Report

Evaluation of Options for Fraser Valley Poultry Manure Utilization

Prepared for:

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Executive Summary

The poultry industry in British Columbia is rapidly increasing in size. Handling and disposal of poultry manure has become an issue in the Lower Mainland, where most of the industry is located. The poultry industry produced 745,000 cubic yards, or about 240,000 tonnes, of manure in 2001 and expects to produce an additional 80,000 tonnes of manure annually by 2010, for a total of 320,000 tonnes annually. This is based on industry and government provided estimated growth figures of 3% per year for the feather industry as a whole. The four "feather associations", Broiler Hatching Egg Producers' Association, BC Chicken Growers Association, BC Turkey Association and the Fraser Valley Egg Producers' Association, commissioned Timmenga & Associates Inc. to conduct a review of technologies and practices for handling and beneficial reuse of poultry manure produced in the Lower Mainland of BC. From the producers' side, this effort was coordinated through the Sustainable Poultry Farming Group.

Approach

The work undertaken included expert interviews with members of the industry, government agency staff, researchers, and developers of technology. As well, an extensive Internet search and literature review was also conducted. Based on available data on livestock numbers, crop acreage, and crop needs, nutrient balances were constructed for the Lower Mainland and the Thompson-Okanagan Region.

Capacity of Land base

The results of the study show that a large nutrient surplus existed in the Lower Mainland in 2001 for the three primary nutrients; nitrogen, phosphorus and potassium of 4,000 tonnes, 5,700 tonnes and 7,300 tonnes respectively. The size of this surplus, which does not include chemical fertilizer, was similar to the amount of nutrients produced by the poultry industry. The poultry industry is currently the largest source of manure-based nitrogen and phosphorus in the Lower Mainland. The dairy industry is the largest source of potassium. When nutrients from chemical sources are included, the nutrient supply in the Lower Mainland is about twice the crop need. The Lower Mainland manure based nutrient surplus, is expected to grow by 37% for nitrogen, 23% for phosphorus and 2% for potassium by 2010. This anticipated growth is entirely based on increased production by the poultry industry.

The Thompson-Okanagan Region in 2001 had a manure based nutrient deficit, primarily in phosphorus and potassium. In 2010 it is expected that due to changes in cropping patterns and manure supply, this deficit will be reduced slightly. The nutrient deficit is mainly related to the need for these nutrients by alfalfa and alfalfa-grass forage, the main crops grown. Alfalfa growers in the Thompson-Okanagan Region, and also in the Caribou Region, could use significant quantities of poultry manure as fertilizer, if marketed in a convenient form and available at an acceptable price. The Thompson-Okanagan Region could absorb between 15,000 and 125,000 tonnes of raw and pelletized manure, depending on the perceived value of the raw or processed poultry manure and on transportation and distribution costs. Transportation subsidies may be required.

Other factors affecting manure utilization

Several future trends are likely to affect the application of manure-based nutrients on land in British Columbia. The Environmental Farm Plan Program, expected to be in place within a year, would decrease the amount of nutrients applied in crop production by as much as 50%. This would result in the need for twice as much land to absorb the present level of manure application, or for the development of alternatives to land applications.

Introduction of amino acid and phytase amended, or micronized feed could reduce the nitrogen and phosphorus content of manure by 20-30% depending on the type of feed ingredients in the ratio. Excretion of potassium cannot yet be regulated with feed additives, and may become the limiting factor in the use of poultry manure as a source of nutrients. Phytase containing feed can be made available in the Lower Mainland and has been integrated in the layer sector. Due to different feed content, different economics, and required expensive feed processing, phytase has not been integrated in the broiler and turkey sectors to a significant extend. Amino acid enriched feed could also be made available, but sufficient testing capacity for analysis of amino acids in feed ingredients, does not presently exist in the Lower Mainland to facilitate large-scale adoption of such feed.

Local market for value-added product

In the Lower Mainland, poultry manure appears to be a low value product, while in some other North American jurisdictions, processed and/or blended poultry manure products command prices above the perceived nutrient value. Although the need for such blended or pelletized manure is limited locally, markets do exist elsewhere. Due to the added value, specialized or “designer” products can be transported over longer distances. The Lower Mainland poultry industry could support a pelletizing facility, producing custom blended product. Such value-added products could find a niche in the turf care market, the residential market, and in other commercial markets requiring custom blended products. The success of a pelletizing plant would depend on the value or perceived value of a poultry manure product in each of the target markets.

The mushroom industry envisions a significant increase in production that would result in a doubling of its demand for poultry manure. Further, the growing organic industry in BC would be able to absorb composted poultry manure. Combined, the future custom blended products market, the mushroom industry, and the compost market offer significant demand growth (60,000tonnes) for poultry manure between 2001 and 2010. However, this “basket of smaller options” will not be sufficient to absorb all of the increase, and other methods of manure disposal are also required. If in fact, the Environmental Farm Plan Program results in a significant decline in the application of poultry manure in the Lower Mainland, the volume of manure that will have to be transported to other regions, or find other applications could be in the order of 300,000 tonnes.

Technology solutions

Technologies that remove manure and nutrients from the land base would be preferred in “solving the manure challenge”. Large-scale operations for generation of electrical power or for producing pelleted manure are probably not economically viable in the Lower Mainland. In some other jurisdictions, such facilities receive significant financial support and relaxed regulations that are not available in BC.

Small-scale technologies such as on-farm gasification of raw or processed poultry manure could be a cost-effective solution to transform poultry manure into heat and energy rich products such as charcoal. These systems should be installed in conjunction with agricultural facilities requiring large quantities of heat such as greenhouses. Depending on the price of natural gas, the current source of energy, this could be a cost-effective solution for both the poultry industry and the greenhouses in the Lower Mainland. On-farm gasification could absorb a significant portion or all of the additional poultry manure produced in the Lower Mainland by 2010. After environmental assessment and testing, and review of economic feasibility, this technology is likely to be economically feasible and capable of meeting strict environmental emission standards. Using a cluster approach, where several poultry producers supply one large greenhouse, its introduction can be incremental, as each cluster might absorb on average 24,000 tonnes of poultry manure. Cost for equipment would be included in the heating costs for the greenhouse, and any downstream benefits, such as the sale of charcoal would produce an additional revenue stream. Smaller greenhouses can also use charcoal for space heating. This would require a specialized boiler that can operate at high temperatures. The economic feasibility of this option is tied to the price of natural gas, the current fuel used in greenhouses. With the price of natural gas expected to increase over the medium term, poultry manure could become a lower cost fuel for the greenhouse industry. This might well be a cost-effective solution for both the poultry growers and the greenhouse operators.

Suitable options

Based on our review of options for Fraser Valley Poultry Manure utilization, we conclude that several options are available to absorb the additional manure generated between now and 2010 (about 80,000tonnes), and also to absorb some or all of the poultry manure produced in 2010 (about 320,000tonnes). Further, we conclude that a selected strategy should be multi-pronged, and should include the transportation of raw manure from the Lower Mainland, the production of customized fertilizer and value-added products, the use of manure as a source of energy, the development of ways to increase the value of the produced manure through selection of supplier, and incorporation of feed additives. Selected options include:

- The Basket Approach
- Shipment to the Thompson-Okanagan (raw and pelletized or granulated)
- On-farm or small scale gasification (raw), and
- Marketing of “designer” fertilizers, custom blended and pelletized or granulated.

These options could be supported by providing poultry with feed enriched with amino acids or phytase, and by establishing manure pelletizing or granulating capacity in the Lower Mainland.

Some lower volume options within the basket approach such as composting, demand from the mushroom industry, and regular pelletizing would also absorb increased volumes of poultry manure, but their total demand would not be sufficient to absorb all of the additional production of manure expected between now and 2010. A “Business as Usual” strategy will not lead to a reduction of poultry manure in the Lower Mainland, an area already over supplied with nutrients. Therefore, even in the most limited case, the Basket approach needs to include the shipping raw manure to the Thompson-Okanagan, combined with the other options. Should larger amounts need to be removed from the Lower Mainland then a combination of pelletizing/granulating, such as the proposed YK pelletizing plant and the greenhouse gasification option would absorb all of the additional poultry manure produced. The gasification option is flexible as total volume removed will be based on establishing between 5 and 7 independent facilities.

The identified options are all environmentally friendly, as they remove poultry manure, as fertilizer, from the region, and do not produce harmful by-products or emissions that cannot be controlled. The option of shipment to the Thompson-Okanagan likely requires support from the industry or the consumers, while the other options including the enrichment of feed, are cost neutral or are expected to generate revenue. Table A, below, provides an overview of selected options, their volume and roughly estimated cost/revenue

Table A: Selected Options, their volume and estimated costs/revenues.

Option	Potential tonnage	Estimated cost $/tonne	Estimated revenue $/tonne	Estimated revenue to program ($/tonne)
Basket Option	20,000 – 35,000	12 - 60	12-250	0 - 190
Raw Manure to Okanagan	15,000 – 25,000	18-36	14-28	(22) - 10
Pelleted manure to Okanagan	25,000 – 125,000	73	30 - 118	(43) - 45
Raw manure in gasifier (clusters)	up to 245,000 tonnes	12	12-62	0-50
Granulated fortified manure (designer fertilizer, specialty market, local and removed).	10,000 – 125,000	160 - 210	250 – 350	90 – 140

Recommendations for Phase II

We recommend further investigating, in a following Phase of this review, the following options and supporting programs:

- Shipment to the Thompson-Okanagan of both raw and pelletized/granulated poultry manure;
- Small scale gasification to support the heating needs of greenhouses;
- Establishing a pelletizing mill or granulating plant in the Lower Mainland to produce customized fertilizer blends;
- Introducing amino acids and phytase to poultry feed to lower the nutrient content of poultry manure in light of the needs of the three options for manure disposal; and
- Developing funding sources to support the development of options, and revenue streams including carbon credits, support for research and demonstration, industry funding and "eco-fee" funding.

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1.0 Introduction

The poultry industry in BC has had a history of strong growth that is expected to continue through 2010. This industry is a large producer of animal manure. Industry growth resulted in an increase in manure production from 465,000 cubic yards in 1991 to 745,000 cubic yards in 2001. Future manure production is expected to increase to 993,000 cubic yards annually by 2010. That increase is equivalent to approximately 80,000 tonnes of low analysis material, apparently with low commercial value. In addition, the probable future implementation of a nutrient management program designed to protect the environment by reducing nutrient run-off and ground water pollution is likely to result in the more efficient use of fertilizer in the Lower Mainland. This could substantially increase the volume of Lower Mainland manure that must find alternative markets.

Historically, poultry manure has been disposed of on land near production areas. The continued application of poultry manure on cropland near poultry production areas at the present level is not considered sustainable for the following reasons:

- the land base suitable for receiving poultry manure is finite
- land use changes are reducing the land available for application
- vegetable farmers are shifting away from fresh manure due to heightened food safety concerns expressed by retailers and consumers
- a proposed nutrient management program will probably restrict the application of manure products.

The increase in manure produced is of great concern to the poultry industry which has been experiencing increased difficulties in marketing its surplus products. The poultry industry cooperates within the Sustainable Poultry Farming Group (SPFG). The SPFG has been advising producers on manure handling and has been marketing manure to crop producers in areas outside the immediate area of poultry production. The SPFG has made great strides in developing markets for poultry manure generated in the heart of the Fraser Valley. Raw poultry manure is now shipped beyond the immediate poultry production area. In the last 5 years the group has increased this market to 40,000 cubic yards, or 5% of the total production. Manure is now transported to cropland in Delta, and in the Interior of BC. However, this transport and use of poultry manure, while significant, has not offset the growth in generation of manure during the same period. Neither transport of manure to other areas nor a potential increase in use in mushroom compost is expected to offset all additional generation of manure expected through 2010.

The poultry industry wished to review available options for handling and disposal of manure. Through funding obtained by the four “feather associations”: the Broiler Hatching Egg Producers’ Association, the BC Chicken Growers Association, the BC Turkey Association, and the Fraser Valley Egg Producers’ Association, the industry commissioned Timmenga & Associates Inc., to conduct a review of technologies and practices for handling and beneficial reuse of poultry manure produced in the Lower Mainland of BC. From the producers’ side, this effort was coordinated through the Sustainable Poultry Farming Group.

