

A photograph of a dairy farm interior. In the foreground, several brown and white cows are standing in stalls, facing away from the camera. The ceiling is made of corrugated metal with several bright lights hanging from it. In the background, a milking parlor is visible, with a white partition and a clock on the wall.

Preventing Fluid Milk Waste

in Albany, New York

Prepared for World Wildlife Fund/Columbia University

SUMA Capstone – Summer 2016

Advisor: Jessica Prata

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Advisor: Jessica Prata

Jennifer Barenholtz
Omer Bese
Roberto Cornejo Crosby
Elena Crete
Melissa Gallant
Samantha Hill
Lenka Malcova
Melissa Meggialaro
Cindy Ramdoyal
Rebecca Ruiz
Shane Son
Danielle Stogdill
Erin Walsworth
Karin Weidner-Mubanda

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¹erin.sexson@dairy.org, ying.wang@dairy.org

²cfrye@idfa.org

Executive summary

With the expectation that the world population will reach 9.7 billion by 2050, simultaneous efforts are needed to increase production yields, supply nutritional products, and minimize the food waste footprint across the supply chain - especially in the market for high-protein animal products (UNDESA, 2015).

The U.S. is the largest producer of cow's milk in the world, supplying 208 million tons of whole milk to the market (FAO, 2013). Yet, the 2016 ReFED study suggests that milk and dairy make up 26% of the food wasted in the U.S., between retailers and consumers (Vared, S., 2016).

The World Wildlife Fund (WWF) is concerned with the loss of habitat, biodiversity, and earth resources – which are exacerbated by the production and disposal of wasted milk. WWF challenged our class, of 14 sustainability management masters students at Columbia University, to 1) map out the flows of fluid milk, 2) quantify fluid milk waste along the supply chain, and 3) recommend methods of prevention – specifically applicable to Albany and New York State.

For the calculated 2.4 million gallons, or 23%, of milk lost, between the producer and consumer for the Albany region, the estimated impact for every 1,000 gallons is:

- For producing: 1.8 acres of agricultural land use, 140,000 gallons of water consumed, 5 metric tons of carbon dioxide equivalent (MTCO_{2e}) emitted, and 68 kg of acidifying compounds equivalent to sulfur dioxide (SO_{2e}) released.
- For processing: 0.31 MTCO_{2e} emitted, 0.22 from processing and packaging milk and 0.09 from transportation, as well as and 3,200 gallons of water consumed.
- For retailing: 5.1 metric tons CO_{2e} emitted for energy use, refrigerant leakage and milk waste disposal.
- For consuming: 3.14 MTCO_{2e} emitted from transportation and disposal of milk and packaging materials (Albany's Solid Waste Management Plan's details that 17.9% of plastic containers and 1.8% of gable-top boxes are recycled) and 0.8 kg of chemical oxygen demand (COD) is added to the sewer load from disposal down the drain.

Our study concludes that the most dramatic losses in the Albany region are at the consumer level, with an estimated 20% of milk wasted (Buzby et al., 2014). If you, as a consumer, want to know how you can help, please watch this short video we produced to start a discussion around preventing household milk waste.

<https://m.youtube.com/watch?feature=youtu.be&v=IVsH4A-TK14>

While this report suggests a number of ways to prevent waste, three key opportunities where legislative action can help include:

- 1) Creating uniform, federal milk labeling. There is confusion as to whether milk is safe to drink past the date on the package, so a freshness indicator would provide a better indication of safety and spoilage.
- 2) Designing education campaigns on proper milk storage and handling, with a focus on temperature, to maximize its shelf life.

Incentivizing the purchase of shelf stable milk (UHT), which requires significantly less energy and refrigeration.

About this report

This report is the product of collaboration between the WWF and Columbia University's Sustainability Management program. The program's capstone group consisted of fourteen individuals with a diverse range of professional backgrounds across the public and private sectors. The report contains recommendations that, if applied, would reduce fluid milk waste across the supply chain and contribute to mitigating the wider negative impacts of such loss.

The client's specific areas of interest include the regulatory environment and its impact on dairy processing and retail, particularly the impact of policy and its effect on the amount of fluid milk waste. As part of WWF's requirements, the scope of this project includes defining the specific flows within the supply chain of fluid milk and the points of loss that exist throughout this process. World Wildlife Fund placed emphasis on exposing potential methods of prevention to reduce fluid milk waste in the future, or divert it from landfill. Another area of focus is the quantification of environmental losses in the supply chain of fluid milk, with consideration given to greenhouse gas emissions from transport and energy use, water consumption, and other factors that lead to the waste of resources associated with the disposal of one gallon of milk.

In light of these directives, our deliverables include:

- An internal briefing presented to an audience of representatives from Columbia University and its Earth Institute
- A presentation to our client (WWF)
- This written report, which details our findings
- An environmental impact calculator
- An educational video

The report outlines the process itself, points of loss, environmental impacts, the regulatory environment, and our recommendations for prevention or diversion. The environmental impact calculator is for adoption by researchers, academics, and policy analysts working in this field who are interested in calculating the environmental and economic costs accrued in wasting milk. Finally, the educational video will communicate the full lifecycle of milk to consumers and delineate tangible ways of reducing milk waste at the consumer level.

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Abbreviations

AP	Acidification Potential
AMS	Agriculture Marketing Service
COD	Chemical Oxygen Demand
CIP	Clean-in-place
CCC	Commodity Credit Corporation
CAO	Computer assisted ordering
Cwt	Hundredweight (20 th of a ton)
DEIP	Dairy Export Incentive Program
DAFOSYM	Dairy Forage System Model
DPDP	Dairy Product Donation Program
ESOP	Employee Stock Ownership Plant
EPA	Environmental Protection Agency
FSA	Farm Service Agency
FMMO	Federal Milk Marketing Orders
FDA	Food and Drug Administration
FIA	Food Industry Alliance of New York State
GWP	Global Warming Potential
GHG	Greenhouse Gases
HT	High Temperature
HDEP	High-Density Polyethylene
IDFA	International Dairy Foods Association
MILC	Milk Income Loss Contract
NRDC	National Resources Defense Council
MTCO ₂ e	Metric tonnes CO ₂ equivalent
DOHMH	New York City Health Department and Mental Hygiene
PMO	Pasteurized Milk Ordinance
P	Phosphorus
PET	Polyethylene terephthalate
SMP	Special Milk Program
USDA	The United States Department of Agriculture
TTI	Time Temperature Indicators
UHT	Ultra-High Temperature
USPHS	United States Public Health Service
WTP	Willingness to pay
WWF	World Wildlife Fund



1 Introduction

1.1 Project objectives

Scope

The scope of this project includes New York State, with the intention of reporting on Albany's fluid milk supply chain and its losses. A case study detailing the history of New York City's fluid milk regulation examines the impacts of policy change on the historical amount of waste created.

Significance

To date, there has been a limited body of literature involving waste creation in the fluid milk supply chain, particularly with regards to the U.S., and New York specifically. There is even less research regarding methods of milk loss prevention or diversion. This study aggregates existing literature and contributes primary data that allows a more comprehensive understanding of losses in this supply chain.

In light of this, the goal of this report is to initiate a discussion with regards to fluid milk waste. Consumers require an improved awareness regarding the journey milk takes, from the point that it is purchased from the corner store, to pouring it over their bowl of cereal. Retailers need to be aware of the ramifications that regulation has and its impact on their practices.

The data that we were able to collect was restricted to information from sources who were willing to participate. We hope that what we have highlighted in this report provides the impetus for more in-depth studies on waste reduction and diversion.

1.2 Methodology

A matrix structure formed the basis of our methodology. Cross-functional teams aggregated research from different sections of the supply chain, with the intention of creating a robust end product. Figure 1 shows our group organization. The teams were organized into a vertical supply chain group (Production, Processing, Retail, and Consumer) and a horizontal category (Regulatory Environment, Impact Assessment, and Process Flows and Prevention).

We consulted existing academic literature to provide support for our conclusions, and began aggregating primary data on the topics that had not yet been formally examined. This involved taking surveys of consumers and milk retailers both in Albany and New York City, conducting interviews with academic and industry experts, and analyzing the data thoroughly to ensure that we extracted informed conclusions from each piece.

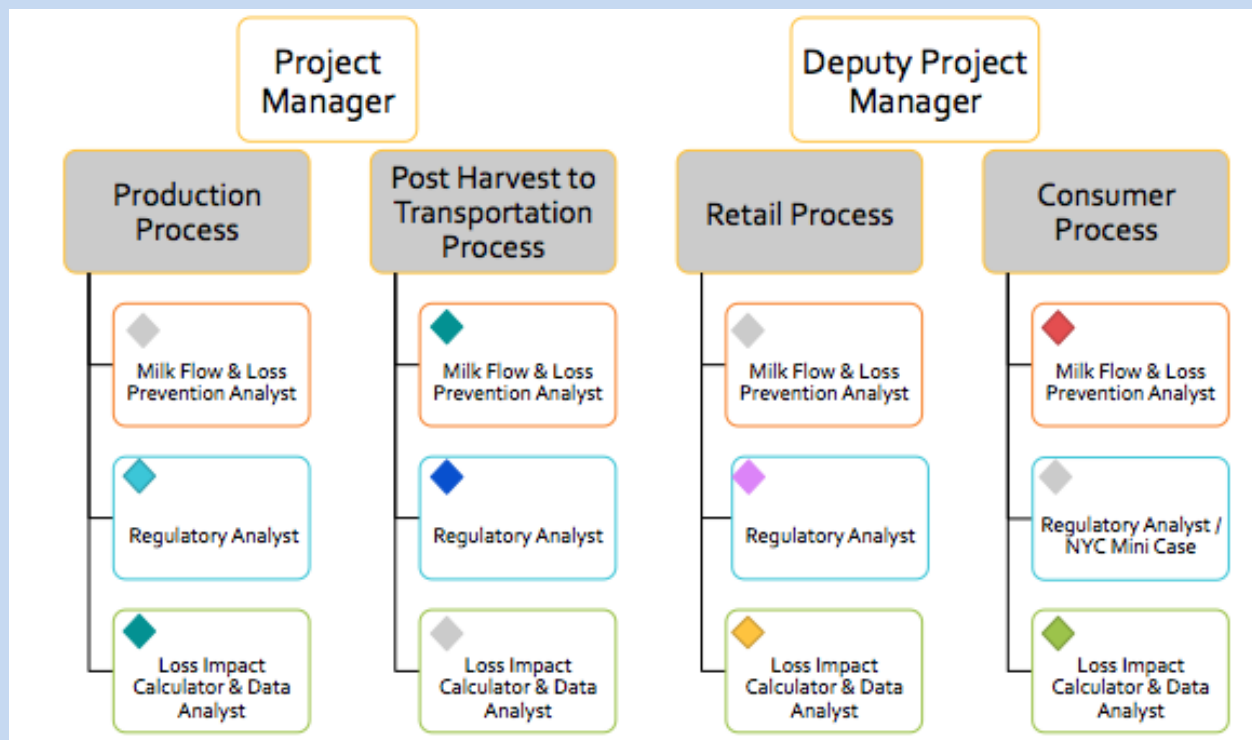


Figure 1 Organizational chart

2 Analysis of supply chain

2.1 Supply chain overview

The supply chain of fluid milk in Albany can be conceptualized as four steps, with losses and impacts occurring at each stage. The flows are summarized in Figure 2. Milk produced on the farm is tested after milking, screened milk may be either processed on the farm or transported to a processing plant at another location. A small proportion of milk in Albany is also packaged without processing and sold directly to consumers as raw milk.

The collection of bulk milk is, in many cases, mediated by a cooperative of several farms. The milk is generally part of a pool regulated by the Northeast Milk Marketing Order, which determines a uniform per-unit price for farmers.

At the processing plant, milk undergoes further testing before it is pasteurized and a proportion is diverted for the production of non-fluid dairy products, such as yogurt or cheese. Fluid (Class A) milk is blended to different fat contents and homogenized before packaging, generally in either high density polyethylene (HDPE) bottles or gable-top cardboard cartons. The packaging is labeled with a “sell-by” date determined by the processor.

The packaged milk is refrigerated during transport to retailers, institutions, and other outlets, which is often mediated by a distributor. This is also the point where milk is exported out of the region and imports enter the system.

Milk at the retailer is held in refrigerated storage and display cabinets until sold. Our research indicated that as early as three days before the marked sell-by date milk is discounted or removed from the shelves. Surplus supply may either be returned to the distributor for disposal or directly discarded to municipal waste. Certain suppliers offer refunds for a limited quantity of unsold milk, which is why the milk is sent back to them.

Households and outlets, such as schools, hospitals and cafes, also discard excess milk. Out-of-date or spoiled milk is disposed into municipal waste and down drains, with some of the packaging recycled. Donations can return some excess milk to households, but this flow is limited by short date coding and refrigeration requirements. Activities across the supply chain impact the environment in a number of ways, and losses occur at every stage.

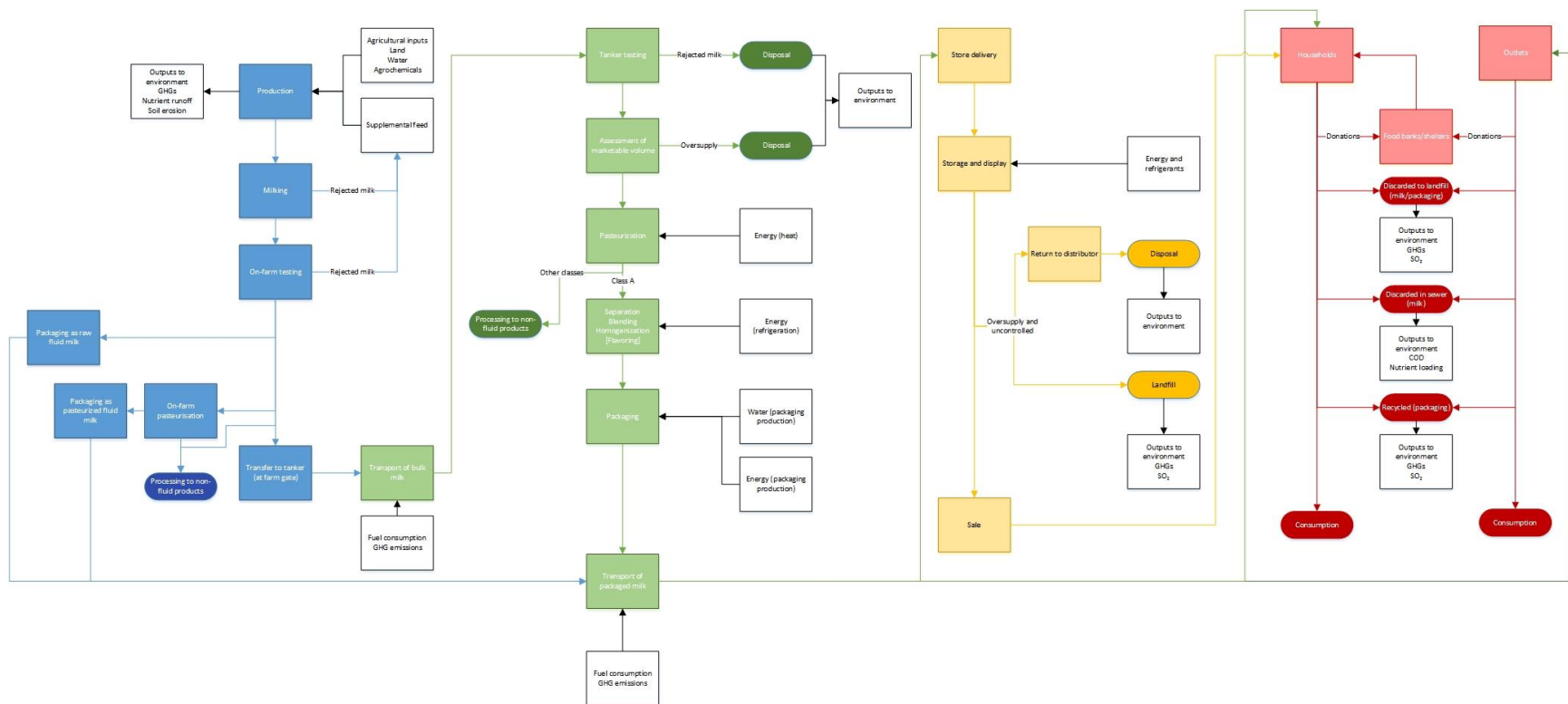


Figure 2. Overview of fluid milk supply chain

2.2 Milk flows and losses

The volume of flows and losses was estimated using the impact calculator described in Section 4 of this report. These estimates are summarized in Table 1. This study focuses on the amount of milk sold in the Albany region, however these values do not represent the volume of milk produced and processed within the region. Likewise, it does not represent the volume sold and consumed. This is due to the nature of the dairy industry, with milk being a globally traded commodity that ascends local, state and even international boundaries. Volumes of milk were calculated using the volume of milk sold in Albany in 2015 (bolded in Table 1) and the loss percentages at each stage of the supply chain.

According to our research, loss rates of 0.49% and 1.19% are common in the production and processing phases, respectively (Alpin et al., 1996). This study finds that in order to sell the 10.17 million gallons of milk that retailed in Albany in 2015, dairy farms must produce 10.55 million gallons, of which 10.50 million gallons are delivered to processing facilities (IRI, 2016). Of the 10.50 million gallons, 10.38 million gallons are delivered to retailers, and 10.17 million gallons are eventually sold to consumers. The consumer phase is where the majority of waste occurs, with a loss rate of 20% resulting in 2.03 million gallons of consumer waste being disposed of in Albany. (Buzby et al., 2016)

Table 1. Summary of milk volumes at each stage of supply chain

	Phase 1: Production	Phase 2: Processing	Phase 3: Retail	Phase 4: Consumption
<i>Milk Entering (gal)</i>	10,552,457.36	10,500,750.32	10,376,053.91	10,168,532.83
<i>Milk Loss (%)</i>	0.49%	1.19%	2.00%	20%
<i>Milk Loss (gal)</i>	51,707.04	124,696.41	207,521.08	2,033,706.57
<i>Milk Exiting (gal)</i>	10,500,750.32	10,376,053.91	10,168,532.83	8,134,826.27

a. Production

The production of milk has grown substantially in recent years. Data from the USDA National Agricultural Statistics Service indicates that milk production per cow in the U.S. has increased by 88% since 1980, while the number of dairy cows decreased by 14%, resulting in a 62% increase in total milk production as illustrated below (Figure 3 and Figure 4). Figure 3 shows both the number of cows and the per-cow milk production in the U.S. since 1980, as reported by the USDA.

