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Environmental Effects of the Single Use Bag Ordinance in Austin, Texas

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For

Austin Resource Recovery
&
The Zero Waste Advisory Commission

According to
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Table of Contents

1	Abstract	3
2	Keywords	3
3	Presentation of Austin Resource Recovery	4
4	Introduction to the Single Use Bag Ordinance of Austin, Texas	6
5	Background	7
6	The Impact of Plastic Bag Litter	8
7	Plastic Bags as a Component of Austin’s Litter	12
8	Measuring Plastic Bags in the Recycling Stream	14
	A. Purpose	14
	B. Goal	15
	C. Method of Capture	15
	i. Texas Disposal Systems	15
	ii. Balcones Resources	18
	D. Results	19
	i. City of Austin Recycling Stream	19
	ii. Comparative Recycling Stream	21
9	Conclusion	22
10	Discussion	25
	A. People	25
	B. Planet	25
	C. Profit	26
11	Summary	28
12	Acknowledgements	29
13	Bibliography	30

1 Abstract

The City of Austin implemented a Single Use Bag Ordinance (SUBO) in March of 2013 as a method to change the behavior of its citizens in an effort to improve the environment and decrease waste as a part of its 2011 Master Plan¹. Bag ordinances such as the SUBO are becoming more prevalent nationwide, gaining momentum as the plastic bags become more unpopular across the northern hemisphere after widespread restrictions throughout the global South². The goal of this report is to show the impact of the ordinance to the City of Austin through anecdotal and empirical evidence. To obtain this evidence, interviews were conducted in many different relevant sectors, including; multiple agencies within the City of Austin, non-profits ranging from local to national influence, private corporations from Austin and beyond, as well as individual stakeholders such as politicians and attorneys. Two comparative studies were completed to gather data related to whether this ordinance has had an effect on consumer behavior;

1. A litter composition study conducted by non-profit litter abatement organizations to track the amount of single use bags in a municipality without a bag ordinance, Fort Worth, and a municipality with a bag ordinance, Austin, and;
2. A single use bag audit performed during the semi-annual recycling composition study performed at both of Austin's single-stream residential recyclable material vendors; this audit also analyzed a co-mingled stream from a combination of municipalities which do not have bag ordinances.

¹ Master Plan. Rep. Austin Resource Recovery, 15 Dec. 2011.

² Clapp and Swanston, "Doing Away with Plastic Shopping Bags: International Patterns of Norm Emergence and Policy Implementation" 315-332

2 Keywords

Single-use bag – Any bag which was not designed to be re-usable as per the specifications of the Single-Use bag ordinance³. These bags are made from high density poly-ethylene (HDPE) resin.

Reusable Bags – Any bag which was designed to be used multiple times. This includes low density poly-ethylene (LDPE) plastic bags with a thickness of more than 4 mils, woven polypropylene, cotton, and many others. These bags are constructed with the purpose of durability for reuse.

Materials Recovery Facility (MRF) – a combination mechanical, manual, and electric recyclable material separating system⁴

Social Norms – rule[s] governing the behavior of certain individuals despite the lack of legal sanctions, often due to social sanctions at the behest of peers⁵

Mil – a common measurement in describing the thickness of plastic, especially in terms of bags. It is equivalent to 1/1000th of an inch, or 0.0254 mm.

³ City of Austin, Texas, *Ordinance No. 20120301-078*.

⁴ "Eco-Industrial Park - MRF (Material Recovery Facility)"

⁵ Kinzig et al., "Social Norms and Global Environmental Challenges: The Complex Interaction of Behaviors, Values, and Policy" 164-175

3 Presentation of Austin Resource Recovery

Austin Resource Recovery (ARR) is the municipal solid waste collection service for the city of Austin, Texas. The tasks of ARR include⁶:

- Residential curbside collection of landfill-bound waste, recycling, and bulk items
- Street sweeping and litter abatement
- Operating a household hazardous waste collection facility
- Promotion of the Zero Waste philosophy and goals.

The Zero Waste advisory Commission (ZWAC) provides oversight of the solid waste management services of ARR and reports policy recommendation and resource management in addition to being tasked with holding hearings, initiating studies, and making reports and recommendations to the city council⁷. It was this commission which created Recommendation Number 20150114-003a: Single Use Bag study⁸ that has become the basis for the following report.

⁶ "ABOUT AUSTIN RESOURCE RECOVERY"

⁷ Austin, Texas, Municipal Code § 2-1-182

⁸ "Recommendation Number 20150114-003a: Single Use Bag study"

4 Introduction to the Single Use Bag Ordinance of Austin, Texas

In the spring of 2007, Mayor Lee Leffingwell and the City Council of Austin drafted a resolution⁹ requesting the City Manager to investigate strategies to reduce the amount of non-compostable bags by stores within the city limits. One year later, a new resolution initiated a voluntary pilot program in an effort to reduce plastic bags entering the waste stream by 50% over the following year. This project paired the Texas Retailers Association with the cooperation of their affiliates alongside the City of Austin and Keep Austin Beautiful (KAB). While the program attained a mildly successful 20% reduction¹⁰, it did not achieve the levels originally sought after by the resolution. After an investigation into the economic impact of plastic bags was released¹¹ by Austin Resource Recovery (ARR)¹², the Council passed the final resolution leading up to the creation of the Single Use bag Ordinance (SUBO).

The SUBO was passed at 2:00 am on the 2nd of March, 2013¹³ and officially went into effect one year later, with the administrative rules following in November of that year. Once the ordinance was in effect, there were very few complaints from citizens, at least directly to the City of Austin. During the first year of its implementation, there were 123 calls placed to 3-1-1 concerning the bag ordinance, and of those calls, only 89 were complaints from residential customers¹⁴. Wording of the ordinance included the ability to request variance in the form of a hardship for residential customers and alternative compliance to the commercial clients. Within the City of Austin, 38 applications for hardship variance were approved, and 45 businesses applied for alternative compliance, of which 6 withdrew their application and 32 were approved¹⁵.

In 2013, The City of Austin commissioned a study¹⁶ to determine the general attitudes and awareness of shoppers from before the ordinance went into effect to establish a baseline, as well as six months afterwards to find a reactionary response. This study found that support amongst heavy shoppers decreased by 12% in the six month period following the implementation of the ordinance. Reasons included the inconvenience of having to bring their own bags, a growing pain associated with a change in behavior, and less opportunity to reuse the plastic bags obtained from stores for secondary purposes. The former will be discussed later in the report, but plays a significant role as an economic argument against a carryout bag ordinance crafted in the fashion of Austin's.

⁹ City of Austin, Texas, *Resolution No. 20070419-026*.

¹⁰ *Summary of Austin Plastic Bag Initiative: Summary Report, 2009*

¹¹ Gedert, "Memorandum to Mayor and Council Members, Austin TX," January 12, 2011

¹² ARR was named Solid Waste Services at the time; the department was re-branded in 2011.

¹³ "Regular Meeting of the Austin City Council March 1, 2012," 2012

¹⁴ "Single Use Bag Ordinance Update Presentation," 2014

¹⁵ *Ibid.*

¹⁶ Decision Analyst, Inc., 2013

5 Background

To better understand how the plastic bag banning movement became so rampantly popular over the last several decades warrants an examination of social norms and their roles in determining societal behavior. Social norms are the “appropriate” behaviors according to the ideas and beliefs of a society, and are often associated with a number of movements around the world, including those with an environmental prominence¹⁷. The most direct way to address and change the pre-existing norms is to craft legislation which is designed to alter the behavior of the citizen. Such was the case with the bag reduction ordinance passed in Austin. While some may view governmental involvement an imposition of unwanted control, it is often the case that heavier handed intervention techniques in the form of legislation mandating change become needed. And in this scenario, the more intense efforts will produce larger gains¹⁸ in terms of a social behavioral adaptation.

On a larger scale, the origination of the anti-bag rhetoric originated in the global South and has only moved north recently¹⁹. The conception of the bag ordinance movement began with the blight of these objects of convenience upon the infrastructure of the Bangladeshi sewage system²⁰, and this serves as an example of an environmental impact of the bags. In India, the bags were being consumed by the sacred cows which are allowed to freely roam the streets, and this caused them ruminants to starve to death as their digestive system became clogged²¹. This effect, among others, on the ranching industry in west Texas has led municipalities to institute an ordinance restricting the use of plastic bags²².