1.1 Objectives

New technologies, and (re)development of markets that currently absorb poultry manure may provide options to accommodate the increase in poultry manure needing environmentally sound disposal through 2010 and beyond. The objectives of this study are to:

- Review possible options to handle, utilize, and dispose of poultry manure from Fraser Valley poultry farms, with regard to technical feasibility and economic viability
- Identify the merits and disadvantages, and estimate the amount of manure that could be utilized by each potential solution
- Rank each option and provide a shortlist or strategy for options to be investigated in Phase II of this project
- Identify mechanisms for funding and managing the selected option(s) recommended for Phase II investigation.

1.2 Report Organization

This report is organized into sections as follows:

- Review and assessment of available data on manure production
- Description of current trends and potential new trends in poultry production, manure handling, and environmental regulations; how they are likely to affect the quality and quantity of manure produced; and how manure utilization will be affected
- Investigation of where surplus manure could be utilized based on land use and cropping pattern
- Review of technical solutions
- Assessment of all viable options, suggested strategy, and recommendations for further studies in a Phase II assessment.

2.0 Methods

To meet the objectives as outlined above, Timmenga & Associates Inc. developed an integrated methodology to obtain and review the required information. Through this methodology, we have attempted to identify the merits and disadvantages and the potential volume of Fraser Valley poultry manure that each identified option might account for, to rank each option, and identify possible funding and methods.

2.1 Identification of Options

The method for identification of manure handling options included several ways to obtain information. The method included a series of "expert interviews" with leaders in the industry and government. Identification of options included:

- interviews with industry leaders
- interviews with BC Ministry of Agriculture Staff
- interviews with leaders in the supply industry
- interviews with developers of technologies
- extensive internet search and literature review of newspaper articles, peer reviewed publications, government publication, minutes of meetings, and data from the Census of Agriculture of 1991, 1996, and 2001 Reports for 1990,1995 and 2000, respectively
- Applicable BC and Federal legislation.

The work undertaken includes a review of a study published in 1995. Aspects of marketing value-added products made from poultry manure were researched by our team members some years ago and were reported in the Marketing Plan for Pelleted and Crumbled Composted Poultry Manure[1]. This report estimated the market for pelletized manure in BC.

2.2 Evaluation of Options

Identified possible options were evaluated for their suitability to reduce the impact of surplus manure on the environment. Each option was tested against three major criteria. These criteria were designed to ensure that the options evaluated are likely to be viable and sustainable in the long run. The three criteria used are as follows:

What volume of manure is this technology or market option potentially able to absorb over the next 8 years?

The purpose of the review is to provide solutions for the increased volume. Small scale solutions, or options that provide a one-time limited market or a market without growth, can provide benefits to the Poultry Industry, as they either can be used as a "filler" solution, or added to a basket of solutions. These options are important and may require more study. However, they may not provide a significant

[1] Zbeetnoff Consulting, DH. Lauriente Consultants Ltd. and View West Marketing Inc., 1995. Marketing Plan for Pelleted and Crumbled Composted Poultry Manure Product. Consultants Report to Environment Canada – Fraser River Action Plan. DOE FRAP 1995-13

solution to the Industry individually on which to build future growth. We have included this criterion to ensure growth potential for the industry.

Will this technology or market option present a "complete" or "sustainable" solution, meaning that no residual materials need to be handled or disposed of?

Several technical solutions are available where a portion of the manure is extracted, and residual materials need to be processed further or require disposal. For instance, using unprocessed manure, processed manure or compost in agricultural or horticultural applications would fulfill the criteria without further evaluation. Anaerobic digestion of (wetted) manure, or extraction of chemicals, would need further evaluation under this criteria, because both technologies create a residual stream of sludge or rejected material, even though the primary product may create both economic and environmental benefits. We have included this criterion to ensure that an option does not generate unacceptable environmental challenges.

Will the technology or market option provide an environmental benefit?

Technical and marketing solutions can provide environmental benefits or pose environmental risks. We assessed the environmental benefits and risks for all options. Only options providing environmental benefits are recommended for a Phase II evaluation.

Financial criteria are important in the evaluation of options. However, we believe that even though some options may be more expensive than others, capital costs and operating costs are mostly depended on scale and market pull, and they therefore may be viable. A solution with a high cost today, may be a cost effective one tomorrow, or could attract future "carbon credits" to finance the facility. Therefore we have not included financial criteria in the "make or break" category of criteria.

This report was specifically written to assess manure handling and disposal methods for poultry manure produced in the Lower Mainland of BC. The study area encompasses the Fraser Valley from the mouth of the Fraser River to Hope. The terms "Fraser Valley" and Lower Mainland are used interchangeable in this study and mean the area between Vancouver and Hope, not withstanding the fact that the majority of the poultry industry is located between Aldergrove and Chilliwack. All land use statistics and animal density statistics used cover the entire Lower Mainland.

In this review we have used the metric system and quoted volumes of manure and of nutrients in metric tonnes (tonnes), and prices in Canadian dollars. Where applicable we have kept short tons (tons) and US$ to indicate that volume and prices were obtained from US sources. As the industry mostly uses "acres", " short tons" (tons), and "cubic yards" in their discussions, we have kept these units and only translated to "hectares" and "tonnes" where required for clarity of presentation.

3.0 Results

This section is divided into several topics. First the volume and the quality of poultry manure produced in the Fraser Valley will be described. Then we present the results of an assessment of trends that may affect the total manure production in the study area, as well as an assessment of trends that could affect the use of manure. We also compare the volume of all manure produced in the study area with the "market", the demand from crops grown in the Lower Mainland and the Thompson-Okanagan Regions. An analysis of technical solutions for handling and disposal of poultry manure follows the market analysis for raw manure. Technical solutions include large-scale operations such as centralized pelletizing, power generation and others, and small scale operations.

3.1 Volume, Quality and Value of Poultry Manure in the Lower Mainland

The poultry industry in BC has had a long history of growth that will likely continue in the future. According to industry sources, industry growth resulted in the increase in manure production from 465,000 cubic yards in 1991 to 745,000 cubic yards in 2001. Production is expected to increase to 993,000 cubic yards by 2010. The current production of 745,000 cubic yards is the equivalent of about 240,000 metric tonnes, using a calculated average bulk density of 717lbs/cubic yard and a conversion of 2204.6 lbs/tonne. By 2010, poultry manure production will increase by about 80,000 tonnes, reaching a volume of about 320,000 tonnes annually. Industry growth estimates were provided by the BC Ministry of Agriculture, Food and Fisheries and the Sustainable Poultry Farming Group and were neither endorsed nor disputed by our team. The Ministry used a conservative growth rate of 3% in their projections for broilers and hatching eggs, while the growth rates over the last 10 years were approximately 7.6% for the broiler sector, and 5.7% for the hatching egg sector.. Growth rates for the last 10 years were 2% in the turkey sector and 0.9% in the egg sector. These growth rates were also used to estimate future growth. The industry indicated that in 2002 growth rates were lower than the average historical growth. In addition, the recent national allocation to the broiler producers in BC for the next period of production has been reduced to levels below last year's levels. After corrections, growth is expected to return back to the historic levels.

Most of the manure consists of broiler and turkey litter, a mixture of manure and bedding, and of layer manure. This study deals with manure from chicken and turkey operations only. Manure generated by duck, geese, quail, squab, pheasant, partridge and ostrich/emu operations were not included in the estimate as their total amount is insignificant compared to the manure volume generated by broiler, layer and turkey operations.

Most of the available estimates for manure production in the Province are based on spot samples taken about 10 years ago. These relatively crude data have been used to estimate the volume and nutrient content of manure production in 2001. The 2001 estimates, therefore, do not take into account any of the changes that may have occurred in the meantime in animal feed technology, materials handling & storage, etc. As a result, this analysis is a subjective, rather than quantitative, exercise.

3.1.1 Volume of Poultry Manure produced in Lower Mainland

The volume and weight of manure generated by poultry varies substantially due to several factors, including bird type, litter management, and feed and water systems. Nevertheless, the volume of manure produced by the Lower Mainland poultry industry can be estimated in several ways. The Sustainable Poultry Farming Group calculated the volume of produced manure based on broiler and turkey production numbers (slaughtered animals), and on egg production, assigning a specific volume of manure production to each bird produced or each laying hen. The University of North Carolina and the North Carolina Department of Agriculture[2] developed an alternative system for estimating animal manure. This system is based on animal inventory, an average weight for the animal inventory, as well as manure excretion rates based on empirical data for each production category. In this model, for instance, a broiler in inventory has an average weight of 2lbs, which accounts for the difference between pullets and slaughter animals, and laying hens have an average weight of 4lbs. The manure excretion rates vary considerably. For instance broilers produce 1.52lb of manure and litter per growth cycle of 37 days (with 6.5 cycles a year, production is 9.88 lbs/year), while hens produce 102lbs of manure annually.

The Lower Mainland data for poultry manure in the following table are based on information supplied by the Sustainable Poultry Farming Group. Data for the Thompson-Okanagan region are directly based on the Lower Mainland data adjusted by the relative livestock inventory numbers from the Statistics Canada Census of Agriculture results from the 2001 Census. The estimated poultry manure volumes and nutrient contents were verified by comparison with information from North Carolina, NRCS, and the University of Kentucky.

It is possible, based on our analysis of the data, that the volume of Turkey manure produced in BC may be overstated by a factor of approximately three times. The possibility was suggested by comparison with the data from North Carolina, and at least partially confirmed by a crude feed balance analysis based on data given to the BC Ministry of Agriculture, Food & Fisheries by local feed suppliers. Should the volume of turkey manure be overestimated, this would affect the total manure volume for the Lower Mainland, which would be reduced by 15%, and for the Thompson-Okanagan, which would be reduced by 4%. Our estimates are based on a margin of error of 25% and the effect of overestimating turkey manure would be within this margin of error.

3.1.2 Characteristics of Poultry Manure produced in the Lower Mainland

The nutrient characteristics of poultry manure can vary significantly with the type of manure and the production system. In general, broiler and turkey manure consist of excrement and bedding, resulting in a relatively dry carbon rich product. Layer manure normally does not contain bedding and therefore contains more moisture. The Sustainable Poultry Farming Group undertook an inventory of nutrient characteristics of manure produced in the Lower Mainland in 1992-1993. Their findings are incorporated in Table 1.