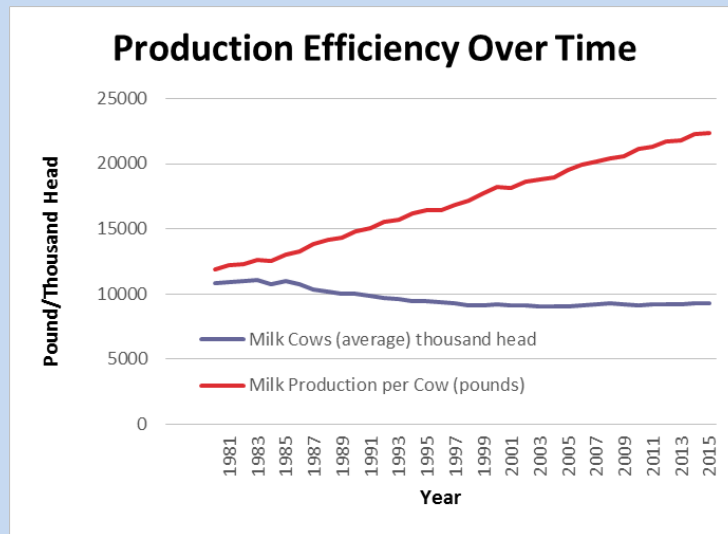


Figure 3. Cows and milk production per cow since 1980

Data source: USDA, National Agricultural Statistics Service.

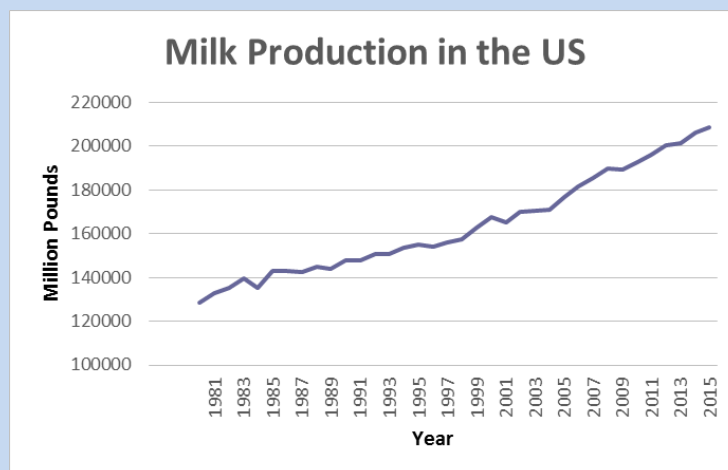


Figure 4. Total U.S. milk production since 1980

Data source: USDA, National Agricultural Statistics Service.

While production has increased, the price of milk has also become volatile, given it's trading as a global commodity, since 1995. In general, volatility was driven more by changes in market conditions, and less by government intervention (Bailey, 2005). Over the same period, milk production evolved from small-scale family farms to large-scale industrial production (MacDonald & Newton, 2014).

Most of the major milk-producing states are located in the West and North; however, while the western regions have grown, other regions have slowly declined in their production efforts (Cessna & Law, 2016). The majority of milk is produced by individual or family-owned farms, many of which belong to producer-owned cooperatives (Cessna & Law, 2016). These co-ops assemble their members' milk and transport it from processors and manufacturers, often operating on their own processing and manufacturing plants. Today, milk production's transition to more mechanized operations has led to national partnerships with co-op members spanning across the country.

Table 2 shows the distribution of herd sizes between 1992 and 2012. In 1992, farms with fewer than 100 cows comprised 49% of the U.S. production base, while farms with 999 cows or more consisted of 10%. In 2012 the dairy industry had a significantly different size distribution, with only 17% of farms having fewer than 100 cows and 49% of farms having herds larger than 1000. This change has been driven by the fact that the cost of operation for large-scale farms is significantly lower than for small-scale farms, on a per-unit production basis (MacDonald & Newton, 2014). Figure 5 below demonstrates the relationship between herd size and gross returns. As herd size increases, gross returns also increase, exceeding the full cost of production for herd sizes larger than 500. The full cost of production is the sum of annualized capital cost, the cost of labor and cash operating expenses (MacDonald & Newton, 2014).

Table 2. Changes in herd size since 1992

	Farms with < 100 cows		Farms with >999 cows	
Year	Farms	Share of cows (percent)	Farms	Share of cows (percent)
1992	134,931	49	564	10
1997	97,134	39	878	18
2002	73,725	29	1,256	29
2007	53,324	21	1,582	40
2012	49,683	17	1,807	49

Data Source: MacDonald & Newton, 2014

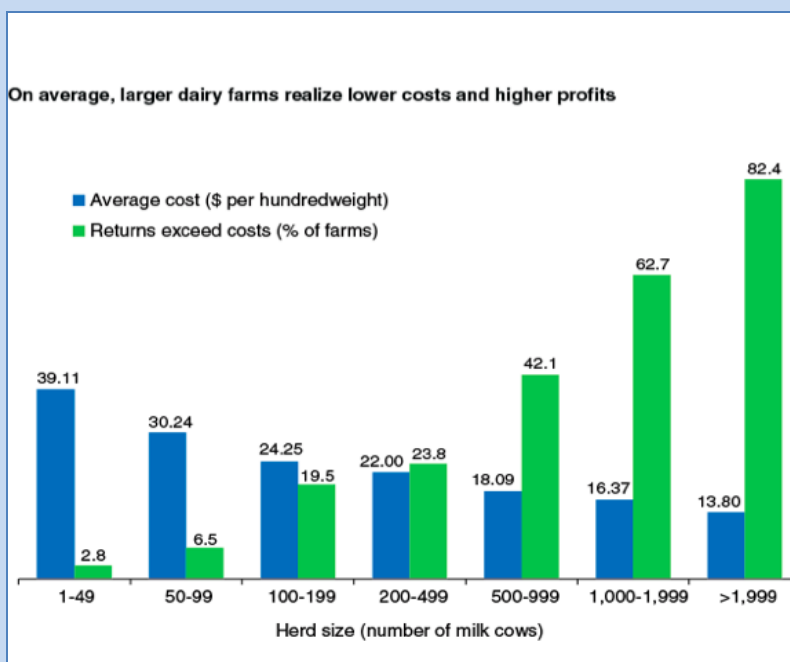


Figure 5. Production costs as a function of herd size

Image source: MacDonald and Newton, 2014

b. Processing

There are more than 4,800 farms in northern New York that may provide fluid milk to Albany, New York at any one time (McCarthy, 2016). Our research focused on four fluid milk-processing plants located close to Albany. These plants receive raw milk either directly from farmers or from cooperatives. Producers may use external shipping carriers to deliver the milk to processors or do their own processing 'in house'. They may also bottle the milk on site and send it directly to retailers or they may send it to a secondary bottling facility. The four plants referenced include Garelick Farms, LLC, Meadow Brook Dairy Farms, Midland Farms Inc., and Stewart's Processing Corp, are all located in northern New York, as shown in Figure 6. Each of the plants differ in size, receives its milk in different quantities, and processes it with different levels of automation.

In the U.S. today, the dairy industry has experienced a fairly steady increase in production and a consistent decline in the number of dairy operations with a cumulative rise in the number of cows per operation (Cessna & Law, 2016). Most of the major milk-producing states are located in the West and North; however, while the western regions have grown, other regions have slowly declined in their production efforts (Cessna & Law, 2016). Many individual or family-owned farms belong to producer-owned cooperatives (Cessna & Law, 2016). These co-ops assemble their members' milk and transport it from processors and manufacturers, often operating on their own processing and manufacturing plants. Today, milk production's transition to more mechanized operations has led to national partnerships with co-op members spanning across the country.

As in other regions, many of these plants purchase their milk from cooperatives. Therefore, the milk supply is sourced from an array of dairy farms, depending on that day's market conditions and other 'balancing' practices that each cooperative employ in an attempt to match the supply and demand of the various stakeholders (farms, processors, retailers and consumers) in the relevant region. This hierarchy of combined milk supply makes it almost impossible to track gallon for gallon where one farm's milk goes once it enters this "cooperative" matrix.

Northern New York has a rich history of farming and dairy milk processors are a key stakeholder connecting farmers and retailers throughout the region. Published research of the milk supply chain has suggested that the greatest area of product loss along the supply chain is at the consumer level. Due to highly automated processing, technology advances, industrial scale operations, and longevity within the market, a relatively small amount of fluid milk is actually lost during post-harvest processing.

One study by Maola Milk concluded that more than 90% of a plant's total waste load comes from milk components that flow into floor drains during processing. In order to reduce waste within the processing cycle is it important to understand the complexity and technology employed in practice at each of the four processing plants that supply milk to the Albany region. Unfortunately only one of the processing plants was willing to provide primary data for this assessment, so this study had to rely largely on information from secondary sources and published research in order to identify recommendations.

One of the processors mentioned above responded to our retail facing survey but requested to be kept anonymous. Their response substantiated loss estimates in literature. Out of the 9.6 million gallons of milk delivered to their processing plant monthly, 90,000 gallons are lost, equivalent to about 1%. The plant reported that the losses were incurred during transfer of the

product, changeovers on equipment, and due to spoilage. The processor is working to mitigate this loss by educating employees and installing metering technology to prevent spoilage.

The plant also reported that 0.25% of product is lost during transportation from the plant to the retailer. This further supports the literature and leads us to conclude that there is minimal milk loss in the post-harvest processing step of the supply chain. This is due to the highly automated nature of the systems and continuous advances in processing technologies.

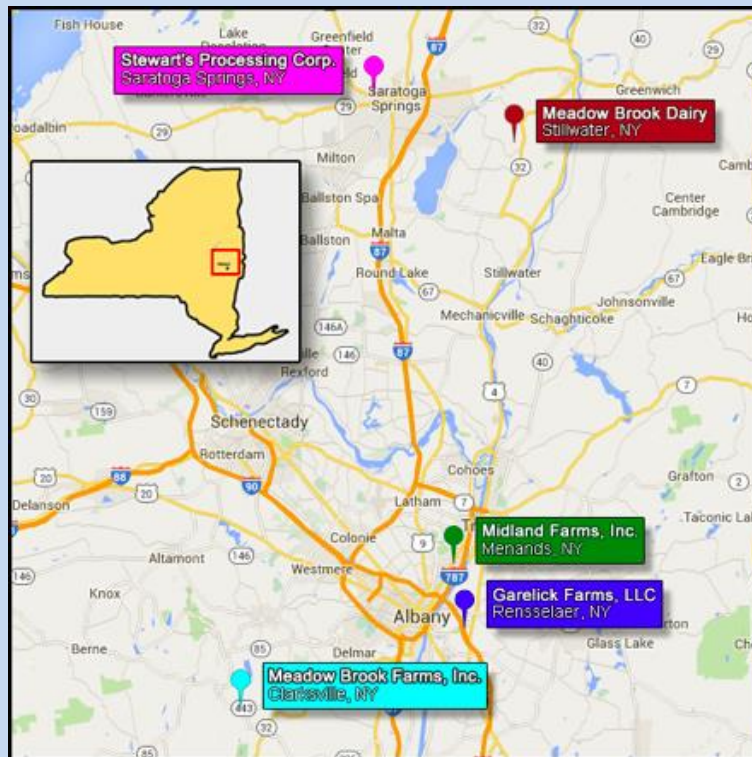


Figure 6 Location of milk processing plants in Albany region

c. Retail

In-store interviews were conducted in four major grocery stores in Albany to identify the points of milk loss at the retail level. Milk is one of the most popular items sold at a grocery store and yet our findings at the retail level show minimal losses. One major study, which was completed in 1995, analyzed fluid milk waste loss at the retail level. The study estimated that about 2% of fluid milk is lost at the retail level (Lipton Manchester, Oliveira & Kantor, 1997). This figure is in keeping with the qualitative responses of the category managers we interviewed.

At the point of delivery, milk is handled differently from other dairy products. While items like cheese, yogurt and eggs can stand for a short period between delivery and refrigeration, fluid milk tends to be unloaded directly into a cooler and, when possible, stocked straight into the display cabinet. The refrigeration systems are temperature monitored depending on the store and some are more technologically advanced than others. For example, the retailers we interviewed explained that if the temperature in the refrigerator starts to move out of the range, a warning light is activated. None of the managers that were interviewed considered deviations from recommended temperatures to be a concern, but one retailer, when referring to milk stated that “when in doubt, [they would] throw it out”.

Overstock could be another point of loss at the retail level, but it is minimized with the aid of Computer Assisted Ordering (CAO) technology. For example, one retailer estimated having only \$100-\$200 worth of shrink (losses) in a week. Others defined their weekly shrink as “minimal”.

The CAO system carries the benefit of greater efficiency since a store with this technology is able to view recent sales and ordering data from the previous year, therefore, they can forecast sales and avoid over-ordering. Supplier/trade partners are incentivized by accuracy. For example, some suppliers offer a return policy where a small number of units are returned at full credit, referred to as a “swell” allowance, but other agreements place the burden on the store. The cost of over-ordering is borne by the retailer in such cases, which incentivizes efficiencies. Other agreements allow for a complete return of all unsold milk without any costs incurred for over-ordering. Other retailers use one supplier for milk; any unsold milk is thrown out. In all cases, retailers emphasized that unsold milk was very low on a weekly basis.

Sell-by dates often determine when stores remove milk from the shelves in order to present a perception of freshness among consumers, even if the milk can last without spoilage for a considerable time afterward. There is some variability as to how this affects specific retailers: while some stores wait until the sell by date, others remove stock from the shelves several days before the sell by date, so there is a perception by consumers that they are buying only the freshest items. However, as noted, stores generally maintain effective inventory management regarding how much milk they will sell and can order accordingly to avoid reaching the sell-by date without sale. Some stores discount their milk as it approaches the sell-by-date to limit the amount of milk that has to be returned to supplier or discarded.

d. Consumer

Our research and the obtained primary and secondary sourced data, suggests that the highest losses in the fluid milk supply chain are found in the consumer section. Twenty percent of milk at the household level is wasted (USDA, 2014) and a loss rate of 20% is equivalent to more than two million gallons of annual consumer waste in Albany. Through our surveys, we found this loss to be closely related to the fact that consumers rely on the date label on the milk container.

According to our survey data, 36% of consumers rely on date labels on the milk container to determine the freshness of milk. Many would not drink milk past the printed label on the carton. Around 7.6% of consumers end up throwing away milk every time they buy it, 49.4% say they occasionally throw it away, while the remaining 43% never throw milk out. Of those who do dispose of milk, 55.6% reported throwing away less than a quarter of the container, 37.4% said less than half, and 7.1% said more than half.

The USDA estimated that in 2010, a total of 10.5 billion pounds (or 1.22 billion gallons) of milk were discarded by U.S. consumers (Buzby et al., 2014). That is equivalent to the annual production from over 450,000 cows. During the 2016 Dairy Forum panel discussion, “Can Dairy Take a Bigger Bite Out Of Food Waste”, the vice president of regulatory and scientific affairs at the International Dairy Foods Association (IDFA) said that “the dairy industry has a real opportunity to try and educate consumers that this [labeling] date is not a safety or spoilage concern, but rather an indicator for stores” (IDFA, 2016).



3 Regulatory environment

Regulation of the dairy industry dates back to the 1930's. Since then, federal and state governments have attempted to set milk prices and distribute pooled milk revenues back to the farmers. Government payments have supplemented dairy farm revenues through buying and selling, subsidizing dairy exports, applying import quotas and tariffs and purchasing dairy herds for slaughter.

a. Production

USPHS and the PMO

Milk production in the U.S. is regulated by the United States Public Health Service (USPHS), a branch of the Food and Drug Administration, which in 1924 developed the Standard Milk Ordinance, known today as the Pasteurized Milk Ordinance (PMO). This program was created to improve sanitation standards and prevent milk borne diseases. Today, forty-six of the fifty U.S. States have adopted the PMO. Since the PMO is a voluntary ordinance, states usually adopt it as a minimum or develop their own milk safety laws with stricter requirements. However, California, Pennsylvania, Maryland and our state of study, New York, have not adopted the PMO (Grade "A" Pasteurized Milk Ordinance, 2011 revision).

Trends in milk production

The fluid milk market varies by day, week, and season – in part because of weather and feed conditions. For example, the number of milk cows on New York State farms totaled 620,000 in May 2016, up 2,000 head from May 2015, and produced nearly 1.29 billion pounds of milk, up 4.9% from the previous year (BJNN, 2016).

High rates of milk waste in the U.S. are partially due to poor legislation at all three levels of government (federal, state, and local). State and local policies particularly warrant improvement at the production, post-harvest, retail and consumer level in order to reduce fluid milk waste.

MILC and DMPP

The Milk Income Loss Contract (MILC) was administered by the Farm Service Agency (FSA) and compensated dairy producers when domestic milk prices fell below a specified level. The compensation was the difference between congressionally mandated milk prices and the actual price (USDA, 2013).

Under the MILC, the USDA made payments on a per-hundredweight (cwt) milk basis, for up to an annual total of about three million pounds of milk. This equates to the annual output of approximately 150 dairy cows, however, most milk in the U.S. comes from dairies with herd sizes of more than 500 cows. As the majority of farms in New York State have herd sizes that are between 50-99 cows. These payments were concentrated on such dairies, i.e., smaller dairies (Sumner, Balagtas, & Yu, 2016).

The compensation pay-out served as a price guarantee for farmers. This had the effect of stimulating excess milk production resulting in large stocks of processed milk goods. Relative to the market value of these goods, support prices became irrelevant – they were much lower than prices found on the market (Sumner et al., 2016).

At the same time that milk prices dropped, dairy feed prices were increasing (MacDonald, Cessna, & Mosheim, 2016). In 2016, dairy feed accounts for approximately 50% of milk production costs (Sumner et al., 2016), which is a significant increase from 2007. Dairy feed has remained above 1998 and 2005 prices (Sumner et al., 2016).

Under the Dairy Margin Protection Program (DMPP), each farm may insure up to 90% of its base period production. A payment is initiated when the margin falls below \$4.00 per hundredweight (cwt) or below the insured value (Table 3) for two consecutive months. The payment is equal to the difference between the national average price of milk and a weighted sum of the national prices of corn, soybean mean and alfalfa hay (USDA, 2016). The formula, which has been written into the 2014 farm bill, captures the average feed cost, however Sumner *et al.*, argue that this cannot accurately reflect the variation of feed rations utilized by different regional areas or the wider country (Sumner et al., 2016). This results in a lower payout to farms with large deviations from the calculated values used in the farm bill.

Farm sizes vary considerably across the country. DMPP provides proportionally greater support to smaller producers through lower premiums. It establishes safeguards against rising costs by restricting annual increases in production covered by the program and raising coverage costs for higher levels of production impacting farms in the western states, which tend to have larger herd sizes. Therefore, lower premiums are paid in the eastern states on all their production, whilst farms in the western states will pay the low premium on a smaller proportion of their milk.

All dairy operations are eligible to participate in the DMPP, and pay only the administrative fee (\$100) if they select protection at the minimum margin level (\$4.00 per cwt of milk). Higher levels of protection are available, for which producers must pay both the administrative fee and a premium. The insurance-based program offers dairy producers an opportunity to choose coverage levels based on their willingness to pay for risk protection (USDA, 2016).

Historic analysis of the DMPP and the USDA's long term projections of feed prices suggest that premiums paid for the MPP appear to be heavily subsidized, except for the highest levels of coverage (\$8.00/cwt). Premium rates are set in law and the program is voluntary. Farms may only opt in to the MPP when payments seem likely to be beneficial. As a result, there can be a financial asymmetry – in years that are favorable for farmers, insignificant revenue would be generated through premiums, but the MPP program can be extremely costly for the federal government when conditions are poor for farmers (low milk prices and high feed prices) and there is a high level of sign-up for coverage pay-outs (Sumner et al., 2016).

