Plastic Ocean Waste on Alaska's Beaches
- There are innovations that can help us to Assess, Collect, and Utilize this Plastic Ocean Waste
- Initial SBIR funding from EPA and USDA is focusing on mobile plastic ocean waste recycling

EPA SBIR Recycling Projects Webinar

Recycling Supply Chain Verification and Measurement System - Blockchain and GIS-Based

Anna-Marie Cook / Kamilo, Inc.

Wednesday March 30th, 2022



Plastic offers many important benefits for society – yet its widespread usage comes with significant negative impacts.



Wasted resource. Less than 10% of plastic is recycled – a lost \$100B resource.



Widespread pollution. Oceans, rivers, soil and ecosystems are increasingly polluted.



Climate. Plastic production has been called “The New Coal.”



Lack of trust. Global recycling system is perceived as broken.



Fraud and criminal trafficking. INTERPOL reports plastic waste crime is booming.



From bad to worse. New plastic production is projected to double by 2040.

Existing recycling claims are largely uncorroborated. Brands need 3rd party verification of recycled content – but currently can't get it.

©CBS NEWS

December 21, 2020

Greenpeace sues Walmart, claiming it lies about plastic being recyclable

Los Angeles Daily News

January 6, 2022

Recycling fraud costing Californians up to \$200 million annually

npr

How Big Oil Misled The Public Into Believing Plastic Would Be Recycled

September 11, 2020 · 5:00 AM ET

Bloomberg Green

September 21, 2021

Regulators Intensify ESG Scrutiny as Greenwashing Explodes

Sierra

THE MAGAZINE OF THE SIERRA CLUB

June 25, 2021

Plastic Bottlers Are Lying About Recycling “100% recyclable”? In your dreams, Coca-Cola.

ADWEEK

September 22, 2021

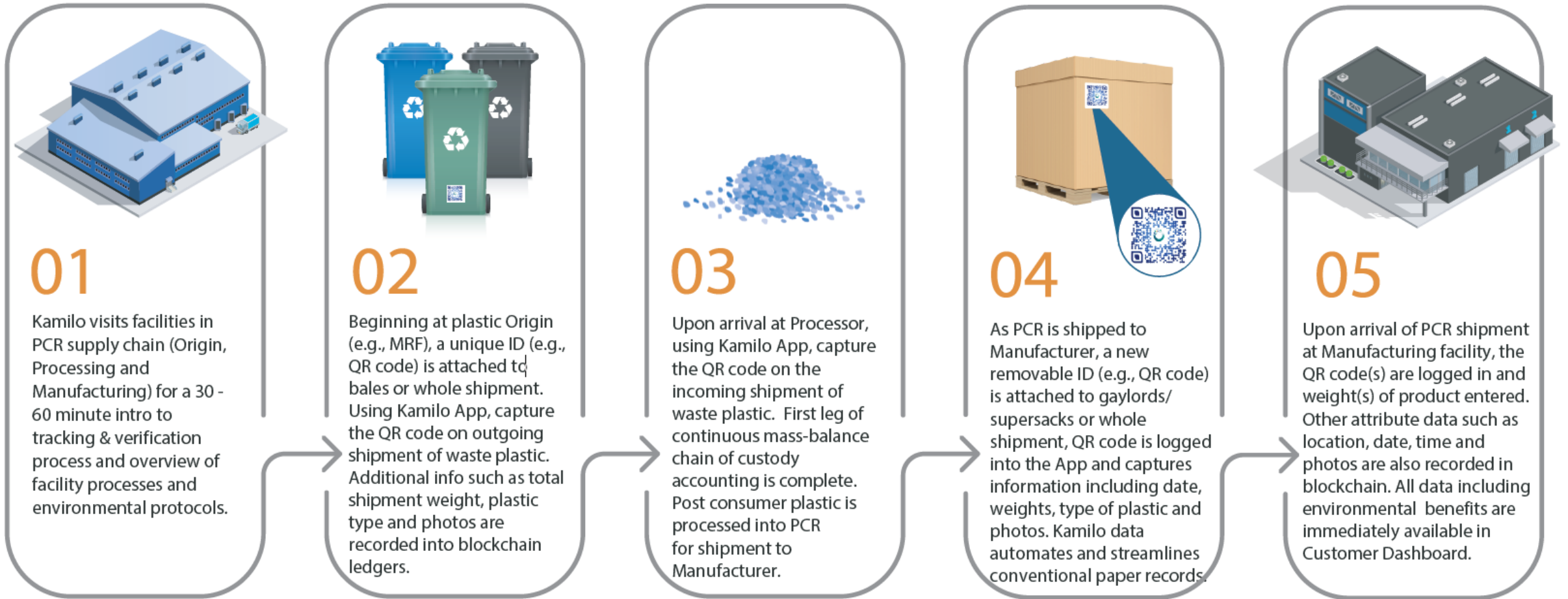
Beverage Brand Innocent Accused of 'Greenwashing' Its Plastics Impact Through Advertising

WASTEDIVE

February 24, 2022

SEC to take hard stand against corporate 'greenwashing'

Our geospatial (GIS) technology platform securely tracks plastic waste through the supply chain and confirms it is recycled into a new product.



Mobile App-based, patent-pending technology platform provides:



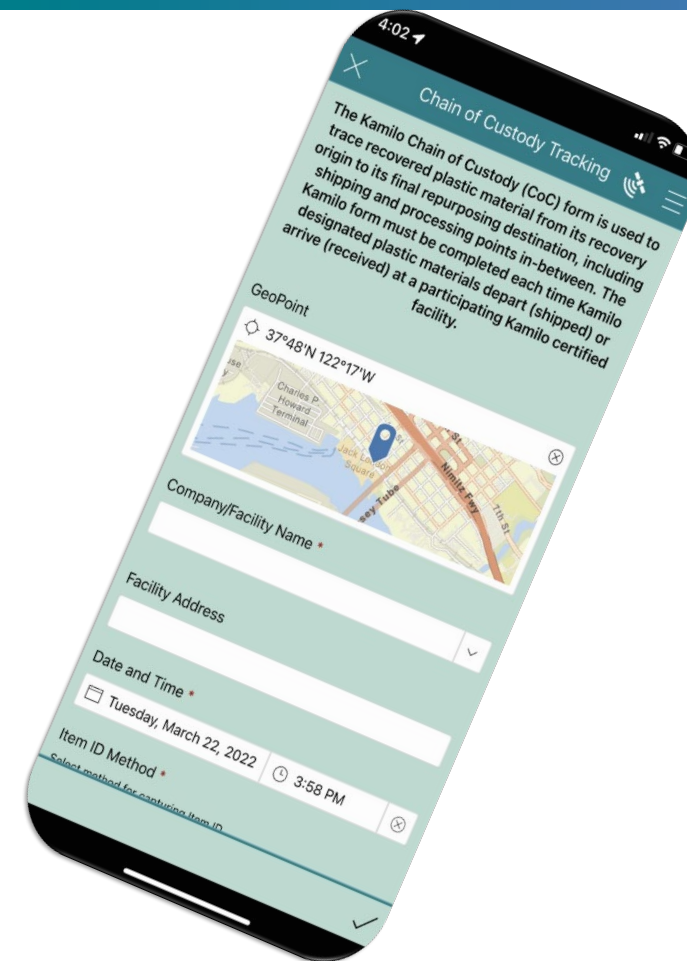
Confirmation of recycling: Plastic waste is tracked and accounted for in real-time from its point of collection/sortation through processing/manufacturing and into the next product using our secure digital Chain-of-Custody (CoC).



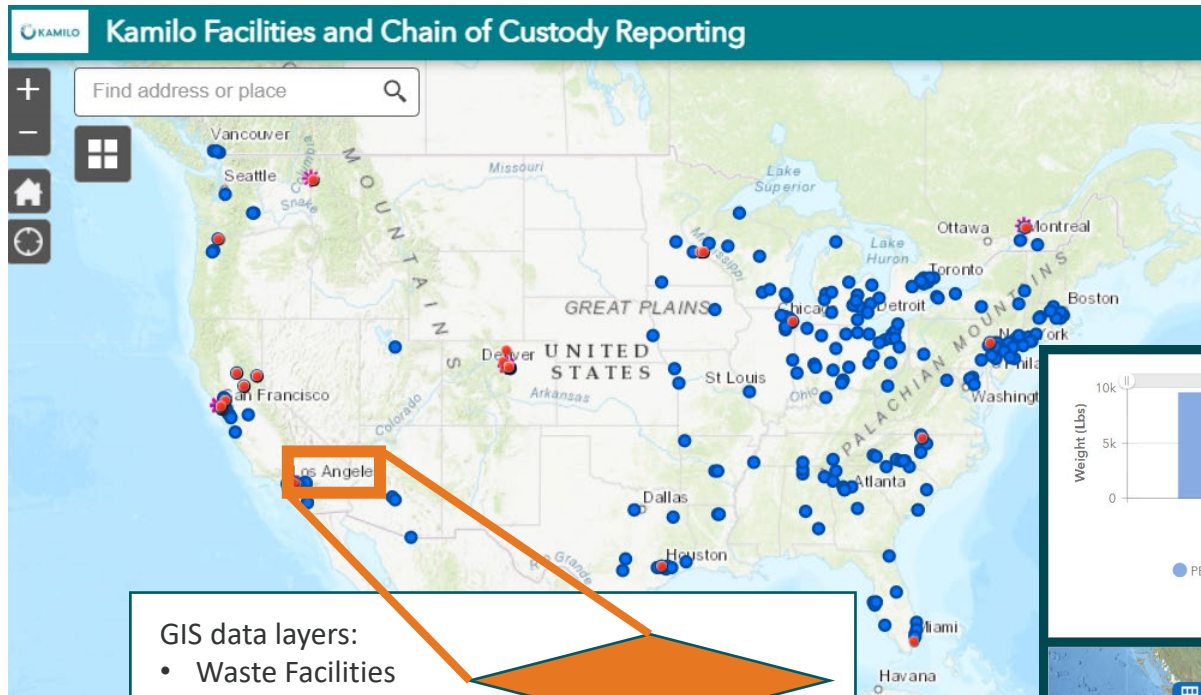
Verification of provenance and recycled content: Processors, manufacturers and brands are able to support their recycling claims with an immutable and auditable CoC created in a Geospatial Information System (GIS) portal deployed in AWS and stored in AWS' Quantum Ledger DataBase (QLDB)



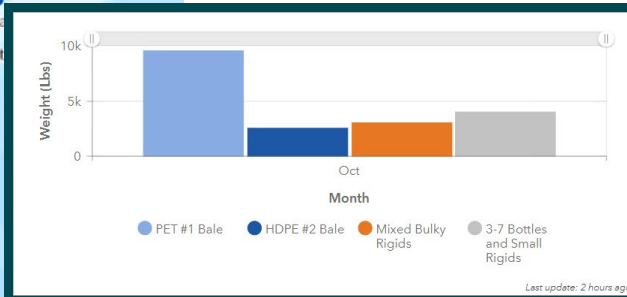
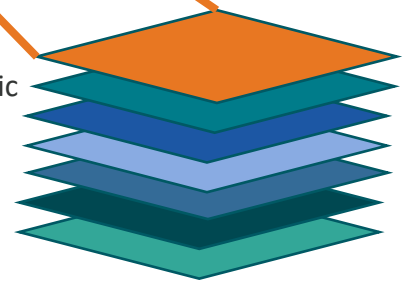
Net Environmental Benefits: ESG impacts such as greenhouse gases (GHG) avoided and landfill space saved are calculated automatically for every customer and continuously updated with each load of plastic waste tracked and confirmed as recycled.



