Addressing Challenging Waste Streams: Textiles & EPS

A Fall 2020
Collaborative Project with
Arizona State University's
Project Cities & the
City of Peoria

Sustainable Cities Network
Arizona State University

Project Cities

PART 1:

Project and community introduction

GET TO KNOW THE PROJECT

ABOUT ASU PROJECT CITIES

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EXECUTIVE SUMMARY

KEY STUDENT RECOMMENDATIONS

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This report represents original work prepared for the City of Peoria by students participating in courses aligned with Arizona State University's Project Cities program. Findings, information, and recommendations are those of students and are not necessarily of Arizona State University. Student reports are not peer reviewed for statistical or computational accuracy, or comprehensively fact-checked, in the same fashion as academic journal articles. Editor's notes are provided throughout the report to highlight instances where Project Cities staff, ASU faculty, Municipal staff, or any other reviewer felt the need to further clarify information or comment on student conclusions. Project partners should use care when using student reports as justification for future actions. Text and images contained in this report may not be used without permission from Project Cities.

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ACKNOWLEDGMENTS

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On behalf of the Julie Ann Wrigley Global Futures Laboratory, the Global Institute of Sustainability and Innovation, and the School of Sustainability, we extend a heartfelt thank you to the City of Peoria for enthusiastically engaging with students and faculty throughout the semester. These projects provide valuable real-world experience for our students and we hope that their perspectives shine light on opportunities to continuously improve Peoria's future livelihood and community well-being.

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To access the original student reports, additional materials, and resources, visit:
links.asu.edu/PCPeoriaRecycling20F

ABOUT PROJECT CITIES

The ASU Project Cities program uses an innovative, new approach to traditional university-community partnerships. Through a curated relationship over the course of an academic year, selected Community Partners work with Project Cities faculty and students to co-create strategies for better environmental, economic, and social balance in the places we call home. Students from multiple disciplines research difficult challenges chosen by the city and propose innovative sustainable solutions in consultation with city staff. This is a win-win partnership, which also allows students to reinforce classroom learning and practice professional skills in a real-world client-based project. Project Cities is a member of Educational Partnerships for Innovation in Communities Network (EPIC-N), a growing coalition of more than 35 educational institutions partnering with local government agencies across the United States and around the world.

ABOUT SUSTAINABLE CITIES NETWORK

Project Cities is a program of ASU's Sustainable Cities Network. This network was founded in 2008 to support communities in sharing knowledge and coordinating efforts to understand and solve sustainability problems. It is designed to foster partnerships, identify best practices, provide training and information, and connect ASU's research to front-line challenges facing local communities. Network members come from Arizona cities, towns, counties, and Native American communities, and cover a broad range of professional disciplines. Together, these members work to create a more sustainable region and state. In 2012, the network was awarded the Pacific Southwest Region's 2012 Green Government Award by the U.S. EPA for its efforts. For more information, visit *sustainablecities.asu.edu.*

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ASU Sustainable Cities Network
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Sustainability through local action

ABOUT PEORIA

Ranked as the No. 1 place to live in Arizona by Money Magazine, the City of Peoria is currently home to over 171,000 residents. The City enjoys a reputation as a family-oriented, active community with an exceptional quality of life. Peoria entertainment and recreational amenities include attractions such as Lake Pleasant, trails, and community parks.

The City has also demonstrated a strong commitment to sustainability, as evidenced by its incorporation of LEED building design standards, a council-adopted Sustainability Action Plan, and the "Green Team" staff dedicated to managing organization-wide sustainability initiatives.

PEORIA TEAM

Project Cities Community Liaison

Jay Davies, Interim Public Works Director, Fmr. Chief of Staff, City Manager's Office

Peoria Project Leads

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Peoria is the place
World class ▪ Sustainable ▪ Future Ready

peoriaaz.gov

City of Peoria

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July 7, 2021

Dear Peoria community members,

It is with tremendous appreciation and excitement that we bring to your attention the results of the second year of our collaboration with ASU's Project Cities program. Although it was a very different kind of year than the first year of our collaboration, that did not dampen the energy of the students or the final results of their work. This partnership has provided the opportunity to work with faculty and students across several academic programs, benefitting from their insights, creativity, and diverse perspectives on a number of projects. Many of these entailed public participation, and you may have participated by completing a survey that was distributed in our community through a variety of platforms.

Project Cities is one of several partnerships we enjoy with ASU, and part of our ongoing strategy to engage with community partners to leverage our resources as we address the many issues that face us as a local government. With a modest investment in this program, we have received extensive research, recommendations, and deliverables that take several key initiatives to the next level for us. These include our efforts around water conservation, transit, recycling, and the possibilities around our Skunk Creek corridor in P83. By engaging students and faculty on these subjects, we have advanced our understanding and positions on each one much more quickly than we could have without their assistance.

The results provided on each project provide us with invaluable insights into many of our most important opportunities, and will position us to better serve our community. The city has already begun to incorporate the students' deliverables into next steps in advancing these projects. We look forward to continuing this work on additional projects in the coming year, and cherish our partnership with ASU and Project Cities.

Sincerely,

Cathy Carlat, Mayor

Jeff Tyne, City Manager

Peoria, Arizona

Proud partner of

ASU Sustainable Cities Network
Arizona State University

Project Cities

Rio Vista Recreation Center

Demographics

total population: **179,872**

median age: **39.8**

highly skilled and educated workforce of 85,252

11,997 veterans live in Peoria

78% of residents are homeowners

median property value: **$331,700**

33% of residents hold a Bachelor's degree or higher

median household income: **$75,323**

Schools

#3 of 131 Best School Districts for Athletes in Arizona

#5 of 40 Best School Districts in Phoenix Metro Area

#7 of 130 Best School Districts in Arizona

The Peoria Unified School District is one of the largest employers in the West Valley. The district consistently receives high ratings and offers signature programs such as the Career and Technical Education programs.

Peoria is also home to Huntington University, a liberal arts college offering digital media education in animation, broadcasting, film, graphic design and other digital media arts.

Leading industries

Peoria, Arizona is not just a scenic suburb of Phoenix, but also a thriving economic development hub with an educated workforce and high-end residential living. There are over 4,000 employers and more than 75,000 people employed within Peoria. Leading industries include health care and social assistance, retail trade, and finance and insurance. Highest-paying industries include utilities, manufacturing and public administration. Beyond these industries, Peoria works actively to attract businesses from aerospace and defense, film and digital media, technology and innovation, hospitality and tourism, and research and development. Peoria is the place for business owners, developers and investors.

Health Care & Social Work
10,905 employees

Retail Trade
10,628 employees

Finance & Insurance
6,574 employees

History

Founded in 1886 by Midwestern settlers, Peoria is nestled in the Salt River Valley and extends North into the foothills around Lake Pleasant. Beginning as a small agricultural town, the economy received a major boost when a railroad spur line was built along Grand Avenue. The construction of the Roosevelt Dam in 1910 secured a reliable water supply, attracting more settlers to the area and business endeavors to the town center. Peoria's economy continued to have an agricultural focus for decades. Continually growing, Peoria assumed city status in 1971 with a population of 4,792. It has since grown into a city with a population over 175,000, and is renowned for its high quality of life and recreational amenities.

Sustainability

Peoria has demonstrated leadership in municipal sustainability efforts through a wide range of actions. Listed below are some of the City's sustainability accomplishments.

- Incorporation of LEED building design standards
- Appointment of a full-time city staff member who manages and coordinates sustainability initiatives
- Sustainable urban planning practices including open space planning and water management principles
- Sustain and Gain: Facebook page and brochures keep residents up to date on city sustainability efforts and ways to get involved
- Water Conservation Program: free public classes, public outreach at city events, and water rebate incentives for residents
- Council-Adopted Sustainability Action Plan: this strategic planning document, in its second iteration, ensures city departments are developing sustainability-oriented goals, tracking success metrics, and encouraging cross-communication in the preparation of Sustainability Update presentations made to the Peoria City Council on an annual basis
- Sustainable University: courses and workshops to empower residents to make small changes that make Peoria a better place to live. Topics covered include residential solar, gardening, composting and recycling

Awards and recognition

- Number One City to Live, Work and Play in 2021 *(Ranking Arizona)*
- Received three Crescordia awards by Arizona Forward at the annual Environmental Excellence Awards in 2016
- 12th City for Green Space in the U.S. in 2019 *(Wallethub)*
- Top 15 Safest Cities in the U.S. 2017-2019 *(Wallethub)*
- 6th Wealthiest ZIP Code in 2020 *(Phoenix Business Journal)*
- Top 50 Hottest Hoods in 2018 *(Phoenix Business Journal)*
- 10th Best City to Raise a Family in 2018 *(Wallethub)*
- Top 100 Golf Course in U.S. 2017-2019 *(Golf Digest)*

Lake Pleasant

1886 — **2020**

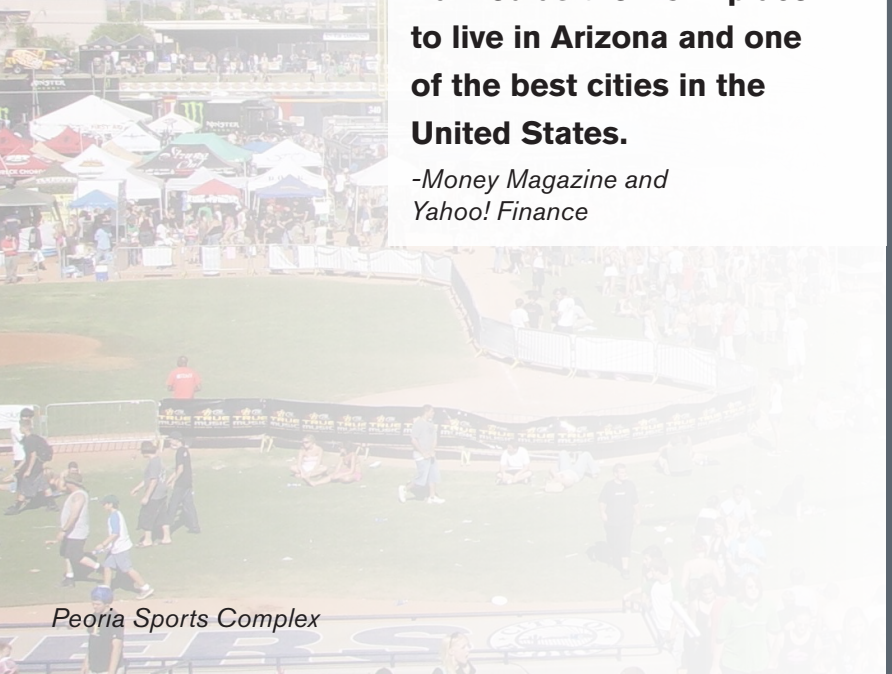
- **1889** — Peoria founded by William J. Murphy
- **1889** — First school district formed
- **1919** — Chamber of Commerce organized
- **1954** — Assumed city status with a population of 4,792
- **1954** — Peoria incorporated
- **1971** — Centennial celebration
- **1977** — Brewers spring training begins at Greenway Sports Complex
- **1986** — Theater for the Performing Arts and Rio Vista Recreation Center opened
- **1994** — Peoria Sports Complex opened
- **2007** — 20-year extension spring training agreement with San Diego Padres and Seattle Mariners
- **2012** — Selected as site of new $70M health clinic for Maricopa County Integrated Health System
- **2017**

Livability

Peoria is renowned as a great place to raise a family and start a career. A plethora of local amenities and attractions contribute to Peoria's livability. Beyond the tourist attractions of Spring Training and Lake Pleasant, the City offers many community facilities and recreational opportunities for all ages and interests such as an extensive public park system and annual community events. Peoria's dedication toward livability is also evident in the City's latest General Plan which addresses sustainable water use, housing, public services and more.

Ranked as the No. 1 place to live in Arizona and one of the best cities in the United States.

-Money Magazine and Yahoo! Finance



Peoria Sports Complex

Peoria strives to uphold these six major livability priorities in order to maintain an exceptional quality of life for its citizens.

- Arts, Cultural and Recreational Enrichment
- Economic Prosperity
- Smart Growth
- Superior Public Services
- Healthy Neighborhoods
- Integrated Transportation

Community facilities

- Peoria Community Center
- Rio Vista Recreation Center
- Peoria Sports Complex
- Peoria Center for the Performing Arts
- 36 neighborhood parks
- 2 libraries
- 3 swimming pools
- 6 golf courses
- 9 lighted multi-purpose ball fields
- 15 tennis courts

Lake Pleasant

Urban ecology, ecotourism and recreation

Peoria is surrounded by the natural beauty of the Sonoran Desert and is home to Lake Pleasant, a 23,000-acre park and major recreational asset to the North Valley. The transient Agua Fria River and New River flow through Peoria, as do a multitude of washes and creeks. Most notable perhaps is Skunk Creek — known for the recreational trails running alongside it — which forges a connection between Peoria and Glendale. Northern Peoria is home to beautiful mountains and buttes including Sunrise Mountain, Calderwood Butte and Cholla Mountain.

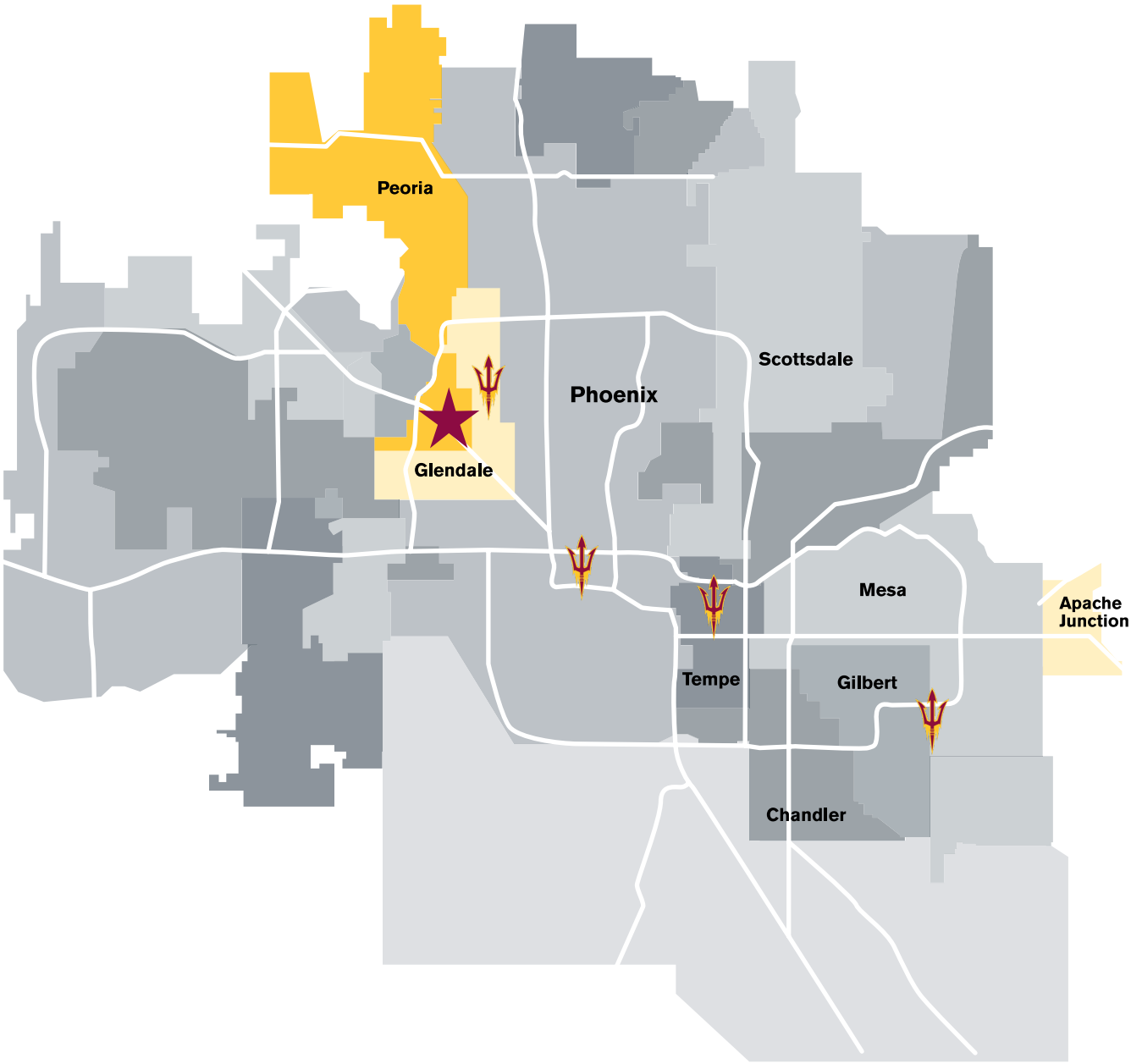
Boasting over 300 days of sunshine annually, Peoria's ecotourism opportunities are a steady industry for residents and visitors. The City features over 60 miles of trails for walking, biking and horseback riding, as well as 570 total acres of accessible park land.