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[2] Barker, J.C., S.C. Hodges and F.R.Wall, 2001. Livestock manure production rates and nutrient content. In: 2002 North Carolina Agricultural Chemicals Manual. http://ipmwww.ncsu.edu/agchem/chptr10/1011.PDF

Table 1: Poultry Manure produced in the Lower Mainland and Thompson –Okanagan (2000)

	Production Estimate			Nutrient tonnes			Nutrient Analysis			
	Cy/yr	Lb/cy	Tonne/yr	N	P2O5	K2O	%N	%P2O5	%K2O	%H20
Lower Mainland										
Chicken	421,988	650	124,418	4,317	3,110	1,928	3.47	2.50	1.55	22.3
Turkey	144,521	780	54,670	1,635	1,551	787	2.99	2.84	1.44	33.2
Commercial Egg	103,498	849	39,858	861	1,168	414	2.16	2.93	1.29	50.7
Hatching egg	64,958	792	23,336	457	700	280	1.96	3.00	1.20	46.0
Total	**744,965**	**717**	**242,282**	**7,270**	**6,531**	**3,514**	**3.00**	**2.70**	**1.45**	**31.7**
Thompson-Okanagan										
Chicken	50,756	650	14,965	519	374	232	3.47	2.50	1.55	22.3
Turkey	4,053	780	1,434	43	41	21	2.99	2.84	1.44	33.3
Commercial Egg	10,677	849	4,112	89	120	53	2.16	2.93	1.29	50.7
Hatching Egg	6,105	792	2,193	43	66	26	1.96	3.00	1.20	46.0
Total	**71,591**	**699**	**22,704**	**694**	**601**	**332**	**3.06**	**2.65**	**1.46**	**30.4**

3.1.3 Potential Value of Poultry Manure produced in the Lower Mainland

Poultry manure is currently considered a low value fertilizer material. Crop producers receive the manure for trucking costs or less than trucking costs. While delivery costs are less than $20/tonne in the Lower Mainland and are $14-24/tonne or more in the Interior, the implicit fertilizer value of the manure is somewhat higher, based on which nutrients that are present. Table 2 presents the calculated fertilizer value, based on current (3Q 2002) prices for nutrients. Poultry manure is discounted in comparison to chemical fertilizer for various reasons, including difficulty of handling, availability, specific storage requirements, nutrient imbalance, etc. We have investigated how characteristics of poultry manure could affect its agricultural value. The agricultural value is the value remaining when reactions of nutrients with soil and plants are taken into account but does not include losses in the barn. (i.e. the nutrient analysis data are "barn door" data). The reactions could include reduced uptake in first year after application (N), soil absorption (P and K) and others. We have not considered second or multiple year effects. Such effects may increase the value somewhat as an investment is being made in the soil. Literature review and discussions with local scientists show that some nitrogen will be lost during application. The loss of nitrogen is greatest without incorporation into the soil (50%), and lowest when the poultry manure is incorporated immediately (0%). In our calculation of poultry manure value we used an application loss of 20%, reflecting incorporation within 48 hours. This may underestimate the nitrogen loss when poultry manure is applied to grass or forage land. Under grassland conditions, half of the ammonia may volatilize, thus reducing the nitrogen value of the manure. However, when poultry manure is used on forage containing alfalfa, a low nitrogen content is more beneficial, and the overall value of the manure would not decrease. On the other hand, the SPFG reported that poultry manure from the Lower Mainland contained 20% of nitrogen in the form of ammonia. Should nitrogen be lost during and after application, the maximum nitrogen loss would be 20%, as ammonia is likely the compound that is lost rapidly from applied manure. The application losses, even in grassland situations would not be greater than 20% of the total manure nitrogen content. The reduction in agricultural value of poultry manure would not be more than implied in our calculations.

Phosphorus tends to adsorb on the soil particles or is complexed with other soil chemicals, resulting in a first year application discount of about 30%. Essentially all of the potassium is available for plant uptake. Opinions on the reduction in first year's effectiveness of micronutrients vary. This reduction in activity can be 40-60% for first year's use[3], but is sometimes considered very low[4]. We used the reduction in availability as outlined in the latest literature reports (see footnote 3) to be on the conservative side. The reduction in sulfur availability is based on research done in Alabama. All calculations are based on current dealer costs for the Lower Mainland. Actual farmer prices are substantially higher, as retail mark-up and product premium are not incorporated in the cited agricultural value. Farm prices may be twice the dealer costs.

Table 2: Calculated first year value for poultry manure (3-3-1.5) based on nutrient content; includes dealer costs.

Nutrient included in Calculation	Nutrient value ($/tonne), dealer costs	Agricultural value ($/tonne), dealer costs
Raw manure delivered	$10 – 12 ($3.50/cubic yard)	$10 – 12 ($3.50/cubic yard)
Nitrogen only	$19.75	15.65
N-P-K	$40.62	33.68
N-P-K plus secondary & micro nutrients	$88.35	59.13

3.2 Trends Affecting Value and Quality of Poultry

The production of poultry manure in the Lower Mainland, and in any poultry producing area in Canada, will be affected by technological innovations and by market pressures. In this section we will address the change in bedding materials and feed ratio including the use of additives, and market pressures such as free trade and consumer preferences.

3.2.1 Change in Bedding

Numerous types of bedding have been used in broiler and turkey production, ranging from sand, shavings of white wood (mostly used in BC), cedar shavings, peat moss, compost, short fiber residual (paper fiber from pulp and paper mills), straw, recycled paper and newsprint and specialty wood based products. These bedding products absorb the moisture in excrements, and based on absorption capacity of the bedding, more or less volume of "manure" is generated. The amounts of nutrients in the soiled bedding, the limiting factor in land application, only changes marginally as all excrements are collected in the bedding. Composting of soiled bedding and then reuse of the resulting compost in the barn will reduce the total volume of manure significantly, but not the total amount of nutrients contained in the bedding. This will also be the case when bedding is kept for more than one production cycle. A change in bedding, or recycling of bedding will not affect the acreage required for land disposal. Adopting different bedding materials will not be a significant factor in reducing the manure surplus in the Lower Mainland. It might, however, have some beneficial impact on the volume and nutrient analysis of the material.

[3] B. Eghball, B.J. Wienhold, J.E. Gilley, and R.A. Eigenberg, 2002. Mineralization of manure nutrients. J. Soil and Water Conservation, Vol.57, No. 6.
[4] Dr. John Paul, Personal Communication, 2003.

3.2.2 Change in Feed Ratio/ Use of Additives

Several additives have been developed to improve the feed conversion ratio in livestock. These feed additives include antibiotics, organic acids, and enzymes. Both antibiotics and organic acids will increase the feed conversion ratio by 8-10%. In a recent study, no difference was found between addition of organic acids (at 5kg/ton) and antibiotics (10ppm)[5]. Both provided an increased feed conversion ratio of 8-10%. This means a reduction of nutrients produced per bird of about 10%. Other methods are being developed to change the animal diets and reduce the release of nitrogen and phosphorus to the environment. The impact on potash appears to be minimal. The impact of more efficient feed practices would appear to have a negative affect on the commercial value of the manure by reducing its nutrient content.

In order to reduce the amount of nitrogen and phosphorus excreted by poultry, several feeding programs have been investigated. These included:

- To feed most digestible ingredients economically possible
- To increase phase-feeding (change in diet with increasing age of birds)
- To feed male and female broilers separately
- To decrease the margins of safety in the concentrations, and
- To feed for maximum economic benefit rather than to manage manure characteristics or for performance.

Perhaps some combination of bedding practice and improved feed efficiency may result in a reduced volume of manure with the same, or even enhanced analysis of fertilizer nutrients.

[5] Van Camphout,L., J. Vanhemel, J. Vanderkerckhoven, K.Mollen, B.Sas, 2001. Performance of an Alternative to Antibiotics in Broilers with high intestinal counts of Clostridium. 13th Eur. Symp. Poult. Nutr. http://www.kemin.com/europe/other/images/broiler.pdf

Reduction of Nitrogen

Specific feeding trials have been performed to reduce the nitrogen levels in poultry manure. These trials are based on the theory to feed the animal what it needs at the time it needs it most. This can be done through feeding the "correct proteins". The "ideal protein" concept, using lysine as the reference amino acid, achieves a balance of indispensable amino acids that exactly meets the animal's requirements with no deficiencies or excesses. US studies indicated that feeding poultry diets that are 2 to 6 percentage units lower in protein and supplemented with amino acids decreased N excretion by as much as 30 to 40%. Generally, it is believed that lysine lowers manure nitrogen content by 7 %, and adding a complete slate of amino acids including methionine, lysine, threonine, tryptophane and isoleucine, will lower the manure nitrogen content with up to 30%. A research project that was conducted in the Lower Mainland by Agriculture Canada a few years ago, showed a 27.2% reduction in N excreted over a six weeks rearing period in broilers when protein levels of starter feed were reduced from 24% to 21% and in the grower diet from 21% to 18% with supplemental amino acids. Reduction in the crude protein level of laying hens from 17 to 13.5% resulted in a 30 – 35% reduction in daily N output per layer. Adding all amino acids to the feed may not be economical in current poultry operations[6]. In combination with other methods, Nitrogen in manure could be decreased by 35% or more[7].

Not much credible information is available for measuring amino acids in poultry diets in North America. To generate this information expensive technical testing facilities are required. Such testing facility is also required for routine analysis of feed ingredients for the purpose of balancing amino acid contents in feed[8].

Reduction of Phosphorus

Poultry lack sufficient intestinal enzyme (phytase) to release phosphorus from phytate, and thus from feed. As a result, feeding with phytase increases phytate P availability and allows a decrease in the amount of inorganic P that is required in poultry diets. The use of feed additives (phytase, vitamin D3 metabolites and organic acids) to free up phytate P will reduce the inorganic P in the diet. Several companies market phytase for use in poultry and pig feed, including DSM, BASF and Roche. In poultry (both broilers and layers) the manure phosphate content will be reduced by 20 - 30% due to the increased phosphorus uptake from feed and therefore, reduces the amount required in feed. A reduction in nitrogen in manure is between 1 and 3 % is also reported. The Agriculture Canada study showed that with the use of phytase in layer diets with reduced dietary calcium and phosphorus, the P output was 34.9% lower compared to the control. The levels of phosphorus in broiler manure was only reduced by 1%[9].

Phytase has generally been adopted for use in layer feed ratios. Locally, about 50% of the layers consume phytase, mostly due to the type of feed used. In the US, also broiler and turkey feed, which is mostly soy based, is amended with phytase in a granulated form. The enzyme has not been adopted in the broiler and turkey sectors in the Lower Mainland, mainly because broiler and turkey feed here includes animal byproducts such as meat meal and bone meal as a source of phosphorus. This source of phosphorus is making the use of phytase less economical, as phosphorus added in animal byproducts is readily available to the animals Further, phytase is heat sensitive and needs to be applied after pelletizing to keep its activity. This requires additional expensive processing when certain types of feed ingredients are used that need heat for processing, making it less economical to use.

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[6] H. John Kuhl, Jr., Ph.D. Personal communication.

[7] Stew Paulson, BCMAFF, Personal communication.

[8] Thom Scott, Agriculture and Agrifood Canada, Personal Communication

[9] Stew Paulson, BCMAFF, Personal communication.

The environmental benefit of phytase is in the reduction phosphorus in the waste. Combining all methods for reduction of phosphorus in manure could reduce the amount of P excreted by at least 30%, with a longer-term goal of 60% reduction, depending on the type of feed used. The research done in the Lower Mainland showed that the benefits of introducing phytase or the cost-effectiveness of its use may not be as high or as profitable depending on the feed source and feed ingredients used.

Reduction of Potassium

Not much information is available regarding methods for reduction of potassium in manure. In the dairy industry where high potassium intake is linked to “grass tetany”, producers search for low potassium feed. At this time no information was found regarding feed additives that can increase the animal’s uptake of potassium, or reduce potassium excretion. This may be a field for further research.

Other methods to reduce nutrient content of manure

Feeding grains and legumes in a different form may also affect the uptake of nutrients and thus their excretion in manure. The University of Manitoba is experimenting with a process of micronizing feed, primarily pulse, in the rations for hogs. This process will make nutrients more available so a lesser quality feed or a lower quantity can be used, thus the amount of nutrients in the waste will be lower. The University reports that nitrogen content of waste will be reduced by 16% while the phosphorus contend decreases with 20%. No decreases for potassium were mentioned. Decrease in waste potassium concentrations could be similar.

3.2.3 Market Size for Poultry/Eggs in Canada and North America - NAFTA

The market size for domestically produced poultry and eggs in Canada may be affected by free trade agreements as well as by international trade negotiations. The outcome of these negotiations may affect production of poultry and eggs in the Fraser Valley and thus affect the amount of manure produced. In January 1995 as part of the Uruguay Round, the WTO required Canada to tariffy non-tariff quantitative import restrictions in its supply managed products, including dairy, chicken, turkey, table eggs and broiler hatching eggs. As part of the WTO Agreement, members were required to reduce tariffs on agricultural goods by 36% over six years with a minimum reduction of 15% for each tariff line.

Historical levels of imports of supply managed products entering Canada within the Tariff Rate Quota (TRQ) were subject to low rates of duty that were eliminated by 1998 as part of Canada's obligations under the North American Free Trade Agreement (NAFTA). However, the TRQ for each commodity is small in relation to the overall domestic market. As of October, 2002, Canada has allowed Brazilian chicken to enter the country and has incorporated that quantity into the total amount allowed for import, which has been entirely from the US in the past. The import over TRQ is subject to tariffs. In 1995 these tariffs were ranging from 177.5% for turkey to 273.4% for chicken and hatching eggs and hatching chicks. According to the schedule, these tariffs will be lowered to 117.7% for turkey, and 181.5% for chicken, hatching eggs and hatching chicks by of 2010.

