



Alberta Agricultural Waste Characterization Study Update 2019

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Funds for the pilot project were granted by the Government of Alberta and are administered by Alberta Beef Producers.



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The views expressed are the views of the author(s) and Cleanfarms Inc.



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Executive Summary

In 2013, Cleanfarms Inc., in partnership with Alberta Agriculture & Rural Development (ARD) through Growing Forward 2, a federal, provincial, territorial initiative, commissioned an Alberta Agricultural Waste Characterization Study, focusing on non-durable, inorganic waste generation on Alberta farms. This study updates the characterization and quantification of significant sources of paper and plastic waste on Alberta farms, utilizing a combination of market information and field generation estimates.

Major waste sources are a result of the two major types of farms in Alberta (Statistics Canada Census of Agriculture 2016 Alberta Highlights):

- grain farms – 33% of Alberta’s farms
- cattle operations (cow/calf farms and feedlots) – 32.2% of the province's farms

Thus, the study focuses on agricultural films like low density polyethylene (LDPE) (silage plastics, grain bags) and on polypropylene (PP) twine. The main paper waste sources were identified as packaging products like multi-walled paper bags (for feed, seed, supplements, minerals, etc.) and cardboard packaging (boxed agricultural film products, pesticides, etc.).

Estimated quantity ranges for the primary sources of inorganic agricultural waste in Alberta are summarized below:

2019	Estimated Total Annual Generation (tonnes) (rounded)	
	Minimum	Maximum
Plastic Film Waste		
Bale Wrap	900	1400
Grain Bags	1480	2500
Greenhouse Film	70	170
Silage Plastic	1800	2600
Total Ag Film Waste	4250	6670
PP Twine	1320	3000
Net Wrap	400	560
Polypropylene Totes	520	600
Pesticide Containers	550	550
Sanitation Containers	4	4
Total Other Plastic Ag Waste	2794	4714
Total Plastic Ag Waste	7044	11384



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2019	Estimated Total Annual Generation (tonnes) (rounded)	
	Minimum	Maximum
Paper Waste		
Paper and Multi-Walled Bags	710	930
Cardboard	730	880
Total Paper Ag Waste (rounded)	1440	1810
Total Ag Waste	8484	13194

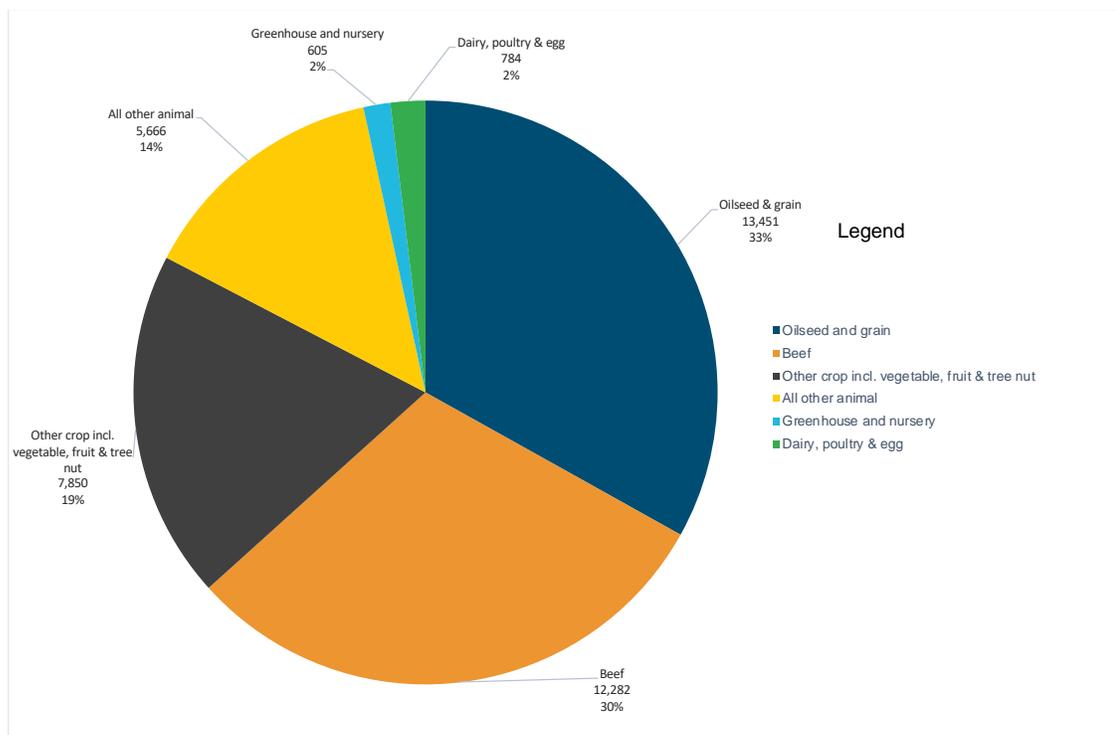
1.0 Introduction

Cleanfarms is a non-profit environmental stewardship organization. Working collaboratively with its members, partner agencies, and the government to ensure that Canadian farmers can actively contribute to a healthy environment and a sustainable future. Cleanfarms programs create meaningful change and offer a tangible way to address agricultural waste management and resources in the community (Cleanfarms, 2019).

1.1 Background

Alberta has a variety of farms, as identified in the Stats Canada Census of Agriculture 2016, illustrated in Figure 1, which may generate inorganic waste as part of their operations. This study attempts to update the significant sources of these inorganic wastes from Alberta farms, as identified in the 2013 *Alberta Agricultural Waste Characterization Study* prepared by Sonnevera International Corp.¹

Figure 1: Number of Farms of Different Types in Alberta in 2016 (Statistics Canada 2017)



¹ Sonnevera International Corp. for Cleanfarms, 2013, [Alberta Agricultural Waste Characterization Study](#).

Agriculture is an important part of the Alberta economy, accounting for 1.55% of the provincial GDP in 2018 (Government of Alberta 2019). The 2016 Census of Agriculture revealed a total of 40,638 farms, down from the 2011 census of 43,234 farms, existing in Alberta, ranging in size from under 10 acres to over 3,520 acres (Statistics Canada 2016), averaging 1,119 acres. Statistics Canada classifies each census farm based on the commodity or group of commodities accounting for 50% or more of the farm's total annual receipts (Statistics Canada 2016). According to this system, two types of farming dominate in Alberta (Figure 1): grain and oilseed crops (33% up from 29% in 2011) and the beef industry (30% up from 28% in the previous study). In fact, Alberta is the largest beef producing province in Canada, hosting 41.6% of the national cattle herd (Alberta Cattle Feeders Association and 2016 Census of Agriculture Alberta Provincial Highlights) up from 39.8% in 2011.

The intention of this study is to update the 2013 study performed by Sonnevera. As such, this update will follow the identical format and retain the same types of wastes as assumed under the previous study. The main components continue to be assumed to stem from the predominant grain and beef production industries. Low density polyethylene (LDPE) film (bale wrap, silage plastics and grain bags) and polypropylene (PP) (baler) twine were the focus of the study, including other waste streams, such as paper and plastic bags and totes for products like seed, feed, fertilizer, minerals and salts, cardboard packaging, greenhouse film and high density polyethylene (HDPE) containers used for sanitation products. Other sources of waste, considered to be less significant were excluded, as their contribution is immaterial to the overall tonnage generated on Alberta farms. Examples of such materials include plastic stretch film used to wrap pallets of goods, and plastic packaging on individual items such as rolls of net wrap. Durable products, such as posts, tires and wire were considered outside the study scope and therefore were also not counted within this research.