The previously mentioned study²³ states that 81% of the general public perceived plastic bags to be harmful before the ordinance went into effect, and of that group, 70% said that was because they are a leading source of litter²⁴. It should be no surprise that citizens often feel this way; plastic bags are voluminous, lightweight, and durable, properties which have made them incredibly popular. However, these physical attributes also allow them to travel freely through the atmosphere as well as waterways and persist when snagged on fences and trees (see Figure 1). Litter often plays a significant role upon a municipality's decision to enact an ordinance governing the usage of plastic bags²⁵, and this study will address the impact the SUBO has had on the litter composition of Austin in contrast to Fort Worth, a comparably sized city without an ordinance.

¹⁷ See *Supra* note 2

¹⁸ Carlson, "Recycling Norms," 2001

¹⁹ See *Supra* note 2

²⁰ Reazuddin, 2006

²¹ Edwards & Kellett, *Life in plastic: The impact of plastics on India*, 2000

²² See discussion *infra* note 37

²³ See *Supra* note 10.

²⁴ See *Infra* notes 33 and 34. Plastic bags are highly visible but are not a leading component of litter.

²⁵ Romer and Tamminen, "Plastic Bag Reduction Ordinances: New York City's Proposed Charge on All Carryout Bags as a Model for U.S. Cities" 237-276

6 The Impact of Plastic Litter

Reducing the impact of litter is often cited as one of the significant driving factors when a municipality decides to implement a single use bag ordinance. This man-made source of detritus can wreak havoc on municipal infrastructure in myriad ways, including;

- Forcing MRF's to shut down their operations to disentangle the bags from their equipment²⁶,
- Clogging drainage systems which can cause floods and lead to stagnant water, a breeding habitat for mosquitos²⁷, a public health hazard relevant to Central Texas due to the recent prevalence of West Nile Virus²⁸, and,
- Compelling litter abatement crews to utilize special tools for the removal of bag litter from trees²⁹.

Additionally, if plastic bags are not removed as litter, they eventually make their way to waterways leading to the sea during which time they undergo photo-degradation through exposure to ultraviolet radiation, oxygen, and natural elements such as wind, rain, and the mechanical motion of waves in the ocean³⁰. Once these plastic products break down into their smaller components, they release additives such as bis-phenol A, a compounding additive, into the surrounding environment³¹. This process also introduces micro-plastic particulates which have adsorbed toxins such as toxins such as polychlorinated biphenyls (PCB's) to the natural environment, allowing the smallest organisms to consume these particles as a food-like substitute for organic matter, thus presenting a source of contamination which may bioaccumulate as energy ascends within the food chain. While the molecular size of the plastic monomers may be too large to have a biochemical effect on most living creatures, the chemicals that are released during degradation, as well as those which bioaccumulate, as considered to be endocrine disruptors, a type of chemical which can lead to detrimental developmental consequences for both environmental and human health³².

While plastic bags represent a growing menace to our ecosystem, they are not the only source of plastic pollution; in fact they are far from the greatest contributor. The 2009 Keep America Beautiful National Litter survey reported that all bags collected, including single use carryout bags, trash bags, bulk food bags, etc., comprised only 0.6% of all litter³³, while the 2013 Texas Litter Survey states that

²⁶ Houck, "Lockout-Tagout: Tackling the Plastic Bag Problem at Oregon's MRF's"

²⁷ See *Supra* note 2

²⁸ "West Nile Virus In Texas"

²⁹ From conversations with Rebecca Saltsman of Keep Austin Beautiful (phone call on 2 March 2015), and, Roxanne Jackson of Austin Watershed Protection (phone call on 13 March 2015).

³⁰ Cole et al., "Microplastics as Contaminants in the Marine Environment: A Review" 2588-2597

³¹ Andrady, "Microplastics in the Marine Environment" 1596-1605

³² Teuten et al., "Transport and release of chemicals from plastics to the environment and to wildlife," 2009

³³ Mid Atlantic Solid Waste Consultants, 2009 National Visible Litter Survey And Litter Cost Study

plastic retail bags comprised 1.95% of roadside litter³⁴ in the State of Texas. A 2004 study conducted by the *Algalita Marine Research Foundation* found that roughly 18% of plastic bound for the ocean was composed of plastic film fragments³⁵, a greater percentage than what is commonly found in roadside litter due to the concentrating effect of watersheds in terms of pollutants³⁶. However, even though the profile of the plastic bag is comparatively low, a reduction in their numbers is regarded as highly beneficial. This is largely due to the ancillary issues associated with plastic bag litter bulleted above; however, there are other factors to be considered.

Plastic bags were designed to be voluminous and lightweight in order to carry a large amount of goods, but this also means they are highly visible as litter. Darren Hodges, Councilman for Fort Stockton, Texas, stated³⁷ that their ordinance was implemented not only to relieve stress on their sewage system, but also to reduce unsightly roadside litter which they felt reduced the number of visitors willing to make a stop while travelling on the interstate through the town of Fort Stockton. As a town with only 8,283 inhabitants³⁸, they consider every visitor to be vital.

Indirectly, litter contributes to an estimated 7.4% reduction in property value³⁹ within communities containing a noticeable amount of visible litter present. The sight of a plastic bag is also widely considered as a contributor to the "broken window" theory within a community⁴⁰. This theory states that if people see an act which is deemed socially unacceptable, but that act goes unnoticed or is ignored, they will often repeat the behavior as there are no perceived consequences. This can translate into a scenario in which an increased amount of the litter in an environment can directly contribute to the likelihood that more people will become litterers, even if they do not normally engage in the behavior on a regular basis. Due to the physical properties of the bags listed above, in addition to the compounding nature of plastic bags growing presence if not attended to, there are those that say these bags are a contributor to urban blight⁴¹, an issue all cities must struggle against.

Austin's residents and municipal employees have remarked on the very noticeable difference since the ordinance was enacted. Within the Watershed Protection Department of Austin, general consensus amongst the Field Operations Division is an "overwhelming decrease" in number of bags

³⁴ Environmental Resource Planning, LLC, *2013 Texas Litter Survey*

³⁵ This figure is not truly indicative of single-use plastic carry-out bags as the plastics in this study were too small to determine the origin; however, they certainly existed as a component since this study predated any form of restrictive bag ordinance in the area.

³⁶ National Oceanic and Atmospheric Administration, "Watersheds, Flooding and Pollution," 2015

³⁷ From a phone call on the 6th of March, 2015. His estimate was that plastic bag litter had been reduced by about half since the ordinance was implemented. He also mentioned that the City manager had corroborated the sentiment of having less downtime in municipal facilities that came into contact with single use plastic carryout bags.

³⁸ U.S. Census Bureau, 2010

³⁹ See *Supra* note 33

⁴⁰ George L. Kelling And James Q. Wilson, "Broken Windows"

⁴¹ See *Supra* note 25

found on a daily basis, and that if the crews do encounter a bag, it would be considered “exceptional rather than expected”, as was the case before the ordinance⁴². Representatives from Austin Community Court, Austin Water Center for Environmental Research, and Austin Parks and Recreation Department have also voiced unequivocal anecdotal evidence in regards to the reduction of plastic bags as litter⁴³. Austin Parks Foundation, a local non-profit dedicated to the maintenance of Austin's parks, trails, and open spaces, reported a 90% reduction in plastic bag litter in the first six months after the ordinance had been passed⁴⁴.

On the 25th of February, 2013, one week before the Single Use Bag Ordinance went into effect, Mr. Kerry Getter, C.E.O. of Balcones Resources, took several photos from a large waste management facility in northeast Austin⁴⁵. This landfill, like many others, is surrounded by large catchment fencing in multiple tiers in order to collect trash which is blown about due to high winds. These fences mostly catch very light debris in the form of paper and plastic film so that it does not inundate the surrounding neighborhood with unsightly litter. Figure 1 shows the site on two windy days, to serve as a comparison between pre-ordinance conditions and the impact on the site two years and one month after implementation.

The first photo from Figure 1 shows the area near the entrance of this facility, and single use plastic bags are clearly seen stuck to the fence. The middle picture is the area across the street from this location, in front of an office building. These fragments are residual pieces from the landfill which were unable to be contained by the fencing. This material also makes it way into the residential area just north of the office building. The final depiction shows the most drastic reduction along the fence line. This picture was taken directly across the street from a neighborhood, so the decline is crucial to the health and safety of the residents.

⁴² From email correspondence with Roxanne Jackson, Division manager of Field Operations for the City of Austin Watershed Protection Department, from the 13th of March, 2015.