The post-2000 WTO negotiations in Seattle in 2000 were disrupted. The current Doha Round of WTO negotiations may be expected to continue the schedule laid out in the Uruguay Round, which gives Canada, what is regarded as, ample time to modify its supply management system to compete in the global market.

Canada has been moving faster than some other major trading blocs, e.g. the EU, in dismantling trade restrictions. For example, Canada provides trade access as follows: 21%-broiler hatching eggs, 7.5%-chicken, 5%-turkey and eggs. The EU allows less than 1% access. As a consequence, the poultry lobby is asking for no further increase in Canadian market access until other trading countries come on board. In addition, the Canadian poultry industry wants the accounting to take into consideration internal subsidies such as the US domestic School Lunch Program.

The short-term effect of freer trade on the output of BC poultry industry is not likely to be significant. Longer term (i.e. > 10 years), the production trend is likely to depend more on efficiency gains related to technology, marketing, and scale of operation, and may be expected to continue to increase rather than decrease due to increased imports.

3.2.4 Consumer Choice

Consumer choice may affect the production of poultry in the Fraser Valley and thus the amount of manure to be disposed of. In case of a future reduced demand for poultry, manure production will decrease. The North American market for chicken is predominantly a white meat phenomenon that is unique in the world. It results in a dark meat surplus. Between 1990-2001, per capita chicken consumption in Canada increased by 37% to 30.3 kg. During the same time frame, per capita consumption of all other meat has declined by 1% to 67.7 kg. While there may be consumption trend shifts in the future, there is nothing to indicate such shift in the short term. Manure estimates will not change due to changes in consumer demand.

It should be noted that margins of BC growers have been under pressure due to pricing arbitration resulting in processor prices being set relative to Ontario (basically the arbitrage rather than cost of production is setting the price differential). The other factor is that a number of years ago, processors fought for and obtained the right to obtain dark meat product for export through expanded grower production by any growers that wanted to produce "at the margin" instead of at domestic cost of production. While this market has grown, the surplus white meat from the birds grown for export enters the domestic market, depressing domestic prices. A further complication in BC is that the bulk of this benefit has accrued to processors, who obtained the export product more cheaply in the first place. Chicken meat exports by the US and Canadian processors are primarily to areas such as Russia, Far East and Middle, and Latin America. Product shipped primarily consists of lower valued chicken backs and dark meat. Canada’s exports to the US are insignificant, and only include the further processed category, since supply management does not result in significant surpluses. Consumer choice is not likely to significantly change the predicted production increase in the Fraser Valley.

3.2.5 Conclusion

The change of feed ratios and feeding patterns, including the use of additives such as amino acids, organic acids and enzymes including phytase, will significantly alter the manure nutrient concentrations. Adding organic acids will reduce the total manure production by 8-10%, amino acids will reduce the manure nitrogen concentration by an estimated 40%, while phytase will reduce the manure’s phosphorus content with 40% or more, with a 1-3% effect on nitrogen. Micronizing feed would reduce the nitrogen concentration in the feed by 16% and of phosphorus by 20%. Costs for such diets appear to be similar to those for regular feed. For instance a phytase based feed was calculated to be cheaper than regular feed. While amino acids and phytase may reduce nitrogen and phosphorus in the manure, these additives are not effective for lowering potassium concentrations. Amino acids and phytase can be seen as effective methods to lower the nutrient load of manure applications where nitrogen and potassium are limiting factors.

Trends in free trade and consumer choice will not change the volume or strength of produced manure. However, some combination of bedding practice and improved feed efficiency may result in a reduced volume of manure with the same, or enhanced, analysis of fertilizer nutrients.

3.3 Available Cropland, Manure Supply, and Nutrient Balance in the Lower Mainland and Thompson-Okanagan

Currently a significant portion of poultry manure produced in the Lower Mainland is applied to land. Poultry manure is shipped to Delta to be used on vegetable land, and large quantities are applied to raspberry fields. Other crops may benefit from poultry manure too, as its nutrient make-up is different from dairy manure and pig manure, which are commonly used on grassland and silage corn.

This section describes the available cropland in the Lower Mainland and in the Thompson-Okanagan. We selected these areas because they are within reasonable trucking distance from the Fraser Valley, where most of the poultry manure is produced. Other areas that may be available for application of poultry manure include farmlands around Williams Lake, BC. However, Williams Lake may be outside the economic trucking range as a one way trip is between 7 and 8 hours.

3.3.1 Available Crop Land in Lower Mainland and Thompson-Okanagan

The potential amount of poultry manure that can be applied to land depends on the different crops and their acreage. Using Statistics Canada data from the Census of Agriculture of 1991, 1996 and 2001, we have examined trends in land use in the Fraser Valley and the Thompson-Okanagan, and then estimated the acreage in 2010 from these trends.

The data showed that there was a shift in reported land use patterns. For instance in field crops, grains lost production area, while forage increased. In berries, strawberries and raspberries declined while blueberries, cranberries and grapes increased. Nursery production increased while sod production decreased. These trends show that crop production is shifting from poultry manure “friendly” crops (sod, raspberries) to poultry manure unfriendly crops (blueberries, cranberries, and nurseries for container production. Further, it appears that crops that can potentially use poultry manure, but are not using it now (alfalfa, grapes, tree fruits), are increasing in production area. Table 3 shows the relative increases and decreases reported between 1991 and 2001.

The largest crop areas, suitable for fertilization with poultry manure in the Lower Mainland and Thompson-Okanagan include: silage corn, alfalfa, tame hay, orchards and vineyards, raspberries, field vegetables, potatoes and bare-root nursery stock. Table 4 shows the projected acreage for each crop in 2010 based on a regression analysis of Census data.

In the Lower Mainland, acreage of field vegetables and improved land for pasture and grazing is anticipated to decline to 2010. Raspberry acreage is also projected to drop while grape acreage will rise, but not enough to offset overall declines in the berry sector. Corn silage, potato, alfalfa and tame hay crop acreage is expected to increase. Based on the trends in the 1990-2000 period, the acreage of crops potentially suitable for receive poultry manure in the Lower Mainland is expected to increase marginally by 1.5% to 2010.

In the Thompson-Okanagan, acreage of corn for silage, tree fruits, field vegetables, potatoes and improved land for pasture and grazing is anticipated to decline to 2010. Grape acreage is projected to increase dramatically, although relatively insignificant to overall acreage shifts. Alfalfa and tame hay crops are each expected to increase in acreage by about 7% in the period. Based on the trends in the 1990-

2000 period, the acreage of crops potentially suitable for receive poultry manure in the Thompson-Okanagan is expected to decrease marginally by –3.0% to 2010.

Potential food safety issues may affect the acreage available for land application of raw manure. The food safety issues include pathogen contamination of fresh-cut vegetables receiving raw manure, proximity of fresh-cut vegetables to land receiving raw manure, and bacterial contamination through contaminated irrigation water. Several research groups including USDA, the California Poultry Industry Federation through the University, and the University of Georgia are addressing manure related food safety issues. It is expected that due to consumer pressure, more precautionary measures will be taken in the application of manure to fresh-cut vegetables and small berries. In the Lower Mainland that would mean that vegetable acreage and small berry acreage might be excluded from manure applications, reducing the potential area by 10%.

Table 3: Relative increases/decrease (%) in crops acreage in the Lower Mainland and the Thompson-Okanagan. Stats Canada, Census of Agriculture, 1991, 1996, 2001.

Selected Crops	**Lower Mainland**		**Thompson-Okanagan**	
	Acres (2000)	% Change in 1991-2000 Period	Acres (2000)	% Change in 1991-2000 Period
Wheat	1,718	+54.4%	3,493	-7.3%
Oats	1,420	-6.3%	2,755	-25.6%
Barley	1,248	-1.5%	7,722	-30.7%
Mixed Grains	Na	Na	911	-35.7%
Corn for Grain	1,696	Na	593	+92.5%
Rye	683	+80.2%	499	+68.6%
*Subtotal grains **	*6,765*	*+54.3%*	*15,973*	*-22.6%*
Corn for Silage	18,348	+21.8%	5,302	-8.4%
Alfalfa & Alfalfa Mixtures	6,458	+134.8%	105,723	+7.0%
Other Tame Hay and Fodder Crops	62,612	+5.5%	43,580	+7.4%
Sub-Total Field Crops	*94,183*	*+15.5%*	*170,578*	*+2.9%*
Potatoes	6,005	+16.5%	347	-38.5%
Tree Fruits	1,661	+36.8%	19,217	-20.8%
Raspberries	5,269	-7.1%	99	-53.1%
Grapes	210	+56.7%	6,565	+277.7%
Sub-Total (Above)	*5,479*	*-5.6%*	*6,664*	*+241.9%*
Field Vegetables	14,135	-17%	1,663	-6.7%
Nursery and Sod	7,795	+44.5%	1,946	+44.7%
Improved Land for Pasture and Grazing	19,092	-31.2%	69,929	-19.7%
Total (All of the Above)	**148,350**	**+3.1%**	**270,344**	**-4.4%**

* = Subtotal includes mostly winter crops, which do not receive manure.

Table 4: Projected trends in acreage of selected crops in the Lower Mainland and Thompson-Okanagan to 2010 (based on regression analysis of 1990 to 2000 data)

Crop	Lower Mainland		Thompson-Okanagan	
	Acres in 2000	Acres in 2010	Acres in 2000	Acres in 2010
Corn for Silage	18,348	21,172	5,302	4,820
Alfalfa and alfalfa mixtures	6,458	10,497	105,723	108,875
Tame hay	62,612	67,164	43,580	46,495
Tree fruits	1,661	2,141	19,217	14,306
Raspberry and grapes	5,479	5,123	6,664	10,698
Field vegetables	14,135	10,287	1,663	1,604
Nursery and sod	7,795	10,090	1,946	2,564
Potatoes	6,005	7,053	347	151
Improved land for pasture and grazing	19,092	10,471	69,929	55,148
Total (All of the Above)	141,585*	143,997	254,371	244,661**

* = Total does not include grains as most crops are planted as winter crops and do not receive manure.
** = Total does not include grains since an unknown percentage is grown as feed.

3.3.2 Potential Absorption Capacity for Poultry Manure by Selected Crops

To obtain a more reasonable estimate of nutrient demand, we calculated the requirement for actual nitrogen, phosphorus and potassium based on crop needs as recommended in BCMAFF publications[10]. Table 5 shows the tonnage of actual nutrients that form the nutrient demand for each crop. Where applicable, we selected the recommendation for soils with a low level of nutrients. This may tend over-estimate the use of nutrients in case of phosphorus and potassium, as Lower Mainland soils typically have received nutrients before and residual nutrients may be available to crops. This over-estimation will reduce the calculated nutrient surplus in the area.

Using the trends in cropping patterns in the Lower Mainland, we extrapolated the land use changes to 2010. Assuming crop nutrient requirements were not changing , we calculated the change in tonnage of nutrients for each crop. Table 6 provides the estimated tonnage of nutrients required by crops in both 2000 and 2010.

[10] Fertilizer Guide for the Lower Mainland, 1977; Fertilizer Guide for Central BC, Interim Edition, 1980; British Columbia Soil Test Interpretations, 1980.

Table 5: Nutrient demand of crops (tonnes) per fertilizer recommendations (2000). Assuming no residual in soil.