1.2 Project Objectives

The intent of the Alberta Agricultural Waste Characterization Study Update was to update the statistics previously developed in 2013 to quantify and characterize significant sources of on-farm agricultural waste (inorganic) in Alberta, to identify opportunities for increased waste reduction and diversion in this sector.

The study does not consider the existence or accessibility of recycling programs or provide any assessment of waste management practices.

2.0 Methodology

In order to understand the waste generation occurring on Alberta farms, and quantify the amounts of paper and plastic waste generated annually on Alberta farms, a variety of tasks were undertaken.

The research presents an Alberta-specific estimation of agricultural waste generation utilizing resources such as:

- Statistics Canada Agricultural Census Data (2016)
- Canadian Importers Database (Industry Canada)
- Alberta Government (Open Alberta)
- Previous studies regarding waste on farms
- Internet searches
- Industry and subject matter experts

The materials profiled in this report include the following:

Plastics:

- low-density polyethylene (LDPE) products such as silage wrap, grain bags or plastic tote bags
- polypropylene (PP) products including twine, woven plastic mini-bulk bags or totes
- high density polyethylene (HDPE) jugs, pails and drums

Paper sources:

- lined and unlined paper bags

Generation estimates used a combination of sales information, as well as usage estimates based on field information. It was felt that this approach would provide the most reasonable range of quantities, mitigating the inherent errors associated with one individual form of research.

2.1 Previous Studies

Two previous studies have estimated plastic agricultural waste in Alberta. Most recently, the Government of Alberta hired IPSOS REID to conduct an *Agricultural Plastics Recycling Producers Survey* (2012) which interviewed 660 Alberta farmers about current practices. The survey results indicated 375 of these farms (56%) used one or more types of plastic in a 12-month period and identified the most commonly used plastic as baling twine (Government of Alberta 2012). Based on interview responses from farmers, combined with estimated mean weights of various plastic applications, it was estimated that about 3,000 metric tonnes of twine, silage covers, grain bags, bale wrap and silage or bale tubes are generated annually on Alberta farms. It is important to note that the methodology used in the 2013 Sonnevera study does

allow for a direct comparison to this current report.

The second relevant estimate of agricultural plastic generation is found in the *Agricultural Plastics Recycling Pilot Project* published by the Recycling Council of Alberta (RCA) in 2009. The report primarily concerns a recycling pilot project for agricultural plastics, but also contains The Alberta Plastics Recycling Association (APRA) estimate of plastic waste generation on farms, based on research into sales of these materials into Alberta. APRA estimated between 3000–4000 tonnes of polypropylene (twine and cord) and 4300–5000 tonnes of polyethylene material (silage bags and covers) were sold into Alberta in 2007 (RCA 2009).

2.2 Expert Consultation

A range of industry and subject matter experts were consulted to obtain information and perspective. A list of these experts is provided in Appendix A.

2.2.1 Industry Experts

To update the quantity and the types of waste agricultural materials generated as a comparison to the 2013 study, this study attempted to engage the same industry experts, including producer organizations and agricultural plastic and paper product manufacturers, importers, government agriculture specialists, distributors and retailers to draw comparisons to the waste generated in 2013 and note the changes in generation volumes. Some industry experts did not respond to the invitation to participate, others declined to contribute, and some were no longer in the positions they held in 2013. Interaction with willing industry experts was conducted via email and telephone. As the study progressed, individuals suggested or were asked to identify other important industry experts.

As in the 2013 study, to reduce the amount of error in estimating annual tonnages through calculations or individual farm estimates, manufacturers, distributors and retailers were contacted to obtain Alberta specific sales data. Industry experts also assisted in understanding waste resulting from product packaging and delivery to farms.

2.2.2 Subject Matter Experts

In order to understand the variety of types of farming occurring in the province, and identify their potential waste streams, subject matter experts were consulted, and data was researched, especially that which was available from Open Alberta, Industry Organizations, Statistics Canada and Statistics Canada's Census of Agriculture 2016.

The industry organizations were instrumental in calculating estimations of waste generation in cases where manufacturers were difficult to identify or unwilling to supply sales data, or the market had a variety of equivalent products with no dominant manufacturer (i.e., sanitation products).

3.0 Waste Characterization

Descriptions of the sources of paper and plastic agricultural waste considered, as well as the respective estimated tonnages follow. General categories include plastics such as film products (bale wrap, grain bags, greenhouse covers, and silage film), net wrap, twine, woven bags and plastic containers, as well as fibre products such as paper bags and cardboard. In order to limit the scope to a reasonable undertaking, only waste sources deemed to be significant were included.

3.1 Description of Plastic Wastes and Packaging

3.1.1 Bale Wrap

Bale wrap and/or silage wrap is a type of stretch film (primarily LDPE) utilized to contain hay, straw or silage. It is predominantly used in the dairy industry, where nutritional content is paramount to milk production (Yaremcio 2013, updated 2019). Bale wrap may come on a plastic or cardboard core, estimated by industry experts to be approximately 1.2 kg (Mazurenko 2013, updated 2019). This product comes in a 0.95 kg cardboard box (Mazurenko 2013, updated 2019).



3.1.2 Grain Bags

Grain bags are an LDPE film product, used for temporary crop storage. These bags provide easy storage for bumper crops and reduce transport costs for crops from land far from grain bins. Each grain bag comes in an individual box, estimated to be 6.4 kg (Mazurenko 2013, updated 2019).



3.1.3 Greenhouse Film

Greenhouse film products are typically manufactured from LDPE and are used for greenhouse cover (roofing and walls). The film is delivered in rolls, with an average unit weight of 0.025–0.029 pounds per square foot.



3.1.4 Net Wrap

Net wrap is a knitted high-density polyethylene (HDPE) netting alternative to baler twine is used on hay and straw bales (Syfilco 2019). Popularity of net wrap has grown in some markets, as it allows faster baling, and reduces spoilage and leaf loss (PAMI, 2019). Net wrap may come on a plastic or cardboard roll, with sizes from 7000 to 9500 feet in length, and an average weight of 0.002 pounds per square foot and is normally packaged in a film bag.



3.1.5 Silage Plastic

Silage plastic refers to agricultural LDPE films used as silage covers or silage bags.

Silage bags form long tubes, similar in appearance to grain bags. They are primarily used by the dairy industry. Silage bags come folded up in a 6.44 kg cardboard box (Mazurenko 2013). Silage covers are LDPE sheeting utilized in covering bunkers or pits, as well as ground piles. Silage covers come on either a plastic or cardboard core (2.1 to 12.4 kg) (Mazurenko 2013, updated 2019).



3.1.6 Twine

Polypropylene twine is used for baling hay and straw and comes in different sizes weighing from 0.001 to 0.006 pounds per foot, delivered in spools of 4000 to 28,000 feet (various producers). It may come wrapped in a plastic film as individual spools or packaged one or two spools per cardboard box. Sisal twine, made from natural sisal plant fibers, was not considered in this study.



3.1.7 Polypropylene Woven Bags and Mini-Bulk Bags or Totes

Agricultural products may come in 25 kg capacity polypropylene woven bags, or in larger polypropylene weave, 1-tonne capacity mini-bulk bags (MBBs).

Items commonly sold polypropylene woven bags include



pesticides, bulk seed or feed, and fertilizers.