Lake Pleasant Regional Park contains a full-service marina, providing opportunities for water-oriented recreation such as kayaking, water skiing and even scuba diving. Visitors can also go horseback riding, take gliding lessons, hike, camp and more.

Skunk Creek

Pleasant Harbor

MAP OF PROJECT CITIES PARTNER COMMUNITIES IN THE GREATER PHOENIX METROPOLITAN AREA



Peoria City Hall

ASU campus

The following report summarizes and draws highlights from work and research conducted by students in ERM 432/532 Sustainable Solid Waste Management, for the Fall 2020 partnership between ASU's Project Cities and the City of Peoria.

To access the original student reports, additional materials, and resources, visit:

links.asu.edu/PCPeoriaRecycling20F

ASU Sustainable Cities Network
Arizona State University

Project Cities

Sustainability through local action

EXECUTIVE SUMMARY

Municipal solid waste management is an integral part of a city's infrastructure. However, as the amount of solid waste increases, finding sustainable solutions to address this growth is crucial. For the City of Peoria, textile recovery and recycling have the potential to benefit the city's Solid Waste Division and its residents.

Students in Al Brown's **ERM 432/532 Sustainable Solid Waste Management** assisted in providing key recommendations for the development of a recycling program to divert expanded polystyrene (EPS) and textiles from landfills, both of which are notoriously difficult to recycle. Throughout the semester, students set out to answer six guiding questions posed by the City of Peoria regarding EPS and textiles:

- Is the material a common enough product to be worthy of a recycle effort?
- What is the best method to collect the material?
- What is the best way to bundle the material for sale?
- Identify financially viable reuse markets for material for sale.
- Research best practices from other entities in the private and public sector that built similar programs.
- Can the financials work out in a way that pays for itself, or gets as close to breakeven as possible?

Students split into two teams, each focusing on a material type that is technically recyclable, but that is infrequently diverted from landfills: clothing textiles and Expanded Polystyrene (EPS), more commonly known as Styrofoam. Each team started by researching and describing the process of collecting, donating, sorting, and reselling of their material. The student research summarizes their efforts, focusing on answering the six questions posed by the City of Peoria. Based on their research, the student teams provide key recommendations for the City of Peoria, focusing on building relationships with businesses and other cities and identifying financial assistance. The research and recommendations presented in this report aim to support Peoria's proactive approach to landfill diversion, which demonstrates the City's commitment to sustainability and the Superior Public Services livability initiative.

KEY STUDENT RECOMMENDATIONS

Recommendations for textile recycling	Read more
Initiate contracts with textile donation centers, such as Goodwill, to offer convenient textile collection services to divert textiles from the landfill.	pp.31-32, 34-35, 42-44, 47
Develop and communicate educational materials for the new Textiles and Clothing Recycling Program, including information on where community bins are located and encouraging residents to take advantage of the program.	pp.31-32, 34, 36, 47
Create and implement community-wide textile drop-off events, ideally twice per year, to provide additional textile collection opportunities.	pp.28, 31-32, 36, 47
Coordinate with other cities in the Phoenix Metropolitan Area to expand the Textiles and Clothing Recycling program and further diffuse the costs of textile sorting and processing equipment.	pp.45-47

KEY STUDENT RECOMMENDATIONS

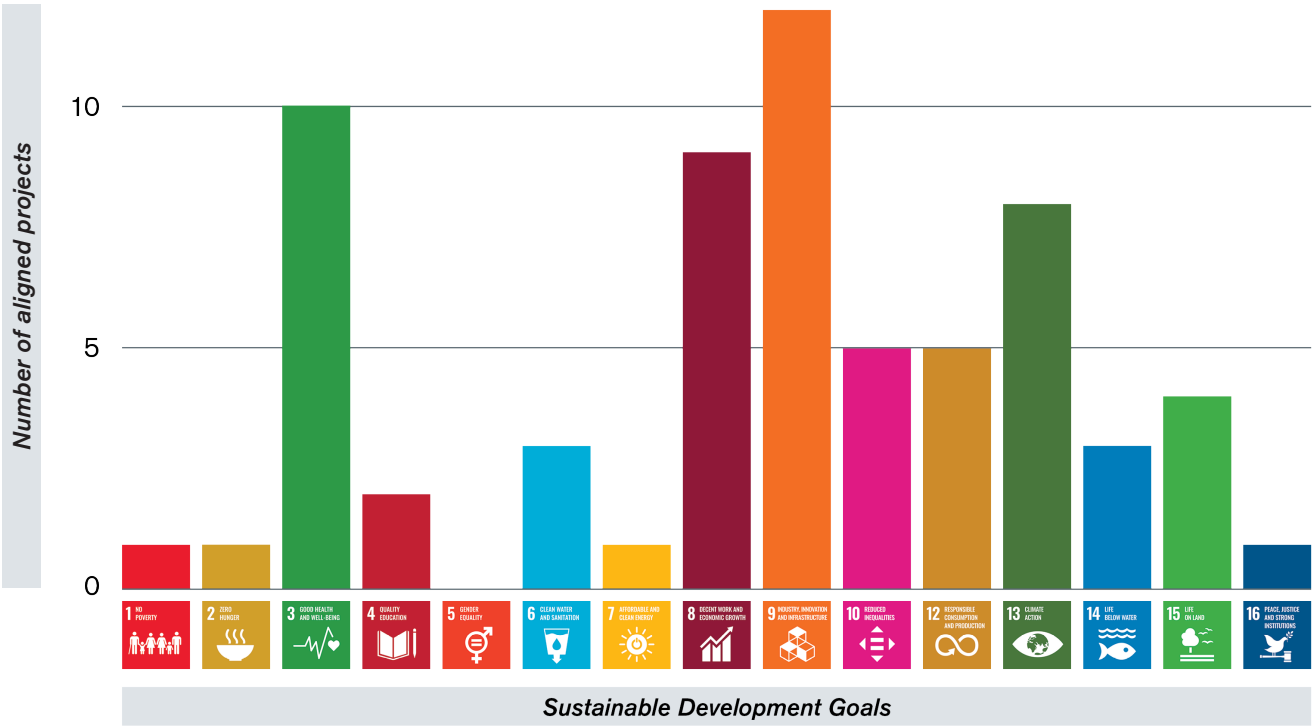
Recommendations for expanded polystyrene (EPS) recycling	Read more
Host an EPS collection day to gauge interest, participation, and potential volume of EPS that could be collected on a regular basis.	pp.51-55, 79, 81
Distribute a survey to residents to collect information about average EPS volumes on a weekly or monthly basis.	pp.51-52, 70-71, 81
Conduct a survey of various local businesses taking advantage of Peoria's municipal solid waste collection. Questions may regard forms and volumes of EPS discarded weekly or monthly, and what collection methods would be preferred.	pp.51, 54, 81
Investigate the use of volunteers at collection events or weekly pick-ups and drop-offs to further reduce program expenses.	pp.55, 57-59, 70, 80-81
Set up public drop-off locations and weekly pickup routes to facilitate recycling participation.	pp.52-54, 57-60, 70, 77, 79, 81
Investigate the possibility of using local business trucks for weekly EPS collection.	pp.52, 55, 57-59, 70, 81
Utilize local vendors and facilities for EPS storage, including local businesses such as Earth Friendly Building Materials and Eco Building Systems.	pp.51, 53, 58, 63-64, 80-81
Develop partnerships with surrounding cities to purchase a densifier, sharing the high cost across communities. The purchase of a densifier can be done through INTCO Recycling or Better Densifiers.	pp. 61-62, 70, 78, 81
Consider applying for grants to fund and promote an EPS recycling program. Potential grant programs include the Foam Recycling Coalition Grant, Arizona Recycling Coalition Grant, and the Coca-Cola Public Spaces Recycling Bin Grant.	pp.71-78, 81
Design a communication plan for the current recycling program, with a focus on informing residents about the program and addressing questions and concerns.	pp.59, 78-81
Focus on building community relations by encouraging residents to take advantage of community services, such as newsletters and welcome packets, to inform the public about current and future recycling options.	pp.59, 78-81

CITY OF PEORIA PROJECTS: ALIGNMENT WITH THE UNITED NATIONS' SUSTAINABLE DEVELOPMENT GOALS

As the leading international framework for sustainable decision-making, the 17 Sustainable Development Goals (SDGs) lay out a path for partnerships toward global peace and prosperity. The SDGs provide a set of goals and metrics for project impact to be measured, offering an illustration of the benefits experienced by the cities, towns, and students who participate in a Project Cities partnership. For details on the SDGs, visit **sdgs.un.org/goals**.

Every project in the PC program aligns with SDGs 11 and 17.

The figure below illustrates SDG project alignment throughout the City of Peoria's partnership with Project Cities, through the Fall 2020 semester.



TOP THREE GOALS ADDRESSED IN THE FOLLOWING REPORT

This project seeks to identify solutions to some market-based limitations on Peoria's recycling operations. As a result of this student research, Peoria will be better able to divert waste from landfills, and develop a more circular economy. This project contributes to the advancement of several SDGs, including SDG 9, SDG 12, and SDG 15.

Goal 9: Industry, Innovation and Infrastructure

"Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation."

Pursuing new recycling technology and processes may help increase availability of recycled materials, while adding jobs to the local economy.

Goal 12: Responsible Consumption and Production

"Ensure sustainable consumption and production patterns."

An increase in the availability of recycled textile and EPS materials can mobilize market forces to decrease the production of new, additional EPS and textiles.

Goal 15: Life on Land

"Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss."

Increased recycling helps decrease the rapid growth of landfills and reduce material pollution.

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PART 2:

Addressing Challenging Waste Streams: Textiles & EPS

OUTLINING FEASIBLE METHODS FOR INCREASED RECYCLING RATES OF TEXTILE AND EXPANDED POLYSTYRENE WASTE

ERM 432/532:
SUSTAINABLE SOLID WASTE MANAGEMENT

IRA A. FULTON SCHOOLS OF ENGINEERING

FACULTY
AL BROWN

ACKNOWLEDGMENTS

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PROJECT GOALS

In this report, student teams investigate the utility of improving the recycling program for textiles and expanded polystyrene (EPS) in the City of Peoria to reduce the amount finding its way to landfills. Students worked on several key objectives:

- Develop recommendations for a possible textiles and EPS recycling program for the City of Peoria.
- Describe the processes of collecting, donating, sorting, and reselling of textiles and EPS.
- Evaluate the necessary financial investment required for improvements to the existing municipal solid waste program.

Figure 1 *ERM 432/532 students present their findings virtually at the Fall 2020 End-of-semester Showcase*

INTRODUCTION

Municipal solid waste management plays a critical role in a city's infrastructure. As a city expands, the amount of solid waste increases, thus presenting waste management with the challenge of addressing its growth with sustainability in mind. The recycling of raw materials presents unique complications for various material types. The City of Peoria's Public Works Department seeks to expand its solid waste recycling program, specifically looking to investigate the potential reuse market for textiles and expanded polystyrene (EPS) from landfills, in addition to the feasibility of implementing such a program in the City of Peoria. In partnership with Project Cities, the City of Peoria tasked two student groups with extensively researching the materials, recycling best practices from other communities, and providing recommendations for the development of a textile and EPS inclusive recycling program.

RESEARCH METHODS

Students investigated the feasibility of an expanded recycling program through case study analysis, literature review, and critical review of benchmarked programs. Armed with their findings, students then provide an in-depth analysis and provide key recommendations for textile and EPS recycling in Peoria. To frame their research, the City provided six guiding questions to determine the feasibility of a recycling effort:

- Is the material a common enough product to be worthy of a recycle effort?
- What is the best method to collect the material?
- What is the best way to bundle the material for sale?
- Identify financially viable reuse markets for material for sale.
- Research best practices from other entities in the private and public sector that built similar programs.
- Can the financials work out in a way that pays for itself, or gets as close to breakeven as possible?

Students split into two groups, one researching EPS and the other researching textiles, in order to dive deeper into the details of each material. The groups evaluated Peoria's potential for an expanded recycling program utilizing census and solid waste data for solid waste and cost estimates in order to determine the feasibility for a recycling program. Students also researched and identified local recycling organizations and programs to determine best practices and potential partnerships for the City of Peoria.

Figure 2A *Polystyrene #6 recycling symbol stamped into packaging*

Figure 2B *Used clothing wholesale textile recycling collection*

TEXTILE RECYCLING

Solid waste

Waste management is an integral part of public health and welfare. The Resource Conservation and Recovery Act (RCRA) of 1976, provides the general guidelines for hazardous and non-hazardous waste management in the United States (RCRA, 2020). Materials regulated under this act are called “solid wastes” (RCRA, 2020).

As defined in RCRA Part 243, Subpart A §243.101(y):
“Solid waste means garbage, refuse, sludges, and other discarded solid materials, including solid waste materials resulting from industrial, commercial, and agricultural operations, and from community activities…” (RCRA, 2020).

This definition of solid waste is broad and applies to both non-hazardous and hazardous waste. RCRA Part 261, Subpart A §261.2(a)(2)(i)(A)-(c)(1)(B) further clarifies and categorizes solid waste materials as shown in Figure 3 below.

"A discarded material is any material which is:"		
Abandoned:	***Recycled:***	***Inherently waste-like:***
Thrown away, Incinerated or burned, Accumulated, stored, or treated (but not recycled), or Sham recycled (recycled in violation of EPA rules).	Reused, Reclaimed, or Used in a manner that constitutes disposal.	Wastes that may pose a substantial hazard to human health and the environment when recycled.

Figure 3 *Resource Conservation and Recovery Act solid waste categories and definitions*

RCRA specifies that waste materials which do not align with the definition of "solid waste" are not considered solid waste (RCRA, 2020). RCRA divides solid waste into two categories: hazardous and non-hazardous. Subtitle C of RCRA deals with solid waste, and it adopts a cradle-to-grave approach to manage and track hazardous waste. On the other hand, Subtitle D deals with non-hazardous waste such as household hazardous waste (HHW), municipal solid waste (MSW), industrial waste, agricultural waste, and bio-medical waste.

Editor's Note

Cradle-to-grave systems suggest a finite life to a product, where it is fully disposed of at the end of its use. Due to the nature of hazardous materials, this system is usually adopted for their disposal. Any treatment or transportation prior to final disposal, must be meticulously tracked and recorded.

Solid waste management is an essential process for any clustering of industrial humans and buildings; effectively carried out, solid waste management contributes positively to a city's public health and welfare, as well as its aesthetics. Conversely, a failure to properly manage municipal solid waste can have harmful effects on public health and welfare. Poor sanitation provides opportunity for many respiratory syndromes, vector-borne diseases (e.g., malaria, dengue), and diarrheal diseases (e.g., cholera, typhoid) to arise. Moreover, physical injuries from contact with poorly managed solid waste can also occur. These risks, however, can be minimized or eradicated through proper waste management programs.