The DMPP annual enrollment was launched in January 2015 and early data suggests that only about half of dairy farmers enrolled in the program, as some did not perceive there to be a benefit. Enrollment was higher in western states that have a larger average herd size per farm (approximately >1000 cows/herd) than New York (Sumner et al., 2016).

There were numerous changes that were made to the 2014 farm bill, but this reform did not extend to the Federal Milk Marketing Order (FMMO) system, which is a complex and convoluted government pricing regulation (Sumner et al., 2016). The federal government and some states regulate milk prices through these detailed sets of minimum prices based on where the milk is processed and the processed end product (e.g. cheese, butter).

The purpose of government directives, such as the FMMO, is to ensure that milk flows in an orderly way to final products and customers. The FMMO can use basic economic principles of price discrimination to generate higher average prices and revenue for farmers without limiting

milk production and by setting higher minimum prices for fluid milk, regulating its flow and price across regions. The scheme also pools revenues regionally and distributes gains across farmers within the marketing order, irrespective of the specific end-use of each farm's milk.

Table 3. Schedule of premiums and coverage available under MPP

Coverage Level (Margin) per CWT	Tier 1 Premium for 2016-2018	Tier 2 Premium for 2014-2018
	Covered Production History less than 4 million lbs.	Covered Production History greater than 4 million lbs.
\$4.00	none	none
\$4.50	\$0.010	\$0.020
\$5.00	\$0.025	\$0.040
\$5.50	\$0.040	\$0.100
\$6.00	\$0.055	\$0.155
\$6.50	\$0.090	\$0.290
\$7.00	\$0.217	\$0.830
\$7.50	\$0.300	\$1.060
\$8.00	\$0.475	\$1.360

Data Source: DMPP, 2014

Pricing and subsidies

Federal and some state level governments subsidize milk production, in order to regulate dairy prices. These programs stimulate additional milk output by establishing a minimum price level. Resulting in a shift in income from taxpayers and consumers to the dairy industry. According to Sumner et.al (2002), economic research indicates that the costs to taxpayers and consumers are significantly larger than gains to producers as a group. Producers tend to receive significantly more in gains than the cost to the taxpayer or dairy consumer (Sumner & Balagtas, 2002). This also stimulates overproduction – producers are incentivized to maximize their output, which does not necessarily reflect demand.

The U.S. government has, for many years, subsidized dairy products, and milk for school meals and supported other food assistance programs. In the last decade, the volatility of milk prices has increased both at a NY State and at a federal level. The price of milk has exceeded government set support levels. The below graph (Figure 7) shows the average milk prices in New York over the last 20 years. This illustrates that prices in NY State trend higher than the national average. This is largely a consequence of dairy farm policy.

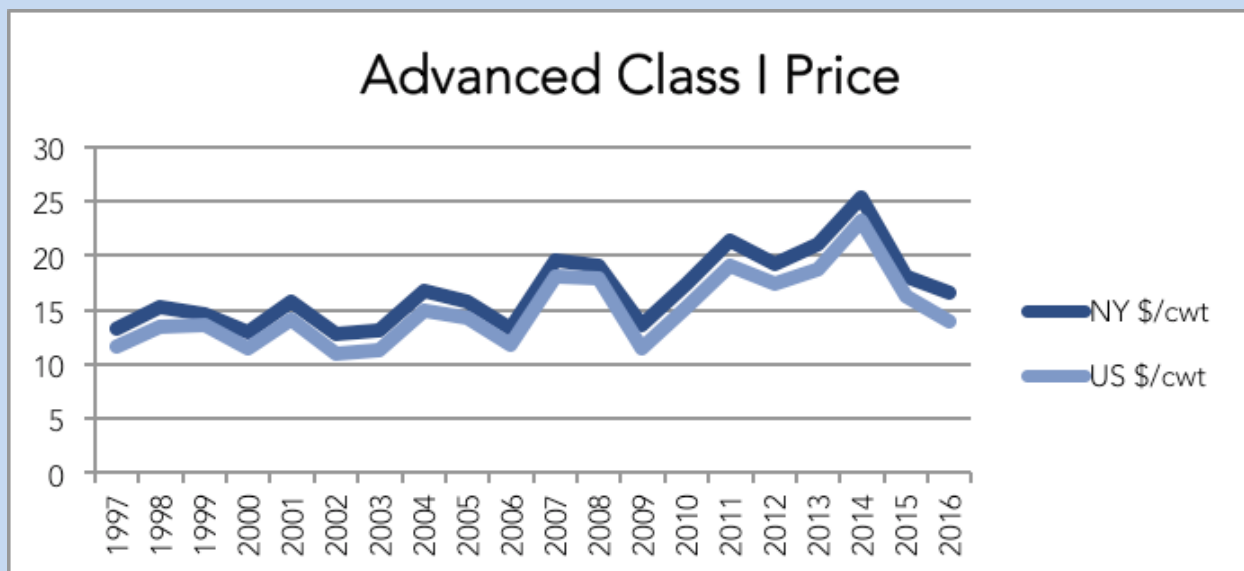


Figure 7. Class 1 milk prices since 1997

Data from USDA, National Agricultural Statistics Service

Effects on productivity

Milk is produced, harvested and transported every other day, if not daily. As a highly perishable product, milk is unique in its qualities as a commodity. Its characteristics, such as fat and protein content, vary depending on the season, along with the volume generated. Spring and summer months typically result in greater yields in comparison to the winter (Federal Milk Marketing Order website). This does not necessarily correspond with changes in demand during this time. Therefore, balancing supply and demand requires careful coordination, particularly as storage capabilities that extend beyond a few days, requires that the milk is processed further to extend its shelf life.

In 2015, there was an increase in the volume of milk shipped to handlers from Northeast Order-regulated producers, according to information on the FMMO website. This was the sixth consecutive year, establishing a new record high, since the Northeast Order's inception in 2000.

Despite this increase in production there has been a steady decrease in the number of dairy cooperatives (USDA - Cooperatives in the Dairy Industry, 2005). Their consolidation has led to greater economies of scale and greater bargaining power in the market place.

Herd size is an important factor of productivity. Table 4 illustrates that New York State farms with larger herd sizes tend to generate a greater output of milk per cow and hence a higher productivity per limited resource.

The processors of raw milk benefit from highly productive herds, as a higher volume of milk available on the market reduces prices, due to supply and demand forces. The price of raw milk is an input cost for a processor and, therefore, lower prices generate higher profit margins.

If the smaller herds in NY State consolidated into fewer, larger herds, it is likely that herd productivity would increase due to economies of scale. In this scenario, raw milk prices would fall, which would benefit milk processors.

Table 4. Reported milk sales, efficiency and productivity for herd sizes from 1-9 to >2500

Herd Size	Number of Cows	Number of Farms	Milk Sales (\$'000)	Efficiency (\$ sales per cow)	Productivity* (Cwt per cow)
1-9	1,864	84	4,096	2,197.4	113.2
10-19	6,180	404	19,552	3,163.8	163.0
20-49	52,310	1,472	161,064	3,079.0	158.6
50-99	111,547	1,676	363,145	3,255.5	167.7
100-199	88,362	659	322,543	3,650.2	188.1
200-499	80,326	257	329,895	4,107.0	211.6
500-999	100,295	143	444,694	4,433.9	228.4
1000-2499	129,622	91	588,923	4,543.4	234.1
> 2500	40,206	12	173,829	4,323.5	222.7
TOTAL	610,712	4,798	2,407,741	* calculated using a 2012 price of \$19.41/Cwt	

Data Source: National Agricultural Statistics Service, 2012

Milk price volatility

Dairy Policy is predominantly concerned with minimizing price volatility and potential financial risks for dairy farmers. Specific programs have followed different strategies, reflecting specific contemporary dairy issues and also included developments in wider farm policy. The instruments of policy have changed over time. These have included market intervention, setting floors on milk prices and direct payments aimed at improving the effects of low milk prices (MacDonald et al., 2016). In 2014, changes to the Agricultural Act sought to improve subsidized insurance programs aimed at the margins between milk and feed prices, explained further in the “Dairy Milk Protection Program” section.

The Federal Milk Marketing Orders originally resulted in 31 orders, which have been consolidated over time to the current number of 10. The cost of capital required by cooperatives to keep pace with new processing capability technology led to further consolidation in order to achieve economies of scale and keep up with demand from large integrated food companies. According to Cox and Chavas (2001), marketing orders can be viewed as price discrimination schemes that increase dairy farmer revenue by raising prices in farm-wholesale markets that have a more inelastic demand and returning these additional revenues to producers participating in the MMOs.

The FMMOs have three key consequences the first effect on U.S. dairy policy is revenue pooling. This results in the regulated farm price being an average of minimum prices of various uses of fluid milk. This eliminates the incentive for farmers to compete in the high-value fluid milk market. The second effect is price discrimination, which results in a minimum processor price applied so that fluid milk plants pay a higher price for farm milk than other types of dairy processor. The third effect on dairy policy is regionalization, where marketing orders use restrictions on inter-region milk shipments to maintain regional differences on prices received by farmers and minimum prices (Cox & Chavas, 2001).

The FMMO classifies different end-uses of product into certain classes. As more stringent sanitation and health standards are required for fluid milk, it is considered “Grade A”. Minimum standards for Grade A milk production and processing are defined by the Food and Drug Administration’s (FDA) “Pasteurized Milk Ordinance”. This controls the wholesale pricing of the product, where a weighted average price is applied as a minimum.

The FMMO administers a pooling scheme, where revenue is shared from end-use classes of milk and pays a uniform average to the order wide price to farmers that deliver milk to that order, regardless of how the milk for that order was used. The weighted average price depends on the milk class and utilization rates of milk by the end-user class, which typically varies from order to order (Bolotova & Novakovic, 2016).

The USDA Agricultural Marketing Service calculates, according to supply of the order, class milk prices. This information is made public via their website (Federal Milk Marketing Order website) on a monthly basis. Dairy farmers do not receive the class milk prices directly; they receive a “mailbox price”. This price reflects prices of all classes of milk sold in a particular order and the utilization rate of each milk class in the total volume of milk. The mailbox price typically includes over-order premiums and other adjustments, such as payments to cooperatives for performing marketing functions (Bolotova & Novakovic, 2016).

The relationship of prices among federal orders is partly determined by formulae used to set minimum prices in each order. According to the formula, the minimum prices for milk used in manufactured dairy products are the same across orders. However, the fluid differentials, and thus the minimum price for milk in fluid uses, can vary significantly across orders. In order to maintain minimum prices within each order, regulations discourage transport of milk across regions.

Milk transported freely across marketing order borders would undermine the maintenance of separate fluid milk markets among the different orders. Regulations on inter-order milk shipments ensure that there is little economic advantage to arbitrage across prices in different orders. Marketing orders create separate fluid milk markets in different regions, therefore, the benefits and costs of milk marketing orders vary regionally (Sumner & Balagtas, 2002)

b. Processing

The role of government

As a consequence of the price support program, export subsidies were utilized as a way to drive demand-side increases in milk. This was achieved through the Dairy Export Incentive Program (DEIP) a policy established by the U.S. Department of Agriculture in its 1985 farm bill and reauthorized by the Food and Agriculture, Conservation, and Trade Act of 1990, the Uruguay Round Agreements Act of 1995, and the Federal Agriculture Improvement and Reform Act of 1996. As part of the DEIP, the USDA provided funds to subsidize exports that were globally uncompetitive. As a consequence, the U.S. dairy industry gained prominence in commercial exports to global markets due to competition (Schnepf, 2014).

Under the World Trade Organization limits, the maximum quantity of subsidized U.S. exports of annual milk production is between 0.5% and 1% of total U.S. production (Hanrahan et al, 2009). Given these limits, the DEIP-assisted exports would have a relatively small impact on U.S. milk prices and income for U.S. dairy farmers (Hanrahan et al, 2009). In 2006, the Office of Management and Budget determined that DEIP was a fairly effective program, but globally,

“have not been able to demonstrate an ability to permanently expand exports or build U.S. market share in targeted countries” (Hanrahan et al, 2009). However, the DEIP was successful in neutralizing EU export subsidies for dairy products to Mexico, enabling the growth of a market for U.S. dairy products instead (Hanrahan et al, 2009).

Federal and state regulation

Legal adoption of the Pasteurized Milk Ordinance is recommended for states, counties, and municipalities. The PMO serves solely in an advisory capacity and its program is designed primarily to assist state and local regulatory agencies. A key purpose of the standard is to facilitate the shipment and acceptance of milk (and milk products) of high sanitary quality for commerce within states and also across states. The ordinance serves to stimulate the adoption of adequate and uniform state and local milk control legislation, promoting a higher level of excellence in milk sanitation practices and encourage the application of uniform enforcement procedures through appropriate legal and educational measures (USPHS, 2011).

Each state regulates its own dairy industry; however, the state's guidelines usually meet or exceed those defined by the PMO (Cornell, 1998). The New York State Agriculture and Markets' Division of Milk Control and Dairy Services, is responsible for all aspects of the state's dairy industry.

The Division has a dual role to protect the health and welfare of the people of New York State and to help promote the agricultural economic development of the dairy industry, via economic controls and programs.

Sampling producer milk is covered by New York State's codes, rules and regulations. The document states that milk obtained from the cow, under sanitary conditions, must be cooled to 45°F (7°C) within two hours of milking. A “handler” then collects the milk and samples the quality. The milk is subsequently pumped from farm's bulk tank into the milk tanker. A handler may pick up milk from more than one farm, so a milk tanker may contain milk from several farms when it is delivered to the processing plant (NY State, Agriculture and Markets, 2006).

Testing

Before the milk can be unloaded at the processing plant, a sample from each load is tested for antibiotic residues. Section 57 of the Agriculture and Markets Law requires that individuals taking these samples be licensed and that the license can be revoked for incompetence or inaccuracy.

During any consecutive six month period, at least four samples must be collected in four separate months for both raw Grade A and Grade B milk, and checked for several standards including: bacterial counts, somatic cell counts, and antibiotics. Cooling temperatures are also checked before the milk is transported. These chemical, bacteriological, and temperature standards are more stringent for the production of Grade A milk, which is eligible for fluid consumption, than for Grade B milk, which is not (Chite, 1991). Dairy Farm Inspection Grade A producers are inspected every six months by an employee or representative of the state regulatory agency (Chite, 1991).

Pasteurization

Although pasteurization destroys most pathogens, certain types of bacteria can survive the process, and these can cause severe gastroenteritis and other diseases in humans. There are regulatory standards for microbial numbers (total bacteria count) as well as quality control and

human health parameters (somatic cell count, and antibiotic drug residues) in milk, as specified by the PMO.

It is not necessary to have bacteria present in fluid milk. If many are present, they interact with milk sugar, which causes souring and unpleasant flavors. Toxins may be produced in the milk if the undesirable types of bacteria are present in large numbers.

On the farm, infected cows are separated from the herd to help control the spread of infection and to protect the overall quality of the milk produced on that farm. On some farms, cows with mastitis - an immune response to bacterial infection that causes the cow's mammary gland to become inflamed - have to be treated with antibiotics. The milk from the treated cows is either discarded or diverted to a separate tank to prevent contamination of milk collected from healthy cows. Milk from cows treated with antibiotics is not used for human consumption. If the milk shows no evidence of antibiotics, it is pumped into the plant's holding tanks for further processing. If the milk does not pass antibiotic testing, the entire tanker of milk is discarded and the farm samples are tested to find the source of the antibiotic residues.

Contaminated milk

Milk can be contaminated in a number of ways throughout the production and processing stages. Improper handling or a failure to meet standards of cleanliness in milk collection can cause the introduction of sediment or bacteria into the milk, effectively contaminating it. Milk that contains an excess of 1.5mg of sediment is discarded. Contaminated milk cannot be used as food or as an ingredient in a food product. The only exception to this rule is the producer, who may use this milk on his/her own farm (NYSDAM, 2006).

Milk that is rejected because of sediment in excess of the tolerable amount carries an identifying tag attached to the container as soon as it has been determined as contaminated. The tag states the reason for such rejection and contains a printed warning declaring that it is illegal for any person to purchase such rejected milk or to use such rejected milk as food or as an ingredient in any form in a food product, except that the producer of the milk. The tag on any container of rejected milk may not be removed during the time the rejected milk is in the container (NY State, Agriculture and Markets, 2006).

Microbial standards for milk

Regulatory action is taken against the farms with positive antibiotic tests. However, positive antibiotic tests are rare, and account for far less than 1% of the tank loads of milk delivered to processing plants (Milkfacts.info). Table 5 indicates the microbial standards for raw and pasteurized milk, as well as the acceptable limits for other contaminants.

Table 5. Contaminant limits for Grade A and raw milk

Milk	Test	Maximum Limit
Pasteurized Milk for Grade A use	Total Bacteria	Individual producer not to exceed 100,000/mL Commingled not to exceed 300,000 mL
	Somatic Cell Count	Individual producer not to exceed 700,000/mL
	Drugs	No positive test on drug residue detection
Grade A Pasteurized Milk	Total Bacteria	20,000/mL
	Coliforms	not to exceed 10/mL
Raw Milk	Total Bacteria	30,000/mL
	Somatic Cell Count	Not to exceed 750,000/mL
	Drugs	No positive test on drug residue detection
<ul style="list-style-type: none"> • Individual producer milk is milk that is still on the farm. • Comingled milk is milk that has left the farm and has been mixed with other individual producer milk in a tank, either during shipment or at the processing plant. • These are New York State regulations for raw milk intended to be consumed as raw milk. 		

Data source: Cornell University, 1998

Testing the testers

Under the terms of the bilateral agreement between the FDA and the National Conference on Interstate Milk Shipments, a national certification program for state centralized laboratories is periodically conducted, which tests dairy products for contaminants and residues. The FDA maintains and controls the accreditation of milk laboratories through regular testing of facilities (NCIMS, 2015).

Milk dealer licensing policy and procedures

Any individual or company that wishes to conduct wholesale purchasing, handling and sales of milk in New York must apply for a milk dealer license from the state Commissioner of Agriculture and Markets.

The application requires that the requestor state the nature of the milk business that s/he intends to conduct and such other information. The New York Commissioner of Agriculture and Markets then decides whether they have sufficient information to determine whether the applicant qualifies for a license (Agriculture and Markets Law, 16, 18, 255, 1995).

For purposes of reviewing and determining such applications, licenses are classified according to the following types of milk businesses (Agriculture and Markets Law, 16, 18, 255, 1995):

- (1) Purchase of milk;
- (2) Sale and distribution of milk;
- (3) Processing of fluid milk;
- (4) Manufacture of milk products;
- (5) Cooperative bargaining and collecting for the sale of milk;
- (6) Brokering of milk; and
- (7) Hauling of milk.

c. Retail

Milk labeling

Strict guidelines and regulations govern the dairy industry and aim to minimize the risk of food related illness to humans. Although some pathogens can withstand pasteurization, the presence of most pathogenic bacteria in processed dairy products implies a failure of the pasteurization process, or post-pasteurization contamination. There are multiple routes that pathogenic bacteria can enter the milk-processing environment, including handling raw milk, contamination by processing site employees, distribution equipment and packaging materials (Boor & Murphy, 2002). The laws and regulations aim to minimize potential contamination events through improved control, thorough testing, documentation and training.