	Lower Mainland				Thompson-Okanagan		
Crop	**N**	**P2O5**	**K2O**		**N**	**P2O5**	**K2O**
Silage Corn	955	914	1412		313	265	409
Alfalfa	177	502	502		1,584	3,360	3,360
Tame Hay	9,946	3,978	4,831		1,187	791	791
Orchards	83	128	188		960	1,483	2,181
Berries	137	137	224		76	91	60
Vegetables	962	1283	1283		98	151	151
Nurseries	177	354	354		44	88	88
Potatoes	164	382	382		9	22	22
Pasture	520	520	520		1,905	1,905	1,905
Total	**12,600**	**7,677**	**9,175**		**4,271**	**6,251**	**7,063**

Table 6: Estimated nutrient use (tonnes) by crops in 2010

	Lower Mainland				Thompson-Okanagan		
Crop	**N**	**P2O5**	**K2O**		**N**	**P2O5**	**K2O**
Silage Corn	1,105	1,057	1,634		284	241	372
Alfalfa	286	810	810		1,631	3,459	3,459
Tame Hay	10,671	4,268	5,183		1,266	844	844
Orchards	107	165	243		714	1,104	1,623
berries	128	128	209		121	146	97
Vegetables	700	934	934		95	146	146
Nurseries	229	458	458		58	116	116
Potatoes	192	448	448		4	10	10
Pasture	285	285	285		1,502	1,502	1,502
Total	**13,418**	**8,269**	**9,919**		**4,174**	**6,066**	**6,668**

3.3.3 Manure Supply

Not all cropland shown in the previous tables will (or can) be used for application of poultry manure. Some crops, such as alfalfa are primarily fertilized with chemical fertilizer. Large amounts of other types of manure are also available in both regions. Mainly dairy and poultry manure are produced in the Lower Mainland, while in the Thompson-Okanagan manure from beef operations is the largest source. In this section we will calculate the amount of manure potentially produced by livestock other than poultry.

Based on the Census of Agriculture (2001) reporting animal numbers, the North Carolina production coefficients for housing and production systems commonly used in the Lower Mainland and the Thompson-Okanagan, we have estimated manure quantities and nutrient tonnage as produced by non poultry livestock in both regions. Unlike chemical fertilizer materials that are produced in sophisticated plants, in which accurate analyses and weight measurements can be made, accurate data for the manure products and volumes produced are not available. Manure is produced on a large number of individual farms and subject to a number of important variables that can materially affect the volume and nutrient content of the product.

Table 7 below, summarizes the major manure sources in the Lower Mainland and the Thompson-Okanagan regions of British Columbia. It combines poultry manure data from Section 3.1.1 with estimates of manure produced by Hogs, Dairy, and Beef Cattle. Table 8 shows the typical nutrient content of the animal waste. The data in Table 7 and 8 for these three commodities are less accurate and somewhat crude compared to the Poultry Industry estimates.

Table 7: Manure Supply from Livestock – Based on 2001 Census of Agriculture (metric tonnes)

	Nitrogen	P2O5	K2O	Gross
Lower Mainland Manure Production:				
- Poultry Manure	7,270	6,531	3,510	242,282
- Dairy Manure	7,453	5,397	11,565	2,210,200
- Hog Manure	1,468	1,055	826	513,780
- Beef Manure *	410	469	801	89,838
Total	**16,601**	**13,452**	**16,701**	**3,056,100**
Thompson-Okanagan Manure Production:				
- Poultry Manure	694	601	332	22,704
- Dairy Manure	71	51	40	24,723
- Hog Manure	1,985	1,437	3,080	588,577
- Beef Manure **	579	662	1,130	132,840
Total	**3,274**	**2751**	**4582**	**768,844**

*** Assumes 100% recovery.**
**** Assumes 30% recovery.**

Table 8: Nutrient and Moisture Content of Animal Manure

	(Nutrient Analysis - %)			
	Nitrogen	**P2O5**	**K2O**	**Moisture**
Lower Mainland Manure Production:				
- Poultry Manure	3.00%	2.70%	1.45%	31.74%
- Dairy Manure	0.34%	0.24%	0.52%	90.00%
- Hog Manure	0.29%	0.21%	0.16%	90.00%
- Beef Manure	0.46%	0.52%	0.89%	65.00%
Thompson-Okanagan Manure Production:				
- Poultry Manure	3.06%	2.65%	1.46%	30.43%
- Dairy Manure	0.29%	0.21%	0.16%	90.00%
- Hog Manure	0.34%	0.24%	0.52%	90.00%

The data for Dairy manure were based on nutrient analysis data in the Government of British Columbia Resource Management publication "Environmental Guidelines for Dairy Producers". In the absence of specific information on "barn door" unit production volumes, data published by North Carolina have been used to estimate the volume of production in the Lower Mainland. These data are in reasonable agreement with a recent feed balance analysis conducted by the Ministry of Agriculture, Food & Fisheries. Data for the Thompson-Okanagan region were directly based on the Lower Mainland data adjusted by the relative livestock inventory numbers in the 2001 Census.

The data for Beef Cattle manure are based on the nutrient analysis data in the Government of British Columbia Resource Management publication "Environmental Guidelines for Beef Producers". In the absence of specific information on "barn door" unit production volumes, data published by North Carolina have been used to estimate the volume of production in the Lower Mainland. Feed balance data for beef production for comparison purposes were not available from the Ministry of Agriculture, Food & Fisheries. Data for the Thompson-Okanagan region are directly based on the Lower Mainland data adjusted by the relative livestock inventory numbers in the 2001 Census.

The data for Hog manure were based on nutrient analysis data published by North Carolina. "Barn door" unit production volumes published by North Carolina have also been used to estimate the volume of production in the Lower Mainland. These data are in reasonable agreement with a recent feed balance analysis conducted by the Ministry of Agriculture, Food & Fisheries. Data for the Thompson-Okanagan region are directly based on the Lower Mainland data adjusted by the relative livestock inventory numbers in the 2001 Census.

Not all manure produced can be recovered for use as fertilizer or other value-added products. For instance manure from beef cattle is used on grass and range land due to the grazing. Generally, beef manure is only collected when produced in feed lots. In the dairy industry some manure is not collected as mostly heifers are kept in pasture. Manure produced by pastured animals will benefit the pasture, which is included in our inventory of agricultural land able to receive manure as fertilizer. Feedlot manure is assumed to be collected at a recovery rate of 85-100%. Manure produced by animals grazing on range land (collected at <5%) was deducted from the manure inventory, as it is not benefiting cropland. Therefore collection of beef cattle manure that would benefit cropland after collection and redistribution, was estimated at 30%. We used this recovery rate in our calculation for the nutrient balance.

Livestock grown in the Lower Mainland produces significant quantities of nutrients. The quantities of nutrients generated by each commodity changes over time. In 2000 (Census data of 2001), the amounts of nitrogen and phosphorus produced by the poultry industry respectively equaled and surpassed the amounts produced by the dairy industry. Due to the increase in production as forecast by the poultry industry, quantities of nitrogen and phosphorus from poultry manure will increase while it is expected that quantities of nitrogen and phosphorus from dairy manure will stay the same or decline slightly. This means that the poultry industry will be the largest producer of nitrogen and phosphorus in the Lower Mainland. However, the majority of potassium will be produced in dairy manure. This is shown in Figure 1 (attached as Appendix A)

Manure is not the only organic source for nutrients in the Lower Mainland. Most of the area's dwellings and commercial facilities are connected to sewer systems and the sewage is treated. Sewage treatment generates biosolids or sewage sludge as a byproduct with a similar nutrient strength as manure. Typical sewage sludge from the Lower Mainland contains 4.3%N, 5.3% P2O5, and 0.2% K2O, as well as trace nutrients, heavy metals, and in some cases organic contaminants.[11] Currently the GVRD produces some 90,000 bulk tonnes of biosolids. This may increase to 120,000 tonnes when the upgrades to secondary treatment are complete. The total production in the Lower Mainland is estimated at 150,000 bulk tonnes. Biosolids are currently used in forestry applications and mine reclamation projects. The GVRD applies about 70% of its biosolids to land including landfills (52%), mines (34%), ranches (5%), silviculture (4%), gravel pits and landscaping.[12] Under the BC Organic Matter Recycling Regulation, biosolids are allowed to be used on agricultural land. When used on agricultural land in the Lower Mainland biosolids could contribute 6,450 tonnes of N, 7,950 tonnes P2O5, and 360 tonnes of K2O. Biosolids may compete with poultry manure as a source of nutrients. This material is a subsidized form of fertilizer, as the generator supplies transportation, application, monitoring, and advisory services.

[11] McDougal, R, M.Van Ham, and MJ Douglas, 2002. Best Management Practices for the Land Application of Managed Organic Matter in BC. http://wlapwww.gov.bc.ca/epd/epdpa/local_govt_section/pdfs/omrr_best_prac.pdf

[12] Duynstee, T., K Lee, 2000. A decade of Biosolids Recycling at the Greater Vancouver District. http://www.nutrifor.com/pdfs/decade_of_biosolidsrecycling.pdf

3.3.4 Nutrient balance

Nutrients are supplied to cropland both in the form of manure and in the form of chemical fertilizer. Based on the application rates and the acreage of selected crops, we calculated the amount of manure based nutrients that can potentially be applied to the different crops reviewed. In reality, this "demand" is covered by poultry, pig, dairy, and beef manure, and others types of manure, and by chemical fertilizer. In the Lower Mainland the largest volume of manure is generated by dairy operations, while poultry manure is the most concentrated in terms of nutrients. In the Thompson-Okanagan, beef operations generate is the largest supply. It would be fair to say that in the Lower Mainland, most of the silage corn and tame hay acreage is treated with dairy manure and pig manure. Further, virtually no animal manure is being applied to alfalfa, which is grown on a substantial acreage in the Interior[13]. Alfalfa is fertilized with chemical fertilizer and some beef manure from winter grazing and feeding operations is added "naturally" to fields and must be subtracted from available acreage.

Our calculations include the effect of chemical fertilizer applications. Unfortunately, the supply of chemical fertilizer is reported for BC only and is not divided for each region. As the fertilizer supply for the Peace River is typically added to the Alberta statistics, the reported supply covers the Lower Mainland and the Interior. We have roughly estimated the portion in the Lower Mainland as 50% of the total supply and the portion for the Thompson-Okanagan as 25%.

The data in Table 9 show that major crops in the Lower Mainland receive a significant nutrient surplus, even with application rates calculated based on maximum yield and when residual soil nutrients were not included. Some crops are extensively fertilized with manure, and others rely on chemical fertilizer for their nutrient needs. The conclusion from this surplus/deficit review is that the Lower Mainland is readily supplied with nutrients and that none or very little additional poultry manure could be accommodated. Further, the data in Table 9 show that when chemical fertilizer is combined with manure nutrients, the surplus of nutrients is larger than the estimated crop use. The surplus of primary nutrients is also larger than the total amount generated annually by the poultry industry in the Lower Mainland.

The calculated surplus for the Lower Mainland does not include losses of nutrients caused by manure application, but include losses in the barn. All reported manure nutrient content data is based on an "as used" or "at the barn door" basis. Application losses would affect the amount of manure used on fields to satisfy crop needs – i.e. more manure is needed.

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13 Kevin Murphy, Ken Awmack, (Personal Communication).

Table 9: Demand, supply and deficit in nutrients as supplied by animal manure and chemical fertilizer in The Lower Mainland (tonnes) - 2001.

	Nitrogen	**P2O5**	**K2O**
Lower Mainland Demand	12,600	7,677	9,175
Lower Mainland Supply			
- Poultry Manure	7,270	6,531	3,510
- Dairy	7,453	5,397	11,565
- Hog	1,468	1,055	826
-Beef	410	469	801
Manure Supply Lower Mainland	16,601	13,452	16,701
Surplus in Lower Mainland	4,001	5,775	7,526
Chemical Nutrient Supply	8,307	4,387	3,510
Total Surplus in Lower Mainland	**12,309**	**10,162**	**11,037**

Ammonia accounts for most of the losses in manure handling. Ammonia is emitted into the atmosphere and is likely not transported far. Thus, on a regional scale, application losses, specifically of nitrogen, will not affect the presented nutrient balance, as emitted nitrogen will “benefit” crops nearby. Barn losses or handling losses are not included in the presented nutrient balance as “barn door” values were used in the calculations. However, barn losses should be incorporated in a regional nutrient balance, as emitted nitrogen would “benefit” crops, or burden the environment. Actual surplus of nutrients in the Lower Mainland could be higher than the calculated surplus. With an estimated overall nitrogen loss from barns and manure storage of 35% (mostly in the form of ammonia), this nitrogen surplus or environmental burden in the Lower Mainland could be some 8,900 tonnes higher than presented in Table 9. Lower availability to plants of other, non-volatile, nutrients such as phosphorus and potassium, are covered in the regional balance as the nutrients do not leave the fields unless they leach and are transported to ground and surface water. The balances for these nutrients are likely not affected. The surplus of nutrients in the Lower Mainland, Table 11, is projected to increase between now and 2010, mainly related to the growth of the poultry industry. As shown in Table 13, the nutrients supplied through manure will increase with 37% for nitrogen, 23% for phosphorus and 2% for potassium.