Figure 4 *Fate of municipal solid waste, by U.S. EPA*

Municipal solid waste

Municipal solid waste (MSW), as defined by the U.S. Environmental Protection Agency (EPA), consists of everyday items such as packaging, furniture, yard waste, clothing, bottles, cans, food, newspapers, electronics, and batteries. Sources of MSW include both residential and commercial wastes (EPA, 2020). Total generation of MSW in 2017 was 267.8 million tons, or 4.51 pounds per person per day in the United States (EPA, 2020). This waste is either composted, recycled, incinerated, or landfilled. Based on data presented by the EPA, the recycling and composting rate was about 35.2% of the total waste, 12.7% of the total waste generated was incinerated and 52.1% was landfilled (Figure 5) (EPA, 2020). In 2018, 11.8% of total MSW was combusted for energy recovery (EPA, 2020).

MSW management within the United States is a cause of concern. Many states actively try to find new ways to deal with MSW. For example, some try adopting the waste management hierarchy, i.e., source reduction and reuse, recycling and composting, energy recovery, treatment, and disposal (EPA, 2020).

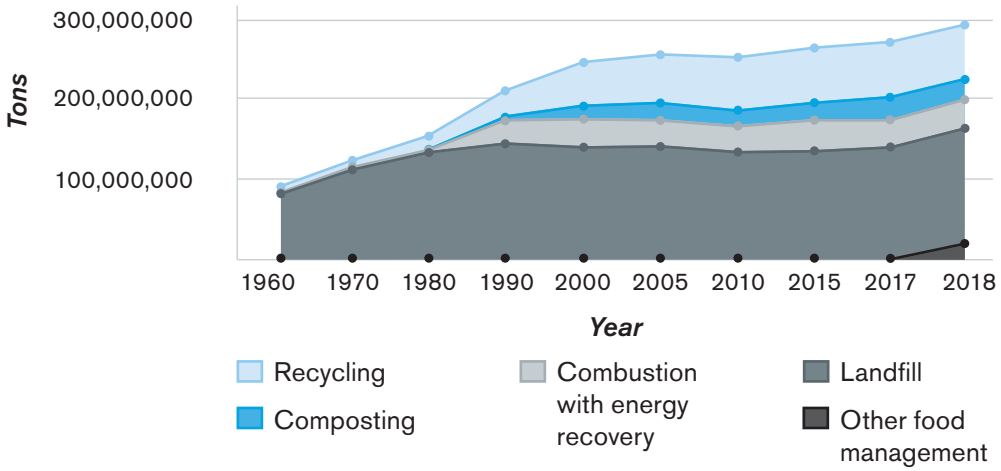

Figure 5 *Municipal solid waste management 1960-2018, by U.S. EPA*

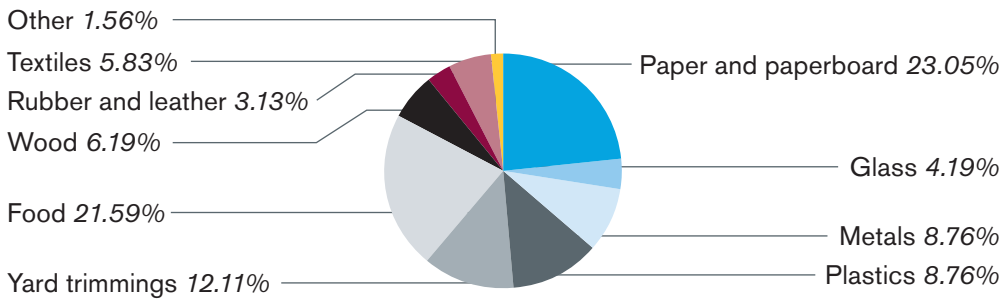

Figure 6 *Total municipal solid waste generated by material, 2018 , by U.S. EPA*

Textiles

Textiles accounted for 6.3% of the total MSW generated in 2017 (EPA, 2020). Common textiles found in MSW include discarded clothing, furniture, carpets, tires, footwear, towels, and sheets (EPA, 2019). According to the EPA, the recycling rate for all textiles in 2017 was 15.2%, and the recycling rate of clothing and footwear was 13.6% (EPA, 2019). The EPA reported that textiles represent 9.3% of the total MSW combusted for energy recovery (2019). Textiles alone make up 8% of landfilled MSW waste (EPA, 2019).

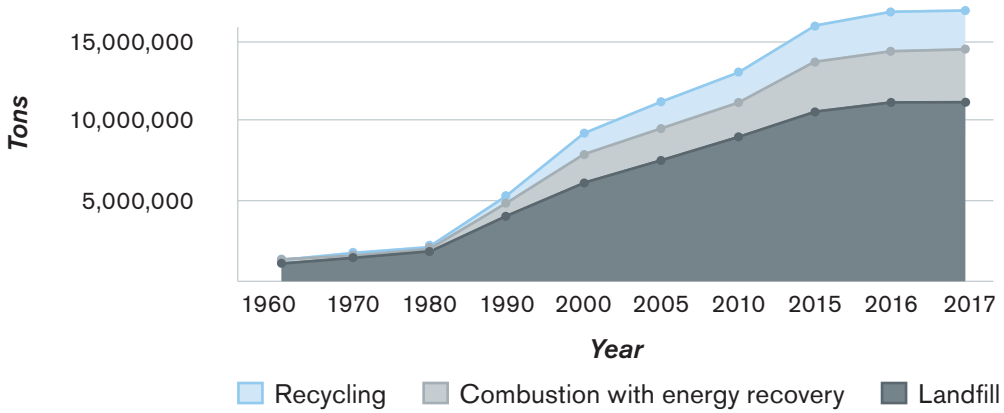

Figure 7 *Textile recycling, combustion, and landfilling 1960-2017, by U.S. EPA*

As consumption of clothing and other textiles increases, subsequent textile waste generation also increases. Therefore, textiles represent 5% of the solid waste generated globally (Simona, 2016). Textiles require considerable disposal space leading to difficulty in landfill management. During the decomposition process, textiles also generate greenhouse gases, such as carbon dioxide and methane, and leach toxic chemicals and dyes into groundwater and soil (Bell, 2019).

City of Peoria

Based on the collection data provided to us by the City of Peoria Solid Waste Division, trash tonnage represents the residential accounts with 90/60/30-gallon containers and bulk collection. It is tracked by fiscal year July 1 to June 30 (Solid Waste Division, 2020). In the year 2020, the amount of trash tonnage generated was 64,283.12 and recycled tonnage was 16,047. The City of Peoria supplements its routine waste collection by hosting various drop-off events. The drop-off event conducted in 2015 for textiles collected a staggering 3,200 pounds of textiles waste.

Consumption of clothing and textiles

According to the World Resources Institute (2017), the average consumer purchased 60% more clothing in 2014 than in 2000 (Figure 8). This rising trend is not sustainable long-term and compounds environmental issues such as greenhouse gas generation (i.e., methane) and contamination of groundwater and soil from toxic chemicals and dyes from landfilled items (Bell, 2019). In conclusion, fashion and overconsumption are a root cause of many contemporary waste management problems.

According to the World Resources Institute (2017), by 2030, there will be 5.4 billion people in the middle class, up from 3 billion in 2015, which will further increase the demand for clothes and other goods (Drew & World Resources Institute, 2017). This situation will cause more pressure on already diminished natural resources.

Editor's Note
"Fast fashion," which refers to lower-quality, mass produced garments that are made to be replaced rather than repaired, is considered a significant contributor to accelerated textile consumption.

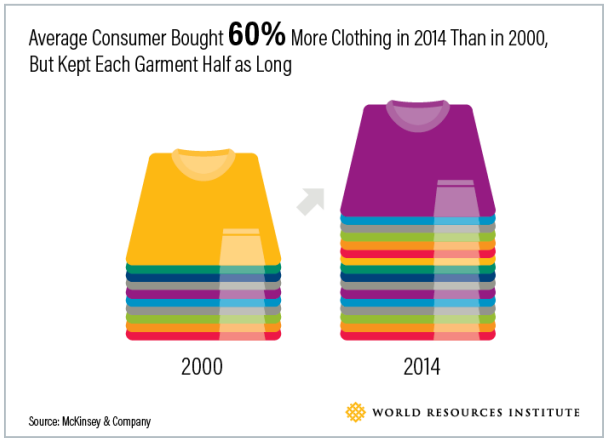

Figure 8A *Clothing consumption increase between 2000-2014, by World Resources Institute*

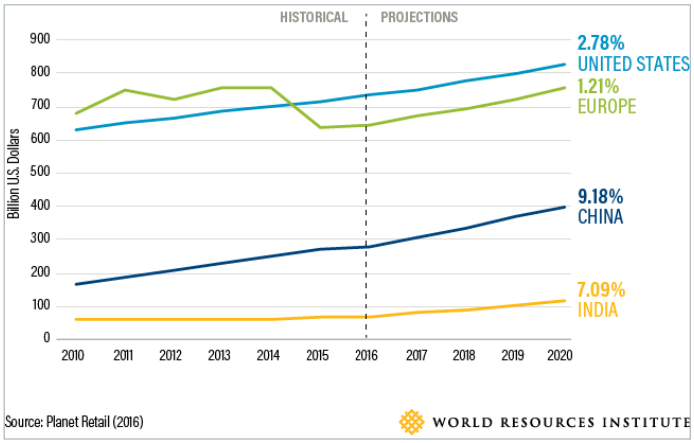

Figure 8B *Historic and projected spending on apparel in key markets, by World Resource Institute*

Generation of textile waste

Textiles are a frequent component of solid waste, posing a significant challenge to the solid waste management system. According to the EPA, approximately 17 million tons of textiles were discarded in 2018 alone (EPA *Facts and Figures*, 2020). This extreme quantity indicates there is great potential for textile diversion and recycling programs.

Editor's Note
Students' original textile waste figures in this section were updated with the most recent U.S. EPA data.

Textile waste is suitable for recovery and recycling efforts, along with traditionally recycled glass, plastics, scrap metals, paper and cardboard, and wood materials (Simona, 2016). Figure 9 depicts the global generation of clothing waste by second, day, and year.

Figure 9 *Clothing waste infographic, by Ellen MacArthur Foundation and World Economic Forum*

Textiles vary greatly in composition and may contain natural fibers, such as cotton or bamboo, which are biodegradable (Weber, 2017). During landfill decomposition, harmful byproducts such as acid leachate, methane, nitrogen gases, and hydrogen sulfide gas are produced (Weber, 2017). The reuse and recycling of textiles prevents these unwanted pollutants from entering the environment, diverts bulky textile waste from landfills, and reduces the overall volume of solid waste. Synthetic fibers such as nylon and acrylic typically undergo slight degradation. They tend to remain in landfills indefinitely, even when they are partially reduced (Weber, 2017).

Textile recycling can save a portion of the raw material inputs required to produce textiles, as well as electricity, time, and labor (Simona, 2016). Many textile manufacturing resources, such as water, dyes, chemicals, and fixing agents, could also be decreased (Simona, 2016). This results in less environmental pollution while reducing the cost of finished goods (Simona, 2016). Over 90% of all textile waste can be reused in the same form as the original waste or as a raw material for various other textile items (Simona, 2016).

Drop-off centers are an efficient way to collect textiles. Reuse options for textile wastes are often charity actions where donations are collected for the needy (Simona, 2016). Retail stores may also accept textiles for recycling, perhaps offering a credit reward program for traded items. Certain brands and companies have also developed and operate global textile waste collection networks, including H&M, Puma, Levi Strauss & Co., and American Eagle Outfitters. These programs collect textile wastes specifically from household consumers (Simona, 2016). Some brands offer return of lightly used clothing for credits towards new purchases. These methods are typically used for direct resale of used textiles that still have value in their original form. Textile items beyond their useful life generally cannot be donated to these resale outlets, and should instead be collected for textile recycling (Weber, 2017). Lower-value textiles do have alternative collection opportunities through companies such as Fabscrap which hosts designated bins in apartment laundry rooms for easy textile waste collection (Waste360, 2018).

Editor's Note

Different collection entities practice varying restrictions and selection processes regarding accepted textiles. Some entities may reject usable textiles for being outdated or past a certain age as indicated by manufacturing numbers. This selectivity presents another barrier to textile donation for the average consumer.

Textiles intended to be reused in the second-hand market must be clean, dry, and not overly worn. Textiles are generally collected in specified collection containers. Curbside collection boxes cost between $800 and $1,168 per bin. An example 480-gallon capacity box is shown in Figure 14 (Recyclingbin.com, 2020)

Due to a lack of awareness, people do not typically bring unwanted clothing items to recycling or donation depots, resulting in high volumes of recyclable textile waste in solid waste landfills (Weber, 2017). Social awareness regarding textile waste may be raised by partnering with retailers. Similar to some of the corporate programs mentioned above, these outlets may offer take-back programs where consumers return old clothes for credit value (Weber, 2017). Individual consumers with greater textile consumption and use are more likely to dispose of textiles, especially when there are no immediate or convenient recycling options (Weber, 2017). However, regardless of their fashion interest, participation, or consumption frequency, most consumers have indicated a willingness to donate unwanted clothes (Weber, 2017).

Textile disposal method survey results	
Method	***Percentage***
Donate	50
Dispose	25
Resell	8
Swap	4
Take-back	4

Figure 10 *Planned textile disposal from survey by Weber, 2017 (n=410)*

The categorization and sorting of textile wastes is critical in bundling the material for downstream processing and sale. This process is labor-intensive and requires physical involvement from personnel during the initial screening and separation processes. The separated materials are cleaned and resold in small stores. Textiles may also be turned into rags for industrial uses or shredded to create padding and insulation.

Subject matter expert interview

Students interviewed Mr. Taimur Burki who is the Global Green Building and Circular Economy Program Manager, Sustainability LEED AP O+M, LEED Faculty, True Zero Waste Advisor at Intel Corporation. Figure 11 lists a brief description of this interview's results.

Additional textile recycling suggestions
Segregation of textiles based on the material used. Nylon, rayon, and other fibers can be separated and reused.
Processing of materials, such as mixing waste textile with other materials or chemicals to form a certain product. Shredding the material also allows for use as fillers. Moreover, it can be drawn into a yarn.
Textile waste must be decontaminated before processing. Methods include air scouring, water washing or steaming.
Perform pyrolysis of fabric.
Use fabric as feedstock for other processes.
Adopt a mechanical methodology to recycle material back to the yarn or contact companies that do the same.

Editor's Note
Pyrolysis is a process used to decompose materials through the use of high temperatures, often used for organic materials.

Figure 11 *Textile recycling suggestions gathered from subject matter expert interview with Intel Corporation's Taimur Burki*

ANALYSIS & DISCUSSION

Estimates of landfilled textiles

Based on the figures provided by the City of Peoria, the trash tonnage for the fiscal year 2020 (July 1 to June 30) is 64,283.12 tons (Solid Waste Division, 2020). Considering that 13% of the total trash tonnage is textiles, then: **64,283.12 tons ×0.13=8,356.8 tons/year** of textile waste is estimated to be landfilled.

Since the City of Peoria pays $27 per ton to landfill waste, the estimated annual disposal cost of 8,356.8 tons/year of textiles is **$225,533.60**. Considering these factors, textile material is common enough to be worthy of a recycling effort in Peoria.

Textile collection and donation

Textile recycling is a complex process that requires different stages for it to be successful. This question is further explored by searching for solutions beyond blue bin recycling, as the City of Peoria does not currently accept textiles in recycling bins. For that reason, this report recommends that the City of Peoria consider collecting textiles using community collection boxes with a capacity of 480 gallons (Figure 13). These bins cost approximately $1,168.00 each. The City of Tempe has implemented a similar program, with collection bins scattered throughout the city, and Goodwill of Central and Northern Arizona (Goodwill) collects and processes the donations at their facility (City of Tempe, 2020).

Another recommendation is advising the citizens of Peoria to take their clothes to drop-off centers in the form of donations. There are several donation companies and thrift stores that accept different types of clothes in the Peoria area. Another donation option available is to homeless and animal shelters. These shelters accept clothing in alignment with their mission to provide a safe place to stay and a need for more bulky winter clothing during the colder months (Colley, 2020).