Geospatial tracking enables our client dashboards showing recycling progress and associated net environmental benefits



- GIS data layers:
- Waste Facilities
 - Census – Lbs Plastic Waste per City
 - Construction Sand Saved
 - Total CO2 Avoided
 - Landfill Space Saved
 - Pollution Prevented



<p>Item List Metrics</p> <p>Plastic Recycled (Lbs)</p> <h1>19,000</h1> <p><small>Last update: 2 hours ago</small></p>
<p>CO2e Avoided (Lbs)</p> <h1>38,000</h1> <p><small>Last update: 2 hours ago</small></p>
<p>Landfill Space Saved (Cubic Yards)</p> <h1>570</h1> <p><small>Last update: 2 hours ago</small></p>



Who buys our services...



Municipalities, Processors and Manufacturers

Kamilo enables communities, businesses and recyclers to confirm their plastic waste is recycled and to quantify the climate benefits.



Companies using recycled plastic in products

Kamilo will enable verified recycled content claims and demonstrate origin of recycled plastic using the “Kamilo-verified” TrustMark.



Market Size for Traceability as a Service

**\$2.5
Billion**

Estimate from # of entities in the waste plastic value chain worldwide. Assumes an average of \$7,500/facility/year.

Addressable Market (North America)

Municipalities	20,000+
Processors/ Manufacturers/ Generators	50,000+
Producers Using Recycled Plastic	1,000+
CPG Brands	1,700+

Kamilo's solution has strong initial traction

EPA Phase 1 SBIR contract supports 4 pilot projects in CA demonstrating efficacy of Kamilo technology

Hired by local CA city for plastic waste traceability project to support 3rd party verification legislation

Invited to speak at industry conferences on need for traceability and climate benefits of recycling

Inundated by attendee interest in Kamilo's TaaS offering while attending Recycling Conferences

Latest Partner Quotes

"You have the right team working on the right problem at the right time" -

"This solution will help us restore trust with our customers."

"Your solution is a game changer – not just for our company, but for the industry"



Thank You!



www.kamilo.com
info@kamilo.com



EPA SBIR Innovative Recycling Technologies Webinar

March 30 2022



ZABBLE

Achieving a Zero Waste World

Nik Balachandran
Founder and CEO

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Zabble's mission is to enable **organizations** to achieve **zero waste** by delivering **real-time actionable insights** that **streamline workflows** and **engage stakeholders**

ASSOCIATED WITH



ZABBLE IN THE NEWS



Reduce Waste. Save Money. Protect Earth.

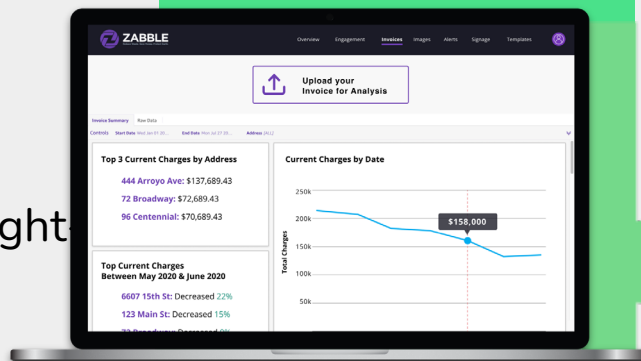
INTRODUCING ZABBLE ZERO™

Patents: 1 Issued, 1 Pending

END-TO-END SAAS PLATFORM FOR WASTE MANAGEMENT AND WORKFLOW AUTOMATION

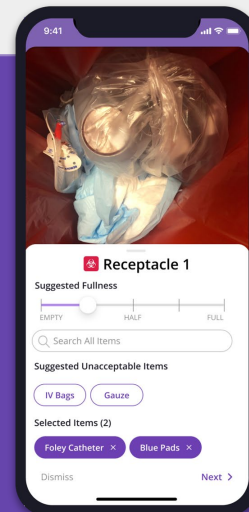
Invoice Analytics

Instantly Digitize Hauler Invoices for Immediate Right sizing Recommendations



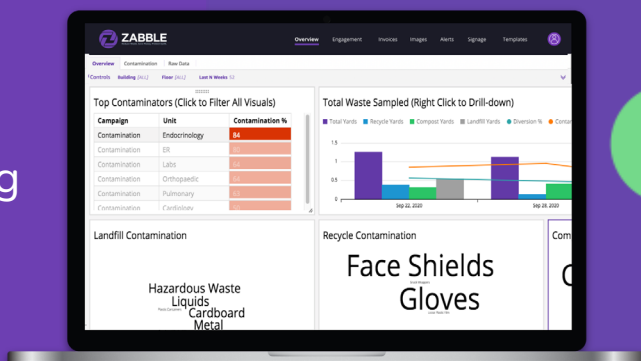
Mobile Tagging

Notify Stakeholders with Real-time Notifications on Contaminants and Maintenance Issues



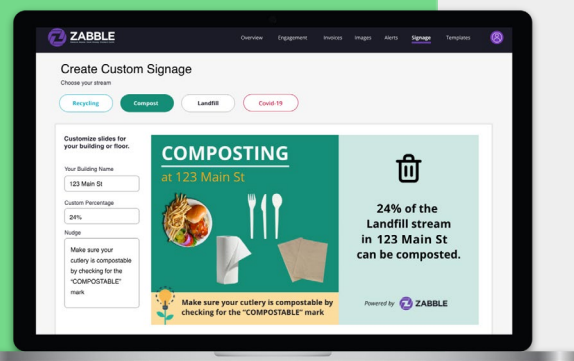
Web Dashboard

Continuously Improve Processes by accessing Granular Insights



Signage

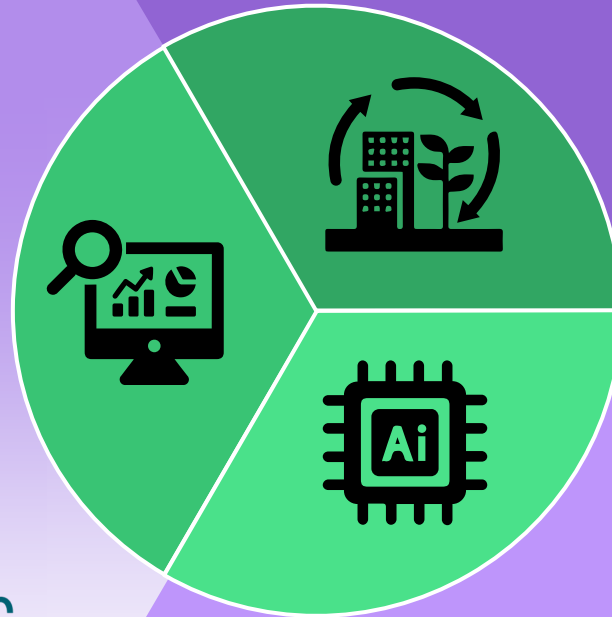
Share Behavior Change Content through Targeted Signage & Outreach



CLOSING THE LOOP FOR ZERO WASTE MANAGEMENT

Industry First End-to-End Digital Transformation

Fully digitize waste inventory, workflows & analytics



Mission-driven to Help Organizations Reach Zero Waste

Full-service solution provider working closely with clients, consultants and haulers

Trusted by



University of California
San Francisco



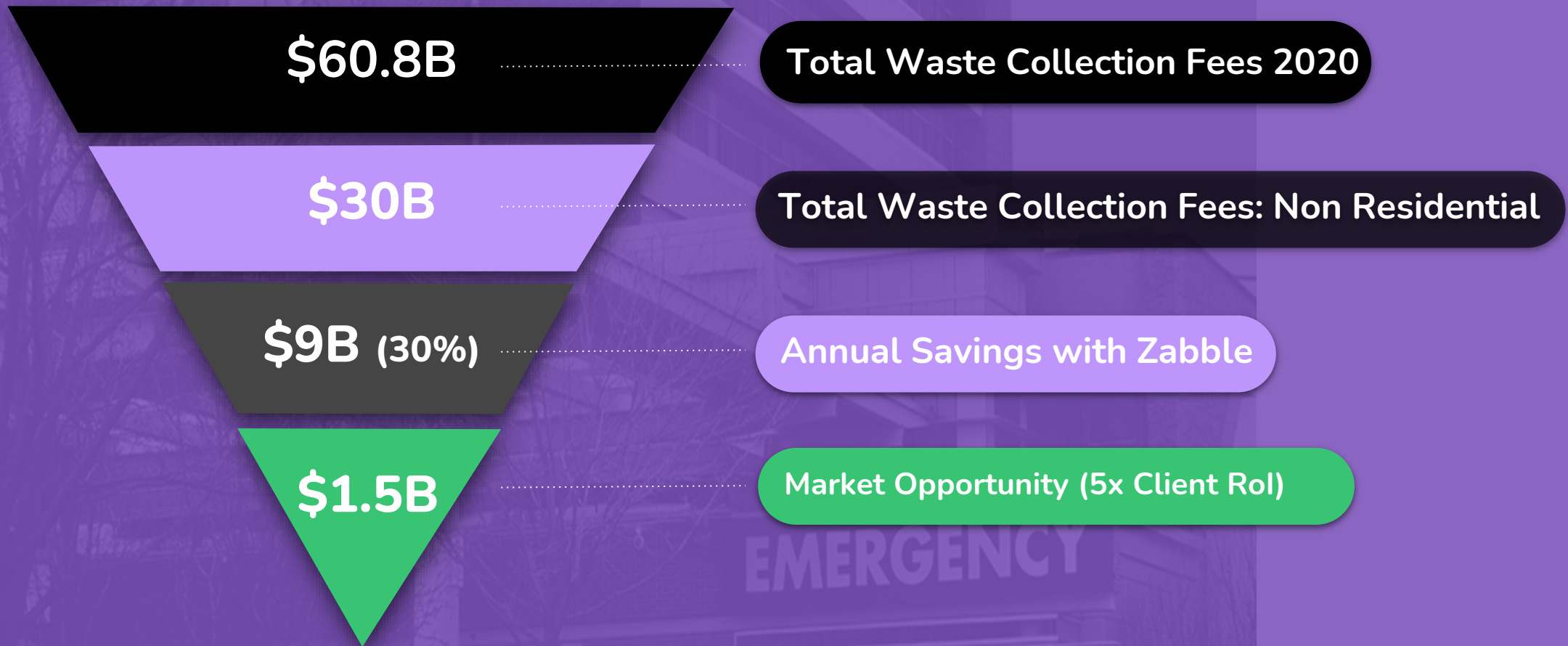
THE RECYCLING
PARTNERSHIP

21st Century Waste Platform with AI

Patented and customizable technology can be deployed in 1 week

TOTAL MARKET OPPORTUNITY = \$1.5B

Initial Target Market: Top 40 Health Systems + Universities = \$155M ARR



IMPACT

Top 40 Health Systems & Universities Generate **4.1M Tons of Waste Every Year**

Source: Estimated from EIA, EPA, Practice Greenhealth

2.7M

Tons
Landfilled or
Incinerated

60-80%

Recoverable
from Landfill

7.8M

MTCO₂e
Potential Annual
GHG Reduction

CASE STUDY: University of California, San Francisco

PROVEN SUCCESS

“The Zabble platform helps analyze the data in ways we have not been able to do so in the past, this will help us target our educational material to move us closer to the Zero Waste Goal.”