3.1.8 Sanitation Products

Sanitation products, including detergent and disinfectants, may be used in the dairy, poultry and hog industries. There are a plethora of options and sizes of containers for use, depending on the farm size and requirements. Sanitation products come in powdered and liquid forms and are available in HDPE containers like 4 L jugs, 5 kg pails, 20 L pails, 55 L or 205 L drums, and 1000 L totes. Some sanitation products, like soap, may come in cardboard boxes when bought in multiple jugs.



3.1.9 Pesticide Containers

Pesticide containers are also available in a variety of sizes, from smaller quantity bottles (<1 L) and jugs (1-10 L) to larger scale pails (20 L), drums (205 L) and totes (450 L or 1000 L). Typically, two 10 L jugs will come packaged in a cardboard box.



3.1.10 Engine and Hydraulic Oil

Oil containers are typically made from HDPE and come in a variety of denominations: <1 L bottles, 1 L and 4 L jugs, 20 L pails, and bulk. Smaller containers may also generate cardboard box packaging waste.

3.2 Description of Paper Wastes

3.2.1 Paper Bags

There are two types of paper bags used in agriculture: unlined paper bags and plastic lined or multi-walled paper bags. These may be used for products including seed, supplements, minerals and salts.



3.2.2 Cardboard Packaging

Numerous agricultural products come in cardboard packaging as previously mentioned; silage and grain bags each come individually packaged in a cardboard box, silage covers and net wrap are on a plastic or cardboard core, multiple spools of twine are often purchased in a box, pesticide containers typically come two per box, and insecticide may also be purchased in a plastic lined cardboard box.

3.3 Description of Animal Health Product Packaging Wastes

The importance of animal health and subsequent maintenance is bound to generate some waste on Alberta farms. Plastic and glass bottles from vaccinations and medical treatments as well as boxboard cartons and informative paper inserts with instructions or advertisements all contribute to waste generation.



4.0 Estimated Waste Tonnages

For this update, the same basis for calculations were utilized as were used for the 2013 study. For comparison, the Appendices will include both the 2013 and 2019 calculations for comparison. As in the previous study, the two significant plastic sources considered were LDPE agricultural films, and PP twine. Primary estimates for these materials came from industry experts, both from sales and field research perspectives and calculation protocols were developed in the 2013 study. These same protocols were used in this study in order to develop a means of comparison to identify the changes between 2013 and 2019. Manufacturers and suppliers of products resulting in other waste streams continue to be reluctant to share sales information.

As in the 2013 study, wherever possible, key stakeholders and industry experts were contacted for sales estimates to provide a base generation amount. Waste generation per unit of production was also estimated based on the type of farming activity and the required inputs. Alberta farms vary in quantity of farms, farm size and operation, and different management practices and styles may lead to utilization of different products and thus different generation rates. The number of Alberta farms in 2011 was 43,234 which was a decrease of 6% from the previous Census of Agriculture performed by Statistics Canada in 2011. The calculations contained herein were formulated in the 2013 study to estimate the annual waste tonnage generated involve standard product unit weights and rely heavily on subject matter expert input. The result of these calculations for 2019 are included in this study.

It should be noted that quantifying waste using calculations based on estimated usage is subject to error and should be considered an iterative process which, with the addition of grain bag, netting, twine and other collection programs, will be refined and once collection data is realized will rely less on calculations or industry experts.

4.1 Estimated Plastic Waste Tonnages

In the 2013 study, manufacturers, retailers and distributors contacted were asked to estimate the average annual tonnage of each type of product sold into Alberta. These estimates are relevant to the current market, but exact sale figures per year were not collected. Since some known retailers / distributors were non-responsive or hesitant to provide estimated sales figures, industry experts were asked to provide market size estimations in addition to sales data. This remains consistent in 2019 and with the advent of new collection programs for agricultural waste, will not be required in the future as collection data will be readily available.

Adverse weather and/or pest conditions affecting crop production and market competition from international imports sold privately off-farm affect the sales of agricultural plastics. As we are comparing two snapshots in time, neither weather nor imports were considered in this analysis. It should be noted however, that the wastes generated by imports will affect the overall generation numbers and cannot be accurately measured until collection programs are

implemented.

4.1.1 Bale Wrap

From discussion with and data collection from industry experts, the estimated annual tonnage of bale wrap was between 900 to 1400 tonnes, and silage wrap sold into Alberta is approximately 2500 tonnes. This includes primarily bale wrap, and some silage wrap plastic.

Prior to using bale wrap, bales are bound by twine or net wrap. Although either of these products may be used, industry experts estimate that net wrap is becoming more popular for this purpose but mainly twine is used in Alberta (Mazurenko 2013, updated 2019). Continuous baling occurs with both large square and round bales, and some rows are wrapped two bales high. For the purpose of calculating an estimated tonnage of waste bale wrap generated per annum, it was assumed that only single rows of round bales were wrapped continuously (see Bale Wrap tab in Unit Weight Estimates, available through Appendix B). It was further assumed that only large round bales were made utilizing bale wrap.

In accordance with the previously stated assumptions, estimates of bale wrap and associated twine waste generation were calculated for both continuous and individual bale wrapping. Based on subject matter and industry expert data (see Appendices Subject Matter & Unit Weights for exact references) it was assumed that 77% of baled hay is made into round bales, of which 14% is continuously wrapped with bale wrap and 1% is individually bale wrapped. Waste bale wrap from individually wrapped bales is between 84 and 121 tonnes per year, generating 9-13 tonnes per year of associated twine waste.

Continuous wrapping of bales generates significantly more waste, as it is estimated to be used more than individual style (Yaremci 2013, updated 2019). The amount of wrapping utilized will also vary from farm to farm as it is the personal preference of the operator. Calculations estimate between 810 to 1200 tonnes of bale wrap waste and 125 - 180 tonnes of associated twine waste are generated from continuous bale wrapping in Alberta (see Bale Wrap tab in Unit Weight Estimates, Appendix B).

Table 1 compares the industry expert and calculation-based estimations for bale wrap waste generation in Alberta.

Table 1: Annual Alberta Waste Bale Wrap Estimates

Year and Type of Estimate	Estimated Annual Tonnage of Waste Bale Wrap in Alberta (tonnes/year) (rounded)	
	Minimum	Maximum
2019 Calculation Based	900	1400
2013 Calculation Based	550	1400

4.1.2 Grain Bags

Grain bags are utilized by approximately 13 - 22% of farms in Alberta (Mazurenko 2019 and Cleanfarms Alberta Producer Survey, 2019). Based on collected sales figures and industry expert estimates of market size, approximately 1700 tonnes of grain bags are sold annually into Alberta. Some farmers use only grain bags to store harvested crops, while others use them for temporary storage during a bumper crop year (PAMI, 2019). This tonnage may be higher since some known retailers / distributors were unwilling to provide estimated sales figures. Some industry and subject matter experts indicated that annual sales continue to increase year after year, suggesting market growth and increased use. Equipment manufacturers also indicated increased sales of grain bagging equipment. Industry experts have noted an increase in the amount of grain bag use in Alberta over the past 6 years (Yaremccio 2019). Calculated estimates for annual grain bag generation show between 1500 and 2500 tonnes are used, based upon the crop yield, weather and other factors.