Textile donation companies in the Phoenix Metropolitan Area			
Company	***Description***	***Items collected***	***Local drop-off locations***
Buffalo Exchange www.buffaloexchange.com/location/midtown-phoenix/	Customers can buy, sell, and trade clothing, giving it a second life and avoiding contributing to the demand and waste of clothing pollution	Clothing, accessories	3450 N. 7th St, Phoenix, Arizona 85014 227 W. University Dr, Tempe, Arizona 85281
Kid to Kid www.kidtokid.com/clean-out-cash-in	A children's resale franchise founded in 1992 on the principle that "kids grow faster than paychecks."	Clothing, outerwear, shoes, costumes, toys, maternity clothes, school uniforms, sport items, nursery furniture, babywear	8360 W Thunderbird Rd., Peoria, Arizona 85381
The Bra Recyclers www.brarecycling.com/	A clothing recycling company specializing in bras and other lingerie.	Bras, sports bras, mastectomy bras, and nursing bras	Mail recycled items directly to: 3317 S Higley Rd, Suite 114-441 Gilbert, Arizona 85297
Salvation Army www.westernusa.salvationarmy.org/usw_thq/	Accepts diverse types of donations in good condition for resale. The Salvation Army family stores also help fund rehabilitation programs.	Clothing, shoes	8517 N.W. Grand Ave. Peoria, Arizona 85345 6750 W. Peoria Ave. Peoria, Arizona 85345
Goodwill Donation Centers www.goodwillaz.org/	A non-profit where people bring their used clothing, household goods, and furniture.	Linens, clothing, accessories, furniture, household goods, and shoes	8517 N.W. Grand Ave. Peoria, Arizona 85345 6750 W. Peoria Ave. Peoria, Arizona 85345 9000 W. Northern Ave. Peoria, Arizona 85345 8679 W. Ludlow Dr., Suite 5, Peoria, Arizona 85381

Figure 12 *Local entities which accept textile donations that may be useful in Peoria's search for different avenues to reduce the amount of textiles being landfilled*

Special textile recycling events are yet another way to collect textiles and divert them from landfills. The City of Peoria held such an event in 2015 where 3,200 tons of textiles were collected. The pilot was considered a success, therefore it is recommended that the City conduct textile recycling events twice per year, so citizens have more textile recycling options available.

Figure 13 *Proposed bin style for textile curbside collection (480 gallon capacity), by Recyclingbin.com*

Preparation and bundling

Waste textiles (those which have been deemed unfit for donation or resale) can have recoverable value in the fibers they contain. Textiles must be sorted into different categories to effectively extract the fibers for reuse. Depending on the composition of the textile, different processing methods are appropriate. This initial process of sorting textiles into different fibers and material types by hand is slow, labor-intensive, and requires a skilled workforce (Beall, 2020). Technology can aid this process; hyperspectral cameras can detect light beyond human vision limits, allowing for better identification of different fabric types (Beall, 2020). The main distinction between textile types is synthetic and natural materials. The sorting criteria also depend on the further applications of fiber. For example, after separation, carpet fibers can be prepared by tearing before being recycled. Nonfibrous materials can be used in industry as building material (Weiß, 2003). The following detailed separation and extraction processes are all commercially available.

Natural vs. synthetic fibers

The different chemical natures of cotton, a natural fiber, and polyester, a synthetic fiber, require efficient separation and demand specific processing conditions (Haslinger, 2019). Interwoven cotton polyester blends are the most prominent textile type, which makes recycling difficult due to the heterogeneity of materials (Haslinger, 2019). Waste textiles are generally blended fibers from a wide variety of sources (Ling, 2019). Polyester is a semicrystalline thermoplastic polymer. This material is made from petroleum-based chemicals and is resistant to biodegradation (Ling, 2019). After three months in a solid waste landfill, polyester only loses about 20% of its weight (Ling, 2019). Cotton is a natural fiber material, and is 95-99% cellulose, a linear and naturally occurring polysaccharide (Ling, 2019). Pure synthetic polymers can be processed to recover recyclable material through the use of biotechnologically assisted depolymerization. This method uses enzymatic hydrolysis to target specific polymers (Östlund, 2017). The separation of blended fabrics from different fiber materials is based on the natural differences of these components. These separation methods depolymerize or dissolve one component of the blended material while preserving the other (Ling, 2019).

Hydro-erosive separation

Selective separation methods utilize mechanical and thermal methods to divide textile wastes into components (Weiß, 2003). This method works well for large and multi-material textiles as it can be used to separate all compounds consisting of fibers embedded in a matrix, such as carpet wastes. Europe produces 1.5-1.7 million tons of carpet waste annually (Weiß, 2003). This type of material is composed of plastic fibers, a latex binder, and a chalk-filled foam latex backing (Weiß, 2003). A hydro-erosive separation method employing high-speed water jets is used for automobile waste textiles. In automobiles, waste textiles include floor carpets, insulation sheets, and luggage trunk coverings, all of which contain needled felt, glue, needle-punched non-woven foam, glass-fibers, and polyester components (Weiß, 2003). The hydro-erosive separation method can selectively clean and remove material components. Applications include selective concrete removal, soil cleaning, and machining (Weiß, 2003). After this water treatment, fibers rest on a wire grill while the other components are ground and separated from the fibers by a water flow (Weiß, 2003). In this position, fibers are completely exposed, leaving the structure of the fiber fabric in place. This allows for the reuse of the entire fabric rather than individual fibers (Weiß, 2003). The individual fibers are clean and not mechanically destroyed or cut by the water jet, enabling them to be recycled (Weiß, 2003).

Thermomechanical separation

Thermomechanical separation uses high temperatures to spin waste textiles through a filter that forms molten pellets used as a material in new textile products. Thermomechanical separation can use textiles from all pre-and-post consumer textile wastes (Östlund, 2017). However, this method is limited as materials with over 10% elastane are challenging to use in the fiber molding and fiber spinning of the thermomechanical separation process (Östlund, 2017).

Hydrolysis

Different degrees of hydrolysis can also be used as textile waste fiber extraction. These methods work when there is a heterogeneous composition of natural and synthetic fiber materials in waste textiles, such as the most common cotton and polyester blend. Neutral hydrolysis is a pollution-free chemical recycling method that degrades the polyester of waste textiles into terephthalic acid and ethylene glycol (Ling, 2019). This reaction occurs without using a catalyst, eliminating chemical waste pollutants in this process (Ling, 2019).

The converted terephthalic acid is an important organic chemical used as a raw material in future production of polyester and plastic materials (Ling, 2019). In partial hydrolysis methods, cotton and natural fibers are depolymerized. The separation treatment hydrolyzes cotton into microcrystalline cellulose and reduces the crystallinity of polyester (Ling, 2019). This depolymerized cellulose forms microcrystalline cellulose, which can then be used in packaging, agriculture, food, automotive, and aerospace applications (Ling, 2019).

Phosphotungstic acid treatment

A phosphotungstic acid treatment process can be used in the recycling of both polyester and cotton blended fibers. The acid itself is used sparingly and can be extracted and recycled with diethyl ether without affecting the extraction yields of either polyester or microcrystalline cellulose (Ling, 2019). Phosphotungstic acid is used as a catalyst in this process to separate out polyester from blended fabrics. Environmental pollution is narrowed as there is only a 1.86% weight loss of the phosphotungstic acid during the entire extraction process (Ling, 2019). In this processing method, both polyester and microcrystalline cellulose can be separated and extracted from waste textile materials with notably high yields, 99.77% and 85.12%, respectively (Ling, 2019).

Innovation in the textile collection industry

Many organizations have emerged that are willing to accept textile waste for further processing. New Jersey-based Trans-Americas Trading Company offers long-term fixed purchase rates of $100 per ton of textile waste (Trans-Americas Trading Co., 2020). This company has been recycling post-consumer textile waste since 1942, processing over 8,000 tons annually (Trans-Americas Trading Co., 2020). More than 20 municipalities in the New York metropolitan area and across the East coast of the United States recycle their textile wastes with Trans-Americas Trading Company (Trans-Americas Trading Co., 2020). This company offers textile recycling as an alternative to landfills, where participating residents are encouraged to donate their unwanted clothes (Trans-Americas Trading Co., 2020). Trans-Americas Trading Company also provides no-cost post-consumer textile waste recycling by providing collection containers, transportation, and educational materials to cities to increase community awareness (Trans-Americas Trading Co., 2020).

Figure 14 *A Trans-Americas Trading Co. shipping container stocked with second hand textiles for distribution, by Trans-Americas Trading Co. (tranclo.com)*

Miller Waste Mills Incorporated, located in Minnesota, is another textile recycling company which utilizes specially designed equipment that allows incoming textile waste to be processed in bulk quantities to reclaim original fibers for reuse (Miller Waste Mills, Inc., 2020). The converted materials are then resold as raw material, including natural fiber blends or a blended cotton-polyester (Miller Waste Mills, Inc., 2020).

One of the latest sorting technologies is Valvan's Fibersort (Figure 15), which consists of an optical sorting technology based on Near-Infrared Spectroscopy. The technique is sensitive to the molecular absorptions of organic constituents in the near-infrared part of the spectrum. This technology automatically sorts mixed garments into homogeneous categories of specified fiber types (Smart Fiber Sorting, 2019). Unfortunately, this equipment is under development and is not yet commercially available. Further details can be found at **www.valvan.com**.

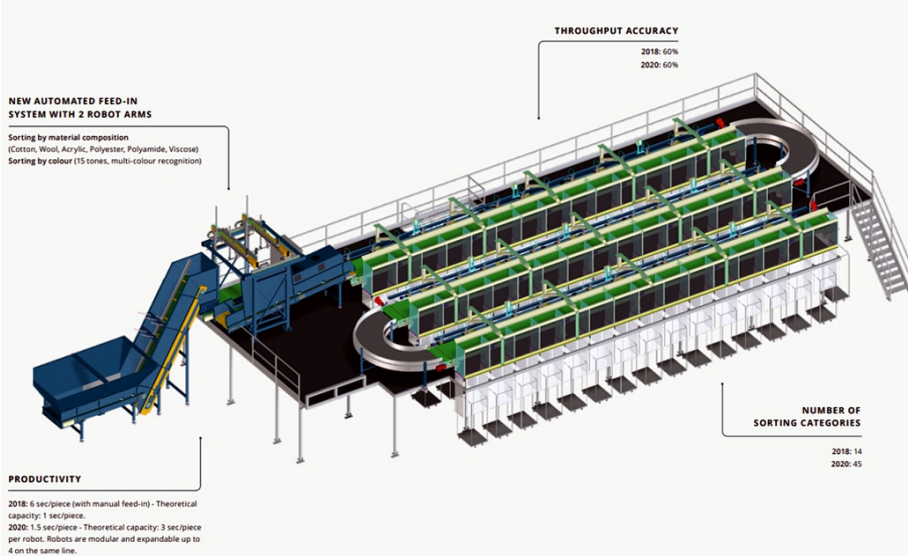

Figure 15 *An example of Valvan's Fibersort automated sorting equipment, by Global Recycling*

Recycling textiles locally

The Phoenix Metropolitan Area is already home to multiple textile recycling entities. These companies transform materials like carpets, denim, and cotton to use as new products or raw materials in other processes. For instance, UltraTouch™ Denim Insulation is a fiber conversion product used in homes and businesses, appliance insulation, automotive insulation, and mattress production (Phoenix Fibers, 2015). Another company located in Phoenix is the Italian company Aquafil, a leading global producer of nylon yarns for carpeting and apparel using 100% recycled nylon. Phoenix's facility is a collection and pre-processing facility that produces raw feedstock from waste (Siegel, 2019).

Textile recycling companies in the Phoenix Metropolitan Area		
Company	***Description***	***Website***
Aquafil Global	Established in 2017, Aquafil Carpet Recycling #1 (ACR#1) is the first of many planned carpet recycling plants for the Aquafil Group in the United States. With state-of-the-art equipment to fully recycle carpet, ACR#1 is on track to recycle 16,000 tons of used carpets per year that would otherwise end up in landfills. Aquafil can regenerate the nylon 6 in carpet and make ECONYL® nylon, a 100% regenerated nylon with the same quality as nylon made from virgin materials.	www.aquafil.com/where-we-are/usa/
United Fibers LLC	Recycling company working with the cities of Mesa, Gilbert, and Chandler.	www.unitedfibers.com/contact.html
Phoenix Fibers	Phoenix Fibers is a Chandler, Arizona based, closed-loop textile recycling company. Opening in July of 2011, it is the newest addition to a group of recycling companies owned by the Kean family. Affiliate companies include United Fibers and Bonded Logic.	www.phxfibers.com/
Bonded Logic INC. Chandler	Bonded Logic INC. repurposes and manufactures textile waste into insulation products.	www.bondedlogic.com/about-us/
Textile Recycling Quotes	Textile Recycling Quotes provides easy and convenient shredding and recycling solutions for clothing brands, corporations, and government agencies.	www.textilerecyclingquotes.com/phoenix-textile-recycling/

Figure 16 *Local textile recycling companies that may be able to accept non-donatable textiles from Peoria*

Best practices of textile recycling

Solutions may be identified by observing other entities in both the public and private sectors engaged in similar resource recovery and recycling programs. The following sections outline general best practices demonstrated in select textile waste recycling programs.

Arizona Department of Environmental Quality

The Arizona Department of Environmental Quality (ADEQ) has a program to help certain businesses reduce the release of toxic substances (ADEQ, 2020). This is done by reducing pollution through source reduction, recycling and reusing materials, conservation, reducing toxic materials, and other methods (ADEQ, 2020). The objectives of this program are to reduce the use of hazardous substances, encourage reduction through substitution, improve housekeeping, encourage recycling and reclamation, and promote conservation and waste minimization (ADEQ, 2020).

Tempe, Arizona

Tempe has implemented a Clothing and Household Textiles Recycling program which collects clothing and household textiles that are not allowed in the blue recycling bin (e.g., stuffed animals, clothing, towels, and other soft toys) (City of Tempe, 2020). Items can be dropped off at recycling containers located throughout the city. The City contracts with Goodwill to remove and process the donated materials. The agreement requires Goodwill to pay the City twelve cents per pound of textiles collected. After the collection, Goodwill processes these items for possible sale in their retail stores. Tempe only offers drop-off boxes and does not run a collection service. According to Dawn Ratcliffe, the City's Recycling Coordinator, Tempe diverted 45,889 pounds of textiles under this program in 2018 (personal communication, Nov. 24, 2020).

Chandler, Arizona

The City of Chandler offers its citizens several ways to reuse or donate textiles. Donating items rather than throwing them away can support local charity efforts to sustain job training and self-sufficiency programs for people with disabilities and families in need (City of Chandler, 2020).

Fabscrap

In New York City, nonprofit fashion recycling company Fabscrap collects, sorts, and recycles waste textiles. Fabscrap collects approximately 8,000 pounds of textile waste from major fashion retailers weekly (Mercel, 2020). Working with over 130 labels in the city, it also hosts collection bins in residential buildings. Certain brands have also partnered with the program to recycle commercial wastes (Waste360, 2018). The waste is sorted based on material, removing staples and tags in the process. Any material not resold is processed at a facility in New Jersey for use in carpet padding, moving blankets, and other industrial materials, creating a zero-waste process (Mercel, 2020).

Editor's Note
Students identified local company United Fibers as a service provider of textile recycling. The company website lists Mesa, Chandler, and Gilbert as clients, but there is no additional information provided on the company or its services.