The NCIMS is a non-profit organization that comprises a diverse set of stakeholders who are involved in the dairy industry. This group includes the dairy farmer, processing plant personnel, persons involved in inspecting the dairy farmer's operation and/or the processing plant, legal teams, law enforcement, academic researchers and consumers of the dairy products. Their objective is to assure consumers of safety in the milk supply chain (NCIMS, 2015).

In collaboration with the National Labeling Committee, the NCIMS developed the voluntary adoption of a federal uniform coding system for identification of packaged products from milk plants was developed. This system allows identification of milk plants at which milk and milk products are packaged by means of nationally recognized state and plant code numbers printed on the packaging (NCIMS, 2015).

This coding system is unique to products pasteurized in a milk plant other than those indicating the brand or any other trade labels. If a processing plant chooses not to use the federal uniform code system, they must identify the name and address of the plant on the packaging.

Each state, in cooperation with local jurisdictions, may assign individual identification numbers to milk plants within the state. If the name and address of the milk plant at which pasteurization took place is not marked on the container or included on the label, a label of a container may include the name and address of the manufacturer, processor, or distributor, including a unique code number that identifies the state and milk plant in which the product was pasteurized (NCIMS, 2015).

Date labeling is a key component of the regulatory discussion surrounding retail practices and consumer behavior with regards to fluid milk. At the federal level, the Food and Drug Administration (FDA) mandates that food must be fit for consumption but this does not extend to dates on any food packaging (such as “sell by” “expires on” or “best by”), with the exception of infant formula. The FDA does not require these dates, therefore, they do not regulate whether retailers sell products past these dates (FDA, 2015). The decision to include these dates is left up to the manufacturer or is regulated at the state and/or local level.

The FDA and USDA are the two federal agencies that have significant authority from Congress on food labeling however, specific federal legislation for a federal, standardized date labeling process does not exist (NRDC, 2013). In lieu of this, the guidance provided by the federal level is primarily voluntary, for example, the FDA Food Code (NRDC, 2013). The FDA Food Code is a scientific, technical, and legal framework to assist local and state regulatory agencies in the retail and food service areas (FDA, 2016).

There is a common misconception that the dates appearing on food packaging indicate the safety of the product, when they are actually based on the manufacturer’s estimate of the freshness and quality of the product (Leib, 2016). In the 1960s, Kroger Co. became the first retailer to include sell-by dates on pasteurized fluid milk in one of the first examples of open dating (Diez, Labuza, & Pal, 2007). Open dating on food packaging is indicated by the month, date and year – a visible and understandable method to the consumer. Prior to the prevalence of open dating, ‘closed dating’ was the norm. Retailers and manufacturers adopted the closed date system to communicate inventory, however, the codes were a source of ambiguity to the general public. Despite recognition that date labels were not a safety indicator (NRDC, 2013), the practice of open dating re-emerged in the 1970s due to consumer demand, which initially incurred resistance from retailers.

The accompanying terminology surrounding open dating is also subject to interpretation and is often a source of confusion. Generally accepted definitions of commonly used terms are listed below (Newsome et al., 2014):

- “Sell by” - date set by the manufacturer indicating to retailers when the product should be pulled from sale; is not considered an expiration date and the product will typically last beyond this date
- “Use by” - date set by the manufacturer which indicates when the product should be consumed by
- “Best by” / “Best Before” - date set by the manufacturer which indicates product’s best quality; not considered an expiration date

A 2013 National Resources Defense Council (NRDC) and Harvard Food Law and Policy Clinic, analyzed past food date labeling systems in the U.S. as part of a wider report and concluded that confusion and misinterpretation surrounding date labeling, contributed to 160 billion pounds of safe food, wasted and discarded annually in the U.S. (NRDC, 2013). In addition to food discarded at the consumer level, retailers incur losses as a result of excess food, which cannot

be sold, particularly in states with strict date labeling regulations (NRDC, 2013). While the NRDC & Harvard Food Law and Policy report evaluated labeling and food waste in general, it is important to note that fluid milk labeling practices vary widely from state to state due to the lack of federal standards (Leib, 2016).

Adding to the nebulous nature of dairy regulation is the fact that, depending on the state, a different agency may be responsible for the date labeling regulations (i.e. Department of Health, Department of Agriculture, etc.) resulting in very strict date labeling regulations in some states, with no regulations in others (NRDC, 2013). This is why the same carton of milk available for sale in New York is subject to a variant form of regulation if it is in an equivalent sales outlet in New Jersey.

The scope of this project has been defined as New York State, including the cities of Albany and New York. Albany does not have any local regulations regarding date labeling of milk. New York State has an open dating policy with regards to fluid milk, leaving the milk processors with the responsibility of setting the date codes based on the milk quality. Factors that contribute to establishing the date include the processing operations, equipment and distribution systems (Bruce W. Kupke, personal communication, June 22, 2016).

The modern dairy industry standard for quality date labeling is between 21-24 days post-pasteurization (Leib, 2016). With regards to date codes, New York State does not regulate how a retailer displays or sells milk or milk products; however, it is good practice that the retailer discards products that are out of code (K. Laviolette, personal communication, July 12, 2016). The term “out of code” can be applied to products past a “use by” date in open or closed date labeling processes (Newsome et al., 2014).

In New York State, the Division of Milk Control and Services within the Department of Agriculture and Markets is the agency that regulates all aspects of dairy industry (NYSDAM, 2008). The Division of Food Safety and Inspection specifically regulates retailers (K. Laviolette, personal communication, July 12, 2016). Article 17 of the Agriculture and Markets law, the New York Codes, Rules and Regulations (CRR-NY) require that retailers must comply with retail food store sanitation regulations. Section 271-2.6 of the Article refers to requirements for refrigeration units and accurately scaled thermometers (CRR- NY, 2004). Fluid milk is addressed as follows:

“Section 271-2.2 Special requirements

“Fluid milk and fluid milk products used or offered for sale shall comply with the Grade A standards promulgated by the Commissioner and set forth in Part 2 of this Title, and shall be maintained at a temperature of 45°F or less. Dry milk and milk products used or offered for sale shall be made from pasteurized milk and milk products.”

(CRR- NY, 2004)

Properly calibrated temperature testing equipment can help retailers minimize fluid milk losses (Bruce W. Kupke, personal communication, June 22, 2016).

d. Consumer

In general, Congress has not mandated a federal date labeling regime on milk. It has, however, delegated general authority to both the Food and Drug Administration (FDA) and the U.S.

Department of Agriculture (USDA) to ensure food safety and protect consumers from deceptive or misleading food package information (NRDC, 2013).

Consumers' purchase, consumption, and disposal of fluid milk are not regulated at the federal, state or municipal level. This decision-making is in the hands of the consumer. The FDA has the power to regulate food labeling on milk but does not choose to exercise its jurisdictional authority. Instead, the FDA regulates food additives, such as preservatives and other substances added to food for 'technical effect'. They ensure that such food is safe, nutritious, wholesome, and accurately labeled following the standardized nutrition facts labeling regulations. The New York State Department of Agriculture and Markets also regulates food safety for consumers by supervising four main areas, one of which is Milk Control & Dairy Services (USDA, 2016).



4 Loss impact analysis

This tool was created to calculate and display information about the estimated environmental impact associated with the production and disposal of fluid milk and its packaging in Albany, New York.

Within the tool, the Executive Summary (Tab A) contains a summary table with key findings, as well as an impact calculator tool (described below). The summary table displays the estimated environmental impact of each stage of the supply chain (Production, Processing, Retail and Consumption) using the three major indicators evaluated in this study: global warming potential, water consumption and agricultural land use. These three indicators were selected because they are most relevant to the milk supply chain, they have the most comprehensive data and they represent three diverse and important areas of environmental impact. The Master Impact Table (Tab B) displays the total estimated environmental impact associated with each stage of the supply chain, for the indicators used in this study (listed in Row 13). Tabs C, D, E and F contain the input data and calculations for each of the four supply chain stages.

The City of Albany, New York is used as the study area for this assessment. The Albany region is unique in that it is home to the entire supply chain, including dairy production, processing facilities, retail outlets and a concentrated population of milk consumers. To the extent possible, this study's assumptions and input data are specific to the Albany region. Where data was not available at the local level, the study uses data at the state or national levels. A complete list of references is included below.

4.1 Assumptions in loss calculations

Imports and exports are common in the milk industry, meaning that milk is often not produced and processed in the same state or region that it is consumed and disposed of. In order to evaluate a consistent quantity of milk, the study uses the volume of milk purchased in the city of Albany in 2015, then calculates impacts based on the production and processing volumes that would be required to supply this sale volume, given the loss estimates available (see Tab B: Milk Flows). By applying per gallon impacts from the production and processing stages to the estimated milk flows, the study determines the estimated environmental impact of the milk purchased in Albany.

The key assumptions that informed the creation of this tool and its calculations are listed in Appendix A: Impact calculator.

4.2 Estimated losses and impacts

One component of this study was to undertake an assessment of the environmental impacts of the milk supply chain. A summary of these results is listed in Table 6 below. These impact estimates were determined based on a combination of primary and secondary research, combining data from: academic literature; federal, state and local government reports; white papers and other industry publications; and a collection of site visits, in-person and telephone interviews, and surveys. To see the full set of input data and calculations, please see Appendix A: Impact calculator.

Environmental Impacts Summary Table				
		Global Warming Potential (kg CO ₂ eq/gallon)	Water Consumption (gallon H ₂ O/gallon milk)	Agricultural Land Use (hectares/ gallon/ year)
Phase 1: Production	Inputs	5.006	140.018	0.00073
	Outputs/Waste	0.000	0.000	0.00000
	Combined	5.006	140.0182	0.00073
Phase 2: Processing	Inputs	0.307	3.188	N/A
	Outputs/Waste	0.000	0.000	N/A
	Combined	0.307	3.188	N/A
Phase 3: Retail	Inputs	0.373	0.577	N/A
	Outputs/Waste	4.733	0.000	N/A
	Combined	5.106	0.577	N/A
Phase 4: Consumption	Inputs	0.250	0.000	N/A
	Outputs/Waste	2.888	0.000	N/A
	Combined	3.137	0.000	N/A
Total: Inputs		5.935	143.783	0.00073
Total: Outputs		7.621	0.000	0.00000
Grand Total		13.556	143.783	0.00073

Table 6. Environmental footprint master table

In the course of defining environmental impacts, three key determinants were quickly apparent; global warming potential, water consumption, and agricultural land use. These components have clear environmental consequences associated with their degradation, but also carry significant economic weights.

A large proportion of the global warming impacts from milk production could be reduced or eliminated through the mitigation of methane (CH₄) emission. This accounts for 48-65% of the total global warming potential (de Boer, 2003). Methane contributes to climate change with an effect equal to 25 times that of CO₂ in a 100-year period (Aguerre et al, 2011). Enteric CH₄ emission from ruminant livestock and stored manure are major contributors to anthropogenic emission of greenhouse gases (Aguerre et al, 2011).

Another undesirable emission of livestock manure is excess ammoniacal nitrogen (NH₃-N), which disturbs the natural ecosystem (Aguerre et al, 2011). Atmospheric ammonia can cause the eutrophication of surface waters, which increases the nutrient load in the water and results in a decline of aquatic species while promoting the growth of harmful algae (Gay et al, 2009). The U.S. Environmental Protection Agency reported that animal agriculture accounts for 50 % to 85 % of total anthropogenic ammonia volatilization in the U.S. (Gay et al, 2009).

As previously mentioned, producers are able to increase their yields as they achieve economies of scale. This economy of scale can be achieved in milk production in an effort to maximize the volume of milk output per individual cow. When grazing on pasture grasses does not provide cows with sufficient nutrients, farmers often supplement their diets with agricultural feed concentrate. However, a point is attained at which diseconomies of scale are experienced as a result of supplementation such as feed harvest and handling costs (Soder et al, 2001). A computer model, Dairy Forage System Model (DAFOSYM), was used to simulate long term (25

year) biological and physical processes on farms, to evaluate economic and environmental impact of feed management decisions (Soder et al, 2001). Results indicate increased levels of concentrate supplementation had a substantial negative impact on profitability and nutrient balance of grazing dairy farms (Soder et al, 2001). Confinement feeding systems had a lower profit in comparison to grazing systems with a higher level of supplementation (Soder et al, 2001).

Pasture is high in nutritive value compared to supplemental feed; subsequently, maximum supplementation levels may not result in maximum production or maximum profits (Soder et al, 2001). A well-maintained pasture is high in nutritional value; therefore extra concentrate supplementation can be kept to a minimum, or not given at all. Soder et al. (2001) found that pasture is higher in nutritional value compared to concentrate supplementation (hay, silage, alfalfa, etc.) and that adding additional feed would not result in more overall profit when considering costs of concentrate supplementation. Despite decreased income from grazing, the net result was greater profitability because of decreased input costs (Soder et al., 2001).

Cows need a certain daily intake of phosphorus, and excess phosphorus would be excreted in the cows' manure. Phosphorus (P) balance was achieved in smaller herds, and as herds increased in size supplementation also increased, along with elevated P accumulation in soil (Soder et al, 2001). The phosphorus in manure is balanced in the soil, when there are smaller herd sizes and does not cause a direct pollution threat to clean groundwater. However, as herd sizes increase, the phosphorus in soil increases to become a direct pollution threat.

A study by Cederberg et al conducted in 2000, compared conventional and organic farming of milk and indicated that low-input agricultural systems, such as organic milk farms, had a reduced impact on the environment (Cederberg et al, 2000). This conclusion was based on the reduced application of pesticides and phosphorus (Cederberg et al, 2000).

a. Processing

The environmental impact from the processing and transportation phase of the dairy supply chain in the U.S. is generated from the consumption of energy and water and the production of waste materials. The waste materials may contribute to climate change, air pollution and water pollution or have other impacts.

Greenhouse gas emissions account for approximately 69% of the dairy processing and transportation environmental impact (Dvarionienė, Kruopienė, & Stankevičienė, 2012). Greenhouse gases (GHGs) are produced by activities associated with the consumption of energy at the processing plant and the combustion of fuel during the transportation of milk. One processing plant in Albany reported an electricity consumption of 3.1 MJ per gallon of milk and fuel consumption for transportation of 0.0087 gallons per gallon of milk. According to the EPA's Emissions Factors for Greenhouse Gas Inventories, each MJ of electricity in Upstate NY produces 0.069 kg CO₂e per MJ, while each gallon of diesel fuel produces 10.21 kg CO₂e (EPA, 2014). The overall greenhouse gas emissions from the processing and transportation phases are described in more detail in the environmental impacts section below.

Water pollution accounts for around 25% of the process' environmental impact (Dvarionienė, Kruopienė, & Stankevičienė, 2012). However, the use of water in dairy processing plants in the U.S. only accounts for 1.5% of the water consumption of the dairy supply chain, whereas farming accounts for 97.1% (Innovation Center for U.S. Dairy, 2012). The Albany processing plant has a water consumption of 3.19 gallons per gallon of milk. After its use, the water is

filtered and purified with ultraviolet treatment. Wastewater contains milk fat, soluble proteins, milk sugars, milk salts, as well as cleaners and sanitizers. Dairy wastewater requires higher levels of treatment than other food waste, since it contains more minerals, soluble solids and fat (Food Processing Environmental Assistance Center, n.d).

Finally, Dvarionienė, Kruopienė, & Stankevičienė, 2012 estimate that solid waste production accounts 5% of the environmental impact, while other activities account for 1%. The main solid waste is the sludge produced in the water treatment process.

Milk loss

In undertaking this study, interviews were conducted with one of the four major processing plants in the Albany region. According to the plant manager, 0.94% of milk is lost in the course of processing, along with transportation losses of 0.25%. A smaller biodynamic producer reported similarly low losses of around 2% in their processing plants, from a monthly production of approximately 5,000 gallons to 7,000 gallons per month, from which 15 - 20% is used for the production of fluid milk products. We assume that there is an average of 1% to 2% of losses in the processing and transportation phase of the fluid milk supply chain, based on these two references from dairy plants in the Albany area.

The dairy industry can reduce its environmental impact by minimizing milk loss throughout the fluid milk supply chain. There are four main types of losses in the dairy processing plants. The first is farm-to-plant shrink, which includes the losses from transportation and the milk that is rejected after it is tested. The second is the plant shrink, which results from spillages in the processing and packaging processes. The third area of loss arises from returns of packaged milk due to packaging or quality defects. Finally, there is loss of milk that is missing or is stolen at the plant (Stephenson, Aplin, Erba, & Mattison, 1996). To minimize losses in the processing phase, it is recommended that processors take measures to prevent spillages, purge lines, maintain equipment, recover and recycle waste, and improve employee awareness. In the transportation phase, truck maintenance and a better route design can help reduce losses and the consumption of fuel (Environment Protection Authority of Australia, 1997). Loss reports are also recommended. In a plant we contacted, milk shrink is recaptured for animal feed or discarded.

Environmental footprint

The average carbon footprint in the dairy processing and transportation phase in the U.S. was estimated by adding impacts from the following three steps: milk processing, milk packaging and transportation. According to the International Dairy Journal, in the U.S. milk processing produces 0.291 kg CO₂e per gallon of milk. Additionally, the packaging process produces 0.204 kg CO₂e per gallon of milk and the transportation of milk from the farm to the plant and the delivery to retailers produces 0.458 kg CO₂e per gallon of milk. These emissions sources account for a total of 0.954 kg CO₂e gallon of milk processed and transported to the retailer (Thoma et al., 2013).

However, after calculating the greenhouse gas emissions from the electricity and fuel consumption from the plant reports using the EPA's emission factors, we found that the company's carbon footprint is much lower than the literature suggests. Milk processing and packaging produce 0.218 kg CO₂e per gallon of milk and transportation produces 0.089 kg CO₂e per gallon of milk, which accounts for a total of 0.307 kg CO₂e per gallon of milk. The plant processes 9,600,000 gallons of milk per year; its annual carbon impact is 2,943 tons of CO₂e.

Availability of data

Significant challenges were encountered when gathering primary data from the four dairy processing plants located in the Albany region. As mentioned above, we received a survey response from only one processor. An in-depth analysis of all the processing plants in Albany would require information that includes electricity consumption, fuel consumption involved in the transportation of milk, water consumption at the plant and the volume of water that requires treatment after it has been used. Additionally, the volume of milk lost at the processing plant and during transportation, and the actions that are being taken to prevent it, would also provide greater insight and analysis for a complete study of the Albany region.

For the reasons described above, many of the environmental impact calculations in this study are based on data gathered from a single processing plant or drawn from the limited literature available.

b. Retail

Milk loss

Annual milk losses from retail are summarized in Table 7. It is estimated that around 207,500 million gallons are lost from Albany retailers each year.

Table 7. Summary of estimated retail losses

Activity	Loss (gal)
Oversupply > landfill	103,760.5391
Return to distributor > distributor disposal	103,760.5391
Total	207,521.0782

Environmental footprint

At the retail level, there are two key activities that directly impact the environment. The first is the storage and display of milk in the store, which consumes considerable energy and generates greenhouse gas emissions; and the second is the disposal of unsold milk and packaging, which generates emissions of greenhouse gases and acidifying compounds.