UCSF

Daniel Chau
Recycling & Waste
Reduction Manager

Using Zabble Zero at 80+ buildings across 3 campuses

Decreased average annual landfill waste tonnage per building by

16
Tons

Resolved incidents (E-waste, Hazardous Waste, etc.) annually per building

50+

Reduced contamination per building to under


15%

Achieved productivity gains and hauling cost savings within a year of

\$300k

CONTACT US FOR A DEMO

Nik Balachandran
Founder/CEO

 510-366-1023

 nik.balachandran@zabbleinc.com

 www.zabbleinc.com



Zero Waste
Advisor



Former Board Member
Northern California
Recycling Association



Veriflux: An End-to-End Platform for Recycled Waste Traceability

EPA Innovative Recycling Technologies Webinar
March 30, 2022

About Us

Experienced Team with Waste-to-Energy, Engineering & Government Expertise



Dani Charles
CEO &
Co-Founder



Scott Bernard
COO &
Co-Founder



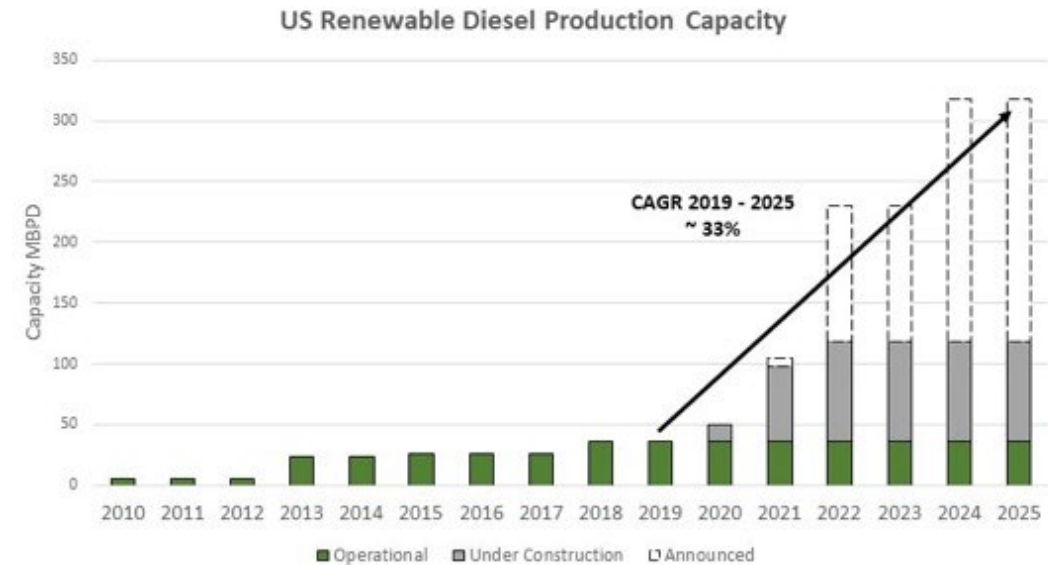
Brian Sobel
Chief Architect &
Head of Engineering



Jenny Tarbox
Head of Product
Management

Spotlight: RD Market

- Renewable diesel (RD) capacity increasing 33% YoY
- Renewable feedstock TAM estimated \$49.2b by 2024
- Federal regulations/mandates
 - U.S. → EPA RFS
 - E.U. → European Commission
 - Canada → Clean Fuel Standard (CFS)
- State credits (LCFS) expanding



Source: Turner, Mason & Company

Regulatory Environment

EPA Title 40: Protection of Environment, Part 80: Regulations of Fuels & Fuel Additives

“Documents demonstrating the amounts, by weight, purchased of...waste oils/fats/greases for use as a feedstock in producing renewable fuel.”

*“Documents demonstrating the location of any establishment(s) from which the waste stream consisting solely of... **waste oils/fats/greases is collected.**”*

European Commission (EU) Renewable Energy Directive II (REDII)

- Includes provisions to set up a single pan-EU database to track all market transactions (from **point of origin**) and the sustainability profile of all biofuels and bioliquids consumed in the EU
- Differentiates between sustainable and unsustainable product

Govts Requiring Traceability to Point of Origin/Collection



Case Study: EU

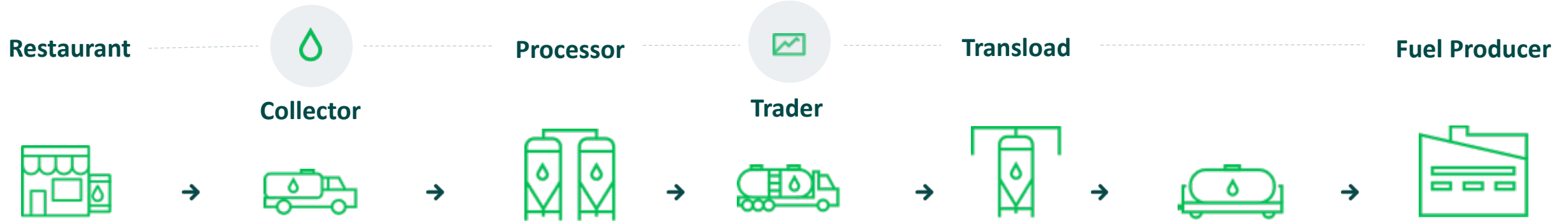
European Court of Auditors

“The audit addressed the question ‘Have the Commission and Member States set up a reliable certification system for sustainable biofuels?’ We conclude that, because of weaknesses in the Commission’s recognition procedure and subsequent supervision of voluntary schemes, the EU certification system for the sustainability of biofuels is not fully reliable.”

- Lack of “reliable statistics with evidence” from Member States
- Third-party certification bodies employed “weak practices”
- Significant concern over social impacts affected by biofuel production



Case Study: Used Cooking Oil (UCO)



Traceability Challenges



Paper



Liquid



Multi-Stakeholder



Competition



Burden

State of Traceability Today

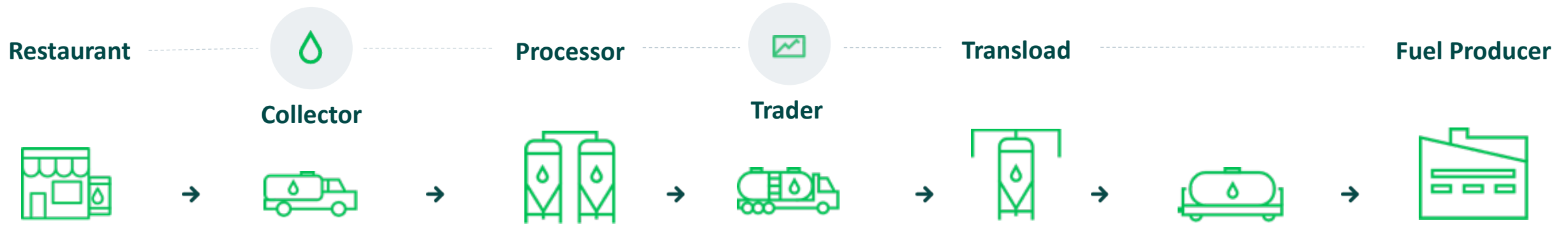
- Self-Certifying
- Spot-Auditing

Why Technology is the Solution

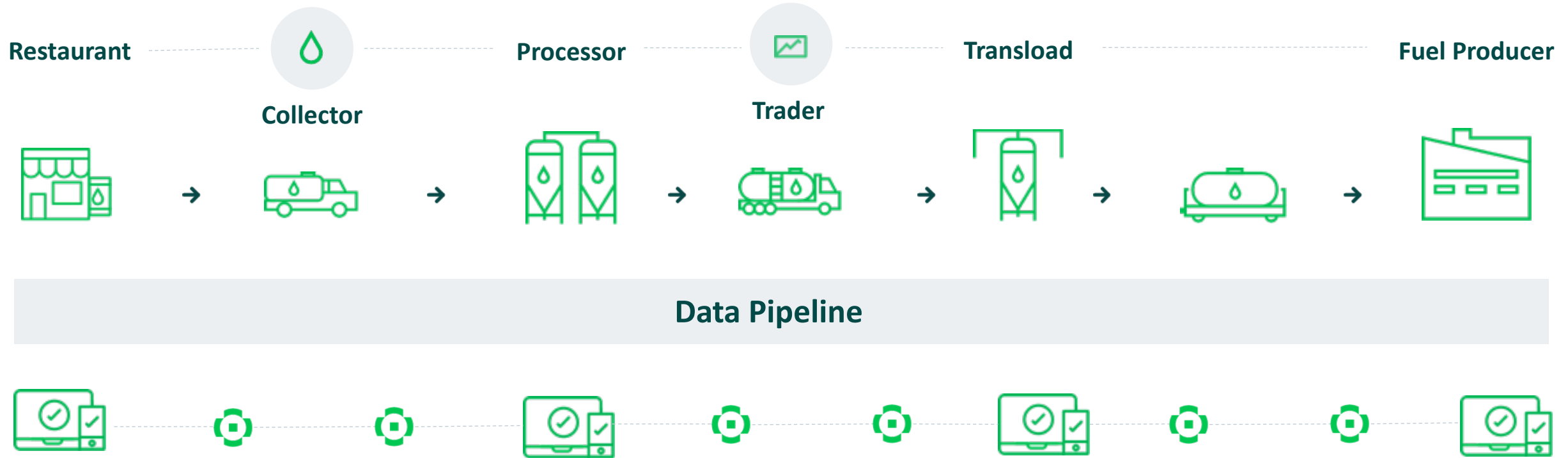
- ~~Self-Certifying~~ **Unauthenticated**
- ~~Spot-Auditing~~ **Unsustainable**

Technology is the solution:
enabling authenticated traceability at scale

Case Study: Used Cooking Oil (UCO)



Case Study: Used Cooking Oil (UCO)



Veriflux enables this today

Innovation Showcase: Veriflux

- Actively capturing and authenticating traceability of feedstock to point of origin / collection