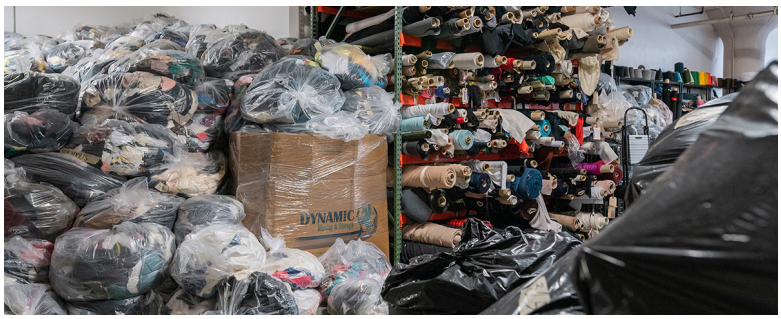

Figure 17 *FabScrap collection center, by Angelica Pasquali via Sierra Club*

Funding strategies for textile recycling

Implementing a recycling program can be expensive for any municipality. Currently, Peoria sends all its recyclable waste to the Deer Valley Transfer Station, a materials recovery facility (MRF) owned by the City of Phoenix and operated by Waste Management. The City has an intergovernmental agreement with this MRF to accept their waste, however the facility does not accept textiles and considers them contamination. This results in more textiles ending up landfilled. Students recommended several options for the City of Peoria to prevent textiles from being landfilled.

Municipal revenue streams from textile recovery

Implementation of textile recovery brings revenue back to a municipality. National costs for waste management have increased by over one billion dollars between 2003 and 2013 (Adler, 2019). With just 15% of textiles removed from the solid waste stream through recycling programs, U.S. taxpayers save an average of $142,275,200 annually (Ecosmith Recyclers, Inc., 2020). With these increases in costs, many municipalities have increased their recycling revenue by up to 10% (Trans-Americas Trading Co., 2020).

Third-Party Collaboration

The City of Peoria can partner with third-party organizations, such as Goodwill, to collect textiles. Goodwill was awarded a contract to reuse and recycle textiles and household items through the City of Tempe's procurement process (City of Tempe, 2020). When comparing both cities' populations, they are similar, Tempe has a population of 195,805, Peoria has a population of 175,961 (United States Census Bureau, 2020). Considering the number of textiles generated may be similar for each city based on the close populations, the City of Peoria could potentially use the same number of community bins (seven) as Tempe.

Based on data from the Solid Waste Division of City of Peoria for the fiscal year June 2019-July 2020, and EPA national waste type averages, students estimate the City generated about 8,356.8 tons of textile waste. This is equivalent to 16,713,600 pounds of textiles generated in that year.

While the following calculations demonstrate much higher revenue compared to costs, it is important to recognize these figures as estimates, which assume 100% of Peoria residents bring their textiles to the community bins. The actual quantity of collected textiles will almost certainly differ, resulting in less revenue than illustrated by Figure 20.

Editor's Note
Students used a variation of the equivalent annual cost formula for these calculations.

$$A = P\left[\frac{i \times (1+i)^n}{(1+i)^n - 1}\right]$$

$$A = \$8,176\left[\frac{0.03 \times (1+0.03)^{10}}{(1+0.03)^{10} - 1}\right]$$

$$A = \$8,176\left(\frac{0.040}{0.344}\right) = \$950.7$$

A = annual cost
P = purchase price = $8,176
i = interest rate = 3%
n = amortization = 10 years

Figure 18 *Student calculated cost, including interest, of implementing a community textile donation bin program in Peoria*

Community textile donation bin program cost

Program	*Volume*	*Cost per bin*	*Total cost for 7 bins*	*Annual cost*	*Notes*
Community collection bins	480 gallons	$1,168.00	$8,176.00	$950.70	Depending where bins are placed, rental fees may also apply, however this can be avoided by hosting bins on municipal property

Figure 19 *Student calculated Peoria collection bin program estimated annual cost for 7 collection bins*

Potential Goodwill partnership program revenue for the City of Peoria

Program	*Textiles collected (tons)*	*Textiles collected (pounds)*	*Cost per pound*	*Total revenue*
Goodwill	8,356.8 per year	16,713,600/year	$0.12	$2,005,632/year

Figure 20 *Estimated annual revenue of textile donation partnership between Goodwill and Peoria, assuming all Peoria residents donate their textile waste via the community collection bins and Goodwill pays $0.12 per pound*

Based on student calculations, the City of Peoria is currently paying approximately $225,633.60 per year for the disposal of textiles in landfills. The proposed community bin textile and clothing recycling program is considered achievable and economically feasible for Peoria, as illustrated by Figure 20. The principal, or initial investment cost for the community bin program, is $8,176.00, which is the price of seven 480-gallon bins. Factoring in interest for this investment, the average cost per year to the City of Peoria for purchasing the bins is estimated at $950.70. The bins can be on City property, avoiding the cost of space rental. The City of Peoria has the discretion to decide where to place the bins.

Editor's Note
By collaborating with a third party, such as Goodwill, Peoria can divert more textiles from the landfill, in turn saving on landfill costs. These savings could help provide additional financial support for the collection program.

To compensate for the cost of placing seven bins, Peoria can collaborate with Goodwill. The City can generate $2,005,632 by allowing Goodwill to collect and process 8356.8 tons of trash tonnage generated per year and pay the City of Peoria $0.12 per pound. This revenue can help pay for all seven bins, further demonstrating the financial viability of this option.

Materials recovery facility

Peoria could potentially build a new materials recovery facility (MRF) where recyclable materials, including textiles, can be processed. One benefit of this option is that textiles would become acceptable to place in residential curbside recycling bins. This is convenient for residents and prevents the need to purchase additional bins specifically for textiles.

On the other hand, this option features its own considerable costs, including the purchase of land, construction, specific machinery for sorting and bundling, labor, and maintenance. According to Megan Workman from Recycling Today, a typical fully equipped facility can cost $20-$30 million (Workman, 2018). Equipment alone comprises half the cost of a typical MRF (Workman, 2018). However, more automation is being used in these facilities than ever before, leading to a higher capital cost (Workman, 2018). It is obviously a much more expensive option than partnering with a third-party. However, the feasibility of a MRF depends on funding availability for a textile recycling program.

Funding opportunities for recycling programs

The City of Peoria could coordinate with other cities in the metro area to build a textile sorting and processing line into an existing regional MRF, or construct a new dedicated textile recycling MRF. This would require a significant intergovernmental process. The Maricopa Association of Governments (MAG) may be interested in hosting a discussion of the idea.

Editor's Note

The Maricopa Association of Governments, or MAG, is an Arizona based regional urban planning agency that facilitates local government collaboration. MAG is based in the greater Phoenix region, with partners from 27 cities and towns, three Native nations, Maricopa County and portions of Pinal County. Further details about MAG can be found at **https://azmag.gov/**

Specific potential funding opportunities for this project include:

- Closed Loop Fund is a social impact fund looking to increase the recycling of products and packaging while reducing greenhouse gas emissions, diverting waste from landfills and creating jobs (funding for municipalities and private businesses) (Closed Loop Partners, 2020).
- Arizona Recycling Coalition (AzRC) is a membership-based, non-profit organization dedicated to promoting waste reuse, reduction, and recycling throughout Arizona and our southwestern region. This organization has a grant program to develop new measurable recycling initiatives that significantly improve the recovery of recyclables and the circularity of Arizona's economy. AzRC awards up to $5,000 in grant funding to the winning applicant (AzRC, 2019).
- EPA grant programs award funding for grants to many small non-profit organizations and state, Tribal, and local governments (EPA, 2020). They help various organizations achieve their environmental goals. Below are a few examples of EPA grant programs.
    - The Multipurpose Grants to States and Tribes offer the FY 2020 Multipurpose Grant (MPG), which provides funding to both the state and tribal partners to deliver environmental and public health results across the nation (EPA, 2020). Recipients of this grant have the flexibility to direct funds to priority access (EPA, 2020).
    - Pollution Prevention Grant Program (P2) seeks to reduce or eliminate pollutants from any waste stream or otherwise released into the environment prior to recycling, treatment, or disposal (EPA, Grant Programs for Pollution Prevention, 2020). P2 grants are awarded to universities, colleges, states, and federally-recognized tribes and intertribal consortia (EPA, Grant Programs for Pollution Prevention, 2020).

Reflections on textile recycling

Solid waste management system success requires sustainable methods to minimize the potential adverse effects municipalities face as the volume of waste increases. Investing time and other resources to find alternative solutions is essential to create a sustainable waste management system that benefits all involved parties in the waste management process while slowly shifting reliance on current waste management techniques such as landfills. By implementing specific measures for solid waste textiles that include diversion and recycling components, the City of Peoria demonstrates its commitment to reducing overall waste processed through the city's solid waste system. Textile recycling may appear to play a small role in modeling how to drive this much-needed change. However, the long-lasting beneficial environmental impacts will benefit the City of Peoria for generations to come.

Recommendations

- Initiate contracts with textile donation centers, such as Goodwill, to offer convenient textile collection services, subsequently diverting textiles from the landfill.
- Once implemented, develop and communicate educational materials for the new Textiles and Clothing Recycling Program, including information on where community bins are located and encouraging residents to take advantage of the program.
- Create and implement community-wide textile drop-off events, twice per year, to provide additional textile collection opportunities.
- Coordinate with other cities in the Phoenix Metropolitan Area to expand the Textiles and Clothing Recycling program and further diffuse the costs of textile sorting and processing equipment.

EXPANDED POLYSYSTERENE

City of Peoria

The Solid Waste Division of the City of Peoria conducts and manages solid waste collection, handling trash, recycling, bulk trash, household hazardous waste, and commercial services. Collection is done once a week for each household using a landfill bin and a recycling bin with a monthly service charge of $15.29 for residential accounts (City of Peoria, 2019). Collection for commercial or multi-family residence accounts is done from one to seven days each week, and billing is dependent on the size and number of weekly visits (Solid Waste Division, n.d.).

Expanded Polystyrene

Polystyrene (PS) is a form of plastic created via polymerization, or chaining together, of styrene molecules. These molecules are found naturally in foods such as coffee, fruits, vegetables, nuts, and meats (National Center for Biotechnology Information [NCBI], 2020). However, the styrene used in commercial and industrial applications is a synthetic version created by "the alkylation of benzene with ethylene to produce ethylbenzene, followed by the dehydrogenation of ethylbenzene" (Chevron Phillips Chemical, 2020). This conversion of benzene and ethylene and the subsequent removal of hydrogen produce a polymer found in appliances, electronics, medical applications, and food service (Chemical Safety Facts, 2020). It can also be extruded via melting and pushing through a die, cooling and creating a "closed cell rigid insulation"; or expanded via heat or steam applied to small polystyrene beads, causing them to expand and fill a mold with a loose cell configuration (Kingspan Insulation Middle East [Kingspan], 2017).

Expanded polystyrene (EPS) is commonly known by the trademarked brand name Styrofoam. Due to its compact and uniform molecular structure, its major properties are its strength, thermal resistance, and thermal conductivity, all relative to foam density, which can be adjusted easily based on the needs of the final product (Figures 21-22). The properties in these tables, along with fairly high water impermeability, make EPS valuable to a wide range of users in the manufacturing, transportation, construction, and food industries and can provide major "savings in design and development, product assembly and distribution costs" (EPS Industry Alliance, 2012).

EPS strengths by density			
Property	***Values***		
Density, pound/cubic foot	1.0	2.0	3.0
Compressive strength, p.s.i.	12-17	31-37	52-56
Tensile strength, p.s.i.	22-27	28-61	92-95
Thermal resistance, R/in.	3.8	4.2	4.3
p.s.i. = pounds per square inch *R/in. = R value (resistance to heat flow) per inch*			

Figure 21 *EPS Compressive and tensile strength and thermal resistance relative to density, by EPS Industry Alliance, 2012*

EPS thermal conductivity		
Density, pound/cubic foot	***Mean test temperature (F°)***	***K factor (BTU-in./ft.2HR F)***
1.0	0	.22
	40	.24
	75	.26
	100	.28
2.0	0	.20
	40	.21
	75	.23
	100	.25

Figure 22 *EPS thermal conductivity, or K factor, relative to density and test temperature, by EPS Industry Alliance, 2012*

These same physical properties that are so beneficial for industrial use of EPS also make it a controversial material to dispose of in landfills. While landfilling is an easy solution, as petroleum-based plastic, EPS may take upwards of 500 years to degrade in normal landfill conditions. As EPS is made using hydrocarbons, it may also release air pollutants during its extended lifetime and decomposition process (Collier County, 2020). The Recycle Tech informational site on their EPS recycling process estimates that up to 30% of landfill space worldwide may be taken up by EPS, with almost 1,369 tons being buried in U.S. landfills every day (Collier County, 2020). The most common methods of reprocessing and recycling are relatively simple, but the logistics of collection, bundling, transportation, and reuse make planning this recycling effort particularly complex.

ANALYSIS & DISCUSSION

Estimates of landfilled EPS

EPS is not currently recycled at the municipal level in Peoria. EPS amounts can be estimated using national data provided by the U.S. Environmental Protection Agency (EPA) in their 2017 Tables and Figures for material generation and recycling (EPA, 2019). The relevant numbers, summarized in Figure 23, include tonnage of total polystyrene (PS), a breakdown of various packaging and containers made using PS resin, and recycling rates for each. It is important to note that expanded polystyrene is not a separate category in the EPA waste facts and figures. These volumes refer to polystyrene in all forms, including plastic, film, and both extruded and expanded foams.

Polystyrene generation and disposal rates

Polystyrene (PS) form	*Amount generated, thousand tons (U.S.)*	*Percent or amount recycled, thousand tons (U.S.)*	*Amount landfilled, thousand tons (U.S.)*
PS in durable goods	770	N/A	N/A
PS in nondurable goods	1,010	N/A	1,010
PS in containers and packaging	570	1.8% or 10	560
Total PS	2,350	0.4% or 10	2,340

Figure 23 *Volume of different forms of expanded and non-expanded polystyrene generated, recycled, and landfilled in the United States in 2017, by the EPA 2019*

Students provided rough estimates of current EPS volumes in Peoria in two ways: 1) amounts of PS relative to total municipal solid waste amounts, scaled from national to city levels; 2) amounts of PS relative to population sizes, scaled from national to city levels (Figure 25). Using both methods may provide a starting point for determining current EPS amounts in Peoria's landfills.

Estimated PS waste volumes in Peoria		
Method 1: Scaling based on PS volume relative to total solid waste volume		
Scale	***Total solid waste, thousand tons***	***PS landfilled, thousand tons***
United States (2017)	139,590	2,350
City of Peoria (2017)	52.6 (Solid Waste Division, 2020)	.89 (ratio-calculated)
City of Peoria (2020)	64.3 (Solid Waste Division, 2020)	1.08 (ratio-calculated)
Method 2: Scaling based on PS volume relative to population size		
Scale	***Population size, million people***	***PS landfilled, thousand tons***
United States (2017)	325.8 (American Community Survey, 2017)	2,350
City of Peoria (2017)	0.168 (USCB, 2017)	1.2 (ratio-calculated)
City of Peoria (2020)	0.180 (USCB, 2017)	1.3 (ratio-calculated)

Figure 24 *Estimated PS volumes based on 2017 and estimated 2020 statistics*

Using the most current data available as provided by the EPA, the City of Peoria Solid Waste Division, and the United States Census Bureau, the current general range for the amount of PS being landfilled annually in the City of Peoria is between 1,080 and 1,300 tons. The amount of EPS being landfilled annually is a percentage of this estimate that is difficult to gauge at this time. Based on the assumption that PS containers are mostly EPS, however, it can be estimated that 570 thousand tons, or approximately 24% of total PS, is EPS (Figure 23). The new calculation of 24% of the original range endpoints for EPS landfilled annually in Peoria now results in a range of 259 and 305 tons.

Collection of EPS

Methods

Storage and collection are two vital economic aspects of any solid waste management system. EPS is a challenging material to manage when it comes to these aspects due to its physical factors. It may come in a large variety of shapes and sizes, from bowls and cups to large blocks for packing furniture or electronics. Although EPS is often large in physical size, the low density invites the threat of escaping from open top waste collection containers. These factors must be examined and accounted for to facilitate an efficient recycling process for residential and commercial EPS waste.