The poultry industry has little access to, or control of the land base. This will make it difficult to apply poultry manure to land in case a program is initiated or legislation enforced that lowers the acceptable nutrient loading. Landowners such as dairy producers will first use their manure on their own land. It is plausible that with increased downward pressure on nutrient use due to environmental farm plans, nutrient management plans, and other measures, the poultry industry must find a solution for all of its manure.

The Thompson-Okanagan, Table 10, on the other hand, shows a deficit in manure phosphorus and potassium supply. Not including chemical fertilizer in the calculation, the Thompson-Okanagan region could absorb about 25,000 tonnes of manure based on the manure’s nitrogen content as a limiting factor, as alfalfa is mostly fertilized with phosphorus and potassium. Replacement of chemical fertilizer with raw or processed poultry manure could absorb an additional 100,000 tonnes, for a total of 125,000 tonnes annually, more than the estimated additional amount of poultry manure generated annually by 2010 (Table 12). This estimate is based on the estimated phosphorus deficit in the Thompson-Okanagan in 2010. The Thompson-Okanagan, however, will receive more animal manure in 2010, which will slightly decrease its nutrient deficit, due to a projected decrease in cropland and an increase in animal production. In 2010, the Thompson-Okanagan can still be used as a receptor of Lower Fraser poultry manure, replacing chemical fertilizer.

Table 10: Nutrient Balance for Thompson-Okanagan – 2001.

	Nitrogen	P2O5	K2O
Thompson-Okanagan Demand	4,271	6,251	7,063
Thompson-Okanagan Supply			
- Poultry Manure	694	601	332
- Dairy	1,985	1,437	3,080
- Hog	71	51	40
- Beef	579	662	1,131
Manure Supply Thompson-Okanagan	3,328	2,751	4,582
Surplus in Thompson-Okanagan	-943	-3,500	-2,481
Chemical nutrient Supply	4,154	2,194	1,755
Total surplus in Thompson-Okanagan	3,211	-1,306	-726

Table 11: Estimated surplus of manure based nutrients in the Lower Mainland – 2010.

	Nitrogen	P2O5	K2O
Lower Mainland Demand	13,418	8,269	9,919
Lower Mainland Supply			
- Poultry Manure	9,721	8,556	4,655
- Dairy Manure	7,340	5,315	11,390
- Hog Manure	1,479	1,063	832
- Beef Manure	369	421	720
Total	18,908	15,355	17,596
Manure based Surplus	**5,490**	**7,086**	**7,677**

Table 12: Estimated surplus of manure based nutrients in the Thompson-Okanagan – 2010.

	Nitrogen	P2O5	K2O
Thompson-Okanagan Demand	4,174	6,066	6,668
Thompson-Okanagan Supply			
- Poultry Manure	930	789	441
- Dairy Manure	1,883	1,364	2,923
- Hog Manure	60	43	34
- Beef Manure	605	691	1,180
Total	3,478	2,887	4,578
Manure based Surplus	-696	-3,179	-2,090

Table 13: Estimated surplus/deficit (tonnes annually) of manure based nutrients in the Lower Mainland and Thompson-Okanagan.

	Nitrogen	P2O5	K2O
Lower Mainland			
2001	4,001	5,775	7,526
2010	5,490	7,086	7,677
Increase	**1,488**	**1,311**	**151**
Thompson-Okanagan			
2001	-943	-3,500	-2,481
2010	-696	-3,179	-2,090
Increase	**247**	**321**	**391**

3.3.5 Conclusion

No additional manure can be applied to crops in the Lower Mainland, due to the surplus of nutrients produced by livestock and added chemical fertilizer. The surplus poultry manure produced between 2002 and 2010, can be applied to crop land in the Thompson-Okanagan, replacing chemical fertilizer phosphorus and potassium, and filling the nutrient deficit from manure. Limited amounts of beef manure are currently used on alfalfa and the crop appears to be under-fertilized. Alfalfa and forage crops in the Thompson-Okanagan Region, as well as in other regions could absorb the surplus of poultry manure generated in the Lower Mainland without adverse environmental impact. Manure could be best applied in a pelleted or granulated form, as this would fit within the current crop management practices. This would also allow the creation of a specific alfalfa fertilizer blended from poultry manure with added potassium and phosphorus.

3.4 Trends in Poultry Manure Utilization

Utilization of poultry manure can be affected by the manner in which it is applied to land and the crop management practices. Utilization can also be affected by environmental regulations. This section will address factors that may affect the utilization of poultry manure on land and estimate how the use of raw or processed manure in land based and non-land based applications is affected.

3.4.1 Relay Cropping

Relay Cropping is a technique in which one crop is inter-planted with another. When the main crop is harvested, the secondary crop takes over because it could be established during the growth of the main crop. In the Lower Mainland of BC, Washington State and in Oregon, relay cropping is implemented in a silage corn rotation. Silage corn is inter-seeded with Italian ryegrass. The corn is then harvested and the ryegrass gets the opportunity to grow in late summer and fall. The ryegrass keeps the field covered during the winter and can be harvested prior to seeding the next corn rotation. Typically, relay cropping is used as a soil conservation measure, rather than for absorption of extra nutrients[14].

The established crop of ryegrass will absorb extra nutrients from the soil. A report from Oregon[15] states that in a good crop ryegrass add about 20% more nitrogen scavenging potential. The report also states that the ryegrass can absorb up to 300lb/acre of nitrogen, while corn absorbs 200lb/acre, for a total of 500lbs. It is also established that ryegrass can absorb 115lb of P2O5 and 500 lb of K2O per acre.

Data from BC show that up to 75kg/ha of nitrogen can be utilized by the ryegrass when it is harvested in the spring[16]. This relates to 2.5 tonnes per ha of poultry manure. At 7,400 hectares (18,300 acres), this equates to about 18,000 tonnes of poultry manure. (Note: the relay cropping is not much of a factor unless the ryegrass crop is harvested).

Silage corn is typically fertilized with liquid dairy manure and liquid hog manure. The introduction of raw poultry manure, while beneficial, would change the management strategy for the farmers as the present regime is based on handling liquids rather than dry manure. Many growers of silage corn utilize the liquid manure produced on their own dairy farms. Although relay cropping in silage corn may increase the utilization of nutrients allowing larger applications, it will not likely benefit poultry producers.

3.4.2 Trends in nutrient utilization due to Environmental Regulation

Utilization of manure on cropland in Western Europe, especially in the Netherlands is strictly regulated[17]. The European Union has imposed a maximum nitrogen rate of 170kg/ha on all arable land. The Netherlands amended this standard and allows 250kg/ha on grass land and 170kg/ha on field crops. Specific regulations for some European Countries and US States are listed below

Netherlands

In the Netherlands the standards for manure and chemical fertilizer applications are regulated by the maximum amount allowed, or through a system of nutrient registration, MINAS, which is based on the balance of crop uptake and removal and nutrient applications. Although the 170 or 250kg/ha standard is used, amounts applied under MINAS may be different depending on crop and soil type. To reach the goal of 170 and 250kg/ha, the Netherlands uses a system of "allowed amounts" over the MINAS standards. Should the allowed amount be exceeded, the excedance will be charged. The allowed amounts are on a declining scale to force farmers to apply the correct amount of manure and nutrients to the land. Both the regulated rates and MINAS are driven by the concentrations of nitrate and phosphate in groundwater and surface water. MINAS not only governs the nitrogen applications to the land. The regulation and bookkeeping system also regulates phosphorus. Due to the over-saturation of the soil with phosphorus, the allowed surplus amount for this mineral is very low, and ideally would be in the 0-1kg/ha range.

Based on this, poultry producers in the Netherlands pay large amounts of money for their surplus phosphorus and nitrogen. Penalties are charged when more manure nutrients are produced than can be

[14] Jeff Hughes-Games, 2002 Personal communication.
[15] M. Gangwer, 1999. Relay Cropping in the Williamette Valley. Special Report 998, Oregon Extension Service.
[16] Bittman, 2002, Personal Communication.
[17] Dugast, P., 2001. Recent Developments affecting Fertilizer Use in West Europe. 2001 IFA Production and International Trade Conference , Quebec City. http://www.fertilizer.org/ifa/publicat/pdf/2001_pit_dugast.pdf

absorbed by crops grown on land under the control of the farmer. Control includes ownership, lease, and spreading arrangements. Typically manure charges of up to 6700 Euro (C$10,700) have been charged for surplus phosphorus from broiler operations and up to 7,200 Euro (C$ 11,500) for layer operations. The Dutch Government expects that due to the imposed system of manure book keeping and the taxes, the amount of manure produced or applied to land, and thus the animal population in the Netherlands will be reduced dramatically, as the total land base available for manure application is limited.

Germany

The Nitrate Directive is applied to each member state - In Germany, a ceiling of fertilizer application is set according to a calculation on a balanced nutrient basis. Often phosphorus is the first nutrient to be limited.

France

A levy on excess nitrogen at the farm level is being discussed that will be in the range of 0.20 to 0.23 Euro per kg of excess nitrogen. The excess, expressed in kg per farm, is taxable at levels exceeding 3000 kg N/farm in 2003. This will be reduced to 1000 Kg N/farm in 2007. Adjustment is provided for nitrogen used by catch crops and grassland.

Denmark

Nitrogen accounting has been implemented, with requirements for fertilizer plans, restrictions of nitrogen use, and plans for higher exploitation of animal waste. It is mandatory to account for the exploitation of about 50% of the N in pig and cow slurry.

United States

The increasing concerns over non-point source pollution of Maryland's surface waters and surface water in other Eastern Seaboard States, could result in future restrictions on the land application of poultry litter. Concerns are related to agricultural runoff, and the presumed linkage of *Pfiesteria* outbreaks to elevated levels of phosphorus. Maryland Department of Agriculture has estimated that if phosphorus-based management practices are implemented, about half of the current amount of poultry litter would be in excess of what could be applied as fertilizer to the lower Eastern Shore

3.4.3 Environmental Farm Plans in British Columbia

BC is not planning to implement manure regulations or legislation similar to those in Western Europe and Eastern US. In the short and medium term, specific manure use or nutrient use regulations will not affect manure applications to land. However, BC is developing an Environmental Farm Plan Program and a Ground Water Protection Act. It is expected that this plan, developed and coordinated with Industry leadership, will be in place within the year, with significant adoption after three years. The Environmental Farm Plan Program will focus on the correct use of nutrients in crop production, among other things, and will specifically address challenges in the most sensitive areas of the Province such as the Abbotsford aquifer. The program will outline how to balance nutrients with crop needs. The nutrient calculations will still be nitrogen based, and enforcement will be through the Waste Management Act, the Code of Agricultural Practice, the Fisheries Act, or the new Groundwater Protection Act. The Fisheries Act will control the quality of, and discharges to surface water in the Lower Mainland as all water ways are connected to the Fraser River or other fish bearing streams. The new ground water Act would protect the quality of ground water, including the Abbotsford Aquifer.

We expect that full implementation of the Environmental Farm Plan program would significantly reduce the amount of manure that will be applied to land in BC, as farmers will strive to match their nutrient applications to crop requirements. When manure is applied according to the limiting crop nutrient need in stead of to nitrogen need, we expect a reduction in nutrient application of at least 30% of the total amount applied annually, including manure based and chemical source nutrients. Where the land is located in a sensitive area such as the Abbotsford Aquifer, manure applications may have to be reduced even more. *This expected reduction is larger than the combined manure nutrient supply generated by the poultry industry*.

3.4.4 Conclusion

The utilization of manure in general, and of processed poultry manure specifically, due to its high phosphorus content, saturated soil and phosphorus leaching to surface water, will be affected by changes in the regulatory environment. Especially in Western Europe, the quantities of manure applied to land have been reduced significantly after regulations were put in place some years ago. Regulations were based on phosphorus loading rather than on nitrogen loading. As soils in Western Europe are saturated with phosphorus, and phosphorus is considered the limiting factor in eutrification, much attention is given to the reduction of phosphorus applications to land. Such regulations are not expected to be implemented in BC in the near future.