Industry and subject matter experts suggested that a 10 ft diameter x 250 ft length grain bag is a standard size; depending on the crop type and density, this bag would hold around 12,000–12,900 bushels (Grain Bag Storage Systems 2013, updated 2019). The calculated estimate of generated grain bag waste is based on 13–22% of the estimated 2016 harvested canola, wheat, oats and barley crops (Census of Agriculture 2016 Alberta Provincial Highlights) being stored in grain bags. Grain bags may well be used for other crops, such as peas and corn, but it is uncertain how much of this practice occurs. For more information and to see these calculations, please see Subject Matter Expert Estimations, available through Appendix B. The calculated estimate listed here excludes any alternative uses of grain bags.

Calculated estimates and industry expert estimates for annual grain bag usage are shown below in Table 2. Assumptions required to derive this tonnage are based on consultation with industry and subject matter experts (Subject Matter Expert Estimations and Unit Weight Estimations, available through Appendix B).

Table 2: Annual Alberta Waste Grain Bag Estimates

Year and Type of Estimate	Estimated Annual Tonnage of Waste Grain Bags in Alberta (tonnes/year) (rounded)	
	Minimum	Maximum
2019 Calculation Based	1480	2500
2013 Calculation Based	700	1800

4.1.3 Greenhouse Film

No sales estimate of greenhouse film in Alberta was obtained, however based upon a study, Economics of Production and Marketing of Greenhouse Crops in Alberta done by the Government of Alberta, 2018, the calculation based estimate was modified (Subject Matter Expert Estimations, available through Appendix B).

Greenhouse plastic (LDPE film) covers generally last 3–5 years, depending on film quality and weather conditions (Emmanuel Anum Laate 2019). Industry and subject matter experts agree that on average these greenhouse covers are replaced every 4 years (Emmanuel Anum Laate 2019). Using this ¼ average as a basis, assuming some margin to account for curvature and walls, approximately 20–40% of the greenhouse area would need replacing per year. Greenhouses often double their film covering, to account for air inflation (Mazurenko 2019). This was accounted for directly in the unit weight estimate for greenhouse film (Unit Weight Estimations, available through Appendix B).

Based on assumptions from consultation with industry and subject matter experts, the calculated estimate of Greenhouse generated film waste (Table 3) is 70–170 tonnes per year depending upon the year.

Table 3: Annual Alberta Waste Greenhouse Film Estimate

Year and Type of Estimate	Estimated Annual Tonnage of Waste Greenhouse Film in Alberta (tonnes/year) (rounded)	
	Minimum	Maximum
2019 Calculation Based	70	170
2013 Calculation Based	60	160

Other wastes from the horticulture, silviculture and greenhouse industries, include plastic growing mediums like plastic mulch, plastic bags, and ground sheeting; periodically replaced circulation ducting, dripper hoses and lines. These waste streams were not considered in this study in part because of difficulty tracking the use and replacement of these items. Subject matter experts also advised that the waste generation would be relatively insignificant.

Cannabis production in Alberta within greenhouses has been calculated into this study. There is currently 1.05 million square feet of greenhouse space dedicated to Cannabis production in Alberta. As this industry is fairly new, there is little data on which projections can be made. However, the industry’s similarity to vegetable crop production in greenhouses allows for comparisons to be made until the Cannabis production industry matures and data is available. Currently, the Government of Alberta is contemplating the type of studies it plans to take to gain specific industry knowledge (Emmanuel Anum Laate 2019).

4.1.4 Net Wrap

The estimated annual net wrap sales in Alberta, after consultation with industry experts and use of previous calculation methodology, is reported as between 400 - 600 tonnes. This estimate is lower than expected as known importers and distributors of net wrap products were unwilling to provide sales data and no net wrap market size estimates were obtained. While some manufacturers and retailers continue to believe net wrap will one day exceed twine as a baling material, estimated sales of twine (1300 to 4000 tonnes) continue to exceed those of net wrap (600 tonnes).

A calculation-based estimate was also constructed to verify the 600 tonne estimate from manufacturers, distributors and retailers data. Using the calculation-based method, assuming 77% of hay bales are large round bales, and 20% of those bales are made using net wrap; the annual net wrap waste generation in Alberta ranges from 388 to 500 tonnes (Baling Waste Generation Est tab available through Appendix B – Subject Matter Expert Estimations).

As shown in Table 4, the cumulative sales data from industry experts falls within this calculated range.

Table 4: Annual Alberta Waste Net Wrap Estimates

Year and Type of Estimate	Estimated Annual Tonnage of Waste Net Wrap in Alberta (tonnes/year) (rounded)	
	Minimum	Maximum
2019 Calculation Based	400	560
2013 Calculation Based	450	700

4.1.5 Silage Plastic

Alberta produces significant silage as feed for cattle, in 2016 approximately 4.5 million tonnes were made, primarily from barley and oats (Census for Agriculture 2016, Alberta Provincial Statistics). Industry expert estimates of market size and collected sales data indicate that the provincial silage plastic market (covers and bags) is approximately 2600 tonnes per year. The associated plastic/cardboard core waste from silage covers and cardboard box waste from silage bags could not be estimated because information regarding sales was collected as one unit (silage plastic).

Silage plastic waste generation, via a calculation-based method, is estimated to be about 2126 tonnes (Subject Matter Expert Estimations, available through Appendix B). This value considers silage storage practices in the province and the number of cattle fed silage as a percentage of their diet, for a given period. It also utilizes an adjusted pound of plastic waste per cow per year generation factor, based on the work conducted by the Environmental Risk Analysis Program at Cornell University (Levitan and Barros 2003).

The adjusted factor (4.2 lb/cow) is a conservative estimate as it assumes that only silage cover plastic is utilized in traditional bunker or ground pile style silage storage systems; however subject matter experts estimate between 5–10% of silage in Alberta is stored in silage bags or silage wrap, mainly in the dairy industry (Yaremci 2013, updated 2019). Table 5 compares study years using calculation-based estimates.

Table 5: Annual Alberta Waste Silage Plastic Estimates

Year and Type of Estimate	Estimated Annual Tonnage of Waste Silage Plastic in Alberta (tonnes/year) (rounded)	
	Minimum	Maximum
2019 Calculation Based	1800	2600
2013 Calculation Based	1500	2300

4.1.6 Twine

Data collected from manufacturers, distributors and retailers estimates the annual tonnage of twine sold in Alberta to be between 4000 to 8000 tonnes. This estimate is reflective of Alberta sales and of market size estimations, since data from some known importers, manufactures and retailers was unobtainable. As this number represents sales, and there is a substantial hay re-bale for export market, it is safe to assume that 100% of the volume of twine sold will not be generated as waste in Alberta. However, in the process of re-baling and export, the cardboard packaging associated with the twine will likely remain in Alberta and is represented in the cardboard packaging number related to twine sales.

In order to verify this estimate, industry and subject matter estimations were used in conjunction with an Agricultural census value of total tame hay crop production in 2016 (Statistics Canada Census of Agriculture, 2016 Alberta Highlights). Estimations of the percentage of bales made using twine and the percentage of each type of bale (large square, round, small square) allowed a per unit- based calculation.

This calculation estimates the annual tonnage of twine from hay bales to be in the range of 1300–2100 tonnes (Table 6), as evident through Appendix B – Subject Matter Expert Estimations. This estimate is low, since a lack of statistical data on straw production and subject matter experts’ reluctance to estimate a value prevented the inclusion of straw bales in the calculation.