⁴³ From Communication between ARR and; Jeremy Myers, Austin Community Court (18 March 2015), Kevin Anderson, Ph. D., Austin Water Center for Environmental Research (9 March 2015), and Rene Berrera, Austin Parks and Recreation (12 March 2015)

⁴⁴ From email correspondence with Ladye Anne Wofford, Program Director at Austin Parks Foundation, from the 6th of March, 2015.

⁴⁵ Mr. Getter emailed these photos to the City of Austin on the 24th of March, 2015.

FIGURE 1. Before and After Photos from the Allied Waste Services Landfill in Austin, Texas.

Photos on the left were taken on the 25th of February, 2013.

Photos on the right were taken on the 24th of March, 2015.

While the photographers were different, the locations were replicated as accurately as possible.



Photo Credit for Above: K. Getter, Balcones Resources

Photo Credit for Above: A. Waters, Austin Resource Recovery

7 Plastic Bags as a Component of Austin's Litter

To define the amount of plastic bags found in Austin, and how that compares to a “peer city”, a study was conducted both in Fort Worth, Texas, and Austin, Texas via their local affiliates of Keep America Beautiful. The goal of these studies was to determine how many plastic bags are found in the open spaces of both cities and find a difference in litter composition.

Keep Fort Worth beautiful sponsors an annual litter cleanup event by the name of the Cowtown Cleanup. For this occasion, volunteers adopt a location which they feel needs attention and converge upon that site in a concerted effort to reduce the amount of trash which did not make it into a waste management location. In 2015, this event brought an estimated⁴⁶ 6,857 volunteers out to aid in the beautification of Fort Worth. These volunteers collected more than 52 tons of material during the cleanup as shown in Table 1.

Table 1. Totals from the Fort Worth Cowtown Cleanup.

Total litter collected (Lbs.) (Estimated ⁴⁷)	109,800
Percentage of Single Use Bags found in Litter based on Sample Sites	0.12%
Total Weight of Single Use Bags Collected During Cleanup (Lbs.) (Calculated ⁴⁸)	135.2
Number of Single Use Bags Collected During Cowtown Cleanup (Calculated ⁴⁹)	8,757

Source: A. Waters and Keep Fort Worth Beautiful

The litter rate for Single Use Plastic Bags was found to be 0.12%. To obtain this figure, the four most productive sites from the cleanup were tasked with the collection of all single use bags, which was then recorded and compared to the total amount of litter from the corresponding site. While this litter rate is very low, especially considering that ER Planning found the number to be 1.95% in their study⁵⁰, it still proves to be much higher than what was found in Austin.

Keep Austin Beautiful holds an annual CleanSweep event with the same intent as the Cowtown cleanup, namely, to garner the help of volunteers to remove as much litter as possible from the open spaces of Austin. In 2015, over 3,000 people took to the streets and parks of Austin to collect about 29 tons of material, as seen in Table 2.

⁴⁶ All estimates for the Fort Worth Cowtown Cleanup come from Keep Fort Worth Beautiful, and are based on standards set by Keep America Beautiful.

⁴⁷ *Ibid.*

⁴⁸ To find this figure, as well as the number of Single Use Bags collected, a weight of 0.0154 pounds per bag was used. This weight was found during the recycling audits conducted at Texas Disposal Systems and Balcones Resources.

⁴⁹ *Ibid.*

⁵⁰ See *Supra* note 34.

Table 2. Totals from the Keep Austin Beautiful CleanSweep Event

Total litter collected (Lbs.) (Estimated ⁵¹)	58,118
Percentage of Single Use Bags found in Litter based on Sample Sites	0.03%
Total Weight of Single Use Bags Collected During Cleanup (Lbs.) (Calculated ⁵²)	18.1
Calculated Number of Single Use Bags Collected During CleanSweep (Calculated ⁵³)	1,131

Source: A. Waters and Keep Austin Beautiful

The litter rate within the City of Austin was determined to be 0.03%. To acquire this figure, Team leaders for cleanup crews partaking in the cleanup event were asked to ensure that all participants collect and count any single use plastic bags they came across. This litter rate for single use plastic bags is one quarter of the rate which is found in Fort Worth. See Table 3 for a translation into total bags reduced in the City of Austin.

Table 3. Total Number of Single Use Plastic Bags Reduced, based on 2009 Estimates

	Austin	Fort Worth
Population in 2009 ⁵⁴	786,386	727,577
Average number of bags used per year by each American ⁵⁵	335	335
Number of Single Use Plastic Bags in Litter Composition as Compared to Fort Worth	0.25	1.00
Equivalent Number of Single Use Plastic Bags Per Person	85	335
Number of Single Use Plastic Bags used by each city based on Population in 2009	263,801,371	246,648,603
Bag totals based on equivalency	66,721,916	246,648,603
Difference (aka bags reduced)	197,079,454	-

Source: A. Waters, Keep Fort Worth Beautiful, and Keep Austin Beautiful, USITC

Table 3 shows that based on litter abatement figures from two large scale cleanup events; the number of plastic bags has been reduced by 75%. This would indicate that since the implementation of the single use bag ordinance, and all other considerations being the same, the City of Austin has reduced their yearly single use plastic bag consumption by more than 197 million bags per year. The totals were calculated based on data from 2009.

⁵¹ All estimates for the CleanSweep event come from Keep Austin Beautiful, and are based on standards set by Keep America Beautiful.

⁵² See *Supra* note 48.

⁵³ *Ibid.*

⁵⁴ See *Supra* note 38

⁵⁵ Polyethylene Retail Carrier Bags from Indonesia, Taiwan, and Vietnam Investigation Nos. 701-TA-462 and 731-TA-1156-1158, 2009

8 Measuring Plastic Bags in the Recycling Stream

A. Purpose

In an effort to determine the impact of the single use bag ordinance on the City, an investigation was performed during the bi-annual recyclable materials composition study performed on-site of both residential recycling vendors for the City. The first audit was performed at Texas Disposal Systems (TDS), which services approximately 40% of the recyclable material in Austin and whose area covers territory lying south of the Colorado River. The second audit occurred at Balcones Resources (Balcones), which services the remaining 60% of the recyclable material in Austin and whose area covers territory lying north of the Colorado River. This compositional analysis is a contractual obligation between the City and each of the vendors to determine up-to-date and accurate billing information in an ever-changing recycling commodities market. While reasonably thorough, the study does not address individual components such as the characterization of detrimental plastic film, types and sizes of bottles, brands of products, or relative percentages of the mixed, 3-7 plastics category. Table 4 details the regularly surveyed items in the compositional study. As the audit does not normally obtain a count of percentage of plastic bags, this methodology will address this concern by completing a one-time survey of bag quantities from both vendors.

Table 4. The categories used to calculate the pricing structure of the following recycling period.

Materials Regularly Monitored During Compositional Study
1. Old Newspaper #8 (ONP)
2. Old Corrugated Cardboard (OCC)
3. Mixed Paper (MP)
4. Plastic Bottles made of PETE (Polyethylene Terephthalate) (PB)
5. HDPE (High Density Polyethylene) Natural (HDPE-N)
6. HDPE Colored (HDPE-C)
7. Mixed Plastics 3-7 (MPI)
8. Used Beverage Cans – Aluminum (UBC)
9. Tin Cans (TC)
10. Scrap Metal (SM)
11. Glass (GI)
12. Mixed Rigid Plastics (MRP)
13. Residuals, Materials to be sent to Landfill (Res)

Source: Austin Resource Recovery

B. Goal of the Audit

The goal of this study was to obtain a representative bag count from the semi-annual recycling audit conducted at each of the City's two recycling vendors, TDS and Balcones. While the bag audit was conducted at both sites, at TDS it was also compared to a recyclable stream containing a commingled mix of incoming material from surrounding municipalities. This commingled material served as a baseline for comparison as it originates from a municipality (or combination of municipalities) that does not have a bag ordinance in place at the time of the study. Due to the nature of operations at TDS, determining the source of the material was not possible other than knowing the origin to be from outside of the city limits. However, the method of capture was the same for both vendors, and in the case of TDS, for both sources of the material⁵⁶.

Before each audit was to commence, the following areas of both facilities were emptied in order to reduce the risk of contamination from other sources;

- The tipping floor area for the material to be audited,
- The materials recovery facility (MRF), including,
- The receiving receptacles used in the MRF operation, and,
- The storage bunkers.