The implementation in BC of the Environmental Farm Plan Program as well as the Groundwater Protection Act will likely reduce the amount of nutrients applied to land, as applications will be required to be balanced between supply and plant uptake. As all nutrients will be considered in the Environmental Farm Plan, the limiting factor in application of poultry manure will likely be phosphorus, and in some cases potassium, rather than nitrogen. *Full implementation of the Environmental Farm Plan Program, likely result in a decrease in nutrient application of more than 30%.*

3.5 Use and Distribution of Poultry Manure- Based Products

Typically, raw poultry manure is distributed to farmers for use as fertilizer. Besides raw or unprocessed manure, poultry manure is also shipped as pelletized, granulated or composted products. This section includes a review of some applications for processing manure products that may be applicable to the Lower Mainland. The following section will describe technologies that can be used to produce the processed manure products

3.5.1 Lower Mainland Market for Pelletized Poultry Manure

To update the market size estimates for pelleted poultry manure in the Lower Mainland we reviewed the 1995 report “Marketing Plan for Pelleted and Crumbled Composted Poultry Manure Product.” Results of this review based, on current information, confirmed its conclusions. At a wholesale price of C$100-150, the maximum available market for pelletized poultry manure in the Lower Mainland is probably in the 2,000-3,000 tonnes range. This is assuming that the physical properties of the material are sufficiently high to allow its use as a filler in blended mixtures for the Home & Garden market. The Home & Garden segment accounts for about 85% of the estimated tonnage for this potential product. Recent changes in golf course and turf management have seen a switch to fertilizer amended with organic products. Based on the number of golf courses in BC and the typical application rates, we expect the demand for this sector to increase to between 1,650 and 2,350 tonnes annually. Actual market will depend on product type and strength, and acceptance of a product with a different color.

3.5.2 Forest Fertilization

Forest fertilization is normally done by air, which tends to preclude the use of low analysis products. A special large size urea granule (forestry grade packaged in 2000 lb. poly bags) is generally used for this application. In Maryland a project was undertaken in 1999 to demonstrate the use of poultry manure on low pH forest soils that are limited in phosphorus. This project is expected to increase forest production with 20-30%.

Forest application is difficult to justify because there is no short-term pay-back. The benefit of applying fertilizer today is not realized for many years - until the forest is harvested, maybe 20 years later. The use of poultry manure in forest application will be insignificant, unless a mechanism can be found to finance this use, as is the case in application of biosolids to forested land where the waste generator pays for the movement and application. Some pelleted or granulated product may be used in forest nurseries as a cost-effective replacement for slow release fertilizer.

3.5.3 Granulated products

Technology exists to manufacture high quality granulated products from poultry manure. Products can range from low-analysis simple manure-plus-binder material to nutrient-enhanced products based on poultry manure that contain various combinations of high-analysis chemical fertilizer materials. Preliminary contact with one equipment manufacturer has indicated that a 10tonne/hour plant might be an economically viable operation. However, it goes without saying that such a plant must have a reasonably sized local market. A 10 tonnes per hour plant could process in the order of 80,000 tonnes of material per year on a three-shift basis.

The question arises: Can 80,000 tonnes of these products be economically marketed from a plant located in the Lower Mainland. We believe that the local market is not sufficiently large to support such a plant. A (presumably) similar product called Sustane (produced in the US mid-west) was selling in the lower mainland in 1995 for about CD$500/tonne. Product analysis was 5-2-4. The product was targeted to the institutional market. The primary market for Sustane was believed to be for golf course tees and greens. The total golf course market in BC, was estimated at less than 5,000 tonnes of all products, of which the tee and green market accounts for 10%. It is unlikely that Sustane presently accounts for as much as 50 tonnes in the Fraser Valley, as it competes with Milorganite from Milwaukee and a biosolids compost from Kelowna. It would seem likely that a large portion of the production from such a plant would have to be exported from the Lower Mainland. This does not necessarily preclude the viability of such an operation, which should be the subject of a serious study. A more reasonable price for a locally manufactured product would likely result in an expanded market.

3.5.4 Ash from Poultry Manure as Fertilizer

Ash from burned poultry manure can be used as a phosphorus and potassium rich fertilizer. Not all ash can be used as fertilizer. The best product is material that is collected as fine precipitator ash. This ash is light in color and has a low carbon content. It can be processed to form a granulated product for easy application. Samples we obtained of granulated manure ash originated from a large power generating facility. It needs to be assessed whether small operations generate enough ash of a quality that can be transformed into fertilizer granules. An interesting aspect of the samples obtained is that we were advised that the volume of ash was only 15% of the volume of poultry manure entering the incinerator with a corresponding large increase in nutrient content. Consequently the ash had a significant potential commercial value as a source of phosphate and potash nutrients.

Small poultry manure burning facilities may produce a different quality ash. Ash from operating wood boilers used in local greenhouses in BC, is either generated in very small amounts in the form of clinker ash, or is a carbon rich precipitator ash. Neither can be used as fertilizer as clinker is an insoluble glass-like material, and the black precipitator ash is like charcoal and will not release nutrients.

3.5.5 Mushroom Industry

Historically, BC mushrooms have been produced mostly for the local market. BC features the highest per capita mushroom consumption in North America and the market in BC is considered to be mature, meaning that future growth in the regional market will mimic growth in population (Advanced Resource Consulting, 2000[18]). The population of BC is expected to grow from 4 million people in 2001 to 4.5 million in 2011, an average increase of about 1.25% per annum. Nevertheless, BC mushroom production increased by about 120% during the 1993 to 2002 period (more than 4% per year), with strong export to the US. The total mushroom production in BC in 2000 was 45.5 million pounds from 2.3 million square feet of growing area. In the 1995-1999 period, exports of fresh mushrooms to the US (e.g. Washington, Oregon, California and Utah) increased by 235% to 17.5 million lbs. in 1999 (Advanced Resource Consulting, 2000). The US market has grown in response to a favorable US-Canada exchange rate, high BC mushroom quality, and increased marketing effort of BC agencies. An additional factor in growth is the continued significant export of fresh and processed product inter-provincially (17.9 million lbs. in 1999).

Significant amounts of poultry manure are used to process mushroom substrate, 10% or more on a weight basis. Almost half of the mushroom substrate compost production in the Lower Mainland is based in the Money's facility located at Kent, near Hope, BC. Money’s only supplies their members. Several other smaller facilities are located in the Abbotsford area and individual growers import compost from the US. The total production of compost is estimated at 260,000 cubic yards annually, based on the inclusion in compost of 10% poultry manure, a bedding area of 2.3million square feet (2000), a rotation of 5.2 crops annually, and a compost depth of 7 inches[19]. Money’s Mushrooms’ Hope facility is currently operating at about 50% capacity, processing approximately 4,500 tonnes (~13,000 cubic yards) of poultry manure annually. The total usage of poultry manure in mushroom substrate production in the Lower Mainland is estimated at 26,000 cubic yards (~10,000 tonnes). Based on continued growth in BC mushroom production, the use of poultry manure in mushroom composting is expected to double to 20,000 tonnes by 2010.

Money’s is considering locating a central Phase II /III composting facility where compost is sterilized (phase 2) and inoculated (phase 3). Money’s is also working on a consolidation program, combining compost production from other facilities into their Hope facility. Consolidation would increase the operating rate of the Hope facility from about 50% now to full capacity, but would not affect the total amount of poultry manure required as the Hope facility would take over production from other (smaller) facilities. Establishing a Phase II/III facility would double the capacity for poultry manure consumption as the process results in increased mushroom compost production through shortening of the mushroom production cycle. Demand for the compost would be predicated on the expansion of mushroom markets in the US. If Phase II/III facility plans go ahead, the increase in production would absorb an additional 15,000 – 20,000 tonnes of poultry manure, resulting in total poultry manure demand in 2010 of approximately 40,000 - 50,000 tonnes, annually.

From the composting facility, the compost is transported to farms where it is incorporated in mushroom growing beds After the production is finished, the beds are emptied and the "mushroom manure" is then

[18] Advanced Resource Consulting Ltd. 2000. A Study of Current and Future Markets for British Columbia's Mushroom Industry.
[19] http://www.chilliwackagriculturalcommission.com/news/files/mushrooms.pdf

discarded or beneficially reused. Most if not all mushroom manure is applied to land in some form or another. Significant amounts are used as low cost fertilizer in home gardening. This means that the product re-enters land base and that the fertilizer value of the mushroom manure (and thus the poultry manure so consumed) needs to be accounted for in regional nutrient balance calculations.

3.5.6 Bioremediation

Poultry manure can be used in the bioremediation of soil contaminated with petroleum hydrocarbons. Contaminated soil is mixed with a source of nutrients and then windrowed for some time. Biological activity by naturally occurring microorganisms (or by those added from prepared stock) degrades the petroleum hydrocarbons.

Currently in the Lower Mainland, some 50,000 tonnes (39,000 cubic yards) of contaminated soil is bio-remediated annually. The largest amount is processed at a facility on River Road in Delta. Additional amounts are remediated on-site. As a rule of thumb, 10% of the volume is added as a nitrogen rich manure product[20]. The maximum amount of poultry manure that can be used annually is about 4,000 cubic yards. The use of manure, although low in cost, adds costs in handling and disposal of soil due to the added volume and required mixing. Poultry manure may not be cost competitive with chemical fertilizer which is commonly used in bioremediation. Therefore, the expected annual use of poultry manure in bio-remediation is estimated at only 2,000 –2,600 cubic yards (650-850 tonnes) annually and will not increase substantially.

3.5.7 Organic Farming

Poultry manure can be used in organic farming under certain conditions. Generally, the use of raw or processed manure is discouraged, and composted manure is favored. The Organic Materials Review Institute (OMRI) tests materials based on the standards for use of manure and processed and composted manure[21]. OMRI performs reviews for some 90 certification organizations around the world. OMRI includes the standards for the USDA National Organic Program (NOP) in its reviews. In BC, the use of manure in organic farming is regulated under the Standards of the Certified Organic Association of BC (COABC). In BC, Only composted manure can be used on food crops, and restrictions apply to the use of raw manure on non-food crops.

Under the OMRI/NOP rules the use of raw manure is discouraged due to the presence of pathogens, weed seeds, unstable forms of nitrogen, and pesticide residue. Raw manure can be used on crop that are not intended for human consumption, when the manure is incorporated more than 120 days prior to harvest, or when incorporated more than 90 days prior to harvest of crops with harvestable parts that are not in contact with the soil. Processed manure is manure that has been heated to above150^{o}F for 1 hour or more, with a moisture content of less than 12%. Processed manure is restricted for supplemental use. It cannot be used as the prime source of nutrients As some farmers are certified by organizations that are not under the COABC umbrella, they can use poultry manure as indicated by other regulations. In fact, some organic farmers in the Lower Mainland are experimenting with a mixture of raw poultry manure and City of Vancouver compost.

Composted manure can be used without restrictions. Conditions are set for composting. In general, windrow composted manure is required to be heated up to 130-170^{o}F for a period of 15 days. During this

[20] Quantum Environmental Services, Personal Communications

[21] Organic Materials Review Institute, 2002. OMRI Generic Materials List; Operating Manual for Review of Brand Name Products.

period 5 turns need to take place. The carbon to nitrogen ratio needs to be in the 25 to 40 range. No prohibited materials are allowed.

The acreage for organic farming is rather small. Statistics Canada cites 319 organic farms in BC in 2001, 270 are producing fruits and vegetables. The estimated total acreage of these farms is 2,500 acres. Based on nutrient requirement this segment could absorb 45,000 cubic yard (~15,000 tonnes) of poultry manure. The amount of raw poultry manure that will be utilized in this sector is negligible due to restrictions in BC ‘s organic standards. This market can best be supplied with composted poultry manure, produced by one medium size composting facility in the Lower Mainland.

3.5.8 Additive to Chemical Fertilizer

The total chemical fertilizer market in BC is not large. According to Ag-Canada statistics, consumption of chemical fertilizer materials is in the order of 65,000 tonnes (excluding the northern region that is of similar size). It is roughly estimated that the commercial farm market accounts for 70 – 75% of the volume, and the specialty markets for the balance. The specialty category includes horticulture, institutional, home & garden, and vegetable market gardening, Generally, the commercial farm market uses higher analysis products, thus the specialty segments probably account for only a roughly estimated 10-15% of the nutrient content (excluding manure).