Residential collection

When choosing the correct EPS collection bin, a lid or protective cover must be built into the container. Since EPS before being densified can be bulky in size, no smaller than a 10-cubic yard recycling dumpster (6 ft. X 8.4 ft. X 6.1 ft) is recommended for use in a residential collection scenario. Unfortunately, this particular option is not likely feasible or desirable in neighborhoods with resident-owned homes. Large dumpsters detract from the neighborhood appearance, attract pests, graffiti, or illegal dumping, and may cause concern over ownership and residential fees for the container.

The most economically viable option for residential EPS waste that does not involve adding onto the current curbside recycling bin service is to provide collection events or easy access drop-off sites. The City of Peoria can implement collection events like the “StyroFest Monthly Plastic Foam Recycling Event” held in Kirkland, Washington (City of Kirkland, 2020). These monthly drop-offs collect waste that cannot be recycled through their regular brown container service, including electronics, tires, and textiles.

Events could be located at public places like community centers or libraries and can allow residents to drop-off certain forms of EPS, depending on any third-party recyclers involved. Requirements for a drop-off collection event, again depending on third-party recyclers' requirements, may include clean and dry EPS, packing tape and labels removed, and sorting by type and color. During these events, the collected EPS can be evaluated using personnel and equipment already in place for waste collection, potentially lowering the costs of holding these events. An introductory collection event for EPS may be useful in gauging potential interest in these events if held regularly; written or verbal surveys, along with an analysis of the EPS drop-off potential, may be useful in estimating their effectiveness.

If monthly drop-offs are not a feasible option due to lack of personnel or effective equipment, front-loading containers, preferably slanted front-loading bins, can be used to add ease for the user and maintain the contents within (Figure 26). These containers may be placed in public places similar to the possible drop-off event locations, like community centers and libraries. Additionally, certain stores or commercial building owners often have similar containers on their property to collect clothes, shoes, glasses, and electronics. Stores with similar containers already in place may allow additional containers for EPS collection. Since residents may already be aware of and using the current collection bins, they may be encouraged to drop off their EPS waste as well.

Figure 25 *Large scale slant-top front loading recycling bin, by Royal Oak Recycling*

Section 21-814 of the Peoria city code contains regulations for donation and recycling drop-off containers designed to prevent poorly maintained sites and refuse pileup (City of Peoria, 2018). Temporary Use Permits (TUP) are required and restrict one box on one acre, two boxes on 1-3 acres, and four boxes on lots greater than 3 acres. They must be placed on paved surfaces and avoid pedestrian or vehicular circulation, fire lanes and loading zones, and "any other location that may cause hazardous conditions, or constitute a threat to the public health, safety, and welfare" (City of Peoria, 2018). Collection needs to be no less than once per week, lids need to be locking, boxes should be marked clearly to identify the accepted contents and the TUP number, and hold a capacity no greater than six cubic yards. This last requirement may be difficult when considering the possibility of permanent drop-off locations since EPS is bulky and a week's worth of residential and commercial EPS waste is not likely to fit in a single six cubic yard container.

Commercial collection

Collection of commercial-scale EPS does occur in the United States and Canada. However, there is a limited number of large-scale EPS recycling operations, most of which are located in central New Jersey, southern Florida, Seattle, Washington, and Vancouver, Canada. If the City of Peoria decides to collect EPS recycling from the commercial and multi-family sector in addition to the residential, Peoria should identify an area large enough to hold EPS drop-off bins. Methods used for residential collection may be used for commercial collection, but with additional challenges.

Larger containers, possibly shipping containers or roll-offs, may be needed to hold larger volumes in the case of commercial collection events. However, the mass collection of commercially generated EPS waste could divert large quantities from landfills. Finding centralized locations accessible to large numbers of businesses where a large container could be placed for an undetermined amount of time must be planned. Additionally, businesses, especially small local businesses, generally do not have the space to store EPS until collection events. Transportation of the EPS to an off-site location would be a loss of time and money. Collection events on a commercial scale may not be feasible due to the financial costs associated with this loss of time and money and the difficulty in determining effective locations central to business operations.

Individual recycling containers, like the brown bins used for residential accounts, could collect EPS in addition to the currently accepted recycling materials. This mixed recycling would require sorting and may also require additional rental or purchase of recycling containers on the part of the businesses, depending on the volumes they generate. This option may not be viable since many businesses operate on small margins and may not be willing to participate. Without enough participation on the commercial side, the time and money spent on sorting lines for EPS may not garner sufficient returns to justify the cost.

Figure 26 *City of Peoria brown residential recycling bin from the Blue Lid Pilot Program aimed at decreasing recycling contamination, from Peoria Independent*

Case study: Arizona State University Zero Waste Program

Another example of small-scale collection method is the Zero Waste Program at Arizona State University (ASU). This program operates on a request basis and only services ASU business operations, with no option currently for student participation in EPS drop-off. Locations have vinyl basket trucks of 17.5 cubic feet (Figure 27), purchased through ASU Zero Waste for $350. The cart is placed in a common location within a building or department and is solely for cardboard and rigid block or chuck EPS. For those buildings that do not have blue bins, the online portal allows Zero Waste customers to request their EPS pick-up or drop off their EPS at their discretion (Arizona State University, n.d.).

Figure 27 *Blue cart provided by ASU for cardboard and EPS recycling, by ERM 432/532 student Alexis Ustariz*

When the vinyl carts become full, staff can place a request through the Styrofoam Waste Request portal, and a Zero Waste student worker, will respond. These vinyl cargo baskets are outfitted with wheels to allow for easy transportation of the lightweight yet bulky contents. The associate picking up the waste transports it to ASU's waste management area for sorting. If a piece of received debris is deemed nonviable, it will ultimately make its way to the landfill. If the polystyrene is acceptable, the associate stores the polystyrene within a large cargo shipping container. This shipping container is rented from the EPS recycling vendor, Earth Friendly Building Materials, LLC for approximately $300 per month.

ASU Zero Waste fills this shipping container with polystyrene until it is full. Once ready for shipment, the container gets sealed off, and the recycling vendor employees bring a truck and transport the materials about a mile away to their facility. In fiscal year 2019, ASU diverted 1.18 tons of EPS from the landfill (Arizona State University, 2019). For further information on ASU's EPS recycling vendor, Earth Friendly Building Materials, LLC, and the reprocessing path of this recycled EPS, see the Arizona vendors section beginning on page 63 of this report.

Case study: Kirkland, Washington

The City of Kirkland, Washington, routinely conducts EPS recycling events once per month. As shown in Figure 29, the City uses at minimum a 10-foot-long cargo box truck to transport the waste, as well as large poly plastic bags to physically contain the EPS. The city relies on workers within the city's recycling department and advertises for volunteers when possible. The City of Kirkland collected an "average of ~120 cubic yards of EPS at each [event] in 2018." (McInnis, 2018) An additional 250 cubic yards is collected at larger Recycling Collection Events, where other materials like wood, scrap metals, appliances, and batteries are also collected. In terms of EPS collection, the City of Kirkland exemplifies proper methods to enact sustainable, cost-efficient practices.

Figure 28 *EPS collection at Styrofest Monthly Plastic Foam Recycling Event in Kirkland, Washington, by McInnis, 2018*

Case study: McHenry County, Illinois

McHenry County in Illinois recycles its EPS through the non-profit organization Environmental Defenders of McHenry County (EDMC), located in Woodstock, IL (Environmental Defenders of McHenry County, n.d.). This organization focuses on strengthening the relationship between the environment and the community through volunteer work and business connections to run their programs. All following information was collected from personal correspondence via telephone and email with Cynthia Kanner, executive director of EDMC.

The recycling team is in charge of collecting EPS. EPS collection happens via a drop-off system using three collection sheds located at public works buildings spread throughout the county in a triangular pattern. The sheds were purchased from home improvement stores and customized as needed to protect against weather conditions and increase organizational capacity. The sheds are approximately 16 feet by 20 feet, and volunteers and county officials worked together to build and customize the structures to best suit their needs. Each shed contains 6-8 frames made of wood or metal with large plastic bags to hold the EPS (Figure 29).

Figure 29 *EDMC collection shed exterior and interior setup, sourced from the EDMC Facebook page with permission, and directly from EDMC via email*

Residents are asked to drop off their clean, white, and printed EPS at any of the three collection sheds. Each Tuesday evening, volunteers check the bins to remove any contaminated EPS or non-EPS waste to prepare the material for collection Wednesday morning. Two volunteers then pick up 26-foot U-Haul rental trucks (Figure 30) and haul the EPS from each collection shed. Depending on the volume, two trips are occasionally needed; the runs take about four hours on average. The EPS is transported to a board member's business, Chicago Logistic Service (CLS), for temporary storage until the CLS truck is full. The board member drops off the EPS at the Dart Container Corporation (DCC) facility in Chicago, where it is then processed for reuse. For more information on DCC and their process and end products, see the City spending and costs section on page 68 of this report.

Figure 30A *EPS pick-up using a 26-foot rental truck*

Figure 30B *Volume of EPS from one weekly pick-up*

Figure 30 *Weekly volunteer EPS pickup results, sourced directly from EDMC via email*

The population of McHenry County is approximately 300,000 people. An estimated 34,000 pounds of EPS is diverted annually through these collection drives. Financially, volunteers, business partnerships, and municipal, community, and local family grants make the program possible. The annual cost is about $4000, which is used to pay for the weekly U-Haul truck rentals at a discounted rate through an official partnership with U-Haul. The remainder of the cost is used for reimbursement of volunteer gas purchases during weekly runs, maintenance on the sheds and bins, purchasing the plastic bags for the bins, and various additional costs. The EDMC used to have a densifier to process EPS in preparation for transportation, but they found that the cost was too much to justify their financial position.

Since the EDMC has several programs set up that residents use regularly, they generally have enough volunteers available for the EPS collection. During times of lower participation, like in the case of COVID-19 stay-at-home orders and worries of spreading general illness, volunteer coordinators for each program keep EDMC directors informed of needs for additional volunteers. To fill open slots, the organization uses outreach through other EDMC programs and sends email blasts to call for volunteers from residents who have signed up for informational emails.

The EDMC also has a waste reduction team that works to encourage a move away from using EPS as much as possible in food service since the packaging is more difficult to control when personal and business shipments come from other states and countries. On a county scale, the team encourages residents to patronize businesses that do not use EPS, either in food service or shipping, through educational events and email newsletters. On a statewide scale, they have been working on a ban on EPS use in food service; the legislation was pushed back due to COVID-19 but should be back on track as governmental activities return to normal.

Case study: San Diego, California

The City of San Diego is currently working on banning polystyrene. Currently, the city does accept EPS in their "blue bin" recycling program along with glass, aluminum, plastics, tin, paper, and cardboard. After blue bin collection, contents are transported to one of two private MRFs for sorting. The separated EPS is then sent to local recyclers for processing. This general information was provided during initial contact with the city's Environmental Services Department; however, the individual responsible for recycling was not available for a follow-up for further information (J. Ott-Rol, City of San Diego, Environmental Services Department, personal communication).

EPS recovered at the MRFs is either densified or baled, then shipped to OMNI Recycling, a Dart Container Corporation subsidiary, for processing. The facility accepts donations locally and out-of-state of #6 polystyrene only. The polystyrene donations can be dirty; however, having the food sprayed off would be ideal. Transportation options include rail, truck, or both. Most donations from out-of-state sources are compacted and baled, making most of transportation costs.

Figure 31 *San Diego recycling guidelines, featuring EPS packaging, by City of San Diego*

Preparation, bundling, and transportation

Some forms of EPS are used in food service for disposable cups, plates, and bowls. While not permeable to water, oils can still penetrate the EPS. This contamination can make it difficult or impossible to recycle. Some recycling vendors wash all EPS prior to processing, so depending on the recycling vendor's requirements, residents may or may not need to wash their EPS before drop-off or collection.

The low density of EPS causes it to take up large amounts of space with little weight. The most effective way to bundle EPS for storage and transportation is to compact it, then bale it to hold pieces together and avoid loss. Compaction could be handled by either the collector or recycling vendor, depending on the vendor's travel distance. EPS material should be compacted as much as possible before long-distance transportation since it is costly and unsustainable to ship material that has not been densified (M. Westerfield, Dart Container Corporation, personal communication). Investing in a pressure or heat densifier could benefit the city in that scenario, by reducing the number of trips to the vendor and the associated volume of gasoline needed per ton of EPS. However, densifiers are expensive, costing upwards of $14,500 for a small-volume processing model. Grants and other funding opportunities can help offset EPS recycling costs like a densifier. For maximum cost and time savings, students suggest local EPS recycling vendors and drop-off locations are an ideal solution at a city-wide scale in Peoria.

Recycling EPS

Common methods

As EPS is a form of plastic, it can be melted down and reformed. The most common process involves sorting to remove other materials, cleaning the EPS to remove dirt and food particles, and breaking down the chunks and blocks using a grinder. The ground bits of EPS are compacted using either heat or pressure in a densifier. Hot melt densifiers use heat and sometimes pressure to melt the bits and extrude densified blocks, or ingots, at compaction ratios around 90:1. In contrast, cold compaction uses high pressure to produce similar blocks, usually at a lower compaction ratio around 50:1 (Figure 32) (Better Densifiers, n.d.). There are benefits to both types of machines, but cold compaction units only work for EPS, while hot melt can process EPS, EPE (expanded polyethylene), and EPP (expanded polypropylene).

Figure 32A *The GreenMax grinder and heat-based densifier uses an exhaust system to "achieve a smokeless and odorless operation" that results in a 90:1 compression ratio in the end foam ingot*

Figure 32B *The GreenMax screw drive compactor uses pressure to smash and compact the foam, resulting in zero emissions and a 50:1 compression ratio in the end foam block product*

Figure 32 *Potential long-term investment opportunities, the featured GreenMax equipment transforms EPS waste into viable foam products, by Rebirth of Foam, 2020*

According to Better Densifiers (n.d.), low-volume hot melt models may process between 50 and 300 pounds per hour, and high-volume models may process up to 1,000 pounds per hour. Manual fed cold compaction models may process between 45 and 700 pounds per hour, and conveyor fed models may process up to 500 pounds per hour. Better Densifiers provided quotes for hot melt and cold compaction densifiers that process various volumes. Hot melt units range from $14,500 to a $162,500 densifier that processes 1,000 pounds per hour. Cold compaction densifiers range from $10,750 to $67,100.

The result of either compaction method is blocks of densified EPS, which can then be stored and transported more easily compared to the original form. Depending on the location and owner of the densifier system, the next step is either done in the same facility or the facility of a broker, processor, or end user; they are often extruded or processed into pellets for use in new products (FoodService Packaging Institute [FPI], 2019).

Arizona vendors

Earth Friendly Building Materials

Earth Friendly Building Materials, located in Tempe, Arizona, is the EF Block manufacturer. Made with post-consumer recycled EPS, the EF Block is a fire resistant, soundproof, bug resistant building material used as an alternative to concrete block and stick framing construction. EPS food containers are not accepted at this facility. Earth Friendly Building Materials is the recycler for Maricopa County Health, Maricopa County, the Veteran's Administration, Mesa Community College, Arizona State University, and the Phoenix Children's Hospital. The location has an open bin for donation drop-offs from the public, and large loads can be coordinated by contacting their offices. Earth Friendly Building Materials is the number one EPS recycler in the state of Arizona.

Figure 33 *EF Block fast facts, by Earth Friendly Building Materials*

Eco Building Systems

Eco Building Systems (EBS), located in Peoria, Arizona, accepts and uses clean EPS #6 to create fire-resistant, storm-resistant, earthquake-safe, and pest-free construction blocks. The Perfect Block uses a mix of EPS, cement, proprietary EBS material mixtures, and water. The company can construct buildings themselves with the product, or sell to contractors.

The company picks up materials on a request and scheduled basis but prefers in-person drop-offs at their facility. They will pick up materials for a fee dependent on location and amount, and they use a 26-foot long drop box to pick up EPS. However, given that the company is in Peoria, drop-off may be a feasible and economical option.