C. Methodology for the Audit

i. Texas Disposal Systems

In order to determine the effectiveness of the Single Use Bag Ordinance in the City of Austin (COA), a count of single use retail bags was performed during the biannual recycling audit conducted at Texas Disposal Systems (TDS). As a basis of comparison, TDS also conducted an audit on a commingled recycling stream from surrounding communities which did not have bag ordinances.

The semi-annual audit of the incoming residential single stream of recycling materials is designed to assess the commodity value of recyclable material as a contractual obligation between the COA and TDS. The audit process is conducted at the TDS Materials Recovery Facility (MRF) located in Creedmoor, Texas. The date of the audit, as agreed upon by TDS and the staff of Austin Resource Recovery (ARR), was the 25th of April, 2015. Representatives from ARR were on site during the audit from start to finish.

⁵⁶ The methodology was developed based on input from each vendor at the request for clarification from ARR. While an official methodology had not previously been outlined in detail for either company, they both commit to a functionally identical operational strategy based on the contractual obligations with the City of Austin. The included methodology serves as a highly detailed description of current operational procedure for both TDS and Balcones.

The collection trucks used for auditing were pre-selected from the portion of Austin which TDS services, specifically, all addresses on the Southern side of the Lower Colorado River (Figure 2). A total of six (6) truckloads of materials carrying 32,201 pounds of recycling material were set aside during the preceding week's collection as a representative sample of the customers served (Figure 2). The trucks were weighed empty to obtain a tare weight, and again full, to obtain recyclable material weight. All loads used in the audit were to be dry and reasonably compacted in accordance to the truck manufacturer's suggested pressure settings for the hydraulic system equipped on each vehicle.

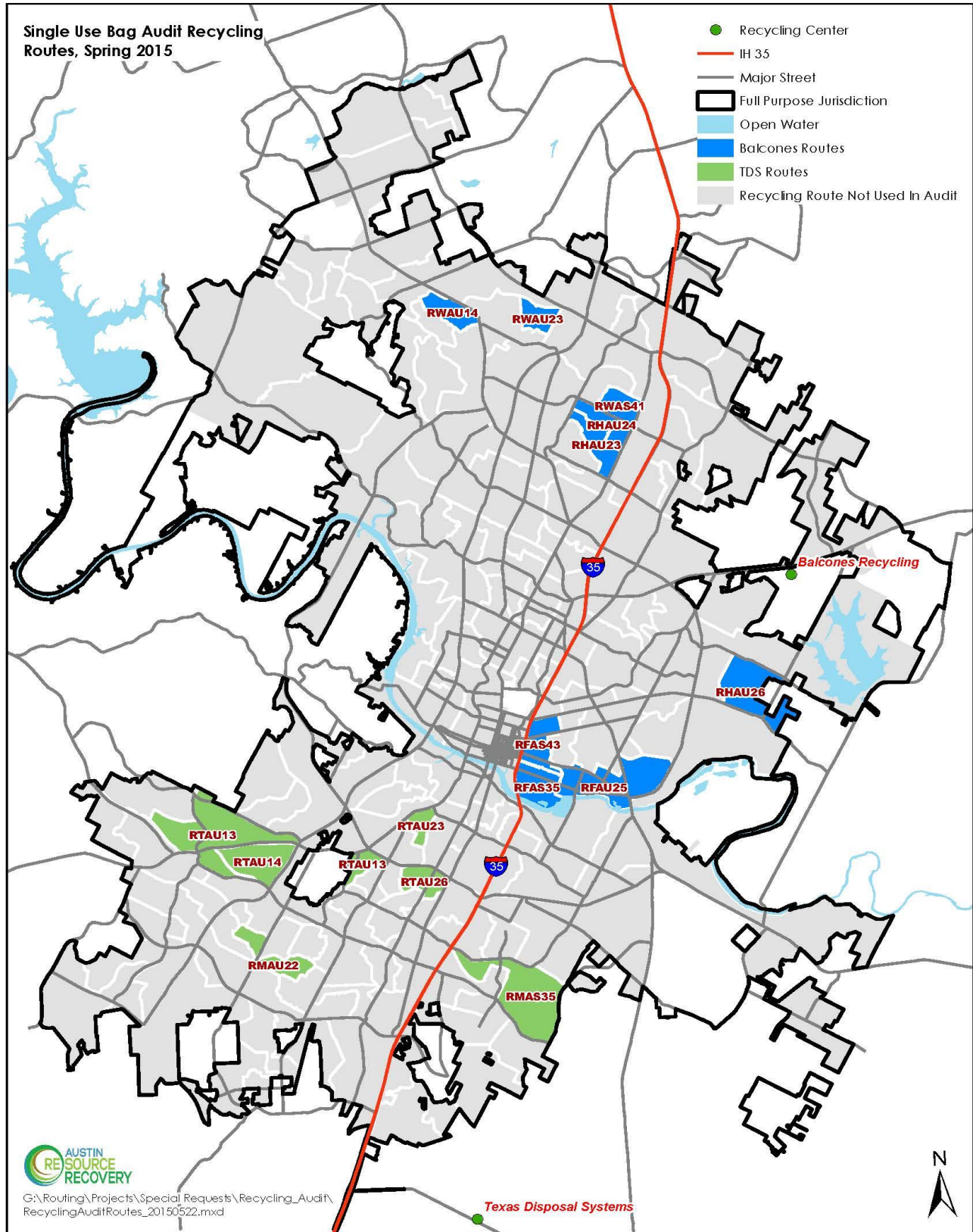
The sorting equipment and employees processed the audited material exactly as though it were a normal operational workday. However, there were six employees dedicated to collecting all plastic bags, from the manual sorting line, including both single use and reusable but excluding other plastic films. The employees manually removed the bags into 44 gallon plastic waste containers as they moved along the first manual sorting line. These vessels were weighed empty⁵⁷, to obtain a tare weight, prior to the beginning of the audit, and again upon completion of the audit, to obtain the weight of the material collected. The single use bags were then characterized by type, counted, and weighed categorically to determine the plastic bag composition percentage and average weight per bag.

Once all the recycling material was sorted, each remaining commodity was baled. These bales were weighed on-site with certified scales provided by TDS. Residual material was not baled, but was also weighed in loose form. The weight of each commodity, including residual, was recorded by both TDS and the City and then reviewed by each party to ensure accuracy. The individual totals were then divided by the total weight of recycling material designated for the audit in order to establish the percentage of each commodity. Percentages were calculated to the second decimal place.

The same procedure was carried out with a recycling stream of commingled material originating from the residential recycling program of a municipality within the CAPCOG region without a bag ordinance in place. This data is to be used comparatively against the City of Austin's figures to define reduction achievement. Originally this audit was designed to establish the basis of revenue due to the COA from the processing and sale of recyclable material semi-annually, it will also serve as a representative data collection tool to analyze the number of single use bags in the recycling stream from the geographic area that TDS services.

⁵⁷ The scale used to weigh the single use plastic bags as well as the tare vessels at both TDS and Balcones was a WeiHeng WH-A Portable Electronic Scale with an accuracy of 5 grams for weights of 0-10 kilograms, and an accuracy of 10 grams for weights of 10 – 45 kilograms. There were no available calibration certificates for the scales, however, weights were measure using two different scales and an average was calculated $[\text{Measurement from Scale1} + \text{Measurement from Scale2} / (2)]$ to obtain a more accurate figure.

Figure 2. Locations of the routes which contributed to the Semi-Annual Recycling Audit



ii. Balcones Resources

The audit process conducted at the Balcones Materials Recovery Facility (MRF) located in Austin, Texas was slightly different from that of TDS, both in terms of volume and the more automated nature of the Balcones equipment. The date of the audit, as agreed upon by Balcones and the staff of Austin Resource Recovery (ARR), was the 9th of May, 2015. Representatives from ARR were on site during the audit from start to finish.

The collection trucks used for auditing were pre-selected from the portion of Austin which Balcones services, specifically, all addresses on the Northern side of the Lower Colorado River (Figure 2). A total of nine (9) truckloads of materials carrying 53,293 pounds of recycling material were set aside during the preceding week's collection as a representative sample of the customers served (Figure 2). The trucks were weighed empty to obtain a tare weight, and again full, to obtain recyclable material weight. All loads used in the audit were to be dry and reasonably compacted in accordance to the truck manufacturer's suggested pressure settings for the hydraulic system equipped on each vehicle.