Assumptions regarding distribution of bale type and the amount of twine used per bale are subjective and could also be potential sources of error. In some cases, hay farmers have developed new management techniques, like a system that uses a baler to bind 12 small

square bales together for easier shipment and handling (Toews 2013, updated 2019). This type of adapted method utilizes more twine than traditional baling methods and is not accounted for in this calculated estimate as it is difficult to determine the number of hay farmers that utilize this method. Therefore, it is reasonable to assume that the upper limit of this twine estimate is more realistic than the lower, resulting in a revised estimate of 1320 – 3000 tonnes.

The calculation-based estimate assumes that total hay production is split between 20% large square bales, 77% round bales and 3% small square bales, based on subject matter and industry matter expert opinions (see Appendices for details). It is assumed that 100% of the square bale production (large and small) is made using baler twine, while 65% of the round bales produced are made with twine. See Appendices for further details regarding unit weights and estimated bale sizes (Appendix C).

Table 6: Annual Alberta Waste Twine Estimate

Year and Type of Estimate	Estimated Annual Tonnage of Waste Twine in Alberta (tonnes/year) (rounded)	
	Minimum	Maximum
2019 Calculation Based	1320	3000
2013 Calculation Based	2000	6000

4.1.7 Polypropylene Woven Bags and Mini-Bulk Bags or Totes

Internet research and industry expert consultation revealed that many bags used for packaging continue to come from China or Vietnam. Agrisac Inc., a company with suppliers in both China and just outside of Montreal, Canada shows variety of products on their website (Agrisac Inc. 2019) for the livestock and horticulture markets, such as polypropylene woven bags for feed, paper bags for supplements and polyethylene bags for fertilizer, as does another global agricultural packaging company, LC Packaging.

There are a variety of types of bags used in the agriculture industry and a variety of sizes as well, ranging from 20 or 25 kg bags to 1000 or 2275 kg totes.

Industry suppliers and distributors of bags continue to be hesitant or non-responsive to inquiries about sales figures. A calculation-based estimate places the polypropylene totes (1000 kg capacity) waste generated between 517 to 598 tonnes (Table 7). This estimate was once again, produced by consulting various subject matter and industry experts (Subject Matter Experts, Appendix A), with specific consideration of the hog, poultry and cattle (beef and dairy) industries. This total also incorporates estimates of polypropylene tote waste generated from wheat, barley and canola seed bags from a national study conducted by Agrirécup (Lajeunesse 2013). The Canada-wide Agrirécup study also estimated that an additional 20 tonnes of other types of seed, fungicide and insecticide bags are generated in Alberta, however this tonnage is

not included as no information regarding the material type of these bags was available.

Table 7: Annual Alberta PP Tote Waste Estimate

Year and Type of Estimate	Estimated Annual Tonnage of PP Tote Waste in Alberta (tonnes/year) (rounded)	
	Minimum	Maximum
2019 Calculation Based	520	600
2013 Calculation Based	275	300

Note: 1. Estimate for polypropylene 1 tonne totes only, does not include any fertilizer packaging.

4.1.8 Pesticide Containers

Pesticide and herbicide containers are also available in a variety of HDPE container sizes, from smaller quantity bottles (<1 L) and jugs (1–10 L) to larger scale pails (20 L), drums (205 L) and totes (450 L or 1000 L).

The estimated annual HDPE waste generated from pesticides in Alberta is 620 tonnes (Table 8). This value is based on Cleanfarms estimates on annual pesticide sales in Alberta and assumes 2.5 gallon (9.46 L) HDPE plastic packaging. The associated cardboard waste, generated from pesticide packaging, is estimated to be approximately 500 tonnes per year (Table 11, Section 4.2.2).

Table 8: Annual Alberta Pesticide Container Waste Estimate

Year and Type of Estimate	Estimated Annual Tonnage of Pesticide Container Waste in Alberta (tonnes/year) (rounded)
2019 Calculation Based	550
2013 Calculation Based	620

Note: 1. Based on Cleanfarms estimate of annual Alberta sales

4.1.9 Engine and Hydraulic Oil

In Alberta, oil products have an environmental handling charge (EHC) incorporated into their sale price to help cover the costs of responsible collection and recycling of these materials. The Alberta Recycling Management Authority is the Delegated Administrative Organization (DAO)

that oversees the collection. While they do track the number of containers returned throughout the Province they do not have farm specific data.

4.1.10 Sanitation Product Containers

A variety of sanitation products and packaging in the form of HDPE jugs, pails, drums and totes, may be used on various farms. Larger items, such as 1000 L totes of teat dip or 200 L drum of foot bath solution used in dairy barns have a container deposit program in place, with manufacturers receiving empty containers for reuse. These programs often backhaul empty containers when refilled supplies are delivered to the farm. These items were not considered in this study since they are reused.

Products purchased in smaller quantities, like detergents or soaps, come in various denominations of HDPE jugs and pails. Since there is no dominant brand or manufacturer of these smaller products and farm management practices and types (laying hen barn vs. broiler barn; hog feeder barn vs. hog farrowing barn, etc.) may differ in terms of use, estimations are variable at best. In consultation with subject matter experts and individual farmers, calculations of annual HDPE waste generation on farms were compiled (Table 9).

This consultation concluded that relatively little HDPE waste is generated on hog, poultry or dairy farms. Most waste comes from detergent or disinfectant product packaging, used periodically to clean and disinfect barns, feeders and water lines. Other products, like manure thickening additives, come in 5-gallon pails but its use is minimal (57 mL per 4000 L manure). The predominant sizes of containers were 20 L (5 gallon) pails which are generally all reused on farms, and 4 L jugs.

Table 9: Annual Alberta HDPE Waste Estimate

Type of Industry	2019 Estimated Annual Tonnage of HDPE Sanitation Product Packaging Waste in Alberta (tonnes/year)	2013 Estimated Annual Tonnage of HDPE Sanitation Product Packaging Waste in Alberta (tonnes/year)
Poultry Industry (1)	1.84	1.75
Dairy Industry (2)	1.39	1.40
Hog Industry (3)	0.58	0.56
TOTAL	3.81	3.71

Notes:

1. Calculated based on subject matter expert and farm estimates (Schneider 2019). See Poultry Waste Gen Est tab in Subject Matter Expert Estimations file, available through Appendix B.
2. Calculated based on farm estimates (Sonnevera 2013, updated 2019). See Dairy Waste Gen Est tab in Subject Matter Expert Estimations file, available through Appendix. B.

3. Calculated based on subject matter expert and farm estimates (Beltranena 2019). See Hog Waste Gen Est tab in Subject Matter Expert Estimations file, available through Appendix. B.

4.2 Estimated Paper Waste Tonnages

Paper waste on Alberta farms is comprised of multi-walled paper bags from products like feed, minerals, loose salts and supplements, as well as cardboard packaging from a variety of items including boxed pesticide, twine and secondary waste like cardboard cores used in rolls of silage plastic.

4.2.1 Paper Bags

Paper bag waste on farms originates from products like seed, feed, minerals, loose salts and supplements. Given the vast variety of retailers and suppliers, in combination with reluctance to provide sales estimates, only calculation-based estimates were obtained (Table 10). Using various subject matter and industry experts, the estimated annual tonnage of paper bags ranges from 700 to 930 tonnes. Specifically, dairy, beef, hog and poultry farms were considered in this calculation. Subject matter experts advise that most bags are 25 kg multi-walled paper bags (Yaremcio 2013, updated 2019); however, no statistical verification is available. It should be noted that this estimate may include plain paper, multi-walled, and potentially some polywoven bags.