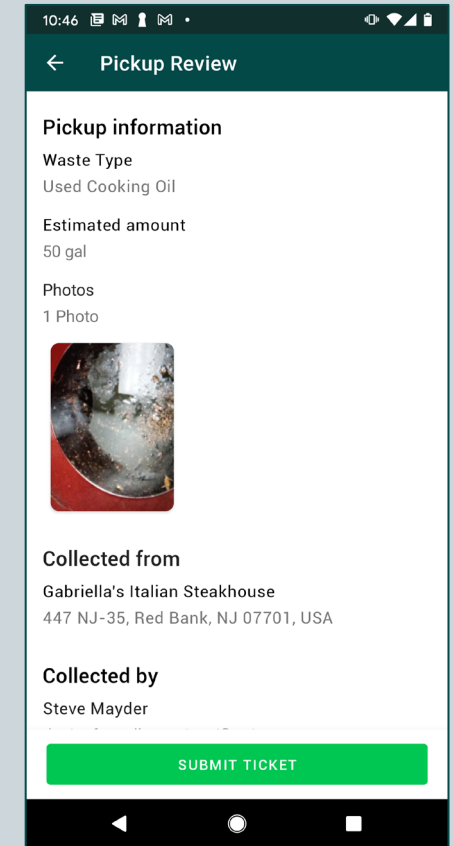
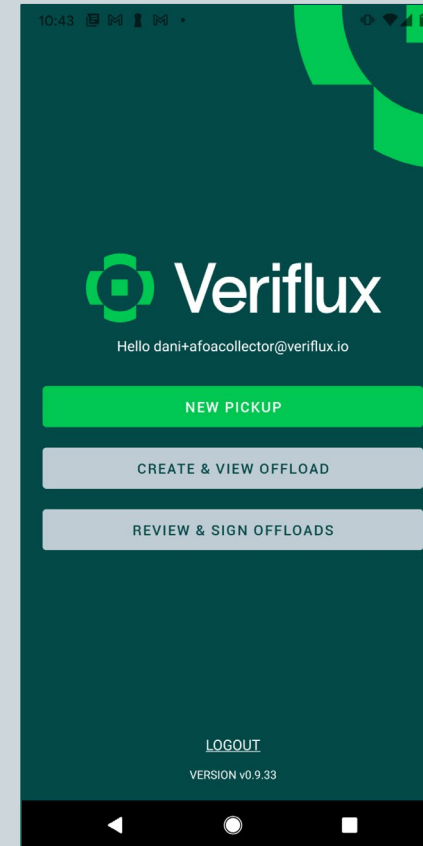
The screenshot displays the Veriflux web application interface. On the left is a navigation sidebar with options: Dashboard/Home, Pickups, Offloads (highlighted), Organizations, Compliance, and Support. The main content area is titled 'Offload Details' and includes the following information:

- Collector and Processor Details:**
 - Collector: [Big City Collectors](#) (Address: 12 Hope St, Brooklyn, NY, USA)
 - Processor: [Big Apple Processing](#) (Address: 20 Hylane, Staten Island, NY, USA)
 - Driver: Steve Mayder
 - Received by: Tom Johnson
- Offload Details:**
 - Waste type: **USED COOKING OIL**
 - Product percentage: 94%
 - Aggregate pickup amount: mlu is 6%
 - Estimated: 200 gal, 1,494 lb
 - Actual: 194 gal, 1,450 lb
 - Actual product amount: 182 gal, 1,383 lb
 - FFA percentage: 14%
- Status:** A legend shows 'Offload initiated' (green dot), 'Offload submitted for approval' (grey dot), and 'Approved' (blue dot).
- Included Pickups:** A map of New York City and Brooklyn with a green route connecting five numbered pickup points (1-5) across the city.
- Artifacts:** A section for 'Collector Sign-Off' featuring a handwritten signature.

Additional UI elements include a 'Back' button, a 'TICKET DOWNLOAD' button, and an 'Initiated: 1/11/2022 6:50:34 PM ET' timestamp.

Innovation Showcase: Veriflux

- Actively capturing and authenticating traceability of feedstock to point of origin / collection
- Customized mobile app that leverages GPS and other atmospheric data



Innovation Showcase: Veriflux

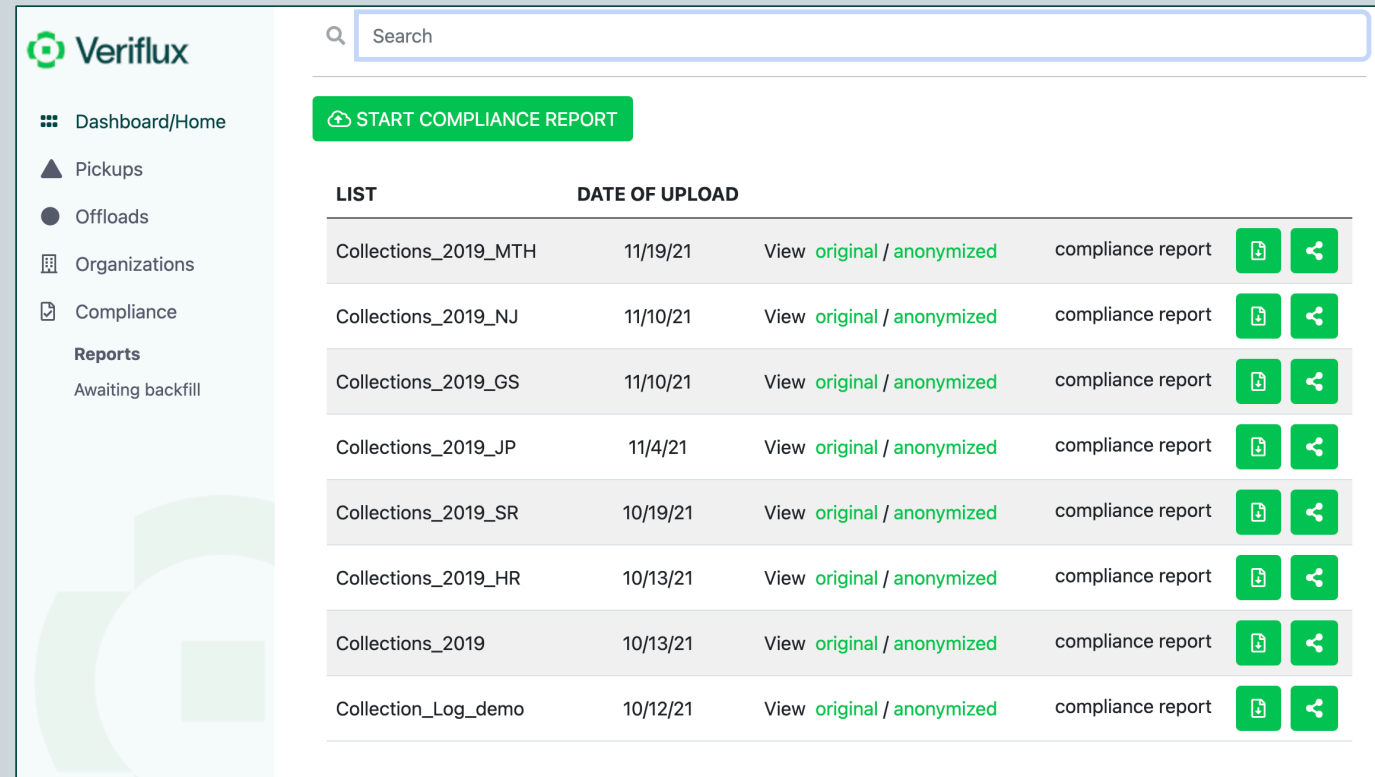
- Actively capturing and authenticating traceability of feedstock to point of origin / collection
- Customized mobile app that leverages GPS and other atmospheric data
- Intuitive, user-centric web platform

The screenshot displays the Veriflux web interface. On the left is a navigation sidebar with the Veriflux logo and menu items: Dashboard/Home, Pickups (highlighted), Offloads, Organizations, and Compliance. The main content area is titled 'Pickups' and includes a search bar, filter options (Collector, Driver, Waste Source, Waste Type, Additional), and a 'RESET ALL' button. Below the filters, it shows '25/71 PICKUPS' and a timestamp filter set to '2021/12/10 23:00'. A table lists the pickup records with columns for DATE, WASTE TYPE, SOURCE NAME, SOURCE LOCATION, EST. AMOUNT, and STATUS.

















DATE	WASTE TYPE	SOURCE NAME	SOURCE LOCATION	EST. AMOUNT	STATUS
12/10/21 10:52 AM ET	USED COOKING OIL	CHICK-FIL-A	4201 CHANTILLY SHOPPING CENTER, CHANTILLY, VA 20151, USA	45 gal 🗑️ 336 lb	>
12/10/21 10:52 AM ET	USED COOKING OIL	WILLARD'S REAL PIT BBQ	4300 CHANTILLY SHOPPING CENTER # 1A, CHANTILLY, VA 20151, USA	60 gal 🗑️ 448 lb	>
12/10/21 10:52 AM ET	USED COOKING OIL	POTBELLY SANDWICH SHOP	14396 CHANTILLY CROSSING LN, CHANTILLY, VA 20151, USA	45 gal 🗑️ 336 lb	>
12/10/21 10:45 AM ET	USED COOKING OIL	JIMMYS OLD TOWN TAVERN	697 SPRING ST, HERNDON, VA 20170, USA	50 gal 🗑️ 374 lb	>

Innovation Showcase: Veriflux

- Actively capturing and authenticating traceability of feedstock to point of origin / collection
- Customized mobile app that leverages GPS and other atmospheric data
- Intuitive, user-centric web platform
- Compliance Portal



The screenshot displays the Veriflux web platform interface. On the left is a navigation sidebar with the Veriflux logo and menu items: Dashboard/Home, Pickups, Offloads, Organizations, Compliance, and Reports (with a sub-item 'Awaiting backfill'). The main content area features a search bar, a 'START COMPLIANCE REPORT' button, and a table of reports.

LIST	DATE OF UPLOAD				
Collections_2019_MTH	11/19/21	View	original / anonymized	compliance report	 
Collections_2019_NJ	11/10/21	View	original / anonymized	compliance report	 
Collections_2019_GS	11/10/21	View	original / anonymized	compliance report	 
Collections_2019_JP	11/4/21	View	original / anonymized	compliance report	 
Collections_2019_SR	10/19/21	View	original / anonymized	compliance report	 
Collections_2019_HR	10/13/21	View	original / anonymized	compliance report	 
Collections_2019	10/13/21	View	original / anonymized	compliance report	 
Collection_Log_demo	10/12/21	View	original / anonymized	compliance report	 

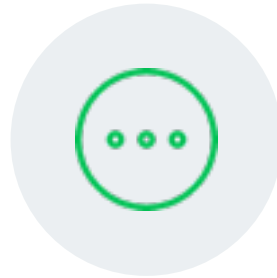
Veriflux Differentiators



**Workflow
Digitization**



**Stream
Tokenization**



**Transaction
Traceability**



**Differential
Visibility**



**Comprehensive
Auditability**



Questions?