The sorting equipment and employees processed the audited material exactly as though it were a normal operational workday. However, there were six employees dedicated to collecting all plastic bags, from the manual sorting line, including both single use and reusable but excluding other plastic films. The employees manually removed the bags which were then collected into large, 50 gallon plastic bags. The large bags were weighed empty, to obtain a tare weight, prior to the beginning of the audit, and again upon the completion of the audit, to obtain the weight of the material collected. The single use bags were then characterized by type, counted, and weighed categorically to determine the plastic bag composition percentage and average weight per bag.

Once all the recycling material was sorted, each remaining commodity was baled. These bales were weighed on-site with certified scales provided by Balcones. Residual material was not baled, but was weighed in loose form on certified scales provided by Balcones. The weight of each commodity, including residual as well as single use bags, was recorded by both Balcones and the City and then reviewed by each party to ensure accuracy. The individual totals were then divided by the total weight of recycling material designated for the audit in order to establish the percentage of each commodity. Percentages were calculated to the second decimal place.

While this audit was originally designed to establish the basis of revenue due to the COA from the processing and sale of recyclable material until the following audit, it will also serve as a representative data collection tool to analyze the number of single use bags in the recycling stream from the geographic area which Balcones serves.

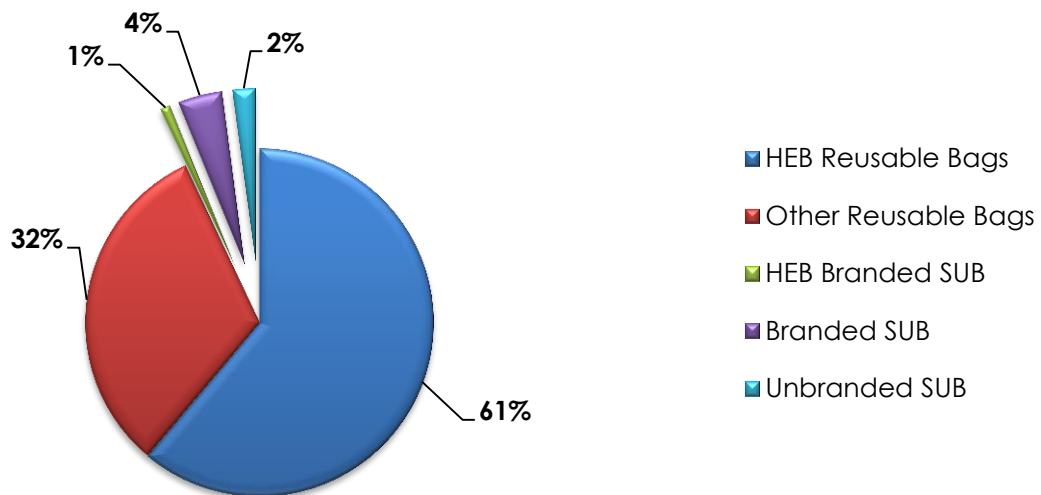
D. Results of the Audit

i. City of Austin Recycling Stream

During each audit, plastic bags were captured by the manual sorting line before being allowed to enter the MRF. These bags were collected, categorized, and weighed to determine the percent composition within the recycling stream. Each facility handles recycling streams of slightly different composition based on socio-economic demographics and other factors, and the results will show a slight difference in composition. However, the scope of this study does not include an investigation into the myriad aspects of consumer behavior; therefore, speculation as to the nature of the discrepancies must be left in the opinions of the reader.

The composition of plastic bags from the audit of the recycling stream at Texas Disposal Systems is shown in Figure 3. The data represents the proportion of each bag type by weight. Single use bags comprised a total of 7% of all bags collected, by weight. However, by count, single use plastic bags represented 35.7% of all bags collected. Plastic bags from H-E-B, a Texas based grocery retailer made up the majority of plastic bags collected, at 62% of all bags from this audit. This is most likely because they are the only grocery chain to distribute a 4 mil reusable bag, while all others provide paper, which is recyclable in the MRF. The amount of unbranded reusable bags represented a large proportion of all reusable bags, which is different than the data from Balcones. There are a variety of considerations as to the nature of this difference; however, those discrepancies fell outside of the scope of this study.

Figure 3. Plastic Bag Composition - Texas Disposal Systems

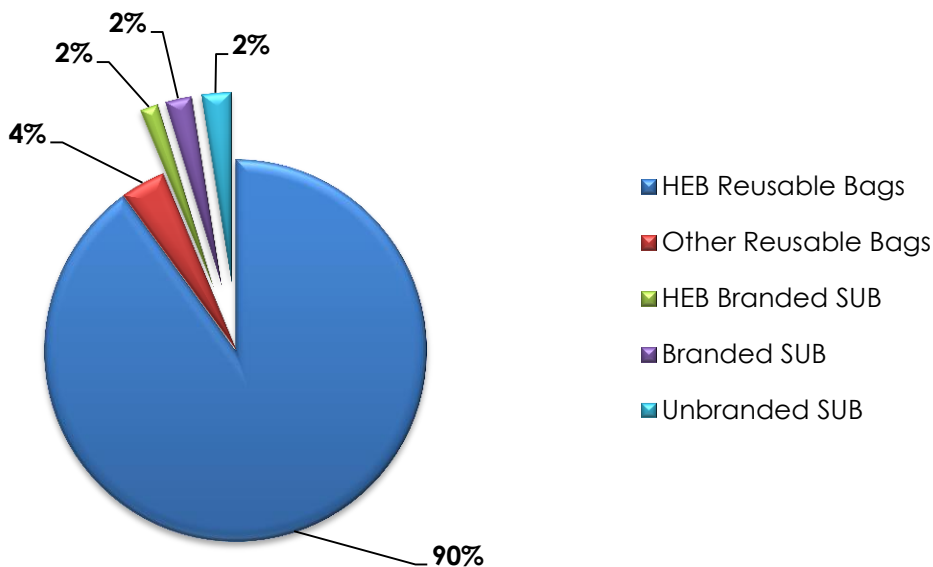


Source: A. Waters, Texas Disposal Systems

The composition of plastic bags from the audit of the recycling stream at Balcones Resources is shown

in Figure 4. The data represents the proportion of each bag type by weight. Single use bags comprised a total of 6% of all bags collected, by weight. However, by count, single use plastic bags represented 29.3% of all bags collected. Plastic bags from H-E-B once again made up the majority of plastic bags collected, at a significantly higher rate of 92% of all bags from this audit. The amount of unbranded reusable bags represented a much smaller proportion of all reusable bags, which is different than the data from TDS.

Figure 4. Plastic Bag Composition - Balcones Resources



Source: A. Waters, Balcones Resources

Once all of the recyclable material had been processed through the MRF, the totals were tallied in order to calculate percentages of both single use and reusable plastic bags in terms of their weight. Table 5 shows that the average total plastic bag composition within the City of Austin is 0.054%, while the single use plastic bag average composition was 0.004%.

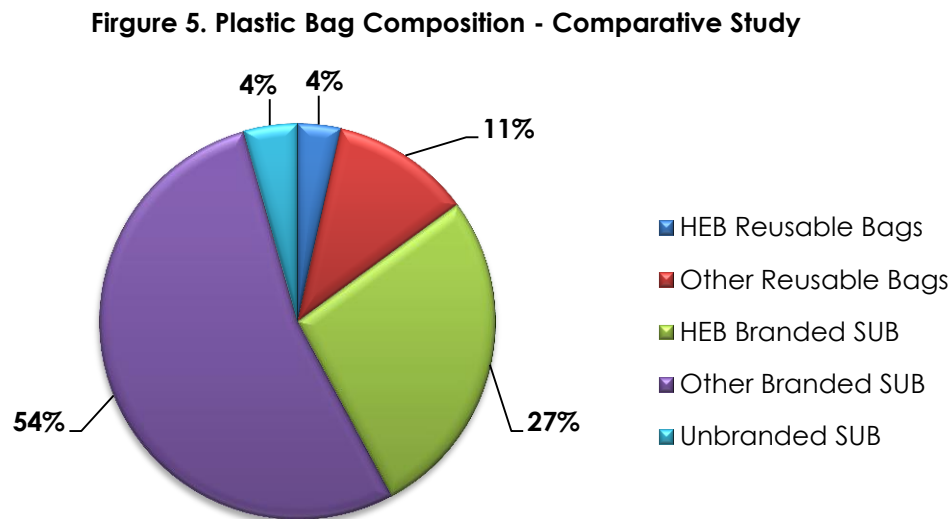
Table 5. Plastic Bag Audit Totals from the City of Austin's Recycling Stream and Comparison

	TDS	Balcones	Average	Comparative
Total Recycling Processed (Lbs)	70,991	117,490		16,320
Total Number of Bags	470	857		591
Number of Bags per Pound	0.007	0.007	0.007	0.036
Plastic Bags Composition (by weight)	0.052%	0.055%	0.054%	0.071%
Reusable Plastic Bags	0.049%	0.052%	0.050%	0.011%
Single Use Plastic Bags	0.004%	0.003%	0.004%	0.060%

Source: A. Waters, Austin Resource Recovery, TDS, and Balcones

ii. Comparative Recycling Stream

The composition of plastic bags from the audit of a municipality within the CAPCOG region which was completed at Texas Disposal Systems is shown in Figure 5. The data represents the proportion of each bag type by weight. Single use plastic bags comprised a total of 85% of all bags collected by weight. By count, single use bags represented 97% of all bags collected, with 574 bags. All totals can be found in Table 5. Plastic bags from HEB represent a lower percentage of the total as all retailers from this municipality are still using single use plastic bags, so there is more variation in contributing sources.