Other livestock, including goat, sheep, and horses were not included in this or the 2013 study. It is expected that the estimate should be greater than that shown for both 2013 and 2019 and these livestock all require some type of feed, mineral, supplement and salt rations.

Table 10: Annual Alberta Multi-Walled Paper Bag Waste Estimate

Type of Industry	2019 Estimated Annual Tonnage of Bag Packaging Waste in Alberta (1) (tonnes/year)	2013 Estimated Annual Tonnage of Bag Packaging Waste in Alberta (1) (tonnes/year)
Poultry Industry (2)	1.35 to 2.68	1.41 to 2.80
Cattle Industry (3)	247 to 468	221 to 394
Hog Industry (4)	16 to 23	19 to 21
Seed Bags (5)	443	365
Other Bags (5)	20	20
Calculation Based	708 - 930	630 to 815

Notes:

1. Includes plain paper and multi-walled paper bags.
2. Calculated based on subject matter expert and farm estimates (Schneider 2013). See Poultry Waste Gen Est tab in Subject Matter Expert Estimations file, available through Appendix B.
3. Calculated based on farm estimates (Sonnevera 2013, updated Agrirécup 2019). See Beef Bag Waste Gen Est tab in Subject Matter Expert Estimations file, available through Appendix B.
4. Calculated based on subject matter expert and farm estimates (Beltranena 2013). See Hog Waste Gen Est tab in Subject Matter Expert Estimations file, available through Appendix B.
5. Data provided by Agrirécup 2012, updated 2019.

4.2.2 Cardboard Packaging

The estimated total cardboard packaging waste generation per year, is 725 to 880 tonnes. This is less than the actual tonnage produced, since cardboard cores and boxes associated with silage bags and silage covers could not be accurately estimated. Table 11 below shows the different components of cardboard waste generators considered and their respective amounts. For additional details, see Cardboard Waste Gen Est tab in Subject Matter Expert Estimations file, available through Appendix B.

Table 11: Annual Alberta Cardboard Waste Estimate

Associated Product	2019 Estimated Annual Tonnage of Cardboard Waste in Alberta (tonnes/year) (rounded)	2013 Estimated Annual Tonnage of Cardboard Waste in Alberta (tonnes/year) (rounded)
Pesticide Boxes	500	620
Twine Boxes (1)	65 to 130	65 to 130
Bale Wrap Boxes and Cores	100 to 150	40 to 70
Grain Bag Boxes	60 to 100	60 to 70
TOTAL	730 to 880	785 to 890

Note: 1. The amount of twine cardboard packaging reflects the total sales number calculated for twine as the packaging and not the twine for export will likely remain in Alberta.

4.3 Estimated Animal Health Product Packaging

The Canadian Animal Health Institute (CAHI) identified four main types of animal health products packaging: boxboard cartons, paper inserts, glass bottles and plastic bottles. Table 12 lists the estimated quantities of distributed packaging in Alberta in 2016 (CAHI 2013). Please note that these estimates are for distribution only and do not equate to waste generation. Some animal health products have shelf lives longer than 1 year; therefore, it is difficult to estimate how much is used per year and subsequently also impossible to relate distribution figures to

waste generation.

**Table 12: Animal Health Product Packaging Distributed in Alberta in 2012
(CAHI 2013, updated 2019)**

Type of Packaging	Boxboard Cartons (tonnes)	Paper Inserts (tonnes)	Glass Bottles (tonnes)	Plastic Bottles (tonnes)
Quantity (1)	6.5	0.7	76	11

Note: 1. These estimated quantities are for animal health products *distributed* in Alberta in 2012 and do not represent an estimate of waste generation in 2012. This was a one-time study relating to a new program and has not been updated since 2012. CAHI did confirm that the change between 2012 and 2017 was negligible and they are comfortable retaining the 2012 numbers.

5.0 Inclusion of the Legal Production of Cannabis in Alberta

Cannabis in Canada became legal for medicinal use only since 2001. The medical marijuana market was insignificant in size and production was limited and therefore not a significant contribution to the agricultural market. On October 17, 2018, less than a year before this study, the production of marijuana is now legal for both recreational and medicinal purposes which includes cultivation, possession, acquisition and consumption of cannabis and its by-products.

According to Jean Marie Uwizeyimana, agri-food statistician with Alberta Agriculture and Forestry (AF), nationally, the cannabis sector GDP was worth an estimated \$6.6 billion in 2018, up 21.2% from 2017. British Columbia (B.C.) accounted for the largest share at \$2.4 billion or 35.9%, followed by Québec at \$2.1 billion or 32.2%, Ontario at \$1.9 billion or 28.3%. Alberta ranked fourth, accounting for 4.8% of the national cannabis GDP.

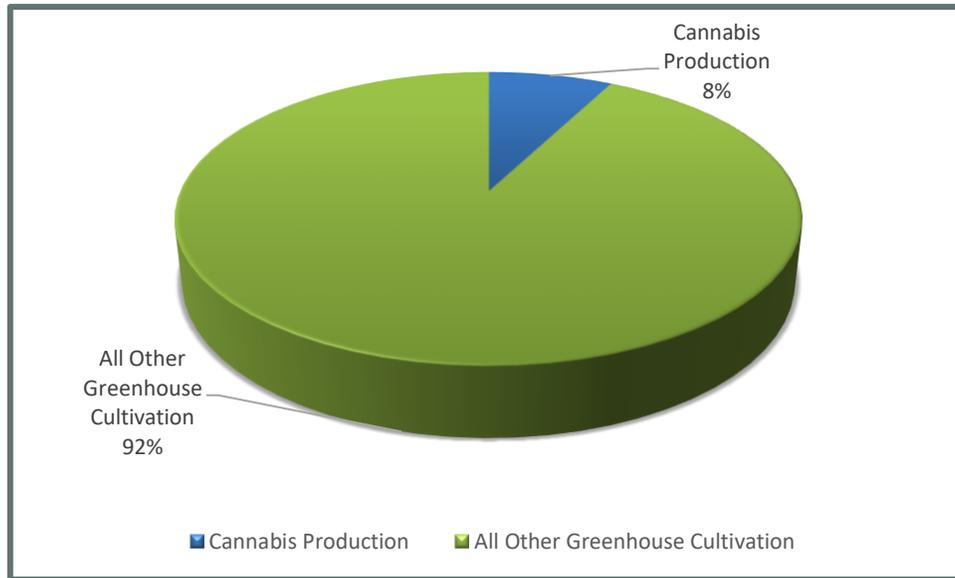


Figure 2: Aurora Cannabis, Edmonton, Alberta

Alberta, having a smaller share of the Cannabis market in total has 1.05 million sq. ft. of greenhouse production for Cannabis cultivation. As there are no studies currently underway to determine the actual amount of acreage or greenhouse capacity, this number has been researched using the internet to identify all cultivators in Alberta and their listed greenhouse capacities.

As 1.05 million sq. ft. is a significant number for Alberta, 7.6%, of the 12.67 million sq. ft. of overall greenhouse under plastic, the waste represented by the Cannabis cultivating greenhouses is included in this study. It should be noted that this is a significant number considering the newness of the legislation and the speed at which these companies came to market for production. There are many more greenhouse expansions planned for Cannabis in all Provinces and it can be expected that this waste generation source will play a significant role in greenhouse waste in the future for Alberta and nationally.

Figure 3: 2019 Current Greenhouse Space Dedicated to Cannabis Production in Alberta



6.0 Summary of Waste Characterization

The following annual tonnages are a compilation of those contained in the previously outlined Estimated Waste Tonnages.