Dani Charles
dani@veriflux.io
www.veriflux.io



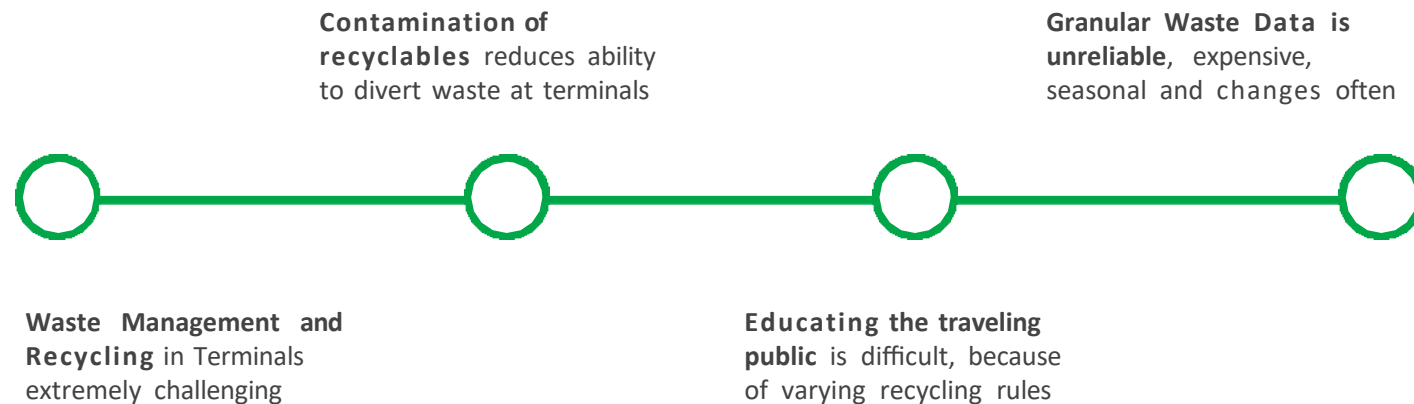


Piloting with CleanRobotics

The Industry Problem

Recycling rules are complex and vary based on location, which results in user confusion when throwing items away. In facilities with transient populations, this leads to large-scale contamination, low recycling yields and poor diversion. The only way to increase diversion and achieve zero waste is to invest in on-site data collection and sorting technology.

The Airport's Reasons for a TrashBot Pilot

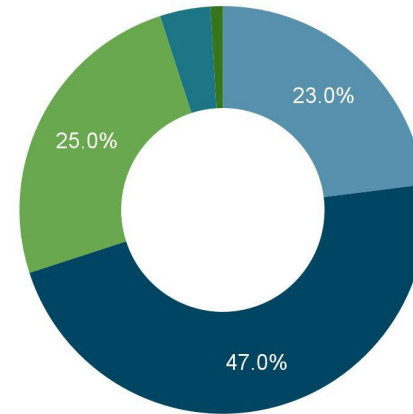


The Historical Problem

Most participants feel they know what items can be recycled. However, when unsure, items tend to be thrown in the trash.

Source: Trash Container Survey.
Sample Size: 300. Historical Data
from report 2018

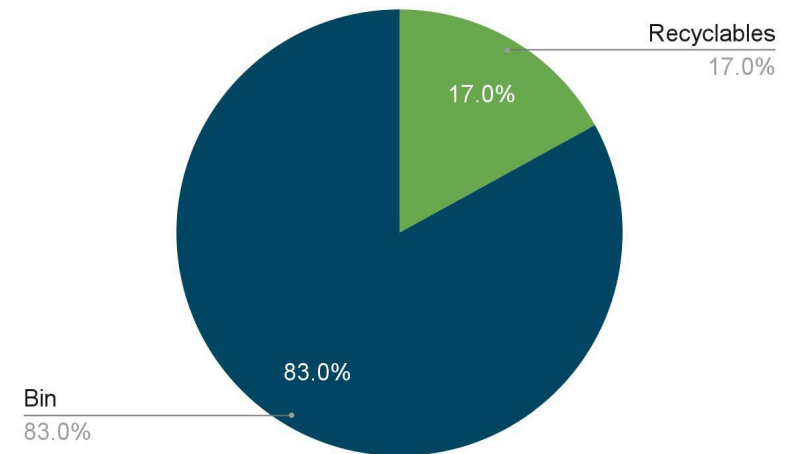
- Completely Certain
- Very Certain
- Moderately Certain
- Somewhat Certain
- Not at All Certain



How certain are you of what items can be recycled?

(1-5 Scale, where 1= not certain at all, and 5=completely certain)

When unsure if an item can be recycled, how do you tend to discard it?



The Why:

Respondent Profile

Top Countries of Residence

US	85%
Mexico	3%
Canada	2%

Top States of Residence Among US Residents

Texas	34%
California	7%
Colorado	5%
Illinois	4%
Oklahoma	4%



6.7

Average Trips
Per Passenger



22%

Local
Residents



59%

Non-Business Travelers



41%

Business Travelers



Average
Age

43



52%

Male Travelers



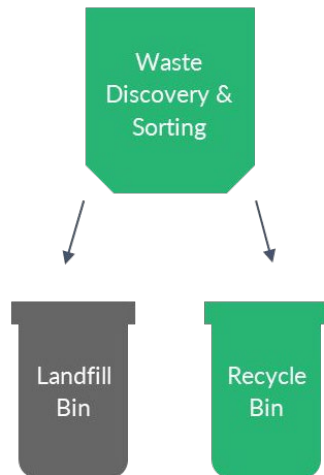
48%

Female Travelers

Source: Trash Container Survey. Sample Size: 300. Historical Data from report 2018

TrashBot Technology

Robotically separating landfill waste from recyclables, our AI is 3x more accurate than human beings at the point of disposal. TrashBot also changes color and notifies custodians when it's getting full.

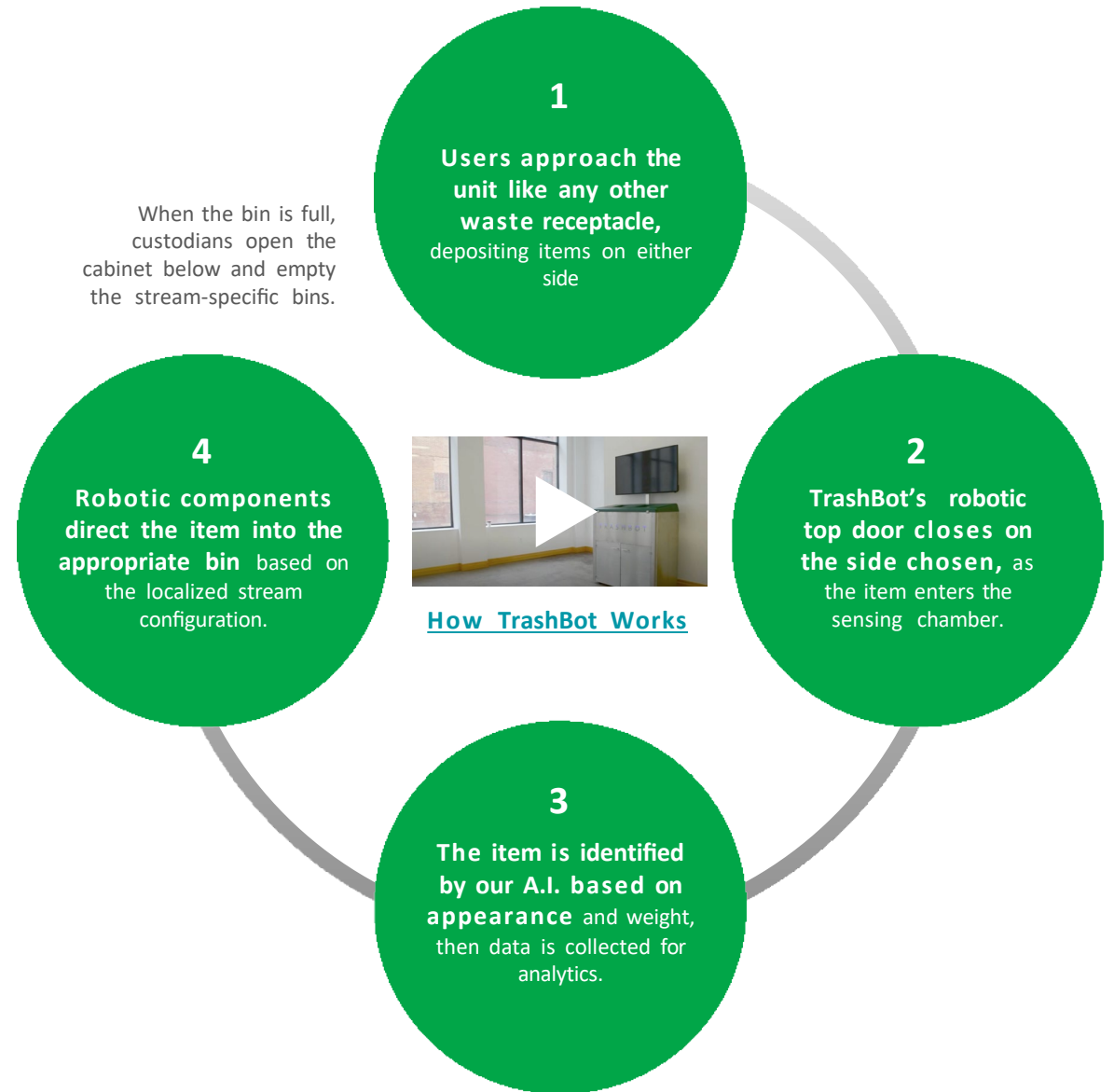


Facilities

- Save on landfill costs
- Easier on custodial staff
- Ability to make data-driven decisions
- Granular waste data

Features

- Automated sorting
- Machine learning
- Computer vision



The Approach:

Measuring Success for the Pilot

GOALS FOR PILOT

1. 95% Sorting Accuracy
2. Eliminate decision making required of the general public
3. Ability to send collected materials to a recycling facility
4. Adapting Sorting AI Remotely
5. Business intelligence surrounding labor management and service levels
6. Conclusive data related to the use of waste supplies