Source: A. Waters, Texas Disposal Systems

Of special note, reusable bags comprise a much smaller proportion of the totals shown in figure 5. This is likely due to the thickness of a bag not being mandated through an ordinance, and as a result, the retailer is not as inclined to use this style of bag, especially as it is more expensive to produce and ship, decreasing the revenues on an industry that already operates on an estimated 1.9% profit margin⁵⁸. Many stores in Austin have elected to either decline the option to provide a thicker plastic bag, or, use a recyclable paper bag as defined by the Single Use Bag Ordinance⁵⁹.

Table 5 also shows that in general, plastic bags are much more prevalent in the recycling stream of this representative community, as they appear at a rate of 0.036 bags per pound, a much higher rate than Austin, at 0.007 bags per pound. Total plastic bags composition is higher in the compared municipality, at 0.071%, due to a higher count of bags having a much lower weight per bag.

⁵⁸ The Reinvestment Fund, *Understanding the Grocery Industry*, 2011

⁵⁹ See *Supra* note 3

9 Conclusions

The Single Use Bag Ordinance for the City of Austin which went into effect over two years has had a variety of responses; from the Texas Retailers Association filing a lawsuit⁶⁰ (later withdrawn), to consumers both praising and forsaking the effort⁶¹, and finally, the Attorney General of Texas, Greg Abbott, issuing an opinion on his perspective of the legality of such ordinances⁶². While most citizen's find the bag ordinance to be beneficially to the environment, at least in terms of the reduction of litter⁶³, the results do not indicate a clear success. Indeed, the amount of single use plastic bags has been reduced, both in count and by weight. However, in their place, the larger 4 mil bags have replaced them as the go to standard when the reusable bag is left at home. This reusable plastic bag, along with the paper bag, has a very high carbon footprint compared to the single use bag. Estimates state that a single paper bag must be used between 3-9 times in order to offset its overall environmental impact⁶⁴. The plastic bag is even higher, necessitating 4-12 uses before its impact is mitigated. The paper bag, however, is fully recyclable, and the ordinance dictates that these bags must be made from 80 % post-consumer material as well, perpetuating the cycle and providing a market for that paper as a commodity.

The heavy gauge plastic bag is a different story. There is no standard for post-consumer material content; therefore, these bags are often made with virgin plastic. Using virgin plastic reduces the consumption of post-consumer, recovered plastic sources. This in turn relies heavily on the production of plastic pellets made from the by-product of liquid natural gas refinement, further expanding the carbon footprint. However, they were designed to be used 100 times or more, and if used consistently over this many uses, their environmental impact decreases dramatically below that of the single use bag⁶⁵.

Plastic film, in all its forms⁶⁶, is generally not recycled in the two MRF's which service Austin; it is removed if possible and sent to the landfill⁶⁷. The lack of recycling for films at the MRF can be explained by two mechanisms. First, plastic film causes major problems for the machinery of the recycling facility⁶⁸, and it is in the best interest of these facilities to limit the amount of exposure to this type of flexible plastic. When the material entangles the various sorting mechanisms of the MRF, the

⁶⁰ The City of Austin, Communications and Public Information Office, 2013

⁶¹ Herzog, 2013

⁶² Lindell, 2014

⁶³ See *Supra* note 10

⁶⁴ Edwards & Fry, 2011

⁶⁵ *Ibid.*

⁶⁶ This can include, but is not limited to, dry-cleaning bags, produce bags, trash can liners, bread bags, and new car wrapping; all of which eventually end up in the waste stream.

⁶⁷ The exception to this is at Texas Disposal Systems. They have a program with the City of Georgetown, Texas, named "Bag the Bag" in which plastic film is collected into city supplied plastic bags. This is then recovered and marketed by TDS as a commodity.

⁶⁸ See *Supra* note 26

efficiency drops dramatically. Both MRFs in Austin reported a decrease in downtime after the ordinance was implemented, however, as both sites also service other communities without bag ordinances, they still have to clean their machinery minimally at the end of each shift, in an effort to remove the film and other contaminants. The second concern stems from the contaminated nature of the film upon its arrival at the MRF. As MRF's are only responsible for the sorting and selling of the recyclable material, the companies which buy this second hand film are primarily interested in the highest quality material possible, as virgin plastic is inexpensive enough to be competitively priced. Once the film is placed in a single stream recycling bin, it comingles with all the other materials, becoming less frequent, and thus making a concerted removal effort more difficult to justify from a cost-benefit perspective. In addition, any organic contamination within the single stream cart can leach onto the film, making it utterly worthless as a commodity. For these reasons, most MRF's will not accept plastic bags, as they cannot collect or sell this material in an economically viable manner.

So, if these plastic bags are not being recycled at our local facilities, what is their fate? More often than not, they make their way into our landfills, taking even longer to degrade than a traditional single use plastic bag as well as taking more space, both due to their thickness which is mandated by the ordinance. The most ideal method for disposal comes from the retail take-back option available at many retail locations. This is the box located near the entrance of a store which accepts plastic films. These materials are then marketed to the buyers⁶⁹ of second hand films as less contaminated product, and can be used more readily than the film coming from a MRF.

However, one unintended result of the single use bag ordinance was that many retailers in the Austin area that were forced to discontinue supplying plastic bags also removed their plastic film recycling boxes, as they no longer received the single use bags after a time. A phone survey of 30 local area pharmacies⁷⁰ found that only one facility still offered plastic film recycling. Most large grocery retailers which were contacted reported that the recycling services were to be available for the foreseeable future. However, as plastic bags are the main component to be recycled at grocery store take back programs, the departure of the single use bag will inevitably signal a removal of the containers within the stores. This could lead to an increase of plastic films in the waste and recycling streams, while reducing the amount of recycled material going to the buyers of this film.

The use of 4 mil reusable plastic bags also increases the overall plastic bag presence as a component of the recycling stream. Table 5 shows that while Austin had a much lower instance of bags per pound in relation to the comparative municipality, figures 3 and 4 show that the reusable bags make up 93% of the composition at Balcones and 90% at TDS. Based on the figures from the Waste

⁶⁹ Buyers include Hilex-Poly, a plastic bag manufacturer, and Trex, a maker of composite decking.

⁷⁰ The survey was conducted by calling 30 different pharmacies and pharmacy chains from north to south Austin, and asking the manager whether the recycling was still offered on site.

Characterization study conducted for the City of Austin in March of 2015⁷¹, removing these bags from the recycling stream could potentially eliminate an additional 23 tons of plastic film from entering the MRF's of Austin⁷². Based on the bag audits conducted at both TDS and Balcones for the City of Austin recycling stream, the removal of reusable plastic bags would be nearly equivalent to the amount of all of the single use bags removed from the recycling stream as a result of the ordinance implemented in 2013.

While this is not an insignificant amount of bags removed, it pales in comparison to the volume calculated from the recycling reduction. Data from the Cowtown Cleanup help annually in Fort Worth, Texas suggests that the amount of plastic bags in the litter stream amounts to 0.12% of all litter accrued. In Austin, during the CleanSweep event held by Keep Austin beautiful, the litter rate of plastic bags⁷³ was 0.03%. Assuming the figures from 2009⁷⁴ are accurate, and using the ratio of the litter rates of Austin to Fort Worth, this reduction would amount to a 75% decrease in plastic bags used. As table 3 shows, this amounts to a decrease in usage of 197,079,454 bags, annually, in Austin.