The refrigeration of milk during storage and display is a critical activity – temperature is the most important factor that leads to spoiling. In order to remain in optimal condition, milk needs to be kept below 40°F throughout its handling (Clemson Cooperative Extension, 2007). The use of energy for refrigeration is therefore essential. A study published by the American Society of Heating, Refrigeration and Air-Conditioning Engineers estimates that refrigeration accounts for as much as half of the electricity consumption in a typical grocery store (Faramarzi, 1999), and it is estimated that approximately 1.6% of a typical store's refrigeration space is dedicated to milk (Thoma, et al., 2013).

Different refrigeration systems have varying energy footprints. While open cabinets can boost sales, particularly of products for which demand is elastic, doored cabinets consume less

energy – 1.71 kwh/day per linear foot compared with 2.21 kwh/day per linear foot for open cabinets (Fricke & Becker, 2010).

All of the stores surveyed use doored cabinets for displaying fluid milk. Milk is more sensitive to changes in temperature than other processed dairy products like cheese or butter. In interviews conducted in Albany, dairy and grocery managers reported that fluid milk was directly unloaded from refrigerated transport into a cold store, and wherever store design allowed, display cabinets backed directly onto the cold store, so that milk could be restocked without ever being removed from refrigeration. This was a contrast to other refrigerated products, which could handle short periods outside of the refrigerator and typically stocked through the front of display cabinets.

In addition to energy consumption, refrigeration contributes directly to greenhouse gas emissions through the gradual leakage of refrigerants such as R-22, R-404A and R-507A, which are potent greenhouse gases. Thoma et al. (2013) estimate the combined global warming potential of energy consumption and refrigerant leakage at 0.095 kg carbon dioxide equivalent per kg of milk, or 1.8 kg carbon dioxide equivalent per gallon. The disposal of milk and packaging also generates greenhouse gas emissions, and the decomposition of packaging additionally generates acidifying compounds.

In stores surveyed, there were two principal avenues for the disposal of milk: return to the distributor and municipal landfill. The calculations used in this study assume that the eventual fate of milk returned to the distributor is also landfill, though this waste stream is a potential area for further study.

The method of disposal is dependent upon the agreement between the store and their trade partners – in some cases unsold milk is required to be returned for the purpose of verification. In other cases, unsold milk may be recorded by scanning out of inventory (scanning the barcode to identify the product as having been removed from the store), and the product simply discarded.

Interviews with retailers found no instances of either substantial recycling of packaging or the donation of unsold milk. Recycling is not practical, due to restrictions on the disposal of milk down drains that lead to municipal sewers. Donation of milk to a food bank is similarly impractical, even in stores that do have a regular donation program for other perishable products such as bread and eggs. Managers indicated that a contributing factor was a lack of refrigerated transport available to food banks.

The principal environmental impacts of landfill disposal are the evolution of greenhouse gases (global warming potential, GWP) and acidifying compounds (acidification potential, AP) during the gradual anaerobic decomposition of milk and packaging. In a life cycle analysis, Meneses, Pasqualino & Castells (2012) observed that these impacts are insignificant when compared to impacts at other stages of the life cycle, particularly during production.

The environmental impact calculator generated as part of this study estimates the per-gallon footprint of these impacts based on the findings of studies in the literature. The contribution of milk itself to the disposal footprint is likely to be fairly low – the U.S. Environmental Protection Agency estimates that the anaerobic decomposition of food waste generates emissions equivalent to approximately 1.75 MT carbon dioxide equivalent per wet short ton (ICF International, 2015), which is a fraction of the disposal footprint estimated in this calculator.

The emissions generated from packaging vary widely depending on both the size and nature of the packaging. Firstly, the ratio of packaging weight to milk depends on the volume of the package – where a 1 L HDPE bottle might weigh 30.1 g (ratio of 30.1g/L), a 1.5 L bottle of the same type may weigh only 3 g more, at 33.7g (a ratio of 22.5g/L) (Meneses, Pasqualino, & Castells, 2012). In this respect, larger packages have lower per-volume disposal impacts.

The environmental impact calculator focuses on the global warming potential footprint of disposal. Limited data is available on the generation of acidification potential in landfill conditions in the U.S., but this could be an important consideration for further study.

It is assumed that the GWP from methane generation under landfill conditions is approximately 0.04 MT CO₂ equivalent per short ton of HDPE, and 1.52 MT CO₂ equivalent per short ton of paperboard, as reported by the U.S. Environmental Protection Agency (EPA) (ICF International, 2015). The footprint is extrapolated based on the average weight of each packaging type.

The calculator applies the storage and display footprint to all milk lost at or after retail, and the disposal footprint to all milk lost at retail. The estimated footprint of each of these activities is summarized in Table 8.

Table 8. Environmental footprint of retail activities.

Activity	AP	GWP	Water
	(g SO ₂ /gal)	(kg CO ₂ eq/gal)	(gal/gal)
Refrigeration (energy and refrigerants) and storage	-	0.373	0.5768
Impacts from disposal (weighted average)	0.000	4.733	
Outputs from distributor disposal	0.000	4.733	
Outputs from direct landfill disposal	0.000	4.733	

c. Consumer

The final phase in the life cycle of milk is the ‘Consumer Phase’, which begins when a consumer purchases milk, and ends with its disposal. For the purposes of this study, the consumer phase was divided into household consumers, including individuals and families who purchase milk for consumption at home, and outlets, which includes companies, organizations and institutions. The quantitative analysis of the volume of milk wasted and the associated environmental impacts focuses on household consumers, as very little detailed, reliable data about outlets’ consumption and disposal of milk is publicly available.

Milk loss

Household Consumers

Retail scan data shows that in 2015, a total of 10.17 million gallons of milk were purchased in retail outlets in Albany (IRI, 2016). Using figures from the U.S. Department of Agriculture (USDA) we estimate that 20 % of that milk is not consumed, and is either poured down the drain where it enters the municipal sewer system or thrown in the trash where it ends up in a landfill.

Outlet Consumers

In this study, we define outlet consumers as any company, organization, or institution that purchases milk, including restaurants and coffee shops, schools and hospitals. In addition to having a large residential population, Albany and its surrounding area is a major economic center and as such is home to a large number of outlet consumers of milk. Some of Albany's top employers include state and City Government Offices, hospitals and health care centers including St. Peter's Health Care Service and Northeast Health, the Albany County School District, and retail groceries, specifically Stewart's Ice Cream Company, Golub Brothers, and Hannaford Brothers (CHA, for Capital Region Solid Waste Management Partnership, 2014). According to data from the Albany Solid Waste Management Plan, each worker in Albany produces an estimated 1.8 lbs of waste per day, or 657 lbs per year. While this is a fraction of the per capita residential waste (10.7 lbs/day), it is still a substantial figure and likely includes a significant amount of milk waste (CHA, 2014).

Unfortunately very little data is publicly available regarding the amount of milk purchased and disposed of by outlets, in Albany and nationwide. For that reason, this report does not include a quantitative assessment of milk loss and its environmental impact for outlets in the Albany region. However, based on our preliminary research in this area, certain types of outlets may produce extremely high quantities of milk loss and would be excellent areas for further study.

Environmental footprint

The environmental impacts from the consumer phase are primarily from transportation and the disposal of fluid milk and its packaging. A summary of the total environmental impacts associated with the milk purchased in Albany is shown in Table 9 below.

The primary environmental impacts associated with the consumer phase are in the form of air pollutants. Transportation between the household and retail store as well as the household and the waste disposal center are included in this study. The impacts of milk at the sewage treatment facility are also included, in the form of Chemical Oxygen Demand (COD).

Transportation emissions were calculated for both the journey from household to retail outlet and household to waste management facility. The emissions associated with household to retail outlet) were determined using the average number of grocery store trips per week (1.5) (Food Marketing Institute, 2015), average distance to grocery store (3.79 miles) (Ver Ploeg, Mancino, Todd, Clay, & Scharadin, 2015) and an average of emissions from a passenger vehicle in the

U.S. (8.78 kg CO₂/gallon, 0.0173 grams CH₄/mile and 0.0036 grams N₂O/mile) (U.S. EPA, 2014). The assumption was made that 0.307% of the total emissions are associated with milk (Thoma et al., 2013).

Table 9. Environmental impacts of activities at the consumer level

Impact Activity	Impact Type	Albany Total	Per Gallon	Unit
Transportation Emissions: Household to Retail Outlet	GWP	784,766.91	0.0772	kg CO ₂ eq
Transportation Emissions: Household to Waste Management Facility	GWP	1,753,055.06	0.1724	kg CO ₂ eq
Subtotal: Transportation		2,537,821.97	0.2496	kg CO ₂ eq
Fluid Milk Discarded to Landfill	GWP	1,584,390.05	2.8877	kg CO ₂ eq
Milk Packaging: Plastic, Discarded to Landfill	GWP	0.00	0.0000	kg CO ₂ eq
Milk Packaging: Paper, Discarded to Landfill	GWP	291.19	0.0000	kg CO ₂ eq
Subtotal: Landfill		1,584,681.24	2.8877	kg CO ₂ eq
Fluid Milk Discarded to Sewer	COD	1,497,266.66	0.7908	kg COD
Subtotal: Sewer System		1,497,266.66	0.7908	kg COD
Milk Packaging: Plastic, Recycled	GWP	-145.07	-0.00001	kg CO ₂ eq
Milk Packaging: Paper, Recycled	GWP	-10.31	-0.000001	kg CO ₂ eq
Subtotal: Recycling		-155.39		kg CO ₂ eq
Subtotal: Waste Management (GWP)		1,584,525.85		kg CO ₂ eq
Weighted average: packaging disposal emissions			0.0000051	kg CO ₂ eq
TOTAL: GHG Emissions (GWP)		4,122,347.82		kg CO₂ eq
TOTAL: Wastewater Load (Organic)		1,497,266.66		kg COD

Emissions associated with transportation between the household and waste management facility, were calculated using national averages from the EPA. The EPA estimates transportation emissions of 0.04 MT CO₂e per short ton of waste.

Milk packaging waste is handled differently from fluid milk in that virtually all containers enter the municipal solid waste management system, where they are either recycled or enter a landfill.

The majority of milk containers are made of plastic, specifically High Density Poly-Ethylene (HDPE) containers commonly known as #2 plastics (Thoma et al., 2013). While plastics are highly desirable as food packaging because of their light weight and stable chemical composition, they are also highly damaging to the environment when they are disposed of because they can last many hundreds of years in a landfill. Because of their long life span, the greenhouse gas emissions associated with disposing of HDPE plastics in landfills is relatively low. The EPA calculated that one ton of HDPE emits 0.04 metric tons of CO₂e, compared with 1.52 CO₂e for paper. (ICF International, 2015). For that reason, our calculated greenhouse gas

emissions associated with the disposal of plastic containers is significantly lower than that of the paper packaging (272,914 kg CO₂e versus 2,698,508 CO₂e respectively).

Aseptic containers make up only 11% of the packaging for fluid milk (Thoma et al., 2013), however due to the predominance of organic chemicals in its composition, its higher weight per gallon of milk, and its lower recycling recovery rates, disposal of milk containers have a greater environmental impact, than plastic in Albany. The weight of an empty paperboard container is approximately 113 grams, which is approximately twice the weight of a one-gallon HDPE container (Keoleian & Spitzley, 1999). On a per ton basis, paper containers emit more GHGs than plastic. As a result, each empty container of milk packaging emits 0.19 kg of CO₂e, whereas an empty HDPE container emits only 0.003 kg (see Appendix A: Impact calculator for calculations).

Containers cannot be recycled across the country and even in municipalities that do accept them, recycling rates are often significantly lower than other materials. Although the City of Albany does accept paper containers, according to a 2014 study, gable top cartons like those used for milk and juice packaging have a recycling recovery rate of 1.8% in the city (CHA, for Capital Region Solid Waste Management Partnership, 2014) this is significantly lower than the overall recovery rate of 39.3%. As a result of all these factors, we found that a total of almost 291.2 kg CO₂e are emitted every year from the disposal of paper cartons in Albany.

Less than 1% of milk containers are made of Polyethylene terephthalate (PET) plastic (Thoma et al., 2013). For the purposes of this study, we examined only the environmental impacts of HDPE and cardboard containers because PET container use, are minimal in comparison.

The high environmental footprint of landfilling milk packaging makes recycling all the more beneficial. According to figures from the EPA, each ton of HDPE recycled prevents 1.38 metric tons of CO₂e from being emitted into the atmosphere (ICF International, 2015). Each ton of paper packaging recycled prevents 2.86 metric tons of CO₂e (ICF International, 2015). The recycling of packaging from milk sold in Albany results in a savings of 155.4 kg CO₂e. Total estimates for the GWP from disposal of milk packaging were calculated using a weighted average of the volume of each package type landfilled and recycled. The overall contribution amounts to 0.0000051 kg CO₂e per gallon of milk.



5 Prevention

5.1 Recommendations

The following measures are recommended to reduce the impacts of fluid milk waste in Albany based on the process, regulatory and environmental impact findings discussed above.

a. Production

i Process improvement recommendations

Most farms already aim to find alternative uses for milk that cannot be legally sold, and also have measures in place to ensure that milk remains in saleable condition. There are five areas that must be managed to minimize losses

Colostrum and transitional milk

Colostrum is milk produced by mammals just before birth and for two to three days after birth. It contains antibodies to protect new-borns from disease. Following colostrum production, cows produce transitional milk for a further two to three days. This transitional milk contains high level of fat, vitamins and lactose. Colostrum or transitional milk are not offered for sale and must be disposed of on the farm according to law. Hoffman and Plourd (2003) published guidelines for the use of this milk in calf rearing operations. Another other option is to mix the colostrum and transitional milk with manure used for improving soil fertility (Holmes & Struss, 2009).

Cows treated with antibiotics

Cows recently treated with antibiotics must be taken off the milking line until the medication has been filtered out of their system (~ 48 hours). If cows are milked during this period, the milk can be used to feed calves or other livestock, or combined with manure as described above (Holmes & Struss, 2009).

Milk spills, bulk losses

Milk spills occur when bulk tank valves are left open, or when the cooling system experiences problems. Deliberate bulk disposal may be required if antibiotic-treated cows' milk has been accidentally introduced into the bulk tank. Land spreading is recommended as the final disposal method, but it can also be pumped or hauled to manure storage. Employee training and operation supervision is important in preventing these spills and bulk losses (Holmes & Struss, 2009).

Residual milk

Residual milk in pipelines is lost during cleaning. Sanitary air systems (especially for larger scale farms), simplified pipeline geometry, and increased pipeline slope can all reduce residual milk waste. Flat-barn and parlor milking systems have lower milk waste

in comparison to around-the-barn systems (Reinemann, 1992), (Holmes & Struss, 2009). Ninety percent of residual milk can be recaptured by pre-rinsing pipelines with warm water. If not contaminated with cleaning chemicals, milk collected by pre-rinsing pipelines, bulk tanks and below milk transfer pump can be fed to calves and hogs. It can also be applied to land or pumped to manure storage (Holmes & Struss, 2009).

ii Policy recommendations

Donations

There are many charities nationwide organized to reduce poverty, hunger and, consequently food waste. However, milk producers can be hesitant to donate milk, due to potential reputational risk and liability caused by donations.

Food Bank for New York City, an organization whose mission is to “end hunger by organizing food, information and support for community survival and dignity” (FBNYC, 2016), place a greater emphasis on milk donation at the production level directly from the farms. The prevalence of such initiatives could help reduce milk waste. Furthermore, educating farmers about donating their excess milk could help to feed approximately 1.4 million New Yorkers — including 1 in 5 children — relying on emergency food (FBNYC, 2016a).

The Dairy Product Donation Program (DPDP) is another way of prompting milk donations in New York. This program was authorized by the 2014 Farm Bill and will be in effect until December 31, 2018. The program requires the Secretary of Agriculture to purchase dairy products for donation to low-income groups when dairy margins (determined under the MPP) fall below \$4.00 per cwt for two consecutive months. This program remains effective until the specified margin or product price level is met, or until purchases have been made for three consecutive months. Dairy products will be purchased at prevailing market prices in consultation with public and private non-profit organizations, which serve to meet the nutritional needs of low-income groups. These organizations distribute the donations through food banks and other feeding programs.

When dairy products fall below the level of \$4 per hundredweight, the DPDP uses Commodity Credit Corporation (CCC) funds to purchase dairy products that are donated to both public and private non-profit organizations that provide nutrition assistance to low-income populations (NMPF, 2016). The CCC is a government corporation that stabilizes farm income and provides credit to farms. Dairy margins act as a cue to the USDA, who purchases different dairy products both to increase farmers’ margins and provide inventory to food banks.

We recommend continued support for legislation of this kind, which encourages milk donations without negatively impacting the U.S.’s burgeoning export market (the program will end if U.S. prices exceed international prices by more than 5 or 7%, depending on margin levels) (NMPF, 2016).

b. Processing

i Process improvement recommendations

The creation of a loss prevention program would require an assessment of exactly how much milk is lost and where inefficiencies arise in processing. The process and machinery used in each plant is unique, therefore, this program would need to be catered to individual facilities to identify system gaps and make subsequent adjustments. Such a program may require initial capital investment to develop, train staff, and implement, however the payback is often tri-fold. Efficiency improvements facilitate a reduction in inputs, reduction of waste-water, and of waste-water treatment costs. Each of these components have a volumetric cost, so a loss prevention program would ultimately result in savings. (Carawan, R. E., & Rushing, 1986).

Product recovery schemes can be a vital part of waste management or product loss reduction efforts (Carawan, R. E., & Rushing, 1986). If the product is no longer in the condition to be used as a part of product creation, it can be used as animal feed to reduce loss.

A carton recovery program would entail setting up a system where waste milk from damaged or improperly filled cartons is recaptured. The product within these cartons is often still of usable quality. The recovery program would collect this waste in a dump tank, which can be used in animal feed to reduce the cost of inputs. The processing plant could then sell back a portion of the product to the dairy farms from whom they purchase their milk, reducing their waste volume and costs.

Research performed by Maola Milk forms the basis of the above suggestions. Processing plant losses are estimated to be approximately 100,000 pounds per month (Carawan, 1987), and adoption of these suggestions would contribute to reducing this waste. While not all of the recommendations could be applied to the four processing plants surrounding the Albany area, the three suggestions discussed above would maximize efficiency and reduce loss across the supply chain, particularly within the post-harvest process.

c. Retail

i Process improvement recommendations

Retailers are generally able to forecast the consumer's demand for milk well. They rely on models that are sensitive to purchasing patterns. Novel forecasting techniques, such as machine learning, may be applied to enhance these models. Such improvements will reduce the amount of milk that needs to be sent back to producers or destroyed.

Sell-by dates, regardless of the degree of pasteurization, are overly conservative and do not adequately reflect the entire shelf life of milk. Stores that wish to maintain their

reputations as providers of fresh products may offer consumers discounted prices. They could also provide information to consumers that clarifies the absence of health risks from milk past the sell-by date. This initiative could reduce the likelihood of returning unsold milk to the supplier, if found to be successful.

Recent evidence suggests that LED lighting can produce degradation of taste and nutritional value while the milk is on the shelves (Nicole Martin, 2016). This can be a future cause of concern for retailers as more stores move towards energy efficient lighting. Bottling methods that prevent harmful light transmission should be researched further and implemented to preserve the taste and nutritional value of milk.

ii Policy recommendations

Consistent and standardized federal date labeling for all food products, including fluid milk, is one of the policy recommendations from the authors of the NRDC and Harvard Food Law and Policy Clinic report and indeed would serve to clarify the labeling process for retailers and consumers alike. Additionally, clear distinctions among quality-based and safety-based dates with consistent language would be required (NRDC, 2013).