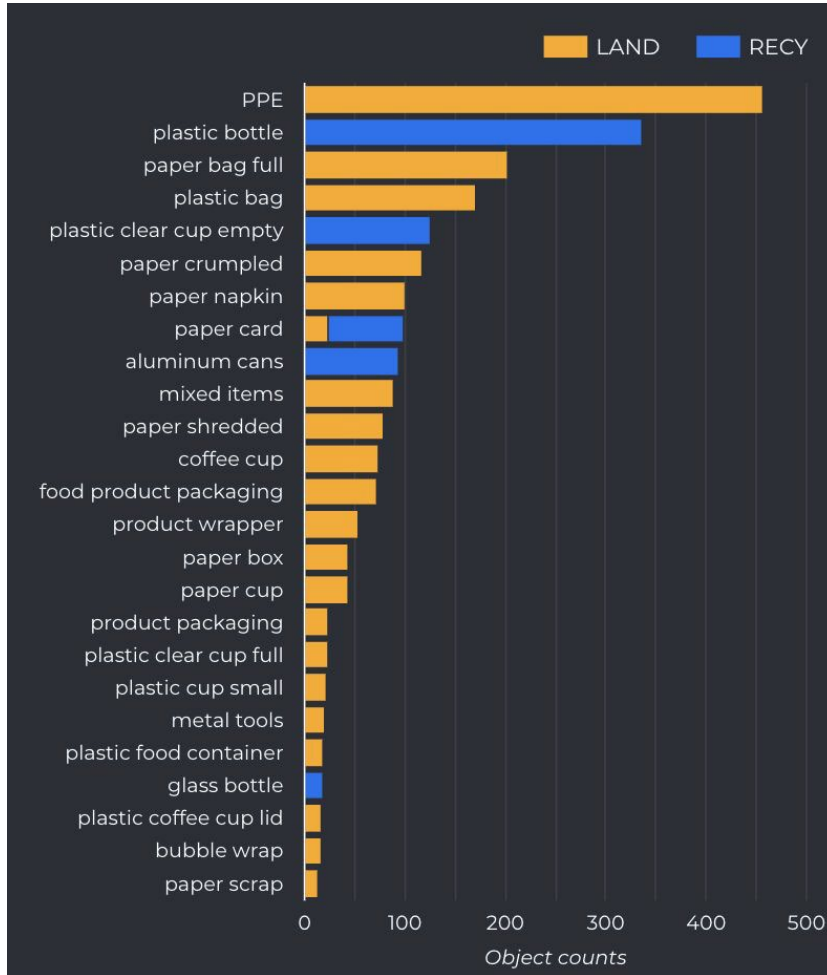


PILOT DATA OVERVIEW

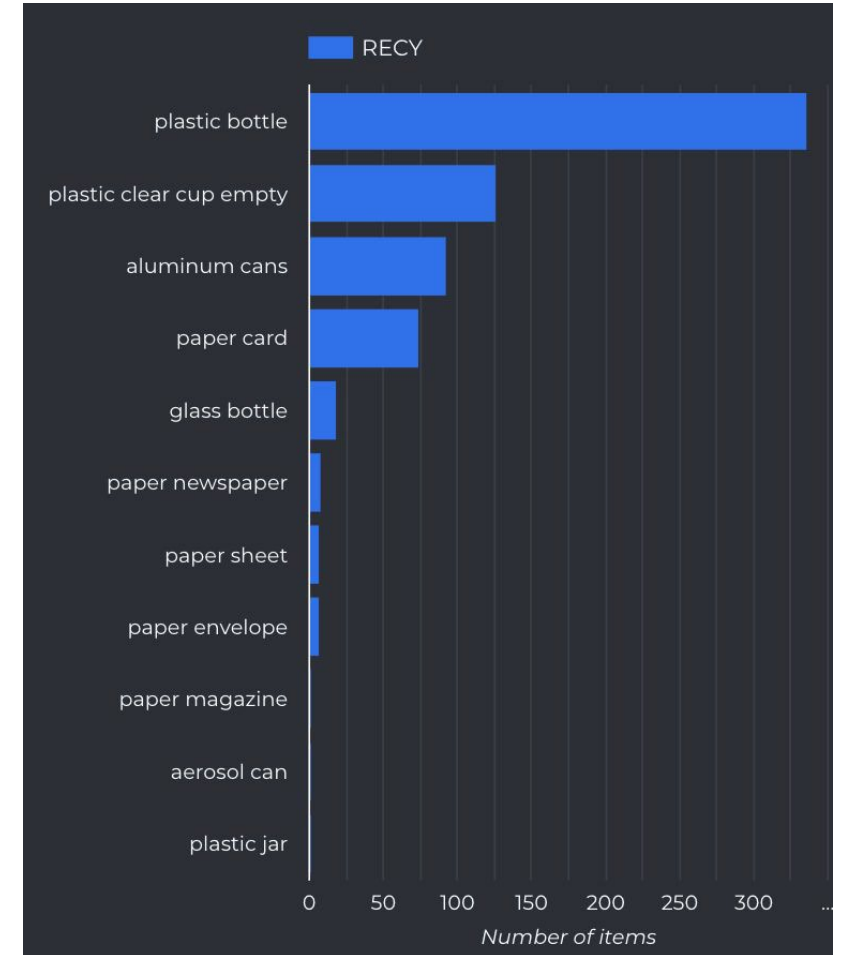


Live Data From TrashBot's Dashboard

Total Number of Items Disposed



Commonly Recycled Items



Live Data From TrashBot's Dashboard

90.4

Landfill, lbs

61.5

Recyclables, lbs

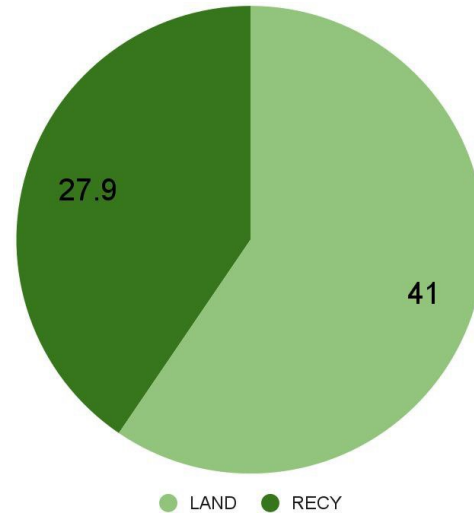
40.49%

Diversion rate

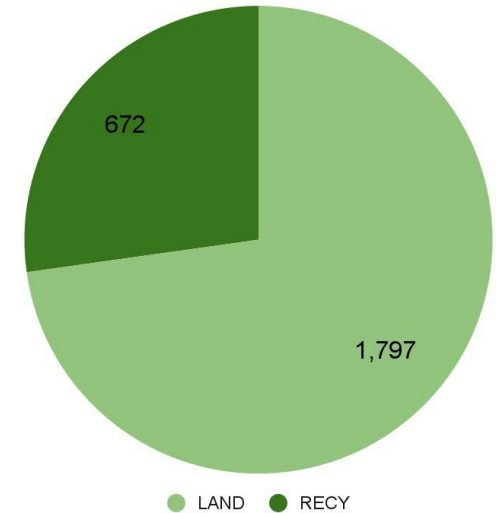
306

CO2 Abated, lbs

Items processed, kg

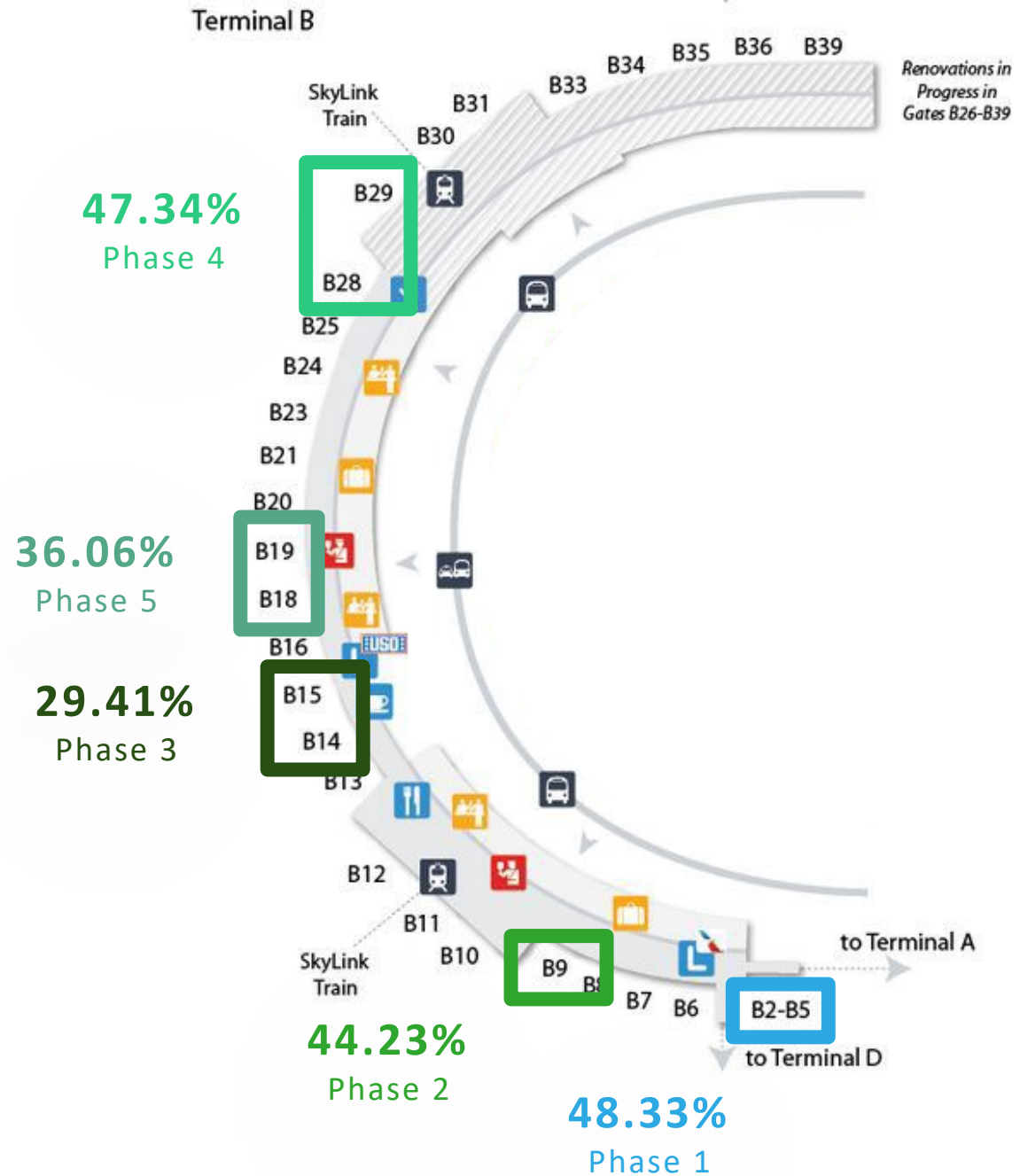


of User Interactions/
Counts of Items Processed

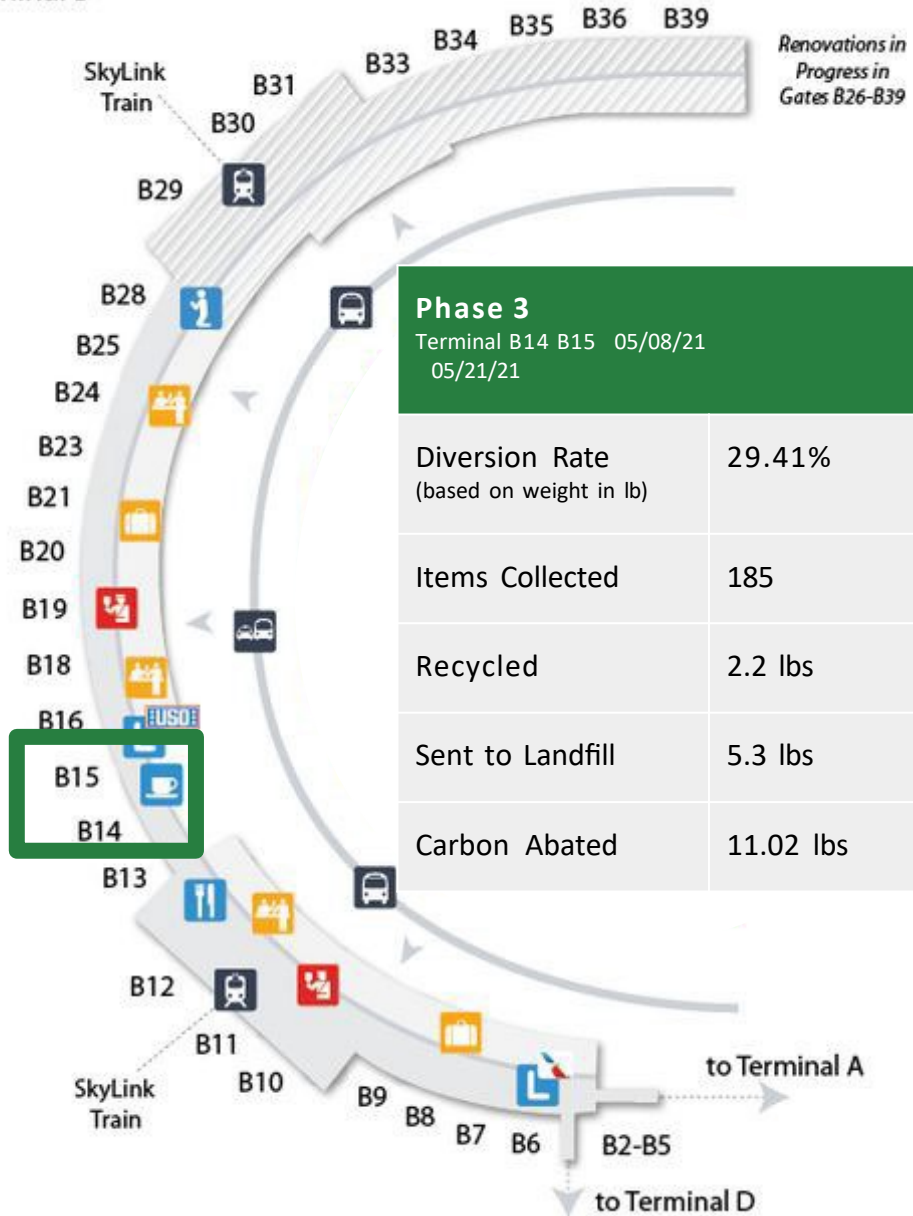


**Abatement is calculated using the EPA WARM Model*

Diversion Rate Mapping



Terminal B



****The diversion rate in this phase** was much lower than other phases because of where it was placed. Being close to a food and drink area showed us that by adding a compost stream and reducing bag usage, we will be able to see a higher diversion rate**

Phase 1 Terminal B3 and B5 04/01/21 04/23/21		Phase 2 Terminal B9 04/24/21 05/07/21		Phase 3 Terminal B14 B15 05/08/21 05/21/21		Phase 4 Terminal B28 B29 05/22/21 06/11/21		Phase 5 Terminal B18 and 19 06/12/21 07/05/21	
Diversion Rate (based on weight in lb)	48.33 %	Diversion Rate (based on weight in lb)	44.23 %	Diversion Rate (based on weight in lb)	29.41 %	Diversion Rate (based on weight in lb)	47.34 %	Diversion Rate (based on weight in lb)	36.06 %
Items Collected	277	Items Collected	147	Items Collected	185	Items Collected	773	Items Collected	1087
Recycled	6.4 lbs	Recycled	5.07 lbs	Recycled	2.2 lbs	Recycled	19.6 lbs	Recycled	28.3 lbs
Sent to Landfill	6.8 lbs	Sent to Landfill	6.4 lbs	Sent to Landfill	5.3 lbs	Sent to Landfill	21.8 lbs	Sent to Landfill	50 lbs
Carbon Abated	31.9 lbs	Carbon Abated	25.3 lbs	Carbon Abated	11.02 lbs	Carbon Abated	98 lbs	Carbon Abated	141 lbs

*Abatement is calculated using the EPA WARM Model



ENVIRONMENTAL IMPACT OVERVIEW





Impact of 1 TrashBot placed in Terminal B

Over Course of 13 Week Pilot

Sorted 2,469 items with 96% accuracy

- Conventional sorting is only 30% accurate

Diverted 61.5 lbs of recyclables

- Compared to 0 lbs with conventional bins

Abated 307 pounds of carbon dioxide equivalent

Projected for a 1 year full roll out**

Sort 20,000 items with 96% accuracy

- Conventional sorting is only 30% accurate

Diverted 20,833 lbs of recyclables

- Compared to 0 lbs with conventional bins

Abate 27.78 MTCO₂e

- Equal to taking four cars off the road for a year.

These figures are calculated based on Pilot data, the EPA WARM Model, and a Top Down analysis of Airport Data



**240 TrashBots will
Educate more than
200M passengers**
Valued conservatively at
\$1.8M (CPM of \$9)



Impact of 40 TrashBots at Terminal B

Projected for a 1 year full roll out*

Sort 800,000 items with 96% accuracy
Conventional sorting is only 30% accurate

Divert 417 T of recyclables
Compared to 0 lbs per conventional bins

Abate 1,111.30 MTCO_{2e}
Equal to taking 222 cars off the road for a
year

Impact of 240 TrashBots Across All Terminals