⁷¹ *City-Serviced Residential Waste Characterization Study, 2015*

⁷² This calculation is based on a processed recycling quantity of 46,415 tons in FY2014.

⁷³ The recycling survey conducted in Austin did not differentiate between single use and reusable bags; however, the original request for the team leaders of each of the volunteer cleanup sites was to capture single use bags only.

⁷⁴ See *Supra* note 55

10 Discussion

Across the board, there was a significant reduction in the amount of single use plastic bags received by the citizens of Austin. From the perspective of judging whether the ordinance was successful in its task, the answer is a resounding “yes”. However, if all other aspects of this issue are considered, the answer becomes less clear. Simply reducing the usage of a product does not guarantee a positive environmental or economic impact, and when evaluating the triple bottom line⁷⁵ of people, planet and profit in regards to sustainable development, it is necessary to consider all viewpoints when broad reaching legislation is enacted.

A. People

Ideally, a piece of legislation is designed to change the behavior of the citizens or institutes within the geographical area governed by political administration⁷⁶. In this regard, the ordinance was a success and a failure. From one perspective, the amount of single use plastic bags has shrunk dramatically, reducing plastic film litter and lessening the impact on the MRF, decreasing downtime when processing the recycling material of the City of Austin. As resolution 20080410-048⁷⁷ achieved a relatively low participation rate of 20%, the current evidence suggests that the single use bag ordinance has achieved a greater reduction than the voluntary reduction's loftiest goals. However, the downside to this reduction is that it only applies to single use bags. The audit of recyclable material, including the comparative analysis of a municipality in the CAPCOG region, shown in Table 5, illustrates that the number of bags per pound is 0.036 in the nearby community while it is 0.007 in Austin. This is a misleading indicator of success, as the weight of all bags, as indicated by the category “Plastic Bags Composition”. From this data, the comparative figures plastic bags to comprise 0.071% of total weight, while in Austin, the total is 0.054%. Looking closer, the data indicates that of the 0.054% composition in Austin, reusable plastic bags make up 0.050% of that total. This amounts to 23 tons of unnecessary reusable plastic bags found in the recycling stream of Austin. For the City to come closer to achieving its Zero Waste Goals⁷⁸, the implementation of a comprehensive educational awareness and outreach program designed to educate the citizens on the recycling standards is the next vital step in attaining the necessary reduction.

B. Planet

According the Zero Waste goals, The City of Austin has planned to divert 90% of its waste out of the landfill by 2040. These efforts include implementation of a Universal Recycling Ordinance, as well as an

⁷⁵ Slaper & Hall, 2011

⁷⁶ Zamir & Teichman, 2014

⁷⁷ Resolution 2008-0410-048 was approved by City Council as an effort to encourage voluntary plastic bag recycling with the goal of reaching 50% reduction in 18 months. When this failed, the City of Austin decided to pursue more aggressive efforts including the drafting of the Single Use Bag Ordinance.

⁷⁸ See *Supra* note 1

organics diversion plan to encourage and facilitate compost collection as a residential service. Reducing plastic bags, both single use and reusable is a positive step in realizing the goals of the Zero Waste plan. While the overall reduction by weight so far is only about 0.017%⁷⁹, with the elimination of the reusable plastic bags, the reduction could amount to a plastic bag rate of only 0.004% or 1.9 tons per year⁸⁰.

One other consideration for the elimination of the 4 mil thickness guideline detailed in the Single Use Bag Ordinance is the carbon footprint of the reusable bag. According to a report published in 2011⁸¹, which performed a life cycle analysis on several different grocery bag types, the reusable bags made of HDPE must be used at least 4 times to offset the amount of additional carbon used in their manufacture and transportation. If these bags are largely being discarded before that point, the environmental gain of Zero Waste is diminished due to a rise in this carbon output.

C. Profit

There are many economic impacts associated with the implementation of a plastic bag ordinance. Directly applied to the retail stores which are the providers of the bags, the cost of providing a single use plastic bag virtually disappears upon the implementation of the ordinance. Once the retailers in Austin were no longer allowed to distribute these bags freely, the cost related to providing them has been removed from their bottom line. Conversely, this cost has shifted to the consumer, who now must purchase a bag, or, if they choose not to purchase a bag, bring an alternative carrying device with them.

Additionally, single use plastic bags are often reused during their lifecycle⁸², as lunch bags, waste management, and pet cleanup to name a few. If the consumer is limited in the availability to use the single use bags for these purposes, they will choose to either travel outside of the area⁸³, or purchase replacement bags from a retailer. These replacements are an added cost to the citizens. One economic analysis estimates the cost related to purchasing bags as a waste management alternative to single use bags to be \$633,588.88⁸⁴ annually.

Indirectly, encouraging the use of reusable bags has ancillary economic influences as well. One of the reasons that plastic bags have a low impact is due to their low weight, roughly 0.016 pounds per bag, according to the recycling audit completed for this study. The 4 mil reusable bag, however, has an

⁷⁹ The comparative municipality's plastic bag rate is 0.71% while The City of Austin's rate is 0.54%, a difference of 0.017%

⁸⁰ See *Supra* note 60, total recycling collection for FY 2014 was 46,415 tons.

⁸¹ See *Supra* note 75

⁸² *Ibid.*

⁸³ Multiple interviews commented on this inevitability, both during the course of the research for this study as well as documented cases from 3-1-1 calls placed in reference to the Single Use Bag Ordinance.

⁸⁴ Rozenski, *The Economics of Plastic Retail Bag Disposal in Austin, Texas*

average weight of 0.11 pounds per bag, according to the same audit. This amounts to almost a seven-fold increase in weight, which translating into more resources to transport the heavier bag, increasing the carbon footprint an addition to the logistical cost of transportation for the retailers. When asked about a quantifiable increase to the shipping costs of the reusable and paper bags, HEB replied that, "Our shipping is co-mingled and we're unable to extract a number for this one product"⁸⁵, however, they did provide the photograph in Figure 6 to serve as a contrast between relative bag sizes.

Figure 6. Three Types of Bags, in Their Respective Shipping Containers



Photo Credit: HEB. From left to right: Fashion bags & Canvas Reusable bags – Quantity 100/case; 4 mil bags – Quantity 250/case; Single-use plastic bags – 2,000/case

The City of Austin's outer limit is an amorphous shape due to annexing throughout the years. As a result, there are many pockets of the city which residents are often surprised to learn belong to the City. One such pocket is located in the northern are of Austin surrounded by the towns of Wells Branch and Pflugerville. Within this area, there is an HEB grocery which is covered by the Single Use Bag Ordinance. However, outside of Austin, in the adjacent towns, there are other larger grocery stores which do not need to comply with the ordinance. The close proximity of the other grocery stores has proven problematic for the HEB in this area of Austin, as they have reported that upon the implementation of the Single Use Bag Ordinance, this store lost between \$60,000 to \$70,000 per week in revenue⁸⁶ as a result of customers choosing to shop at a store which would provide single use bags.

⁸⁵ A prepared list of question was submitted to HEB and subsequently answered via email correspondence.

⁸⁶ See *Supra* note 84

11 Summary

The Single Use Bag Ordinance has been successful in reducing the amount of single use plastic bags in the City of Austin. However, there have been unintended consequences such as an increase on reusable plastic bags in the recycling stream, increased cost to the consumer, and unforeseen costs to certain retailers.

Recommendations for improving the existing ordinance include:

- Elimination of the availability of the 4 mil reusable bag
- Further educate the consumer on proper recycling practices to remove film from recycling stream
- Encourage retail take-back of plastic bags throughout the City of Austin to increase efficiency of MRF
- Encourage surrounding communities to adopt a plastic bag ordinance, both to alleviate litter concerns as well as facilitate consumer behavior change.
- Further educate the consumer on proper reuse practices to add longevity to purchased reuse bags.