In May 2016, the Food Date Labeling Act was proposed in Congress by Senator Richard Blumenthal (D-CT) and Representative Chellie Pingree (D-Maine) to create a uniform federal labeling system, which was crafted, in part from recommendations from the NRDC/Harvard report finding standardizing date labeling is among “the most cost effective strategies to reduce food waste” (“Introducing common sense bill to standardize food date labeling,” 2016).

In the interim, there are immediate steps that can be taken while legislation is pending, such as making the date labeling system more transparent for consumers and implementing some of the same recommendations as the pending legislation but at a voluntary level among stakeholders in the food industry (NRDC, 2013). Major retailers such as Wal-Mart, realize the need to address date labeling as a step to combat food waste with a consistent and transparent date label aligned with their “Great Value Brand” foods (Greenaway, 2016).

d. Consumer

The highest losses are in the consumer part of the supply chain. To summarize, we need to either change or emphasize:

- Consumer behavior: 57% discard milk past expiration date (Columbia Capstone Group Surveys, 2016)
- Consumer awareness: more education on milk safety and milk spoilage (36% will not apply sensory test on milk (Columbia Capstone Group Survey, 2016)).
- Labeling: label is perceived as expiration and spoilage date of milk
- Labeling: outlet and restaurants have lot of milk over but cannot donate due to food donation law pertaining to labels.

i Process improvement recommendations

Providing facts on milk spoilage & storage, smart packaging, offering educational programs and raising awareness, are all methods that could accomplish the complicated task of changing consumer behavior. In light of the IDFA's findings, consumers are aware of both food and milk waste that occurs nationwide and are keen to see improvements concerning this topic. This is an opportunity for the dairy industry, which consists of producers, processors and retailers, to respond to the consumers' willingness to save milk and money.

Preventing waste of unspoiled milk

Consumer behavior, education and awareness

Consumer's buying decisions and their willingness to pay (WTP) is based on a demand for fresh, quality products (Tsiros & Heilman, 2005). According to a survey conducted by the Food Marketing Institute, as much as 91 % of U.S. consumers have at least occasionally discarded food past its 'sell by' date due to food safety concerns. A separate study found that 16 % of consumers typically dispose of milk past its sell by date (NRDC, 2013).

A better understanding and awareness of the labeling rules and the actual freshness of perishable foods, combined with a retail incentive mechanism of discounting products approaching their expiration dates, could reduce milk waste. Discounting perishables that are approaching their expiration date, increases the consumers' WTP for a product throughout the course of its shelf life. Discounts may be necessary to sell aging inventory to consumers that are aware of expiration dates (Tsiros & Heilman, 2005). Retailers are advised to educate their customers. However, this responsibility should not be limited to the retailer but also include influential organizations such as Food and Agriculture Organization (FAO), Food and Drug Administration (FDA) and World Health Organization (WHO). This would encourage a change in consumer perception regarding the quality and health risks associated with milk.

Education initiatives and raising awareness are instrumental in influencing both the behavior of the consumer and household/outlets. Currently most consumers determine milk spoilage by observing the labels, but such dates are estimates and retailers and consumers discard billions of gallons of unspoiled milk each year while relying on inaccurate printed expiration dates (Lu et al, 2013). The household consumer has the power to decide, based on their judgment, whether to consume milk that is fresh even if the label indicates otherwise by applying a simple sensory test termed "sniff & taste". Outlets such as schools and restaurants have to rely on labels alone and are not at liberty to exercise any kind of judgment. They are legally bound by food dating labels. Restaurants and similar establishments are required by law to dispose of milk upon expiration. They face sanctions and high fines from the Department of Health, if found to be in breach of such regulations.

Changing labeling regulations would make the milk supply chain more efficient for all consumer groups but especially for schools and restaurants, allowing them to donate unused and unspoiled milk. Accuracy in determining the state of milk will support the decision to donate.

According to a survey conducted in 2014, called Wasted Food: U.S. Consumers' Reported Knowledge, Attitudes and Awareness, (International Dairy Foods Association, 2014), 42% of consumers heard about food waste and 43% said it would be easy to reduce waste, which indicates the consumer's appetite for change in this area. 23% of consumers expressed a strong interest to learn more and 30% are already making an effort towards reducing their food waste (IDFA, 2016).

A reported 72% of consumers are already using their senses to judge freshness, 39% defer to the 'use by' date and 22% to the 'sell by' date. The dairy industry could 'potentially use this information to educate consumers, informing them that these dates serve as an indicator for the retail industry and not as safety and spoilage information.

The report suggests that the consumer wants a clear message from authorities on safety and freshness as well as on expiration dates to make educated consumption decisions based on the information received. Consumers would benefit from smart packaging, different sizes, resealable containers as well as economic incentives.

However, improving personal shopping practices (by refraining from bulk shopping) and optimizing food management at home (by utilizing all purchases) are two goals that could be accomplished by individual consumers. These practices should be promoted, and could be summarized by a slogan such as "buy what you need and use what you buy".

Packaging for waste reduction

Packaging plays a major role in reducing milk waste, as well as reducing the environmental impact of food waste. According to a study from 2012, called "Reasons for household food waste with special attention to packaging", 20–25% of the food waste relates to packaging design attributes (Williams, Wikström, Otterbring, Löfgren, & Gustafsson, 2012). Consumers often perceive packaging as inconvenient, due to their large portion size, or too difficult to empty fully, encouraging waste. Variations in packaging size that meet the various consumer demands, could influence consumer behavior directly and reduce milk loss. Providing information to consumers regarding how to store the food item, make it durable for a longer periods of time, or how to interpret the 'best-before-date', represents an indirect influence that packaging could have on milk waste (Williams, Wikström, Otterbring, Löfgren, & Gustafsson, 2012). Prices of smaller packages should not be priced higher. Such pricing mechanisms where larger quantities are sold at a proportionally lower cost, encourages bulk buying, which leads to food waste.

Preventing milk spoilage

As discussed earlier, every year millions of dollars are wasted as consumers, households, schools and restaurants, throw away millions of gallons of milk due to incorrect labeling and inaccurate assessments of spoilage (Labeling is further discussed in the regulatory section). The milk that is disposed of may be in an excellent condition for consumption.

Milk sold in supermarkets and retail stores in New York is either pasteurized via heat treatment at 161 F (72° C) for 16 seconds, or ultra –pasteurized, via high-temperature (HT) treatment at 280F (138° C) for 2 seconds (Cornell University, 2007). Pasteurization kills most pathogenic bacteria and disease causing microbes, including most coliform

bacteria. As a result, pasteurized milk is considered a low ranking disease risk food group. However improper handling during the production or processing stage, as well as at the post-pasteurization stage could result in the contamination of milk.

Rationale for spoilage detectors

Pasteurization is the single most significant step in the control of foodborne illness caused by the consumption of milk.

However there are two types of bacteria that could potentially exist in pasteurized milk due to improper handling. Thermotrophic bacteria are capable of surviving extreme temperatures incurred during pasteurization. Improper handling can contaminate milk with psychrotrophic bacteria, which comprise the greater proportion of bacteria that exists in pasteurized milk. These bacteria originate from unsanitary conditions post-pasteurization (Lu et al., 2013). Psychrotrophs can thrive and cause spoilage at temperatures at, or below 45°F (7°C), emphasizing the importance of cool handling (“cold chain”) and maintaining recommended storage temperatures throughout the supply chain.

In the event that milk spoilage occurs, milk spoilage detectors could act as a valuable tool in relying on actual facts of milk spoilage instead of labels, encouraging demand for such initiatives.

Detection mechanisms

One solution could be to empower consumers and their decision-making by introducing better indicator mechanisms, informing them on the freshness of milk. This would give the consumer a useful tool, should the case arise where pending regulatory improvements to food labeling are not approved by Congress.

Two such applications that are ready to be used and have the potential to minimize milk waste are Fresh-Check® Indicator and Time-Temperature indicators.

Fresh-Check® indicator

TempTime Corporation is the leading manufacturer of Fresh-Check®, an example of a ready to use application stemming from milk spoilage research. This recent innovation specializes in time-temperature sensitive indicators for milk that change color to indicate freshness. Fresh-Check® uses a self-adhesive device with an active ‘center circle’ that darkens irreversibly. The circle transitions from a light colored oval to a dark oval indicating that the product is no longer fit for consumption, irrespective of package labeling (“Fresh check temperature indicators,” 2014). This product is set at a low price-point (\$0.025 to \$0.035 per package) (Lu et al., 2013), however, this application is currently not in use by the milk industry.

Time-temperature indicators

Assessing the shelf life and accurate expiration date is a crucial step in preventing milk waste. Zhang et al., (2013) developed a low cost, reliable indicator, specifically tailored for milk, referred to as a time-temperature indicator (TTI). This tool can be deployed for advanced quality control, assessing and monitoring the cold chain of milk throughout the supply chain (Zhang et al., 2013). The product works by tracking growth rates of bacteria that are temperature dependent and responsible for spoilage. TTI could indicate whether the product is nearing or past its best quality and whether it can still be safely consumed. This could give the consumer greater assurance of freshness in the absence of revised labeling laws.

The low cost and non-toxic TTIs are the size of a kernel of corn, have a gel like appearance and are environmentally friendly. TTIs are metallic nano-rods that change color over time as they react, mimicking the length of time that microbes grow in milk.

TTIs are constructed based on an extremely sensitive composition of bimetallic nanocrystals and can generally be utilized to track perishable products and kinetically mimic deteriorative processes, which are indicated by a multicolor change (Zhang et al., 2013). The gold nano rods indicate the highest level of freshness when they are red in color; they turn green to indicate spoilage.

The color of the indicator changes throughout the shelf life of the product. The indicator is attached directly to the packaging, which ensures that it undergoes the same temperature history (Zhang et al., 2013).

This new TTI model offers multiple benefits, and meets the World Health Organization (WHO) criteria of being “Affordable, Sensitive, Specific, User-friendly, Robust and Rapid, Equipment-free, and Deliverable to the end-user” (ASSURED). This criteria was proposed by the WHO in relation to disease diagnostics, but could also be leveraged in food spoilage detection (Zhang et al., 2013).

The two applications Fresh-Check® Indicator and TTIs are similar, however, Fresh-Check controls the adherence to the cold chain, whereas, TTIs monitor the actual spoilage level of milk.

Packaging for spoilage prevention

Packaging has another direct influence on milk loss as freshness of milk, being a light sensitive product, is best conserved in opaque material such as dark glass or fiber-based carton. Evergreen Packaging is working on prolonging freshness with Barrier Technologies to lessen negative outside factors – moisture and oxygen barrier board – that are deteriorating milk and decreasing product quality (Evergreen, 2014). Fiber-based packaging can keep vitamins and taste in while minimizing light and temperature changes as well as oxygen levels (Lu et al., 2013).

TetraPak is a leading food packaging and processing company, with an emphasis on research and development, which seeks to improve food safety and availability globally. TetraPak processes milk via pasteurization at ultra-high temperatures and then packages it in their sterile shelf stable cartons. In India, TetraPak launched a ‘Right to Keep Food Safe’ campaign, which is designed as a large-scale public awareness initiative to promote the safety of packaged UHT milk. Such campaigns could be envisioned for the U.S. market to inform and educate consumers on the longevity and nutritious quality of UHT milk. Table 10 summarizes the packaging solutions for spoilage prevention and highlights their advantages and disadvantages.

Table 10. Packing solutions for spoilage prevention

Product	Description	Advantage	Disadvantage
Time Temp Indicators TTI	Smart tag attached on outside of package Growth rate tracking of bacteria responsible for spoilage	Measures milk quality level Easy to read visual indicator Indicates milk quality through color change Meets WHO ASSURED standard	Not in use yet
Fresh-Check	Freshness indicator attached to outside of package	Easy to read visual indicator Inexpensive \$0.025 - \$0.035/package	Not in use at moment Only based on temperature exposure Does not measure milk quality level
Evergreen	Lessen outside factors- light and oxygen – due to fiber based packaging	Prolongs freshness Patented barrier technology	No spoilage indication on package
TetraPak	UHT Milk Technology	UHT Milk (shelf stable milk) could stay on shelves for 6 month. No refrigeration needed.	No spoilage indication

Fresh-Check, Evergreen and TetraPak information from: (Lu et al., 2013). TTI information from (Zhang et al., 2013).

Minimizing the footprint of waste

Packaging for impact reduction

One of the goals of the Environmental Protection Agency concerns a reduction in packaging in the milk supply chain. Source reduction has been studied in depth and lightweight cartons have been introduced to save costs and resources (Marenghi, C. 1992).

Carton milk consumption in schools is a source of waste. At present, Boston has five projects running across different schools in the area with milk dispensers. According to research performed by Fairhaven Middle School, a student that drinks milk from a carton throws away two gallons of milk per year, which is five times as much as a student who drinks from a dispenser (Farm-to-School, 2016). If this were to be adopted in New York and Albany, large volumes of milk could be saved. Fluid milk is a food requirement in

school meals, which offer 8 oz. to each student (Farm-to-School, 2016). Milk dispensers may contribute to minimizing milk waste in schools as the project in Boston revealed a 40% reduction in packing waste.

The Special Milk Program (SMP), run by Department of Agriculture reimburses schools and institutions for the milk they serve, which was estimated to be 61 million half pints of milk in 2012 (special milk program (SMP). The USDA is currently not advertising the use of milk dispensers in their programs.

UHT Milk

Ultra-high temperature (UHT) technology has been used for over forty years in the dairy industry. It involves heating milk in a continuous flow system to 280 °F (138 °C) for a short time, followed by rapid cooling. Ultra-high temperature technology, coupled with aseptic packaging, revolutionized the ability of the milk industry to maintain the bacteriological safety of milk and extend its shelf life – from 2-3 weeks to 6-9 months without refrigeration (Tewari & Juneja, 2008). Aseptic packaging of UHT treated milk is necessary to prevent the recontamination of the sterilized product (Tewari & Juneja, 2008).

The properties of pasteurized milk, ultra-pasteurized milk and UHT milk are summarized in Table 11.

Table 11. Comparison of pasteurized, ultra-pasteurized and UHT-treated milk.

Parameter	Pasteurized	Ultra-Pasteurized	UHT (Aseptic)
Heat treatment	72°C (161°F)/15 sec	138°C (280°F)/2 sec	138°C (280°F)/2 sec
Bacterial kill	some survival	nearly “sterile”	nearly “sterile”
Recontamination	possible/likely	prevent/minimized	prevent/minimized
Equipment	sanitized/exposed	sterilized/closed	sterilized/closed
Fill equipment	limited protection	protected	sterile environ
Package material	paper, plastic	paper, plastic	hermetic seal
Package treatment	untreated	treated with H2O2	sterilized
Product storage	refrigerated	refrigerated	shelf-stable
Shelf-life	10-21 days	30-90 days	6 months +

(Cornell University, n.d.)

According to a 2007 news article, the highest consumption of UHT milk is found in Belgium, with a market share of 96.7% (Elliott, 2007). There is also a high market share in Spain (95.7%) and France (95.5%). In the UK, USA and Australia, the figure is less than 10%, and in Greece UHT accounts for less than 1% of total milk consumption (Tewari & Juneja, 2008; Elliott, 2007).

A crucial factor in increasing the consumption of UHT milk is customer acceptance. Shelf stable milk is often perceived as inferior in the U.S even though the decrease in most vitamins caused by UHT treatment differs little from the decrease associated with normal pasteurization (Varnam & Sutherland, 1994). Aside from a difference in vitamin C concentration (Varnam & Sutherland, 1994), the nutritional profile of UHT and

pasteurized milks is similar, with comparable calorific and calcium contents (Robb, 2014). Moreover, the consumer perception that milk should be refrigerated at the point of sale leads some to this perception on the consumer that milk should be in refrigerator leads some UHT brands to pay extra for refrigerated shelf space at the retailer (a similar trend is seen in soy milk) (Robb, 2014). It is also important to highlight that UHT milk contains no additional preservatives or any chemicals – a concern for some consumers.

One of the challenges to acceptance of UHT is misinformation about probiotics. Both beneficial and harmful bacteria are introduced to milk after milking (Marler, 2009), and most are eliminated by pasteurization as well by ultra-heat treatment.

The other challenge to acceptance is flavor. Milk should be heated enough to eliminate heat-resistant bacteria without causing excessive changes in flavor (Tewari & Juneja, 2008). The change from prolonged or high-temperature heating is often described as a “cooked flavor”, to which many U.S. consumers may be unaccustomed (Robb, 2014). There are various reasons for the change in flavor, mostly the generation of free sulfhydryl groups and other sulfur compounds from the denaturation of whey proteins (Datta 2002). While pasteurized milk is typically heated to 161 °F (72 °C) for 15 seconds, UHT and ultra-pasteurization involves heating to 280 ° F (138 °C) for at least two seconds. There is no significant taste difference between ultra-pasteurized and UHT (aseptic) milk as they both undergo similar heating. Considering this, taste difference should not present a barrier to consumers who currently purchase ultra-pasteurized organic milk, such as that produced by Horizon and other brands.

Consumers in the U.S. have in the past shown themselves adaptable to new beverages, such as coconut water, so there might be scope for effective marketing or governmental subsidies to improve the uptake of UHT milk. For example, in the UK, where the consumption of UHT is also less than 10%, the Department for Environment, Food and Rural Affairs (DEFRA) has announced a strategy to ensure that, by 2020, 90% of milk available for purchase will not need refrigeration (Robb, 2014; Elliott, 2007).

There are many potential benefits to increasing the market share of UHT milk. It breaks the energy-intensive cold chain (pasteurized milk requires refrigeration in every step, including transportation and storage); and offers a solution for waste arising from variations in demand (such as holidays and school vacation times) by prolonging shelf life. It could also increase the potential for exports to countries such as China, where the demand for UHT milk is projected to reach 1.3 billion pounds by 2020 (Next Export Stop, 2014).

5.2 New York City Mini-Case

Milk in New York City is stamped with a single sell-by date, which is set anywhere from 15 to 24 days after pasteurization (variances depend on the brand). This method is similar to other cities within New York State. However, this wasn't always the case. New York City has had an active political history regarding milk regulation at the city level.

From 1987 until June of 2010, milk in New York City had to be sold by retailers within 9 days of pasteurization (Lucadamo, 2010). Containers of milk meant to be sold in New York City were stamped with two sell-by dates: one displaying the dairy industry's recommended 15 day “sell-by” date, and an additional New York City-specific date that showed the milk expiring 6 days earlier (Hager, 2010). New York City was one of only a

handful of cities in the U.S. that had its own date labeling system for fluid milk. This rule applied to all types of milk (Fabricant, 1982).

Since these sell-by-dates lacked a clear explanation, consumers struggled to discern what milk was good and what was spoiled. As a result, large quantities of milk were discarded that could still very well have been consumed. A brief history on milk and milk processing in New York City in the next section sheds light on the city's justification for demanding a city-specific sell-by date.

i History

Manhattanville and Sheffield Farms

In the early 20th century - prior to refrigeration, cool trucks, and supermarkets - cows roamed and grazed in different parts of upper Manhattan. Milk production infrastructure consisted of direct deliveries from local dairies to residents in lower Manhattan and Brooklyn. As the city's population increased, rapidly increasing real estate values pushed dairy farmers out of the city, and subsequently farther away from their consumers (Columbia, 2016).