6.1 Plastic Agricultural Waste

Plastic Film Waste	2019 Estimated Total Annual Generation (tonnes) (rounded)		2013 Estimated Total Annual Generation (tonnes) (rounded)	
	Minimum	Maximum	Minimum	Maximum
Bale Wrap	900	1400	550	1400
Grain Bags	1480	2500	700	1800
Greenhouse Film	70	170	60	160
Silage Plastic	1800	2600	1500	2300
Total Ag Film Waste	4250	6670	2810	5660
PP Twine	1320	3000	2000	6000
Net Wrap	400	560	450	700
Polypropylene Totes	520	600	275	300
Pesticide Containers	550	550	620	620
Sanitation Containers	4	4	4	4
Total Other Plastic Ag Waste	2794	4714	3349	7624
Total Plastic Ag Waste	7044	11384	6159	13284

Figure 4: 2019 Agricultural Plastic Waste Breakdown (average)

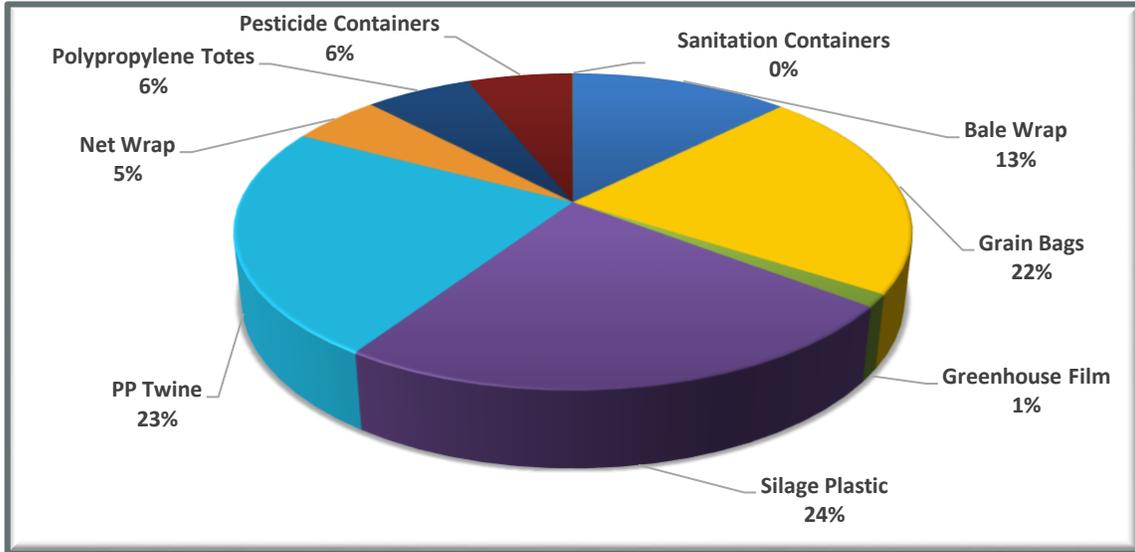
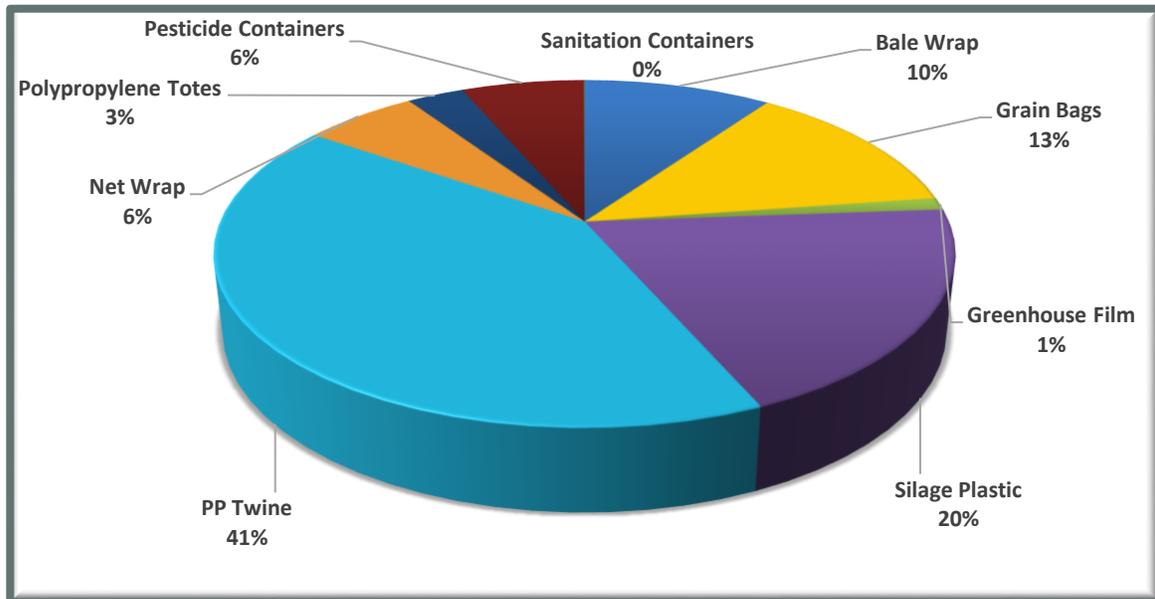


Figure 5: 2013 Plastic Agricultural Waste Breakdown (average)



6.2 Paper Agricultural Waste

Paper Waste	2019 Estimated Total Annual Generation (tonnes)		2013 Estimated Total Annual Generation (tonnes)	
	Minimum	Maximum	Minimum	Maximum
Paper and Multi-Walled Bags	710	930	630	820
Cardboard	730	880	650	800
Total Paper Ag Waste (rounded)	1440	1810	1280	1620

Figure 6: 2019 Paper Agricultural Waste Breakdown (average)

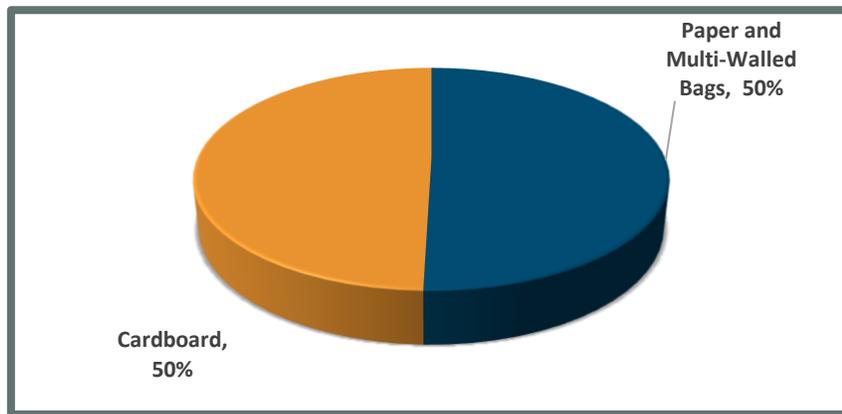
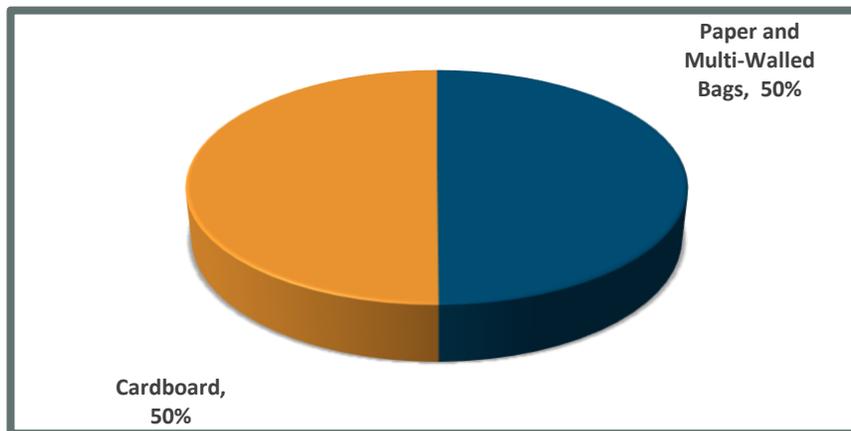