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13 Bibliography

- ABOUT AUSTIN RESOURCE RECOVERY. (n.d.). Retrieved April 10, 2015, from <http://austintexas.gov/department/about-austin-resource-recovery>
- Andrady, A. L. (2011, August). Microplastics in the marine environment. *Marine Pollution Bulletin*, 62(8), 1596-1605. <http://dx.doi.org/10.1016/j.marpolbul.2011.05.030>
- Austin Resource Recovery. (2014, April 9). Single Use Bag Ordinance Update Presentation. Retrieved March 2, 2015, from <http://www.austintexas.gov/department/document.cfm?id=209279>
- Austin, Texas, Municipal Code § 2-1-182 - ZERO WASTE ADVISORY COMMISSION.
- Carlson, A. E. (2001). Recycling Norms. *California Law Review*, 89(5), 1231-1300. Retrieved from <http://scholarship.law.berkeley.edu/californialawreview/vol89/iss5/1>
- CB&I Environmental and Infrastructure, Inc. (2015). *City-Serviced Residential Waste Characterization Study* (USA, Austin Resource Recovery). Austin, TX.
- The City of Austin, Communications and Public Information Office. (2013, September 17). *TEXAS RETAILERS ASSOCIATION DROPS BAG ORDINANCE LAWSUIT* [Press release]. Retrieved May 11, 2015, from <https://austintexas.gov/news/texas-retailers-association-drops-bag-ordinance-lawsuit>
- City of Austin, Texas, City Council. (2007). *Resolution No. 20070419-026*. Austin, TX.
- City of Austin, Texas, City Council. (2012). *Ordinance No. 20120301-078*. Austin, TX.
- Clapp, J., & Swanston, L. (2009, May 01). Doing away with plastic shopping bags: International patterns of norm emergence and policy implementation. *Environmental Politics*, 18(3), 315-332. doi:10.1080/09644010902823717
- Cole, M., Lindeque, P., Halsband, C., & Galloway, T. S. (2011). Microplastics as contaminants in the marine environment: A review. *Marine Pollution Bulletin*, 62(12), 2588-2597. Retrieved April 15, 2015, from <http://www.sciencedirect.com/science/article/pii/S0025326X11005133>
- Decision Analyst, Inc. (2013). *Austin Single-Use Carryout Bag Ordinance Awareness & Attitudes Post-Ordinance Report* (Rep.). Austin, TX: Sherry Matthews Advocacy Marketing.
- Eco-Industrial Park - MRF (Material Recovery Facility). (2011). Retrieved from <http://www.texasdisposal.com/index.php/services-eco-industrial-park>
- Edwards, C., & Fry, J. M. (2011). *Life Cycle Assessment of Supermarket Carrier Bags: A Review of the Bags Available in 2006* (UK, Environment Agency).
- Edwards, R., & Kellest, R. (2000). *Life in plastic: The impact of plastics on India*. Mapusa, Goa: Other India Press.
- Environmental Resource Planning, LLC. (n.d.). *2013 Texas Litter Survey* (Rep.). Retrieved March 2, 2015, from Sherry Matthews Advocacy Marketing, Don't Mess With Texas website:

http://www.dontmesswithtexas.org/docs/DMWT_2013_Litter_Survey.pdf

- Gedert, B. (2011, January 12). *Memorandum to Mayor and Council Members, Austin TX* [Plastic Bag Findings and Clarifications].
- Herzog, M. (2013, March 6). Austin Bag Ban Generates Mixed Bag of Reactions. *Texas Monthly*. Retrieved May 11, 2015, from <http://www.texasmonthly.com/story/austin-bag-ban-generates-mixed-bag-reactions>
- Houck, B. (2011, January 30). Lockout-Tagout: Tackling the Plastic Bag Problem at Oregon's MRF's. Retrieved March 15, 2015, from <https://www.youtube.com/watch?v=qoBSW75-AqM>
- Kelling, G. L., & Wilson, J. Q. (1982, March 01). Broken Windows. Retrieved April 20, 2015, from http://www.theatlantic.com/magazine/archive/1982/03/broken-windows/304465/?single_page=true
- Kinzig, A. P., Ehrlich, P. R., Alston, L. J., Arrow, K., Barrett, S., Buchman, T. G., . . . Saari, D. (2013, March 01). Social Norms and Global Environmental Challenges: The Complex Interaction of Behaviors, Values, and Policy. *BioScience*, 63(3), 164-175. doi:10.1525/bio.2013.63.3.5
doi: 10.1525/bio.2013.63.3.5
- Lindell, C. (2014, August 29). Austin bag ban may violate state law, Greg Abbott says. Retrieved May 11, 2015, from <http://www.statesman.com/news/news/abbott-bag-bans-may-violate-state-law/nhCGq/>
- Mid Atlantic Solid Waste Consultants. (2009, September 18). *2009 National Visible Litter Survey And Litter Cost Study* (Rep.). Retrieved March 2, 2015, from Keep America Beautiful, Inc. website: http://www.kab.org/site/DocServer/Final_KAB_Report_9-18-09.pdf
- Muthu, S. S., & Li, Y. (2013). Life Cycle Assessment of Grocery Shopping Bags. *EcoProduction Assessment of Environmental Impact by Grocery Shopping Bags*, 15-54. doi:10.1007/978-981-4560-20-7_3
- National Oceanic and Atmospheric Administration. (2015, March 11). Watersheds, Flooding and Pollution. Retrieved April 20, 2015, from http://www.education.noaa.gov/Freshwater/Watersheds_Flooding_and_Pollution.html
- Office of the City Clerk. (2012, March 5). Regular Meeting of the Austin City Council March 1, 2012. Retrieved March 2, 2015, from <https://faustintexas.gov/department/city-council/2012/20120301-reg.htm>
- Reazuddin, M. (2006). *Banning Polyethylene Shopping Bags: A Step Forward to Promoting Environmentally Sustainable Development in Bangladesh* (Rep.). Retrieved March 23, 2015, from BANGLADESH CENTRE FOR ADVANCED STUDIES website: ekh.unep.org/files/Paper%20on%20Polythene.doc
- Recommendation Number 20150114-003a: Single Use Bag study. (2015, January 15). Retrieved

- February 24, 2015, from
<http://www.austintexas.gov/2Fedims/2document.cfm%3Fid%3D224691>
- The Reinvestment Fund. (2011). *Understanding the Grocery Industry* (USA, U.S. Treasury, Community Development Financial Institutions Fund).
- Romer, J. R., & Tamminen, L. M. (2014). Plastic Bag Reduction Ordinances: New York City's Proposed Charge on All Carryout Bags as a Model for U.S. Cities. *Tul. Env L.J.*, 27(2), 237-276.
- Rozenski, P. R. (2012). *The Economics of Plastic Retail Bag Disposal in Austin, Texas* (Assessment of Cost Avoidance's, Revenues and Costs to Residents, Companies and the City of Austin, Working paper).
- Slaper, T. F., Ph.D., & Hall, T. J. (2011). The Triple Bottom Line: What Is It and How Does It Work? Retrieved May 28, 2015, from <http://www.ibrc.indiana.edu/ibr/2011/spring/article2.html>
- Summary of Austin Plastic Bag Initiative: Summary Report* (Rep.). (2009, December 9). Retrieved March 10, 2015, from Texas Retailers Association website:
http://austintexas.gov/sites/default/files/files/Trash_and_Recycling/plastic_bags/TRA_Report_-_City_of_Austin_Plastic_Bag_Initiative_-_12.9.2009.pdf
- Teuten, E. L., Saquing, J. M., Knappe, D. R., Barlaz, M. A., Jonsson, S., Björn, A., . . . Takada, H. (2009, June 15). Transport and release of chemicals from plastics to the environment and to wildlife. *Philosophical Transactions of the Royal Society of London B: Biological Sciences*, 364(1526), 2027-2045. doi:10.1098/rstb.2008.0284
- Thousandth of an inch. (n.d.). Retrieved April 10, 2015, from
https://en.wikipedia.org/wiki/Thousandth_of_an_inch
- United States, International Trade Commission. (2009). *Polyethylene retail carrier bags from Indonesia, Taiwan, and Vietnam investigation nos. 701-TA-462 and 731-TA-1156-1158 (preliminary)*. Washington, DC: U.S. International Trade Commission.
- U.S. Census Bureau. (2010). American FactFinder - Community Facts. Retrieved April 20, 2015, from
http://factfinder.census.gov/faces/nav/jsf/pages/community_facts.xhtml
- West Nile Virus In Texas. (2014, December 30). Retrieved April 16, 2015, from
<https://www.dshs.state.tx.us/idcu/disease/arboviral/westnile/>
- Zamir, E., & Teichman, D. (2014). Ch. 10, Law, Moral Attitudes, and Behavioral Change. In *The Oxford handbook of behavioral economics and the law*.