Over 5 Years

Projected for a 5 year full roll out*

Divert 12,500 T of recyclables
Compared to 0 lbs with conventional bins

Abate 36,750 MTCO_{2e}
Equal to taking eight hundred cars off the road
for a year

***These figures are calculated based on Pilot data, the EPA WARM Model, and a
Top Down analysis of Airport Data***

FINANCIAL IMPACT OVERVIEW



Immediate Financial Impact

# of TrashBots	1	10	40	100	240
Tons of Materials Recycled	10.42	104	417	1,042	2,500
Recycling Rebate	\$208	\$2,083	\$8,333	\$20,833	\$50,000
Cost of Landfill	\$(468.75)	\$(4,687)	\$(18,750)	\$(46,875)	\$(112,500)
Total Savings from a Improved Diversion Rate	\$677	\$6,770	\$27,083	\$67,708	\$162,500

Airport's Trash Bag Expenses Analyzed Based on Passenger Traffic in 2021

Location	Terminal A	Terminal B	Terminal C	Terminal D	Terminal E
		\$64,063		\$61,772	\$69,065
		55		32	43
		10,002,894		9,207,943	9,524,779
		\$0.64		\$0.67	\$0.73

**Terminals A, C, and half of D are managed by a private entity*





“We were overestimating waste.

Before we optimized waste measurement from our monitoring systems, our estimates assumed that bins were full each time they were emptied, leading us to overestimate waste by as much as 50 percent.

We also found that products often ended up in the wrong bins. We used this information to better target our efforts and raise employee awareness.”

APPLE'S 2020 ENVIRONMENTAL PROGRESS REPORT

How TrashBot Can Save Money on Custodial Supplies

Data provided by the Airport shows the airport is overspending on trash bags. We were able to break down the cost of trash bags per 100 passengers at each terminal averaging a bag cost of \$0.55.

Utilizing TrashBot's Fullness Indication we would accurately be able to show when the TrashBot or surrounding waste bins are full, allowing for a more accurate and efficient use supplies resulting in savings on materials and operational costs.

Reduction	20%	30%	40%	50%
Amount Saved	\$57,739	\$86,609	\$115,479	\$144,349

\$288,698.65
2021 Total Trash Bag Expenses



How TrashBot Can Save Money on Custodial Labor Costs

Since we know the airport has savings opportunities for trash bags, the same assumptions can be made regarding custodial labor. We were able to calculate annual spending based upon the following assumptions:

10 Employees Total, Working 40/hrs per week at a rate of \$22/hr.

Reduction	20%	30%	40%	50%
Amount Saved	\$91,520	\$137,280	\$183,040	\$228,800

\$457,600.00
Total Custodial
Collections Expenses



Financial Impact Summary

# of TrashBots	1	10	40	100	240
Total Diversion Savings	\$677	\$6,771	\$27,083	\$67,708	\$162,500
Total Trash Bag Savings	\$600	\$6,000	\$24,000	\$60,000	\$144,000
Total Labor Savings	\$953	\$9,533	\$38,133	\$95,333	\$228,800
Gross Savings per Year	\$2,230	\$22,304	\$89,217	\$223,042	\$535,300

5 Year Projected Savings* **\$16,290** **\$162,900** **\$651,600** **\$1,629,000** **\$3,909,600**

*Bag and Labor Savings added after Year One, Carbon Savings after Year Two.