"By 1841, more than 300,000 residents lived in Manhattan, and most of the city's milk was being imported from Long Island or New Jersey."

(Columbia, 2016)

Thompson Decker established a one-horse milk delivery route from his rural farm in the Bronx to the Lower East Side, which eventually grew to become Sheffield Farms, located on 130th street in Manhattanville. In the 1920s, the plant processed milk from more than 30,000 city dairies and supplied the entire city with milk and dairy products. Increasing demand for fresh milk was met with industrialized systems that relied on transportation infrastructure, refrigeration, advances in technology, pasteurization, and inspection (Columbia, 2016).

Deadly Milk

Milk delivered by train from surrounding dairy farms was sold at 15 cents per quart and only the wealthy could afford to purchase it. Most families with young children purchased "loose milk", which was ladled out of open vats in putrid groceries for 4 cents per quart. City cows, which were often fed industrial waste, would produce "swill milk" — milk that was tinted a sickly blue, and had a lumpy consistency and visible chunks of dirt in it. This swill milk was swarming with deadly bacteria that could cause tuberculosis, cholera, and a wide range of digestive ailments. In the 1840s, half of all children in New York City died before reaching the age of five – and milk-borne disease was a prime cause. It took years for scientists to realize that milk was actually the culprit behind this fatal scourge (Columbia, 2016).

By the 1880s, all of New York City's milk arrived from surrounding county farms by railroad. Transit delays kept containers of milk sitting in the sun, causing spoilage. By the time the milk reached consumers, it was often stale and bacteria-laden. This contaminated milk created an epidemic of diseases that sickened children. The poorest residents of the city, surviving in crowded tenement houses suffered the most from this lack of clean, affordable milk. Ironically, milk became increasingly more dangerous as New York City became a modern metropolis. Infant-mortality rates were twice as high in

the city as they were in the country (Columbia, 2016). As a result, New York City has played a very active role in milk sale regulation (Articles, 2013).

In the 1920's date labels on milk were voluntarily provided by processors and retailers. These date labels only became a required compliance mechanism for state or city regulation as New York City became more urbanized and its citizens relied more heavily on processed foods. In the 1930s issue of Consumer Reports magazine, it was stated that urban Americans increasingly checked expiration dates as an indication of freshness and quality. In the 1970s, several supermarkets responded by implementing their own dating systems. Consumer groups even held hearings to establish a federal regulatory system, however nothing came out of this gathering (Cindy, 2015).

Due to the outbreak of disease from untreated milk, pasteurization became required in New York City starting in 1911. It later became a federally mandated regulation throughout the entire U.S. (NYC department of Health, NYC food policy," 2016). Food related illnesses are generally traced to pathogens that may have contaminated the food during processing (CSN, 2015).

The sale period of all pasteurized milk in New York City was 36 hours long (1.5 days) until the 1960s when it was altered to 98 hours (4 days) after the day of pasteurization. In 1978, sell-by dates were further extended to 9 days, where the regulation remained until 2010 (Articles, 2013).

Thus the antiquated labeling system was introduced and the New York City Department of Health and Mental Hygiene began to regulate the sell-by date for New York City retailers. Their regulations specified that milk had to be sold within 9 days for pasteurized varieties and 45 days for ultra-pasteurized varieties.

When asked why it was necessary to sell milk at an earlier date in New York City than the accepted industry standard, the city's reasoning was that milk spoiled faster in New York City. John Gadd, a spokesman for city's Department of Health was quoted by the New York Times stating that milk which was shipped to the city was more likely to stand unrefrigerated for brief periods of time, both before it reached the stores and on the way from store to home. Therefore the city found it reasonable to require milk to be sold within 9 days (The Atlantic, 2009 and Articles, 2013). His statement reflected the problematic role milk played in New York City's health code historically. Due to improvements in milk sanitation and technological advantages in milk production, pasteurization processes, storage and handling, both the Executive Vice President at the Northeast Dairy Foods Association and Vice President of Public Affairs at the Food Industry Alliance of New York State, Inc (FIA) rightly argued there was no longer any need for milk control to be included in the New York City Health Code.

As a result, Article 111 regulating fluid milk was repealed in July 2010.

Rules of the City of New York -

Title 24

Department of Health and Mental Hygiene

§111.33 Standards generally; time of delivery.

No person shall possess, store, offer for sale, sell, give away or distribute milk, low sodium milk, low fat milk, skimmed milk, modified skimmed milk, cream or half and half after the expiration date indicated on the label required pursuant to §111.61. No person shall possess, store, offer for sale, sell, give away or distribute any such product the label of which bears an expiration date beyond the period specified in this section. The expiration date shall not be more than nine (9) calendar days following the date of pasteurization. However, in the case of such milk and milk products which have been ultra-pasteurized pursuant to subsection (d) of §111.25, the expiration date shall not be more than forty-five calendar days following the date of ultra-pasteurization. This section does not apply to cans of milk or cream to be used for manufacturing purposes or to milk and milk products which are not to be sold in the City of New York.

New York City's rules on milk expiration dates / Screenshot by E. A. Wright from The Public Access Portal To the Laws Of the City Of New York

Figure 8. Excerpt from NYC rules on milk expiration dates – Title 24

ii Primary data collection methodology

To better understand at-home and away-from-home milk losses, we relied on limited published research and primary data from 172 consumer surveys which we conducted during June and July 2016. In the following section we identify our overall procedure, the materials we used and the questions we asked. We then summarized our data, identified findings and clarified prevention recommendations.

We created a one-page survey composed of 14 questions. We took surveys both in Albany and NYC by approaching random individuals in cafes and at outdoor gatherings. We explained our connection to Columbia University and our goal of studying fluid milk supply chains. We clarified that we were interested in consumer purchasing, consumption, and disposal habits pertaining to milk. We didn't explicitly state anything about milk fluid waste during these interviews, so as not to impact interviewee responses. 50 of our surveys were aggregated online, 26 were collected in person in Albany, and 96 were collected in person in NYC.

Questions included how often individuals purchase milk, as well as where they buy it and in what type of container. Whether they dispose of any portion of the milk, if so how do they dispose of the packaging. Most importantly we were curious to learn what consumers thought of the date label on the packaging. We also asked whether they would consider direct farm to consumer delivery, and for their year of birth and zip code to aggregate our surveys' demographic diversity.

The results of our surveys indicated that consumer purchasing, consumption and disposal habits were not significantly affected by the labeling changes that took effect

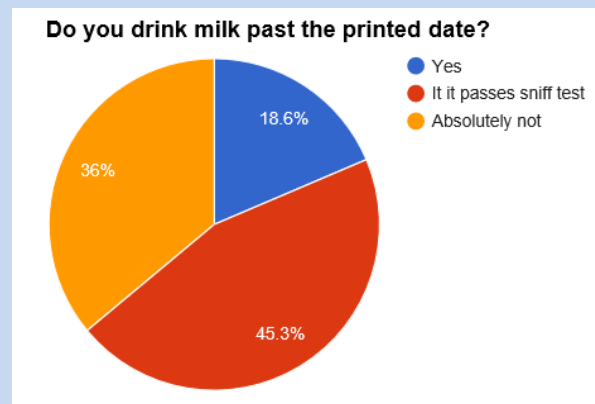
after 2010 in New York City. First, we were limited in our secondhand research that postdates 2010 labeling. Second, large numbers of the consumers interviewed were relatively young college students, not individuals who remember that there were 2 differing dates on milk containers prior to 2010.

In spite of streamlined date labeling since 2010, the confusion between such labels as “best-by”, “use-by”, “sell-by” are misleading and offer no uniformity in their accuracy (Greenaway, 2016). This confusion was visible in our results. One of the questions asked consumers: *What does the printed date on milk bottles mean to you?* We received a wide variety of answers from *Expiration date* to *Freshness* to *I don’t know*. We purposely didn’t give multiple-choice answers so as not to affect the results. Sample responses include:

- “It’s expired”
- “When no longer good for consumption”
- “If close to date don’t buy it and stop drinking by date”
- “Last day to consume it”

The most telling response that we received was; “It means that the manufacturer wants me to think it is bad by that date but only my nose tells me when to throw it out”. This statement reflects an understanding that the date label is really intended for retailers, not consumers.

Over half of all surveyed (57%) discard milk that is past the sell-by date. An alarming 36% will not even smell or taste the milk to test whether it is still good to drink. They mistakenly take the label for an expiration and spoilage date, which translates into a food and safety concern.



Data source: Consumer Surveys

If a pathogen is present, milk starts to deteriorate from the moment it’s milked, collected and processed. The rate at which it spoils depends less on time and more on the conditions under which it is stored. Thus date labels truly indicate quality and optimum freshness, not food safety (Cindy, 2015).

According to the International Dairy Foods Association (IDFA) in Dairy Forum 2016, consumer reasoning for discarding milk involves: using senses (72%), using best by

date (39%), using sell by date (22%), thinking about how long it has been open (18%), thinking about how long it has been stored (12%) (IFDA Dairy Forum, 2016).

iii Health and Safety Concern

Current NYC milk stamp sell-by date is 15 days after pasteurization. However, milk is consumable 21-24 days standard after pasteurization, therefore if stored properly it is still consumable even 7-10 days after sell-by date. Thus current sell-by date on milk isn't at all relegated to food safety. The variations in state and city labeling laws across the U.S. further proves how these labels are not indicative of food safety. Yet, the majority of customers still mistakenly think the sell-by date is an expiration date and dump unspoiled milk (Williams, 2016).

Confusion over date labels – such as “best by”, “use by” and “sell by” – can often muddy the water for consumers looking to make sure they're not eating expired or unsafe food. (Greenaway, 2016). It's important to understand label dates Label dates are misleading and there's no uniformity in their accuracy. They mean very little as milk starts to deteriorate from the moment it's milked, collected and processed. The rate it spoils depends less on time and more on the conditions under which it's stored. Thus label dates truly indicate quality and optimum freshens, not food safety (Cindy, 2015).

In the 1970s, the National Association of Food Chains had lobbied against a serious effort to regulate date labels, arguing that new rules would raise costs and discourage companies from voluntarily providing date information (Delaney, 2016). The city hired its first milk inspector in the 1870s, but the origins of this particular code date back to 1959, when the Health Department mandated milk have an expiration date of no longer than 54 hours after distribution. Since then, the code has been modified several times. For many years, milk could only be sold in New York City up to four days after pasteurization. In 1987, the period was extended to nine days. This remains the current standard for "milk, low sodium-milk, low fat milk, skimmed milk, modified skimmed milk, cream or half and half," according to the city code (Hamblin et al., 2009).

Date labels are misleading without any uniformity in their accuracy giving consumers a false sense of security. Pasteurization and ultra-pasteurization allows milk to stay fresh much longer than the dairy industry's recommended sell-by date. Milk should be kept between 38-40° F and not left out on the counter for extended periods of time. Various sources state that milk can be confidently drank after sell-by date if it passes a quick sniff test without any health risks to consumer (NRDC, 2013).

Overall efforts should be focused more on what matters most: our health, not just random spoilage bacteria. Disease causing pathogens such as salmonella and listeria, infect milk not because it's old but as a result of unsanitary conditions at production or elsewhere along the supply chain. Federally supported system that can detect the next food outbreak would be far more useful than arbitrary set of date labels only to guarantee best taste (Cindy, 2015). Ironically, despite the original intention of increasing consumer knowledge about their food, date labelling has become a largely incoherent signalling device for consumers,” the Harvard Food Law and Policy Clinic and the Natural Resources Defence Council said in a 2013 report. The report cited research that found label confusion caused roughly 20 % of avoidable food waste.

Another reason that milk waste is an issue is related to its monetary value. Over time, wasted milk translates to potential revenue lost.

iv Donations

There are varieties of donations programs in which consumers can participate throughout New York City. Donation programs face a challenge in that the cold chain must be maintained and not all of them have access to refrigerated trucks or storage facilities that would safely handle milk.

City Harvest safely accepts milk and dairy products directly from consumers prior to stamped “sale-by” date (Harvest, 2016). Through the Great American Milk Drive Consumers can donate money anytime online at MilkLife.com via credit card or send a short text code to make \$5 donation. During seasonal burst, consumers can make \$1, \$2, \$5, etc. donations for fluid milk for families in need at the checkout. Consumer donations are collected on the program website milklife.com/give, via text to give and are used to fund coupons for free milk. These coupons are shipped to food banks across the country based on the consumer donations. Food banks receive \$4.50 coupons. They can be treated as cash and are redeemable for any brand of fluid white milk at any retail location (Feeding America, 2016).

6 Conclusion

With the expectation that the world will grow to 9 billion people by 2050, global food producers are working to meet demand, especially in the market of high-protein animal products. Despite this rise in population, we are losing food across the supply chain. As discussed throughout this report, milk waste has both a financial and an environmental footprint – including the land, water, and fuel that goes into producing it, as well as all of the pollutants and greenhouse gases that are released during its production and transport.

As hypothesized from the start, we are able to reaffirm the ReFED estimate that puts 20% of fluid milk waste at the consumer level – resulting in 2.03 million gallons of fluid milk waste in Albany in 2015. A large proportion of this waste is unspoiled milk that is discarded simply because it has passed the coded date label. The recommendations summarized in the list below offer a significant opportunity to reduce waste and the environmental impact of milk production at all stages in the supply chain.

While we have identified a number of interventions that could reduce either the volume of milk lost, and the environmental impact of activities in this supply chain, we want to highlight three actions in particular:

- Firstly, a uniform federal standard of milk labeling could help to remove confusion and reduce unnecessary waste. The current system of marking milk with a “sell-by” date is targeted at the retailer, but since most losses occur after the milk leaves the store, we recommend the use of closed date labeling, which communicates shelf life information to the retailer however does not impact consumer behavior.
- Secondly, education about proper milk storage and handling – particularly regarding temperature – could significantly reduce the amount of unnecessary household waste. This could take the form of clear and conspicuous information on milk packaging, or other education interventions. Towards this goal, we have produced a [short video](#) that we hope can be used to start conversations around household milk waste.
- Thirdly, we suggest an awareness campaign to introduce UHT milk to the US public in a more comprehensive way so they can understand the overall benefits to both the environment and economy by extending milk shelf life and reducing waste.

By educating stakeholders throughout the supply chain, we hope that the information we have gathered will help to inform the ongoing conversation around milk supply and milk waste, and offer a starting point for further studies. We have identified a number of areas of interest which we believe warrant further research. These include the variability between individual processing plants, the shopping habits of consumers, and the impact of retail supply agreements on milk waste.

The impact tool estimates that each gallon of milk accounts for 13.6 kg of CO₂e, 143.8 gallons of water, and 0.0007 hectares of agricultural land per year. According to our calculations, by not producing the 2.4 million gallons of milk that goes to waste every year, 30.7 thousand metric tons of CO₂e, 347 million gallons of water, and almost 1,800

hectares of agricultural land could been prevented. Further we found that in terms of the supply chain, Production has the highest impact in terms of water consumption and agricultural land use and Retail has the highest in terms of global warming potential.

Prevention Recommendations Summary by Supply Chain Stage

Production

- i. Process improvement recommendations
 - a. Redirect colostrum and transitional milk into other uses on the farm
 - b. Reduce residual milk losses by improved handling practices
- ii. Policy recommendations
 - a. Support donation programs, for example: The Dairy Product Donation Program
 - b. Investigate the impacts of minimum pricing agreements on overproduction

Processing

- i. Process Improvements recommendations
 - a. Loss prevention programs at manufacturing facility
 - b. Recycling/carton recovery programs
 - c. Packaging and the application of bacterial indicators of spoilage
- ii. Policy recommendations
 - a. Develop reporting standards that encourage transparency and traceability and facilitate disclosure of data

Retail

- i. Process improvement recommendations
 - a. Explore accurate forecasting techniques for supply purchase planning
 - b. Discount products as they approach their sell-by date
 - c. Use of LED lighting in storage of milk to prolong shelf life

Consumer

- i. Process improvement recommendations
 - a. Consumer education programs on labeling and smart packaging
 - b. Reduce portion sizes to reduce spoilage at home
 - c. Encourage the use of spoilage detectors (Ex. Fresh-Check indicator or Time-temperature indicator)
 - d. Encourage the adoption of UHT milk by the general public
 - e. Improve data capture of losses and opportunities in outlets such as schools and restaurants



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Appendix A: Impact calculator

Impact Calculator			
Supply Chain Stage	1: Production		
Gallons of Milk Waste	50		
	Global Warming Potential* (kg CO2 eq)	Water Consumption (gallons)	Agricultural Land Use (hectares/year)
Impact per gallon of milk	5.006	140.018	0.000729
Total Impact	250.296	7000.910	0.036

Key Assumptions:

- The volume of milk evaluated in this study is the volume of plain white milk (skim, 1%, 2% and whole) purchased at retail outlets in the city of Albany in 2015: 10,168,532.832 gallons (IRI, 2016).
- A certain quantity of milk is lost, for various reasons, at each stage of the supply chain. This tool assumes that 0.49% is lost in production (Alpin et al., 1996), 1.19% in processing (Anon., 2016), 2.00% in retail (Kantor, Lipton, Manchester, & Oliveira, 1997) and 20.00% in consumption (Bubzy et al., 2014). These literature values were corroborated by information conveyed in interviews with relevant stakeholders.
- The Master Impact Table displays the total estimated environmental impact associated with each stage of the supply chain, for the indicators used in this study. Grey-colored cells indicate that there is no estimated environmental impact resulting from the associated item. A dash (-) indicates that there is likely to be a non-zero impact, but it is not quantified in this study due to the availability of reliable data.
- The 'Environmental Footprint of Milk Loss in Albany' should be read as the environmental impact that would be avoided if the specified volume of milk were not produced and wasted.
- In the tables for each supply chain stage individually, black-colored values indicate raw input data. Blue-colored values indicate calculated values.
- Oversupply of fluid milk to the Northeast Milk Marketing Pool is not considered in the annual losses because this is generally diverted to alternative uses. This is an area that warrants further analysis.
- Energy-related emissions are based on New York state averages (New York State Research and Development Authority, 2014)
- Transportation emissions were calculated based on national averages (EPA – A, 2014; EPA – B, 2014).