Figure 7: 2013 Paper Agricultural Waste Breakdown (average)





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APPENDICES

Appendix A – Subject Matter Experts Contact List

Industry Experts:

ADM Alliance Nutrition
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Appendix B– 2019 AB Waste Characterization Subject Matter Expert Calculations, Estimations and Unit Weight Estimates

Available upon request. Please contact info@cleanfarms.ca



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Appendix C – References*

Agrisac Inc website. 2019. Accessed August 28 and available online at:

<http://www.agripak2m.com/agrisacen/index.html>

Alberta Agriculture and Rural Development. 2016. Agricultural Statistics Factsheet. Accessed 12 August 2019 and available online at:

<https://open.alberta.ca/dataset/79f01912-5e5c-469e-8cf4-97cfc6901cea/resource/0e45f8e4-031b-4840-811c-88ae0486c9be/download/2016-agriculture-statistics-factsheet-july-2016.pdf>

Alberta Agricultural Statistics Yearbook 2016, available online at:

<https://open.alberta.ca/dataset/da3573a5-465c-4dc1-8793-36e9dc02b775/resource/e371e6dd-429a-4cc5-a00b-ad604cf75b6a/download/agriculture-statistics-yearbook-2016.pdf>

Alberta Agriculture and Rural Development. 2017. 2016 Census of Agriculture for Alberta - Provincial Highlights. Accessed August 2019 and available online at:

<https://open.alberta.ca/publications/census-of-agriculture-provincial-profiles-alberta-farm-and-farm-operator-highlights>

Alberta Agri-Food Statistics Update. Accessed August 2019 and available online at:

<https://open.alberta.ca/dataset/e1b7e388-7b03-4bb9-80eb-64237550ce21/resource/24f2fe23-a628-4f09-83c1-64b285626b75/download/cr16-2-feb8-2017.pdf>

2018 Real Gross Domestic Product for Alberta's Agri-Food Industries Accessed 17 August 2019 and available online at: <https://www.alberta.ca/2018-real-gross-domestic-product-for-Albertas-agri-food-industries.aspx>

Economics of Production and Marketing Greenhouse Crops in Alberta 2017 Available online

at: <https://open.alberta.ca/dataset/fbb2b0b5-53b9-4dbd-92b7-f37ec8ed9369/resource/d074794d-7ec0-4bef-bc93-99a57bbc2cf2/download/2017greenhousecop.pdf>

Cannabis markets and Greenhouse space, <https://www.leafly.ca/news/industry/cannabis-inject-life-alberta-economy>

<https://renx.ca/canadas-cannabis-production-boom-require-millions-square-feet/>

Cannabis Producers Websites:

<https://www.albertacraft.com/>

<https://investor.auroramj.com>

<https://www.boazpharm.com/>

<https://www.canopygrowth.com/>



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Egg Farmers of Alberta, Egg Quota

<https://eggs.ab.ca/industry/egg-quota/>

Other livestock and poultry in Canada

<https://www150.statcan.gc.ca/n1/pub/96-325-x/96-325-x2019001-eng.htm>

Farm numbers fall but some sectors in Alberta buck trend

Alberta lost six per cent of farms overall, according to the latest census, but some sectors see gains

<https://www.albertafarmexpress.ca/2018/03/28/farm-numbers-fall-but-some-sectors-in-alberta-buck-trend/>

Alberta Crop Report Alberta 2016 Crop Season in Review available online at:

<https://open.alberta.ca/dataset/7a221dae-7b04-4da9-8458-8ea135721523/resource/b73b7e98-7093-45b4-ae5b-7ab3be6dd1a3/download/2016-crop-season-in-review.pdf>

Alberta Chicken Producers Market Reports Accessed August 2019 available online at:

<https://www.chicken.ab.ca/market-information/>

Alberta Organic Producers Association Organic Livestock Accessed August 2019 available online at:

http://www.albertaorganicproducers.org/Alberta_Organic_Producers_Farmers/Organic_product_livestock.html://www.chicken.ab.ca/market-information/

Egg Producers of Alberta Sustainability Report 2016 Accessed August 2019 available online

at: https://eggs.ab.ca/assets/2017/03/EFA-2016_Annual_Report.pdf

Effects of the Crop Reporting Cycle on Field Crop Statistics, Accessed August 2019 and

available online at: <https://www150.statcan.gc.ca/n1/pub/21-004-x/2018001/article/00001-eng.htm>

Feedlots 101 Alberta Cattle Feeders Association available online at:

<https://www.cattlefeeders.ca/industry-overview/feedlots-101/>

Highlights of the Alberta Economy 2018

<https://investalberta.ca/publications/highlights-of-the-alberta-economy/>

Grain Bags and Grain Bag Systems, Flaman Agriculture available online at:

<https://www.flamanagriculture.com/grain-bag-system-p587>



Alberta Agricultural Waste Characterization Study Update 2019

6 Sure-Fire Tips for Getting The Most Out of Your Greenhouse Poly, GGS Structures Inc Website, Accessed August 2019, available online at:

<https://ggs-greenhouse.com/blog/surefire-tips-for-getting-the-most-out-of-your-greenhouse-poly>

Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA). 2013. Net Wrap or Twine? Has not been updated since 2013 available online at:

http://www.omafra.gov.on.ca/english/crops/field/news/croptalk/2006/ct_0906a7.htm

Statistics Canada. 2017. 2016 Census of Agriculture: Tables 004-200 to 004-246

<https://www150.statcan.gc.ca/n1/en/type/data?cansim=004-0200,004-0201,004-0202,004-0203,004-0204,004-0205,004-0206,004-0207,004-0208,004-0209,004-0210,004-0211,004-0212,004-0213,004-0214,004-0215,004-0216,004-0217,004-0218,004-0219,004-0220,004-0221,004-0222,004-0223,004-0224,004-0225,004-0226,004-0227,004-0228,004-0229,004-0230,004-0231,004-0232,004-0233,004-0234,004-0235,004-0236,004-0237,004-0238,004-0239,004-0240,004-0241,004-0242,004-0243,004-0244,004-0245,004-0246>

ULINE Shipping Supply Specialists website. 2013. 2.5 Gallon F-Style Jugs - Natural. Accessed August 2019 and available online at: <http://www.uline.ca/Product/Detail/S-12759/Jars-Jugs-and-Bottles/2-1-2- Gallon-F-Style-Jugs-Natural>

UNDERSTANDING GRASS FED AND GRAIN FED BEEF, Canada Beef Website available online at: https://canadabeef.ca/wp-content/uploads/2015/04/3208_CANBEEF_factsheet_NUTRITION-2016.pdf

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