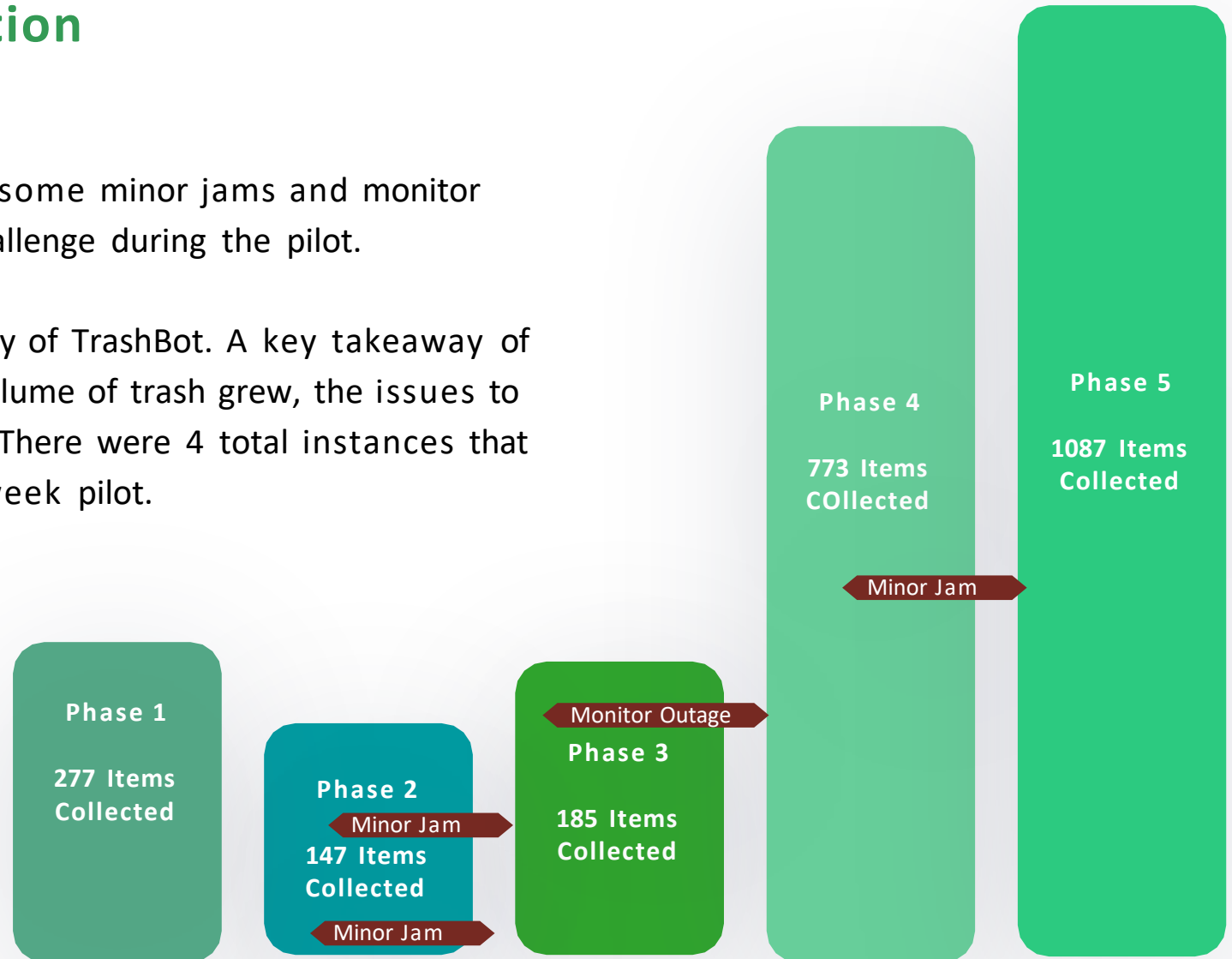
Lessons Learned & New Hardware



Pilot Challenge Visualization

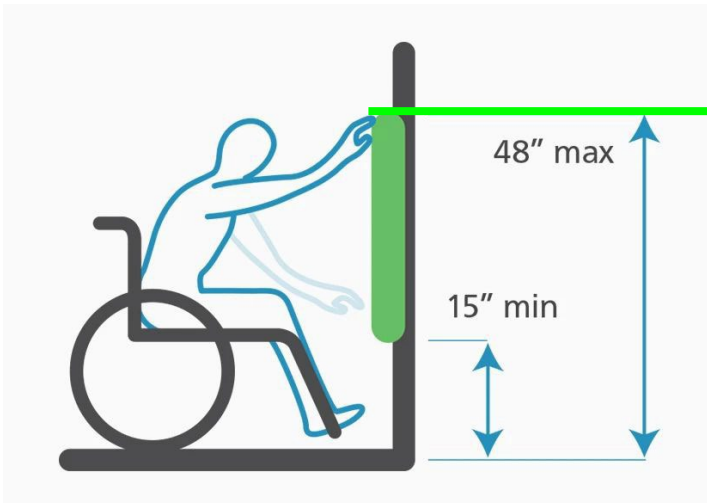
Over the course of the pilot we detected some minor jams and monitor outages, which represented the main challenge during the pilot.

Airport traffic relies on the full functionality of TrashBot. A key takeaway of the success of the pilot is that, as the volume of trash grew, the issues to troubleshoot saw a significant decrease. There were 4 total instances that needed resolution during during the 13-week pilot.



ADA Height Regulations

- Range of height requirements: 10 inches for wall outlets, 60 inches for pay-phone coin-slots no specifications on Bins, apart from those around ATM's (54 inches, max)
- We settled on ATM and Payphone limitations given our capacity and technical requirements
- ATM bin requirement is at 54 inches; we thought that was too high.
- By way of comparison, the common reverse vending machine user portal is 60-54 inches high.
- They've been deployed in malls, grocery stores, airports around the country.
- Sited from ADA relevant for wheelchairs are sections:
4.2.5, 4.2.6, 4.3.4, 4.27.3



Pilot Findings

Key Takeaways

1. Robotic Sorting can ensure 95 to 99% sorting accuracy, compared to the public at less than 30%
2. The available front of house diversion rate with robotic sorting is between 20 and 66%
3. The amount of divertable waste varies significantly depending on the location within the Terminal. Concession areas rarely have more than 20% of recyclable waste.

What's Next

1. Better Fullness indication
2. Business intelligence on custodial services
3. Improved user experience with content
4. Organic Waste Collection
5. Scaling up / verifying extrapolations
6. Economic viability



The Conclusion:

Make TrashBot Better.

During the Pilot:

- Updated the monitor content to create a better user experience.

Post Pilot:

- SMS service for custodial staff
- New dashboard for better reporting and easier data manipulation
 - Real-time operating status of each unit

Hardware Redesign

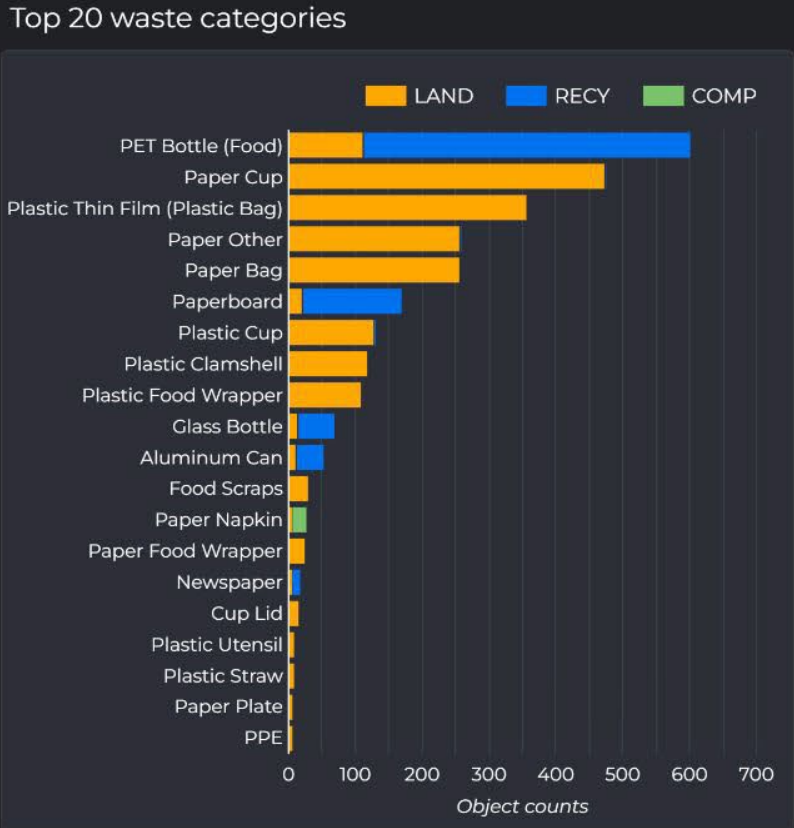
- Lower profile
- Support of Composting
- Up to 4 streams of waste
- Edge AI resulting in faster sorting speed and improved reliability
- Sensors to detect custodial interactions

New Analytics Dashboard

- Disposals overview
- Contamination
- Trashbot fleet
- Data Export

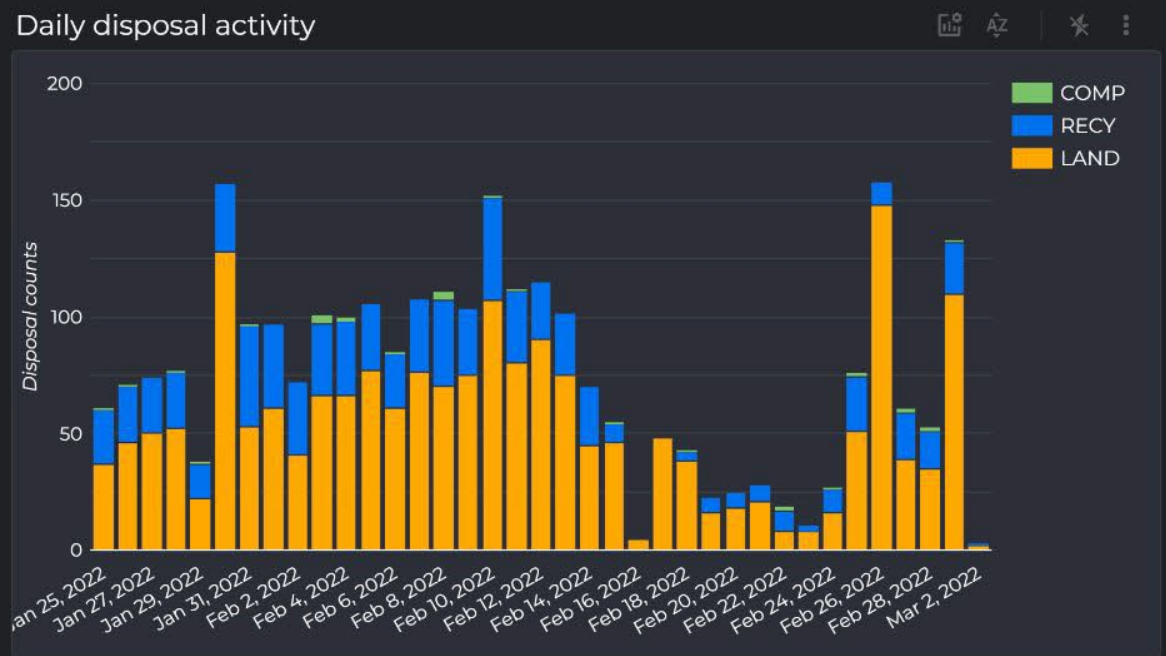
Disposals Overview

Waste streams: Streams
Item category: Category
Time period: Nov 19, 2021 - Dec 31, 2022
Trashbot name(s): Names: Exclude BIOPAK1, BIOPAK2 (2)



Summary metrics

Recyclables, lb	Landfill, lb	Carbon abated, lb	Diversion rate
29.7	173.2	87.32	11.26%



Questions?

- For Questions/Feedback
 - Please use the chat or
 - Raise your hand
 - Can also reach out to companies directly
- Slides will be posted on EPA SBIR Events Page
- Speakers
 - **Rebecca Popowsky** [OLIN](#) (Philadelphia, Pennsylvania)
 - **Patrick K. Simpson** [PKS Consulting, Inc.](#) (Anchorage, Alaska)
 - **Anna-Marie Cook** [Kamilo, Inc.](#) (San Francisco, California)
 - **Nik Balachandran** [Zabble Inc.](#) (Walnut Creek, California)
 - **Dani Charles** [Veriflux Corp](#) (Washington, D.C.)
 - **Zak Wehman** [CleanRobotics, Inc](#) (Longmont, Colorado)



For More Information

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Website: www.epa.gov/sbir

Listserv: <https://www.epa.gov/sbir/sbir-listserv>

SBA SBIR website: www.SBIR.gov

Sustainable Materials Management @ EPA:

<https://www.epa.gov/smm>

Coming soon

- **2nd SBIR Sustainable Materials Webinar**
 - 7 materials projects related to embodied carbon, resiliency, beneficial reuse, and alternatives to single use plastics
 - Wednesday April 13th @ 2:00 pm EDT
 - Register here:
www.eventbrite.com/e/epa-sbir-sustainable-materials-technologies-webinar-tickets-300098321157
- **Annual EPA SBIR Solicitation**
 - Scheduled to open in June 2022
 - Plan to include SMM topics
 - Informational webinar prior to opening
 - Sign up here for to receive announcements: www.epa.gov/sbir/sbir-listserv