Environmental Impacts Summary Table				
		Global Warming Potential (kg CO2 eq/gallon)	Water Consumption (gallon H2O/gallon milk)	Agricultural Land Use (hectares/ gallon/ year)
Phase 1: Production	Inputs	5.006	140.018	0.00073
	Outputs/Waste	0.000	0.000	0.00000
	Combined	5.006	140.0182	0.00073
Phase 2: Processing	Inputs	0.307	3.188	N/A
	Outputs/Waste	0.000	0.000	N/A
	Combined	0.307	3.188	N/A
Phase 3: Retail	Inputs	0.373	0.577	N/A
	Outputs/Waste	4.733	0.000	N/A
	Combined	5.106	0.577	N/A
Phase 4: Consumption	Inputs	0.250	0.000	N/A
	Outputs/Waste	2.888	0.000	N/A
	Combined	3.137	0.000	N/A
Total: Inputs		5.935	143.783	0.00073
Total: Outputs		7.621	0.000	0.00000
Grand Total		13.556	143.783	0.00073

Milk Flows				
	Phase 1: Production	Phase 2: Processing	Phase 3: Retail	Phase 4: Consumption
<i>Milk Entering (gal)</i>	10,552,457.36	10,500,750.32	10,376,053.91	10,168,532.83
<i>Milk Loss (%)</i>	0.49%	1.19%	2.00%	20%
<i>Milk Loss (gal)</i>	51,707.04	124,696.41	207,521.08	2,033,706.57
<i>Milk Exiting (gal)</i>	10,500,750.32	10,376,053.91	10,168,532.83	8,134,826.27 (consumed)

-

indicates no impact

indicates that there is an impact but it is not quantified in this study

Environmental Impact Table

Supply Chain Stage	Activity	Input/Output	Agricultural land area	Global warming potential	Acidification potential	Water consumption	Wastewater load (organic)
			ha/gal/year	kg CO2 eq/gal	g SO2 eq/gal	gal/gal	g COD/gal
Production	CO2 milk production	Input		0.833			
Production	CH4 milk production	Input		1.894			
Production	N2O milk production	Input		1.364	-		
Production	Emissions from Energy	Input		0.915			
Production	Area of Farmland per Gal	Input	0.0007				
Production	SO2 milk production	Input			68.106		
Production	Total Water	Input				140.018	
Production	Pesticides (90% Herbicides)	Input					
Subtotal: Production Phase			0.0007	5.006	68.106	140.018	
Processing	Milk processing and packaging	Input		0.218		3.188	-
Processing	Milk transportation	Input		0.089			
Subtotal: Processing Phase				0.307		3.188	
Retail	Refrigeration/storage	Input		0.373	-	0.577	
Retail	Impacts of landfill disposal	Output		4.733	0.000		
Subtotal: Retail Phase				5.106	0.000	0.577	
Consumer	Transportation Emissions: Household to Retail Outlet	Input		0.077	-		
Consumer	Transportation Emissions: Household to Waste Management Facility	Input		0.172	-		
Consumer	Fluid Milk Discarded to Landfill	Output		2.888	-		
Consumer	Milk Packaging: Plastic, Discarded (Recycled, Landfilled)	Output		0.0000051	-		
Consumer	Fluid Milk Discarded to Sewer	Output					0.791
Subtotal: Consumer Phase				3.137			0.791
Grand Total (per gallon)			0.0007	13.556	68.106	143.783	0.791
Grand Total (Milk Purchased in Albany)			7,694.50	140,924,959.67	718,686,300.64	1,516,992,134.85	8,041,174.33
Environmental Footprint of Milk Loss in Albany			1,762.86	30,651,651.65	164,655,329.94	347,346,477.32	1,608,234.87

Phase 1: Production						Calculated value
						Raw input value
Production Flows (Milk Purchased in Albany)	Volume (gal)	Volume (L)	Mass (lb)	Mass (kg)	Proportion of previous	Reference
Milk Entering Production	10,552,457.36	39,945,377.62	90,962,182.45	41,259,718.26		
Milk Exiting Production	10,500,750.32	39,749,645.27	90,516,467.76	41,057,545.64	99.51%	(Alpin et al., 1996)
Milk Loss (Production Phase)	51,707.04	195,732.35	445,714.69	202,172.62		
Production Environmental Impacts						
Impact Category	Impact Type	Impact Per Gallon	Albany Total	Unit		
GWP	CO2	0.833	8793714.468	kg CO2e		
	CH4	1.894	19985714.699	kg CO2e		
	N2O	1.364	14389714.584	kg CO2e		
	Emissions from Energy	0.915	9655555.720	kg CO2e		
Subtotal		5.006	52824699.471	kg CO2e		
Total Water Intake	Total Water	140.018	1477536085.310	Gallons Water		
Subtotal						
Land	Land Use For Cows	0.001	7694.500	ha.		
Pesticides	Pesticides	0.447	4716628.669	grams		
Methane Per Cow		0.587	6195571.557	kg		
SO2-equivalents		0.068	718686.301	kg		
Subtotal						
Energy	Energy Req on Farm	12.652	133504574.193	mJ		
	Primary Energy Use	13.447	141898574.366	kg		

Phase 2: Processing							Calculated value
							Raw input value
Processing Flows (Milk purchased in Albany)		Volume (gal)	Volume (L)	Mass (lb)	Mass (kg)	Proportion of previous	Reference
	Milk production	10,500,750.32	39,749,671.88	87,449,278.14	39,749,671.88	100%	
	Milk Processing	10,402,305.79	39,377,018.71	86,629,441.16	39,377,018.71	99.06%	(Seybolt, 2016)
	Milk Transportation	10,376,053.91	39,277,644.53	86,410,817.96	39,277,644.53	98.81%	(Seybolt, 2016)
	Milk loss (Processing Phase)	124,696.41	472,027.35	1,038,460.18	472,027.35	1.187500%	
Processing Impacts		Impact Type	1 gallon of Milk	Total: Milk Purchased in Albany	Reference		
CO2e Emissions from Electricity (kg)	Global warming potential	0.2175	2,284,004.79				
CO2e Emissions from Diesel Fuel (kg)	Global warming potential	0.0890	934,640.73				
Total CO2e Emissions (kg)	Global warming potential	0.3065	3,218,645.52				
Total Water Consumption	Water consumption	3.19	33,471,141.65				

Phase 3: Retail					Calculated value		
Retail losses summary		Loss (gal)			Raw input value		
R5	Oversupply > landfill	103760.5391					
R7	Return to distributor > distributor disposal	103760.5391					
Total		207521.0782					
Retail impact summary		AP (g SO2/gal)	GWP (kg CO2 eq/gal)	Water (gal/gal)			
RA	Refrigeration (energy and refrigerants) and storage	-	0.373	0.5768			
RB	Outputs from distributor disposal	0.000	4.733				
RC	Outputs from direct landfill disposal	0.000	4.733				
RB, RC	Weighted average: landfill disposal		4.733				
Conversion factors			gal > L	gal > lb	lb > kg	MT > kg	short ton > lb
			3.78541	8.62	0.453592	1000	2000
							kg > g
							1000
Flows		Volume (gal)	Proportion	of flow	References and notes		
R1	Transport > Store delivery	10376053.91		from previous			
R2	Store delivery - Storage and display	10376053.91					
R3	Storage and display > oversupply	207521.0782	2.0%		R2 See assumptions below.		
R4	Oversupply > return to distributor	103760.5391	0.5		R3 See assumptions below.		
R5	Oversupply > landfill	103760.5391	0.5		R3 See assumptions below.		
R6	Storage and display > sale	10168532.83	98.0%		R2 See assumptions below.		
R7	Return to distributor > distributor disposal	103760.5391	1		R4 See assumptions below.		
Impacts		AP (g SO2/gal)	GWP (kg CO2 eq/gal)	Water (gal/gal)	References and notes		
RA	Refrigeration (energy and refrigerants) and storage	-	0.372619478	0.5768	Acidification potential not quantified.		
RB	Outputs from distributor disposal	0	4.733374487				
	RB.1 of milk	-	3.0601		Acidification potential not quantified.		
	RB.2 of packaging	-	1.673274487		Acidification potential not quantified.		
RC	Outputs from landfill disposal	0	4.733374487				
	RC.1 of milk	-	3.0601		Acidification potential not quantified.		
	RC.2 of packaging	-	1.673274487		Acidification potential not quantified.		

Phase 4: Consumption					Calculated value		
					Raw input value		
Fluid Milk Flows		Volume (gal)	Volume (L)	Mass (lb)	Mass (kg)	Proportion of previous	References
	Fluid Milk Purchased in Albany	10,168,532.83	38,492,065.87	87,652,753.01	39,758,587.54	100%	(IRI, 2016)
	Fluid Milk Waste in Albany	2,033,706.57	7,698,413.17	17,530,550.60	7,951,717.51	20%	(Bubzy et al., 2014)
	Fluid Milk Discarded to Landfill	140,325.75	531,190.51	1,209,607.99	548,668.51	6.9%	(Consumer Survey, 2016)
	Fluid Milk Discarded in Sewer	1,893,380.81	7,167,222.66	16,320,942.61	7,403,049.00	93.1%	(Consumer Survey, 2016)
Packaging Flows		Mass (g)	Mass (kg)	Mass (lb)	Proportion of previous	Notes/Assumptions	References
	Milk Packaging: Plastic	581,009,628.95	581,009.63	1,280,908.02	89.0%	weight for 1 gallon container used - this is likely	(Thoma et al., 2013)
	Milk Packaging: Paper	126,394,863.10	126,394.86	278,653.20	11.0%		(Thoma et al., 2013)
	Milk Packaging: Plastic, Discarded to Landfill	579,969,621.72	579,969.62	1,278,615.19	99.8%		(CHA, 2014)
	Milk Packaging: Plastic, Recycled	1,040,007.24	1,040.01	2,292.83	0.2%		(CHA, 2014)
	Milk Packaging: Paper, Discarded to Landfill	126,372,112.03	126,372.11	278,603.04	100.0%		(CHA, 2014)
	Milk Packaging: Paper, Recycled	22,751.08	22.75	50.16	0.0%		(CHA, 2014)
Impacts		Type	Amount (Total)	Amount (per gal)	Unit	Assmptions/Notes	References
	Transportation Emissions: Household to Reta	Global Warming Potential (G	784,766.91	0.0772	kg CO2 eq	95% of consumers drive to the grocery store	(Ver Ploeg, Mancino, Todd, Clay, & Scharadin, 2015)
	Transportation Emissions: Household to Was	Global Warming Potential (G	1,753,055.06	0.1724	kg CO2 eq		
Subtotal: Transportation			2,537,821.97	0.2496	kg CO2 eq		
	Fluid Milk Discarded to Landfill	Global Warming Potential (G	1,584,390.05	2.8877	kg CO2 eq		
	Milk Packaging: Plastic, Discarded to Landfill	Global Warming Potential (G	0.00	0.0000	kg CO2 eq		
	Milk Packaging: Paper, Discarded to Landfill	Global Warming Potential (G	291.19	0.0000	kg CO2 eq		
Subtotal: Landfill			1,584,681.24	2.8877	kg CO2 eq		
	Fluid Milk Discarded to Sewer	Wastewater load (organic)	1,497,266.66	0.7908	kg COD		
Subtotal: Sewer System			1,497,266.66	0.7908	kg COD		
	Milk Packaging: Plastic, Recycled	Global Warming Potential (G	-145.07	-0.00001	kg CO2 eq		
	Milk Packaging: Paper, Recycled	Global Warming Potential (G	-10.31	-0.000001	kg CO2 eq		
Subtotal: Recycling			-155.39		kg CO2 eq		
Subtotal: Waste Management (GWP)			1,584,525.85		kg CO2 eq		
Weighted average: packaging disposal emissions				0.0000051	kg CO2 eq		
TOTAL: GHG Emissions (GWP)			4,122,347.82		kg CO2 eq		
TOTAL: Wastewater Load (Organic)			1,497,266.66		kg COD		



Appendix B: Video methodology and link

In order to more creatively convey learning objectives from this project, the Summer 2016 Capstone class chose to create a video. This video is meant to target consumers, as well as policy-makers, persuading them to think more deeply about the fluid milk process and supply chain. As a consequence, this audience will become more aware and better informed on the subject of fluid milk waste, possibly influencing both consumers' purchasing choices and policy-makers' legislative power.

Access the video at the following link:

<https://www.youtube.com/watch?v=IVsH4A-TK14&feature=youtu.be>

Appendix C: Primary data

a. In-Class Mini Case Study

To personally experience the subject of our study, we conducted a mini In-Class Milk Tasting experiment. This experiment was initiated to test notable differences in milk. Twelve of fifteen members from the capstone project agreed to participate in an experiment to rank 3 different milks - Pasteurized, raw and ultra-pasteurized, of various prices according to their taste. The variable was expiration date and level of pasteurization.

The pasteurized milk was 17 days past its expiration; however it was ranked the best tasting by the class, followed by the raw milk then ultra-pasteurized.

This indicates that date labeling does not offer the consumer relevant and useful information. We recommend based on this and other literature found in our report that date labeling laws should be reviewed to ensure accurate information is relayed to the consumer, who would be better able to make an informed decision as to whether to dispose of milk after purchase.

Whole, Organic and Pasteurized	Bought on 6/28/2016 (date label 6/11/2016) 17 days past sell-by date
Whole, Raw and Unpasteurized	Milked on Friday 6/24/2016 and delivered on Saturday 6/25/2016
Whole, Conventional and Pasteurized	Bought on 6/28/2016 (date label 7/4/2016)

Subjects were informed of the 3 types of whole milk that they would be sampling. They were also informed that one milk sample was past its sell-by date, but were not informed of the exact number of days that it was past this label. They received one milk sample at a time. We then asked the subjects to smell and taste the sample and write their observations down. After tasting all 3 types of milk, they were asked to select their favorite.

The results of this experiment were not as we hypothesized. Out of the 12 subjects who participated, all but one chose the organic pasteurized milk - which was 17 days past its sell-by date - as their favorite.

This result informed us that we could not judge the freshness of milk solely on the basis of a date stamped on the packaging. These findings also support the research we aggregated throughout the course of the semester stating that milk can be safely consumed past the sell-by date on the package.

In-Class Mini Milk Taste Experiment /// Tuesday June 28, 2016			
Student	Favorite		
1			
2			
3			
4		Milk Type	Obtained on
5		Whole, Organic and Pasteurized	Purchased on 6/28/2016 day of the experiment (date label 6/11/2016)
6		Whole, Raw and Unpasteurized	Milked on Friday 6/24/2016 and delivered on Saturday 6/25/2016
7		Whole, Conventional and Pasteurized	Purchased on 6/28/2016 (date label 7/4/2016)
8			
9			
10			
11			
12			
Results: 92% of the class chose the milk that was 17 days past sell-by date as their favorite.			

b. Consumer Survey Template, Results and Charts

SURVEY TEMPLATE: Let's talk about milk...

Interviewer: _____

Date: _____

#1: How many times/week do you normally buy milk?

1: _____ 2: _____ 3: _____ 4+: _____ Less: _____

#2: Where do you buy milk most often?

Supermarket/Grocery Store _____

Convenience Store _____

Farmers Market _____

Other (please specify) _____

#3: What size container do you normally buy?

Gallon _____

Half Gallon _____

Quart _____

Pint _____

#4: What type of container does your milk come in?

Plastic _____

Cardboard _____

#5: Do you normally throw away milk?

Every time _____

Occasionally _____

Never _____

#6: If yes how much?

More than half the container _____

Less than half the container _____

Less than a quarter of the container _____

#7: How do you throw out the milk?

In the trash _____

Pour it down the drain _____

#8: How about the container?

Trash _____

Recycling _____

#9: What does the label date on milk mean to you?

#10: Do you drink milk past the printed label date?

Yes _____

Absolutely not _____

If it passes the 'sniff test' _____

#11: Would you consider switching to buying your milk directly from a farm and having it delivered to your home?

Yes _____

No _____

Maybe _____

#12: Could you expand on that?

Last, but not least, could you tell us a bit about yourself?

#13: What year were you born?

#14: What is your zip code?

c. Consumer Survey Results

For our full excel document of results, please contact the report authors.

Row Labels	Count of Do you normally throw away milk?			
Every time	13	13		
Absolutely not	4		4	4
It it passes sniff test	7			
Yes	2			
Never	74			
Absolutely not	27			27
It it passes sniff test	35			
Yes	12			
Occasionally	85	85		
Absolutely not	31		30	31
It it passes sniff test	36			
Yes	18			
Grand Total	172			
		98	34	35%
		57%	20%	36%
		Number of people who throw out milk AND will not drink past the sell by date.		
		Of those who throw away milk, how many would not drink milk past sell by date		

Row Labels	Do you normally throw away milk?			
Every time	13	13		
Absolutely not	4		4	4
It it passes sniff test	7			
Yes	2			
Never	74			
Absolutely not	27			27
It it passes sniff test	35			
Yes	12			
Occasionally	85	85		
Absolutely not	31		30	31
It it passes sniff test	36			
Yes	18			
Grand Total	172			
		98	34	35%
		57%	20%	36%
57% of consumers surveyed throw milk away and 36% refuse to drink it past its sell-by date.				

e. Retail Survey Template

These questions are for use in in-person anonymous interviews with various milk retailers within Albany and New York City, New York.

1. What is your weekly shrink?
2. How do you discard waste milk?
3. Do you have a donation program for milk?
4. How close to the sell-by date do you remove milk from the display?
5. Do you control and monitor the temperature of the display case? How?
6. Do you use any form of computer assisted ordering? How do you predict your sales volume?
7. Have you ever had to throw out milk because of problems with refrigeration?

f. General Information Survey

First Hand Data Methodology Template

1. Interviewer

2. Interviewee

3. Company

4. Title/Function

5. Date of Data Gathering *Example: December 15, 2012*

6. Medium *Mark only one.*

Live
Phone
Email
Other:

7. Information Requested

8. Information Received

9. Short Summary of Finding

10. Relevant to: *(Mark only one).*

Production
Post-Harvest
Retail
Consumer
Other

11. What criteria were used to select sample to be interviewed?

12. Do you feel it is a representative sample? *Mark only one.* Yes / No

13. If not, what was missing?

g. Processing Plant Survey

Fluid Milk Waste in Albany, NY

* Required

1. What's the name of your company? *
2. What kind of facility is it? * *Mark only one.*
 - Cooperative
 - Bottling
 - Pasteurization/Processing
 - Other:
3. Please provide your name (optional):
4. Please provide you title (optional):
5. Please provide your email: *
6. Can we reach out to you for supplemental information gathering? * *Mark only one.*
 - Yes
 - No
7. Who are your milk providers (list by company name)?
8. What is the monthly and/or annual amount of milk that is delivered to your plant?
(please specify metric)
9. What is the monthly or annual amount of milk lost (wasted) at the plant? (please specify metric)
10. What are the causes for losses and how do you measure them? (please specify if they are measured or perceived)
11. What (if any) actions are being taken to prevent losses?
12. What is the monthly amount of shrink you get and what do you do with it?
13. What is the monthly and/or annual energy consumption of the plant and from what sources?
14. What are the primary sources of energy used and their relevant proportion? (on site vs. electricity)
15. What is the amount of water consumption of the plant? Is the water treated after consumption?

16. Do you transport the milk from the farms to your plant with your own milk tankers?

Mark only one.

Yes

No

17. Do you have your own vehicles to deliver the milk to stores / clients? *Mark only one.*

Yes

No

18. If yes to either of the above two questions, what is the monthly or annual amount of fuel consumption?

19. If you don't transport the milk, please specify which company does?

20. What is the average distance from where the milk is harvested (miles)? (can provide multiple if this varies)

21. What is the distance to where the milk is delivered (miles)? (can provide multiple if this varies)

22. How much milk is lost in the transportation process per month or year?

23. How do you measure losses in the transport process?

24. What are the primary causes for losses and are these measured or perceived?

25. What actions are you taking to prevent losses in the transportation of milk?

26. Do you use the PMO as a minimum operating standard? If no, how has it been altered? If yes, are there instances when you depart from the guidance given in the PMO?