Eco Building Systems does not rent out collection containers, but they currently provide a drywall company with 4 by 8 by 3 feet bags for collection and indicate they could provide the city with the same on a case-by-case basis. They are also open to the possibility of a collection event but have not held one to date. This vendor does not pay for foam but does accept regular post-consumer foam that has not been shredded or densified.

In a personal communication, an additional question was asked regarding how the City of Peoria could provide resources to scale capacity and processing. Eco Building Systems stated that they do not need additional resources in terms of processing or capacity now but believe that it would be beneficial for the city to build with their product in the future. Given Peoria's projected future growth, a partnership with Eco Building Systems could help create cost-effective, energy-efficient, and environmentally friendly homes and businesses to accommodate increasing populations. While the company may not have the capacity to deal with the potential volume of EPS from Peoria, they may still be a valuable member of a network of vendors that collect EPS, alongside Earth Friendly Building Materials.

Sedona Recycles

Sedona Recycles accepts EPS only in polystyrene foam blocks and does not accept food service materials or packing peanuts. EPS must be dropped off in their facility and not at drop-off locations. According to the Sedona Recycles website (2020), donations from local groups allowed the facility to purchase a densifier to process the EPS into denser logs. These logs are shipped to Berg Mill Supply in Los Angeles, California, to become crown molding, picture frames, and CD cases. In 2017, Sedona Recycles processed 5 tons of EPS. Personal communication with Executive Director Jill McCutcheon reveals that the facility is at maximum capacity for the densifier and labor force they currently have; therefore, the program cannot currently work with the City of Peoria. An option may be to create a partnership with Sedona Recycles and work with them to fund additional densifiers to increase their capacity in preparation for accepting Peoria's EPS.

Sedona Recycles is very open about its dependence on donations to continue its service since it is a labor- and energy-intensive process that "results in a large financial loss for [the] operation" (Sedona Recycles, 2020). Donations are largely sourced from the Sedona Community Foundation, the Yavapai County Community Foundation, the City of Sedona, and several cultural groups and local businesses.

Southern California vendors

INTCO Recycling

INTCO Recycling, with the closest facility located in Chino, California, accepts clean EPS from packaging, food service, and insulation and prefers materials to be in densified form. They indicate that they cannot buy shredded foam since the material is too light for the organization to use.

INTCO does accept out-of-state EPS recycling and will pay the shipping cost. They pick up materials on a request basis and coordinate pick-ups with a local freight forwarder when the consumer is ready for pick-up. Unfortunately, INTCO Recycling does not currently partner with communities for collection events, but they may consider this option. The EPS that they receive is mainly repurposed to make picture frames and decorative moldings. According to a company representative, the organization also sells a variety of densifiers, with the medium processing densifier, M-C100, priced at $40,000, including delivery; this is the recommended size for the city, according to a company representative (Figure 35). Appendix A contains brochure information for INTCO's densifier stock and Better Densifier's stock.

M-C100
22.9 kw/30.6 hp
100 kg per hour/220 lbs per hour
600-800 kg/m³/1320-1750 lbs/cubic yard
800*555 (l/w) mm/31.5*21.9 (l/w) in.
2030*1430*2040 (l/w/h) mm/79.9*56.3*80.3 (l/w/h) in.
2130*1530*2290 (l/w/h) mm/83.9*60.2*90.2 (l/w/h) in.
1,500 kg/3300 lbs

Figure 34 *M-C100 densifier model, recommended by INTCO for Peoria, by GreenMax INTCO Recycling*

The City of Peoria would need to purchase a densifier to meet INTCO's requirements. Though quite sizable, the densifier would be the only cost if the city chose to send EPS to INTCO Recycling. While technically not gaining any money by utilizing this organization, Peoria would save on shipping and landfilling costs, which could eventually reach the densifier's price depending on the length of time the city chooses to recycle EPS.

Dart Container Corporation

Dart Container Corporation is a manufacturer of plastic and virgin EPS dinnerware, cups, and containers for the food industry. Their pilot effort is to encourage recycling EPS to reduce the environmental impact of their products. They often work with cities, counties, and organizations to take their collected EPS and recycle it through collaboration with Omni Recycling and Plastics Recycling, Inc. According to an information video available on their website (Dart Container Corporation, 2016), their process is improved over that of many other vendors in that they bundle together rigid and expanded polystyrene to equalize transportation costs. They also accept contaminated EPS since their process involves breaking large pieces, air-jet optical sorting, grinding, then washing ground bits in an attrition waste tank and rinsing them. Sink tanks then allow rigid material to fall to the bottom and expanded material to float. Additional contamination is removed with 150-micron screens.

Other EPS Recycling Vendors

There are several other programs that recycle EPS but may not be feasible options for the City of Peoria to pursue, mostly due to transportation distance and international borders. However, these programs may still offer valuable insights to consider when designing a municipal system.

Michigan Foam Products

Michigan Foam Products is a self-contained recycling program (Michigan Foam Products, LLC, 2020). They manufacture an extremely varied portfolio of EPS products, including packaging, insulation, hobby foam, theater props and sets, and sheeted goods. MFP accepts clean, white EPS products with the #6 label, and any product already produced by MFP. These used products are added directly back into the manufacturing process to create the primary blocks they use for all other products.

TerraCycle

TerraCycle is a program based in New Jersey that offers recycling for various materials that are not typically accepted in the regular recycling bin, including EPS. The main method of recycling EPS through this company is by requesting a Zero Waste Box, available in small (11 by 11 by 20 inches), medium (11 by 11 by 40 inches), and large sizes (15 by 15 by 37 inches) (TerraCycle, 2020). While this has great potential for working on a small, individual scale, it is inefficient for the bulk EPS that would regularly come from a city the size of Peoria. TerraCycle offers bulk pickup of other wastes like lamps, batteries, and electronic waste but does not currently offer bulk EPS pickup (AirCycle, n.d.).

Styro-Go

Styro-Go is an EPS recycling program based in Alberta, Canada (Styro-Go, 2020). They offer flexibility to their clients in the form of mobile collection units that crush and densify the EPS as it is collected. These 5-ton trucks can collect as much as five 53-foot transport trailers by compacting the EPS at a ratio of 90:1. The trucks output bricks about 1 cubic foot in size that weigh about 60 pounds each; these bricks can be directly taken to the warehouse and shipped out to retailers. Since its launch in 2016, Styro-Go has recycled 557 tons of EPS, an original volume of over 2 million cubic feet diverted from the landfill.

Foam Pack Industries

Foam Pack Industries, located in Springfield, New Jersey, serves "over 15 different industries, ranging from aerospace and agricultural to marine, medical, and military." (Foam Pack Industries, 2020). Foam Pack Industries accepts clean white EPS from both commercial and residential sources but enforces strict guidelines, including no food packaging sources and removal of any adhesives (tape, stickers, and labels). This vendor uses thermal recycling methods to transform blocks of styrene to window frames (Figure 35), vial holders, display models for the retail industry, and reusable coolers. Foam Pack Industries has three methods for collecting EPS. The first method is the more common drop-off method between regular business hours of 8:00 am-4:30 pm. The second method is sending the items through the mail service, and the last is using a delivery company service to haul the products. The last two options are unique when dealing with a situation such as Arizona's polystyrene (i.e., too much volume, not enough densifiers). These two methods could prove costly, so a large enough waste stream needs to be collected and sorted for clean white EPS.

Figure 35 *Custom window frames made from recycled EPS, alongside other products made by Foam Pack Industries*

Reuse markets

Once EPS has been reprocessed into dense masses to improve transportation efficiency, it is extruded into small pellets that closely resemble the original form of polystyrene. These pellets are often cheaper than those made from virgin materials since no additional oil and chemicals were required to process them (Foam Pack Industries, 2019). Virgin materials are mostly used in packaging, construction, and insulation, or other applications such as food service supplies, surfboards, and similar products (Plastics Insight, n.d.).

Recycled EPS is commonly used in tiles, frames, moldings, synthetic timber, airplane interior parts, and plastic cases (Styro-Go, 2020 & Somerville, 2017). The end product depends on the components mixed with the EPS. When mixed with concrete, like Eco Building Systems and the Perfect Block, it creates concrete blocks that are strong, resistant to fire and storms and doubles as an insulation layer. According to Knapp (2020), "[when] combined with soil and compost, it helps promote aeration" and can be sold as a light fertilizer; decking and interior trim products are made by blending the EPS with other forms of plastic. However, recycled EPS cannot be used for food service products such as cups, trays, or plates due to potential contamination.

Funding

City spending and costs

The current average fee for Peoria to dispose of its municipal solid waste is $27/ton at the Glendale landfill (K. Burke, City of Peoria, personal communication), and $22.08 and $30.17 at the Waste Management-owned Northwest Regional Landfill and Deer Valley Transfer Station, respectively (A. Redd, City of Peoria, personal communication). Combined with the calculated EPS estimates, the City of Peoria may be spending between $6,993 and $8,235 annually to landfill EPS. According to the City of Peoria Comprehensive Annual Financial Report For Fiscal Year 2019 (Andrews, 2019), the cost for Peoria to handle its solid waste was $13.7 million, of which $12.9 million was sourced from fees associated with residential and commercial municipal solid waste. The difference between the annual cost and total fees for solid waste management was $800,000.

According to that same fiscal report, the City of Peoria had a total of 58,816 residential solid waste accounts in FY2019. The average monthly billing amount for each account was $14.42. The residential cost for one container of landfill and recycling is $15.29, with additional containers costing $12.53 each. Commercial recycling container costs are a flat $25 per container, regardless of size (Maricopa Association of Governments [MAG], 2017).

In addition to the standard costs of solid waste collection, funding would be required to cover the costs associated with an additional and specialized recycling program for EPS. Each step of the recycle and reuse process has added costs associated with it. Whether collection bins would be provided in public and residential areas or collection days would be held regularly, or a local vendor would be sufficient to handle the city's EPS volume, or a vendor outside of Arizona would be required. City-relevant steps of the recycling process and their associated costs are outlined in Figure 36.

Peoria EPS recycling costs		
	Method	***Costs***
Collection	Residential, commercial, and/or public collection containers	Collecting in current recycling bins would not add cost except to residents and businesses who may need additional containers to hold all recyclables City may need to purchase additional recycling containers to meet demand Not desired by city or residents Neighborhood EPS containers could be provided at the neighborhood's cost City would likely need to purchase large containers for neighborhoods to rent Large public containers could be purchased and placed in parks or willing retailer parking lots, similar to clothes and shoes drop-off program All three options may require additional pickup routes, trucks, or personnel
	Regular collection days during seasons with good weather	Current personnel or volunteers could assist with little to no additional cost to the city Otherwise, hiring more personnel may be needed City may need to purchase or rent truck to collect EPS being dropped off Kirkland, WA, case study suggests the purchase and use of large poly plastic bags to temporarily contain the EPS
Preparation and bundling	City densifies	Densifier to match max volume of EPS would need purchased Additional personnel may be needed to operate Potential transportation cost to get densified blocks to vendor Personnel, trucks and maintenance, fuel Potential storage costs Air pollution permits, depending on type of densifier
	Vendor densifies	Higher transportation cost without densification prior to shipping Personnel, trucks and maintenance, fuel Vendor may transport, but likely at a higher cost for pickup or lower purchase price of EPS Potential storage costs
Reuse	City keeps the EPS and reuses it in municipal and public projects	Additional equipment and personnel would be needed to create desired products
	Vendor reprocesses EPS and reuses for a variety of applications	No additional costs for city beyond previously mentioned

Figure 36 *Costs for the City of Peoria associated with each relevant step of the recycling process*

Editor's Note
The students did not provide a source for the $400,000 figure provided in their original work.

The City of Peoria has generated about $300,000 in revenue annually since implementing a curbside collection of recycling in 2017 (K. Burke, personal communication). In 2018, recycling markets were disrupted as China implemented a ban on waste and recycling imports. The cost of recycling ranged from $400,000 to $800,000, making landfilling a cheaper option in many cases. The costs of recycling in general and those specific to EPS should be compared to the potential benefits of recycling EPS, including financial and environmental, to justify these expenses beyond the landfill tipping fees.

Many of the costs associated with a city-run program to recycle EPS could be passed on to taxpayers or residential and commercial solid waste accounts. However, this may increase attitudes of recycling being a burden and unnecessary, rather than a valuable service and environmental responsibility. A better option could be to look at grant funding and organizational partnerships to share recycling costs.

Grant opportunities

Resource Recycling has a comprehensive watch list for recycling grants and includes case studies as well. Grants are not limited to EPS recycling but may still be of interest to Peoria for other opportunities for diversion. The watch list can be accessed on their website (Resource Recycling, 2020).

Foam Recycling Coalition Grant Program

The FoodService Packaging Institute provides eligible organizations, businesses, and municipalities the opportunity to apply for their Foam Recycling Coalition (FRC) Grant Program. This program provides up to $50,000 to a public or private entity in the US or Canada that can commit to recycling polystyrene for 3 years and reporting volumes collected, processed, and marketed (FPI, 2019a). Additionally, selected entities must accept post-consumer foam, including food service, egg cartons, meat trays, and protective packaging, and invest in the required equipment to collect and process.

This FRC grant is made possible by support and donations from large corporations interested in reducing the environmental impact of their products. These include Dart Container Corp, NOVA Chemical Corp, Genpak, and Pactiv Foodservice/Food Packaging (FPI, 2019c).

The grant application requires a plan from the entity on EPS recycling, including equipment requirements, and is contingent on implementing said plan within six months. There is also an educational aspect of the grant if received, as entities are required to communicate foam recycling opportunities with the community and incorporate acceptance into regular communications and educational materials. Cities that already have a ban on EPS, such as San Francisco, New York City, and San Diego, are not eligible for this grant. The impacts of this grant program are further detailed in Figure 38.

Case study: Austin, Texas

In 2020, the Austin Resource Recovery (ARR) Department in the City of Austin, Texas, was awarded a $45,000 grant to process post-consumer polystyrene (FPI, 2019a) The grant will help advance ARR's goal to reduce waste sent to landfills by 90% by the year 2040 through curbside collection, hazardous waste management, outreach and education, and free voluntary consulting services for local businesses (FPI, 2019c).

The city currently has a Recycle & Reuse Drop-Off Center (RRDOC) for collection from primarily single and multifamily complexes. Most collection services the city offers are free; however, services offered to the business community have associated fees which are paid to the city.

Due to Austin's Universal Recycling Ordinance, businesses are required to provide access to recycling; this has led to increased volumes of polystyrene collected at the RRDOC by nearly 8,000 pounds per month. The city already had one densifier for processing. However, support from the FoodService Packaging Institute's grant helped ARR purchase another densifier to handle the influx of polystyrene from businesses.

To comply with the grant's educational and communication requirements, ARR's outreach program includes social media and monthly utility bill informational pamphlets to convey information about the EPS recycling program. ARR estimates they have reached approximately 195,000 residential customers throughout Austin in February of 2020, where the city's total population is approximately 978,908 (U.S. Census Bureau, 2020). Given that the city received the grant relatively recently in 2020, its outreach efforts have reached a significant number of residents in a short period of time.

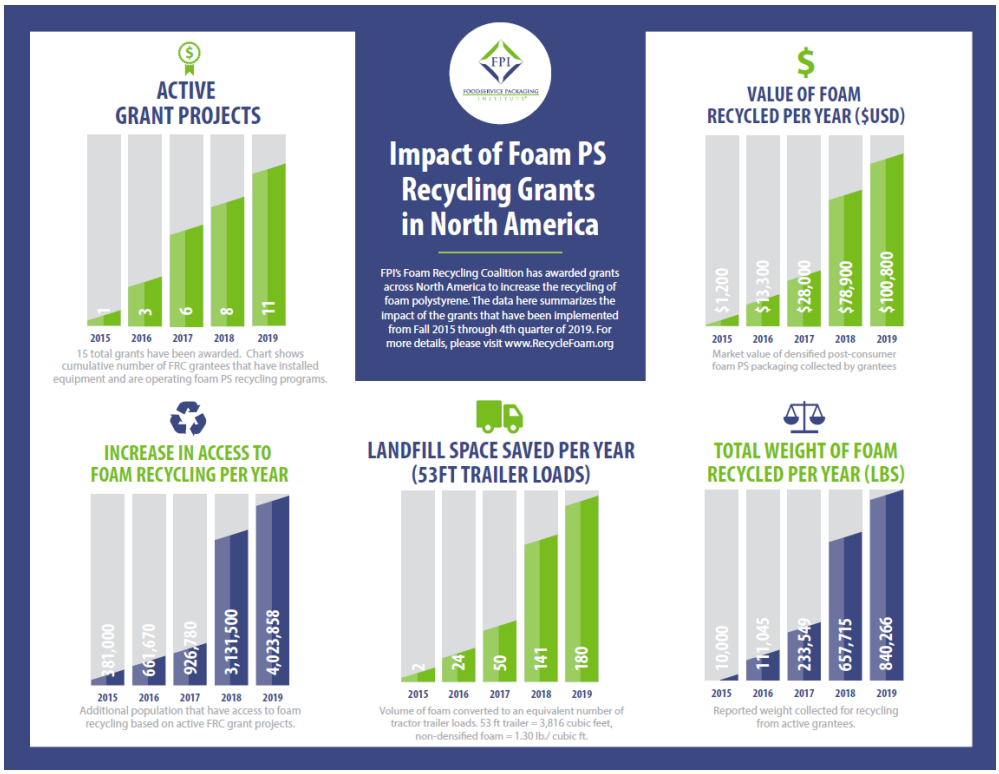

Figure 37 *Impacts of EPS recycling grants across North America, by FPI*

Arizona Recycling Coalition

The Arizona Recycling Coalition (AzRC) offers grants of up to $5,000 to eligible nonprofits, local governments, and tribal nations to increase recycling efforts and promote waste diversion (Arizona Recycling Coalition [AzRC], n.d.). The coalition began in 1993 and has since awarded more than $250,000 in funding to support recycling initiatives across Arizona.

Eligible applicants should be AzRC members, but if the organization is not a member, part of the awarded grant will be used toward a one-year membership, which costs $125. Furthermore, the applicant should be either a nonprofit, government agency, school, entrepreneur, or tribal nation engaged in the recycling industry from collection to education. The grant is awarded to entities whose projects result in the reduction of materials that would otherwise be landfilled, such as polystyrene. Applicants are assessed on the criteria listed in Figure 38.

Arizona Recycling Coalition grant eligibility criteria	
Principle	***Criteria***
Impact	The impact the project will have on recycling and circular related efforts in Arizona
Plausibility	The likelihood the goals outlined in the project proposal can be completed
Creativity	The project promotes new, innovative, and replicable ideas for recycling efforts and/ or improves the recovery of recyclables and circularity in Arizona. Preference for ideas that have not been awarded in the past
Financial viability	The ability to demonstrate financial need for the project as well as the ability to sustain and operate after AzRC funds have been expended.

Figure 38 *Criteria from AzRC used to assess recycling grant applicants*

If selected, AzRC requires that winners attend the Arizona Recycling Coalition Conference, credit AzRC, put the AzRC logo on project materials, participate in a video interview, and provide a project update by Earth Day, approximately 6 months after the application cycle closes in October.

Previous grant winners include the Town of Queen Creek (2015), Phoenix Union High School District (2015), the Flagstaff Sustainability Program (2015), and White Mountain Apache Tribe (2014). The City of Peoria was awarded the Recycling Excellence of the Year for a Municipality in 2013. 2019 grant recipient videos can be viewed on the Arizona Recycling Coalition YouTube channel.

Case study: Town of Queen Creek

The Town of Queen Creek has been recognized numerous times for its dedication to recycling and waste diversion by the AzRC. In 2013 and 2015, they were awarded the AzRC grant of an undisclosed amount to increase recycling efforts in the community.

The grant helped the municipality alleviate budget constraints, increase recycling education, facilitate hazardous waste management, and organize a textile recycling collection program (AzRC, 2013). The program collected over 27,000 pounds of textiles and raised money for the Boys and Girls Club. Due to the collection event's success, they designed a curbside textile recycling program in cooperation with United & Phoenix Fibers.

EPA financial assistance

The EPA offers a variety of grants for different sustainability initiatives sponsored by various Federal Agencies. All grants can be viewed on their grant page (EPA, 2020). One grant that could be of particular interest to Peoria is the Solid Waste Management Grant Program.

The U.S. Department of Agriculture (USDA) hosts the Solid Waste Management Grant Program. It offers eligible applicants up to $1 million to assist communities with technical training programs to improve waste management (grants.gov, 2020). Public entities are eligible and encouraged to apply for the grant program. Funds may be used to evaluate landfill conditions, provide technical assistance and training to enhance operations, or maintain landfills or facilities. Funds may not be used toward consulting, political activities, construction, or personal gain. The application is available online, but applicants must create a Grants.gov account to apply. An informational session was held in September 2019 for the application during the fiscal year 2020-2021 and can be viewed online at **https://www.youtube.com/watch?v=IJbGsuakyHA**.

Peoria may be interested in applying for many other grants that do not necessarily relate to recycling or solid waste initiatives through the EPA. Furthermore, many grants are not available for public entities. However, Peoria could partner with local businesses or universities to apply for a grant and conduct research on their behalf if interested. Grants range from water management, clean energy, agriculture, and environmental engineering.

Closed Loop Fund

Closed Loop Partners focuses on sustainable solutions for plastics and packaging materials and provides two funding opportunities for entities to improve recycling and encourage a circular economy: the Infrastructure Fund and the Venture Fund (Closed Loop Partners, 2020b). This discussion will focus on the Infrastructure Fund, as it is more applicable to the City of Peoria's needs.

The Closed Loop Infrastructure Fund typically awards applicants loans ranging from $3-$5 million over a 3-10 year period for organizations to scale recycling infrastructure and innovation from collection to end-product manufacturing. These loans accrue zero interest for municipalities, but it should be noted that each asset-based loan is secured by collateral. The company invests in applicants who have the potential to reduce greenhouse gas emissions, divert from landfills, repay the loan, scale the project, increase participation in recycling and recovery, provide economic benefits to the community, or leverage additional sources of capital. The application requires applicants to provide information about additional funding sources (if applicable), project details, total project cost, and the loan request amount (Closed Loop Partners, 2020b).

Case study: Scott County, Iowa

Scott County received a $10.75 million loan from the Closed Loop Fund. As part of the Closed Loop Infrastructure Fund, the loan helps recipients invest in new recycling initiatives (Sustainable Brands, 2017). As of 2017, it is estimated that Scott County has increased recycling by 61% and generated more than $100,000 in savings and revenue. The county used part of its loan to finance single stream household recycling for over 48,500 households and upgraded their MRF to double its throughput over time.

After implementation, Scott County advises future applicants and potential awardees to research best practices in education and outreach (Sustainable Brands, 2017). The county used data from a public perception survey to determine what messaging, and outlets were best to communicate information. They also used educational resources and tools from The Recycling Partnership to inform their decisions.

The Recycling Partnership

The Recycling Partnership offers grant opportunities for eligible organizations to create or expand residential curbside recycling programs (The Recycling Partnership, n.d.). Grant amounts vary depending on project proposals but can be upwards of $300,000.

To be considered, applicants must be a local government, solid waste authority, or federally recognized tribe to receive this award. Additionally, funding is only available for purchasing recycling carts for residential curbside programs, and education initiatives. If selected, the applicant must provide recycling collection weekly or bi-weekly and utilize the educational materials The Recycling Partnership has developed. Furthermore, reporting is required to track monthly and annual MSW and recycling tonnage before, during, and after cart implementation. There are also specific cart requirements detailed on their website (The Recycling Partnership, n.d.).

Competitive applications are those that have thoroughly described the potential diversion resulting from the project, the number of households impacted by the project, strategies the organization intends to use for implementation, and have attached any relevant documentation. Grant recipients will be reimbursed after demonstrating that requirements have been met.

Coca-Cola Public Spaces Recycling Bin Grant Program

The Coca-Cola Public Spaces Recycling Bin Grant Program, in coordination with Keep America Beautiful, provides grants to municipalities, nonprofits, tribal governments, schools, community groups, and religious organizations to expand recycling efforts in communities across the United States (Keep America Beautiful, n.d.). The grant program aims to provide recycling bins to communities to either create new recycling services or expand current recycling initiatives. Instead of receiving a monetary award, recipients receive recycling bins, which helps both organizations "leverage their purchasing power to provide more recycling bins than would be possible if selected grant recipients were to use monetary awards to purchase independently" (Keep America Beautiful, n.d.). Bins are available in different forms depending on the type of recycling intended, requests by the applicant, and number of bins desired. Keep America Beautiful and the Coca-Cola Foundation also cover delivery costs.

Recipients must complete a grant agreement, issue a press release, use and maintain the bins for at least 5 years for the recycling project described in the application, track quantity collected in the first year, and complete online reports as requested. Keep America Beautiful chooses grant recipients based on need, the likelihood of increased recycling, planning, the organization with articulated goals, and the ability to track and report collection and access to bins.

Case study: Orange County, Florida

In 2019, Orange County received $343,000 as part of both The Recycling Partnership Grant Program and the Coca-Cola Public Space Recycling Grant Program (Floer, 2019 & "Keep America Beautiful", 2019). The county will utilize funds to improve the recycling program by inspecting carts, educating residents on recycling, and expanding recycling opportunities throughout the county. Orange County's website asserts the county is "committed to sustainability, and [will use] grant funds [to] better educate [their] residents on how to properly recycle" (Floer, 2019). Results are ongoing and will be updated as they become available.

Key findings

The aforementioned awarded communities, along with other communities and recycling groups, commonly note that "grant funding significantly lowered the barriers to [recycling] participation" related to the high costs of densifiers, outreach program creation, and connecting with end markets (FPI, 2019e). They also note that grant funding is most effective, and the program is likely to succeed when residents are ready to participate, highlighting the importance of careful planning and consistent promotion. While new equipment is important and useful, spreading the word about the opportunity to recycle EPS is key to getting participation on a large enough scale to justify the funding.

In this report's explored examples of funding opportunities, the common requirements are adequately demonstrating the need and the plan. Careful scoping of residents and businesses in Peoria and potentially the surrounding metropolitan area will help determine whether the time and effort needed to apply for these grants will be worth it. Many of these grant programs are competitive, which shows the increasingly positive desire to improve municipal sustainability options. However, this competitiveness requires applicants to be fully committed to their plan and their preparation work.

Scoping will be necessary to provide more accurate data for EPS volumes to be recycled and closer estimates of the number of participating households and businesses. The volumes calculated in the Estimates of Landfilled EPS section of this report (beginning on page 50) can be considered appropriate to use while formulating a plan. However, the more data specific to the City of Peoria and the surrounding areas, the more competitive a grant application will be.

Along with scoping, a plan for education and outreach is needed to achieve as much participation and recycling volume as possible. According to the EPA, communication, and outreach is the number one consideration for improving and increasing participation in a recycling program (United States Environmental Protection Agency [EPA], 2016). The EPA provides several suggestions for bettering communication with the public at a low cost, including:

- Clearly labeling drop-off centers, where they are located, where materials are to be placed; talking to residents who go to these centers can help point out flaws and difficult instructions;
- Publicize program changes, such as new materials being accepted, and show residents that the program is committed to being up to date with current science and technology;
- Distribute promotional materials using curbside collection employees on their regular routes by using masking tape to attach a flyer or letter to residents' containers;
- Hire passionate recyclers to write columns in the newspapers, discussing the program and subtly encouraging participation;
- Take advantage of any community services that welcome new residents, and provide brochures and flyers for them to distribute;
- Maintain a current website for residents, both committed recyclers and newcomers to the concept, to be able to find all available information on the recycling program, including in-depth information such as collection, sorting, bundling, and shipping processes.

Reflections on EPS recycling

The City of Peoria is taking an excellent first step towards increasing its sustainability impact. Adding EPS to their list of accepted materials for recycling will help their residents and local businesses achieve their environmental goals and improve the current and future operation of Arizona landfills. Encouraging volunteer participation will increase residents' consistent recycling of their EPS and increase justification for spending additional money on new and updated recycling programs.

Through careful scoping and consideration of all options for collection, bundling, and vendors, this EPS recycling program can be effective in diverting significant amounts of EPS from the landfill. In addition to our team's research and recommendations, there are many resources available to the City, including case studies not discussed in this report and other vendors and technological pioneers creating new EPS waste solutions.

Peoria is in a unique position, being directly in the Phoenix metropolitan area. Given sufficient funding, promotion, and planning, Peoria can become a center and model of sustainability for other cities to follow in the future as they recognize their potential for improving sustainability and making positive environmental impacts.

Recommendations

- Host an EPS collection day to gauge interest, participation, and potential volume of EPS that would be collected on a regular basis.
- Distribute a survey to residents to ask about average EPS volumes on a weekly or monthly basis.
- Conduct a survey of various local businesses taking advantage of the City of Peoria solid waste collection. Questions may regard forms and volumes of EPS discarded weekly or monthly, and what collection methods would be preferred.
- Investigate the use of volunteers at collection events or weekly pick-ups and drop-offs to further reduce program expenses.
- Set up public drop-off locations and weekly pick up routes to facilitate recycling participation.
- Investigate the possibility of using local business trucks for weekly EPS collection.
- Utilize local vendors and facilities for EPS storage, including local businesses such as Earth Friendly Building Materials and Eco Building Systems.
- Develop partnerships with surrounding cities to purchase a densifier, diffusing the high cost across communities. The purchase of a densifier can be done through INTCO Recycling or Better Densifiers.
- If local vendors cannot handle the volume of EPS, INTCO Recycling and Dart Container Corporation may be feasible out-of-state options, but transportation costs and vendor requirements would make a densifier a necessary purchase.
- Consider applying for grants to fund and promote an EPS recycling program. Grant programs include Foam Recycling Coalition Grant, Arizona Recycling Coalition Grant, and the Coca-Cola Public Spaces Recycling Bin Grant.
- Design a communication plan for the current recycling program, with a focus on informing residents about the program and addressing questions and concerns.
- In conjunction with a communication plan, focus on building community relations and taking advantage of community services, such as newsletters and welcome packets, to inform the public about current and future recycling options.

CONCLUSION

The City of Peoria's aim to reduce textile and EPS waste in landfills is a considerable effort in the city's sustainable transformation. The recycling of textiles and EPS waste present several challenges for a large-scale recycling program. Expanding Peoria's recycling program to include these wastes can be costly and time consuming; however, a more robust recycling program can redirect solid waste from landfills and repurpose it for further use.

Through their research, the students in ERM 432/532 Sustainable Waste Management were able to evaluate Peoria's potential investment into a recycling program for unique materials, with a primary focus on EPS and textiles. Students have identified that there is, in fact, a need for textile and EPS recycling and provide various resources to contribute to its planning and implementation.

The City of Peoria would benefit from developing relationships with third-party organizations that specialize in recycling efforts. Students have identified several local organizations that specialize in textile or EPS recycling and recommend establishing partnerships with these organizations to reduce additional costs in supplementing the necessary materials and equipment needed for textiles and EPS. In addition, Peoria can develop relationships with other cities to design a cross-city effort for expanding recycling capabilities. In collaboration with various stakeholders, Peoria can host community wide collection events for Peoria residents. There are various funding opportunities available to provide the necessary resources and funds for enacting a comprehensive recycling program. The City of Peoria can tap into various funding and grant programs to strengthen its existing solid waste program, as well as design an inclusive recycling program for various materials.

As part of Peoria's sustainability effort, there are numerous opportunities for recycling and waste diversion to project Peoria to the forefront of sustainable policy and living. As other cities aim to reduce their recyclable waste in landfills, Peoria can look to potential funding and programs to expand its solid waste recycling program. Peoria has already demonstrated itself as a forward-thinking community, and with the expansion of its recycling efforts, Peoria has the potential to become a model for sustainability.

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