Suitably processed poultry manure could be used as filler in chemical fertilizer. The Federal Fertilizer Act allows 15% inclusion of “organics” to label the product “organic based”. We do not expect the fertilizer industry to add more than the amount required to meet this label requirement. If processed poultry manure were used as filler (at 15% of the gross chemical fertilizer tonnage) the volume consumed would amount to about 10,000 tonnes, or about 12% of the new market for poultry manure that must be developed by 2010. However, it is not likely that processed poultry manure would be substituted for other filler material to any significant extent - although possible in some cases where soil remediation is required, or where the market demand is high such as in the turf grass industry.

If it assumed that the use of processed poultry manure as a filler will be restricted to specialty markets such as the horticulture, institutional, home & garden retail, and vegetable market garden segments (a gross market of about 15,000-20,000 tonnes), 15% filler would account for 2,000-3,000 tonnes of potential. This is the same market discussed above for pelleted and granulated product, and the tonnage is not additive.

The golf course and turf market is currently moving towards using more organic fertilizer in their maintenance programs. Required product should have nitrogen content of about 15%. Based on the market size and nutrient requirements this market segment could absorb an additional 2,300 tonnes of pelletized or granulated poultry manure product. Such product would need to be supplemented with chemical fertilizer to reach the required strength. This volume is in addition of the amounts mentioned above for pelleted or granulated products.

3.5.9 Conclusion

The direct application market for pelleted, crumbled or granulated poultry manure in the Lower Mainland is small, probably in the range of 2,000-3,000 tonnes annually. No major changes or additional uses are expected in the future. Chemical fertilizer materials such as urea, ammonium phosphates, and potash can be used to fortify the manure during the pelletizing or granulation operation. The granulation operation, in particular would probably produce a material that could be readily used in some of the specialty markets. We estimate this total market to be between 10,000 and 25,000 tonnes by 2010, including the filler market, the golf course market and other markets for pelletized or granulated products. Other markets would include the organic market with a potential for 15,000 tonnes, and the additional market for mushroom compost of 20,000 tonnes. This "basket" of options could absorb in the order of 60,000 tonnes of poultry manure, significant, but less than the estimated increase in poultry production anticipated between now and 2010.

3.6 Processing of Poultry Manure

Poultry manure is currently used in the Lower Mainland primarily in a raw form. Only small amounts are composted for use in specific markets, and none is processed, pelletized, granulated or utilized in non-fertilizer applications. This section presents the result of our review of technologies and processes that have been commercialized, that are in a demonstration stage, or have been developed and tested in a laboratory.

Many processes have been developed to enrich and densify poultry manure. Many products are marketed regionally and continent wide in North America, Europe, Australia and Asia. Although many processes are of a small scale, several are large enough to possibly assist poultry growers in the Lower Mainland. These may include Dynamic Lifter from Australia, the Harmony products from Richmond Virginia, and Perdue-AgriRecylce. Processed poultry manure products can be separated into several categories. The Table below indicates the type of products produced and the frequency of the occurrence of the process. This is not an exhaustive list as this survey was based primarily on an Internet search. Several smaller outfits would not have their information published as they only market regionally and depend on word of mouth for marketing. The list of granulated or liquid value-added products is presented in Appendix B. Table 14 summarizes the type of processes that are used to generate value-added products.

Not all sources indicated product prices. The (farm) prices for pelletized, enriched product packaged in 30 or 50 lbs bags are around $US230/ton. Prices for smaller packages of product certified for use in organic farming can be much higher in the range of $500-1000/ton, depending on fertilizer strength. However markets are very small. Below we have selected some of the processes that may be suitable for implementation in the Lower Mainland, that have been introduced in the Lower Mainland, or that are of local origin. Further, we have included some of the other technologies available for processing poultry manure.

Table 14: Value-added products made from poultry manure

Process/product	Relative frequency
Liquid fertilizer	4
Pelletized of granulated, no enrichment	9
Chemically enriched, pelletized	2
Organically enriched, pelletized	4
Biosolids enriched, pelletized	1
Otherwise processed, pelletized	1
Composted	1
Total	22

3.6.1 Composting

On-farm and centralized composting of poultry manure has been undertaken in many areas in North America. In BC, commercial on-farm composting takes place on several farms. For instance, the Kal-Mar

Egg Ranch in Winfield near Kelowna, composts all manure from their (mostly layer) operation. The Kal-Mar farm operates an enclosed trough composting system. This system produces a dry compost product in about 35 days. The prepared compost is marketed locally both bagged (Valley Brand Fertilzer) and bulk to an established market. In the Lower Mainland, Olera Farms (Aldergrove) composts layer manure from a certified organic (poultry) farm in an covered windrow system. All manure is either used on their own vegetable farm, or is marketed. Transform Composting in Abbotsford is currently starting up facilities composting poultry manure. Transform uses a trough composting system and likely will pelletize.

The quality of composted manure and the environmental impact of composting facilities are affected by operating parameters and implemented technology. Compost quality is determined by attention to C:N ratio, proper turning, particle size , nutrient content and analysis. Composted poultry litter has the potential to become a substitute for imported peat in potting mixes and as part of a soil replacement mix when growing woody ornamentals. Since compost is a low value-added product, the distance to market is a critical factor in economic feasibility. An additional issue to be sorted out involves bio-security concerns.

Several small to medium size composting facilities operate in the US. These facilities market composted poultry manure to local landscapers, vegetable farms, horticultural operations and garden centres. Compost is used in moisture retention, disease suppression, mulch and disinfectant, and fertilizer. Bulk sales prices range from US$10/cubic yard to US$35/cubic yard (equivalent of US$90/ton. Sustane (Minnesota) processes up to 50,000 tons of poultry manure (turkey) annually and markets continent wide.

3.6.2 Vencomatic (0n- farm drying and handling systems)

A Dutch company with distributors in Canada, Vencomatic, produces manure handling and drying systems for use in both broiler and layer barns (David Thompson/Eric Dryer, Personal Communications). The broiler system consists of a belt on which bedding is placed. At the end of the production cycle, the barn is cleaned by cleaning the belt. The system for layer barns includes manure belts and an exhaust air system for drying layer manure. Belts transport the manure from the barn every 5-7 days. The manure is dried immediately, reducing the in-barn emission of ammonia and methane. This system has benefits in The Netherlands, where all manure must be removed from the farm. Drying of layer manure significantly reduces shipping costs. An alternative system includes a drum dryer. This dryer is too large to be shipped by container, therefore it is not available in North America. The Vencomatic system for layer barns reduces the manure's moisture content from about 50% to about 12-15%, reducing shipping weight by 35%. This is a significant cost saving to the producer, should the producer pay for hauling. Installing a Vencomatic system in a layer barn would not change the amount of land required for the application of manure as a source of fertilizer as the total amount of nutrients would be equal to or higher than nutrient levels in conventionally handled manure.

3.6.3 Pelleted manure (KDS-Micromex)

KDS-Micromex is a drying-pulverizing system with an intergrated punch pelletizer. The Cloverdale based company First American Scientific Corp markets KDS-Micromex in Canada through the Vernon, BC, based First Canadian Environmental Solutions. The drying-pulverizing system is based on a high velocity hammer mill, in which material is pulverized through abrasion and oscillation, rather than through hammer impact. This makes the system suitable for pulverization of hard materials such as lime stone, coal, zeolite , gypsum , talc and gold ore. The pulverization process releases water from materials processed. Moisture content is reduced to less than 10%. Moisture, volatiles, and some dust are released to the atmosphere. The drying/pulverizing process eliminates pathogens to below the EPA 503 standards for Class A sewage sludge.

The KDS Micromex is connected with two punch type pelletizing mills, each with a capacity of 1.5 tonnes/hour. The pelletizer produces 3/8 inch diameter pellets of 0.5 inch length. The system requires a 3-phase 600 amp electrical connection. Production costs for pellets is C$36-to 38 per tonne, not including amortized cost for equipment, land and buildings. Total costs are estimated at C$56-58 per tonne. These costs are based on a production rate of 3 tonnes/hour during 3 shifts, with a total production per plant of 18,000 tonnes annually.

First American claims to have markets for the product. Product could be sold for $US40-60 per tonne. This means that a KDS type plant may be viable based on the current exchange difference between Canada and the US. Any transportation to market would consume the exchange benefit. First American envisions processing for the local bagged retail market. As the local market for crumbled pelleted fertilizer is about 3,000 tonnes, most of the product is to be marketed outside the region. First American is in the business of building and selling processing plants. Marketing of product would be left to the operators of the plants. According to First American, operators could be groups of farmers or individual companies.

3.6.4 Granulation

Granulation is a process where by moist material is mixed with a binder (sulphonate, lime, etc.) and released onto a rotating angled disk or in a drum. The moist material rolls to the bottom of the disk or drum, forming small uniform balls. In case of a disk, the formed wet balls are collected on a belt and dried in an oven. In case of a drum, the balls are dried directly in the drum. The granulated product is produced in a granule similar in size to urea pellets and can be spread in commonly used cyclone spreaders. It has good physical properties and can also be used as a filler in, or as a component of, bulk blended fertilizer mixtures. The process can also be used to granulated manure ash from power generating plants or small boilers. The volume of ash is reported to be in the order of only 15% of the volume of the manure. As a result, the product has a relatively high P2O5 and K2O analysis with a commercial value in the order of C$115 per tonne delivered to dealer.

Several companies produce granulation equipment. Sackett from Baltimore has successfully produced granules from poultry manure and poultry manure ash. They market a drum type granulator. Sackett provided samples and rough production cost estimates. The cost of production in a 10ton/hour mill and a 3 ton/hour mill would be in the order of C$65 and C$ 100 per metric tonne respectively, including depreciation for capital equipment, land and building. The facility would handle about 80,000 tonnes of material annually.

3.6.5 Steam pelleted manure (AGRI-RECYCLE)

Perdue Farms, a large integrated poultry producer, and Agri-Recycle, a US company with a manure handling technology, operate as Perdue-AgriRecycle a manure processing plant in Sussex County, Delaware. The Sussex County plant produces about 80,000 tonnes annually of pelleted chicken manure. The drying and pelletizing process renders the manure pathogen free. The Organic Materials Review Institute in Oregon, an organization reviewing materials allowed for use in organic farming, classified the produced fertilizer as a restricted material to be used under their Processed Manure category. Processed manure is removed from the region (Delaware) by train or truck, and is sold as fertilizer (Microstart 60) to grain farmers in the Mid West (corn?) as a source of micronutrients and organic matter. Perdue-Agri-Recycle cleans out barns and transport manure to the processing plant at no cost to the farmers.

Finances are important in establishing a manure processing plant. The Perdue-AgriRecycle plant was co-financed under a bond from Sussex County, and is subsidized by the State of Delaware with $2million over a five year period. A Nutrient Relocation Policy is in place in Delaware, paying US$0.08 per mile per ton (one way), up to US$20/ton to remove manure from the production area. This subsidy is split between processed and unprocessed manure, with a maximum for unprocessed manure of US$10 per ton.

Agri-Recycle and local "project developers" Young and Klassen[22] (YK), wished to establish a similar plant in the Lower Mainland. Recently, YK discontinued their cooperation with Agri-Recycle and developed a similar technology for the production of 600tonnes/day (130,000tonnes annually. The technology proposed for the Lower Mainland plant consists of a rotary dryer, a hammer mill and a granulater. All off-gases, containing odour, moisture, ammonia and other gases, and some dust will be treated by cyclones, and a cold plasma air pollution control system The processing building will be under negative pressure. YK signed a Letter of Intent with the Sustainable Poultry Farming Group to supply them with required manure with revenue to the farmers. The plant will be engineered locally. YK proposed two sites in Chilliwack. However, based on public pressure, Chilliwack Council rejected the plant proposal. YK has now secured a site in Kent BC, and received approval from the District of Kent and from the Land Reserve Commission, as the plant will be built on agricultural land. The plant is expected to be operating in 9 months with a first year's production of 60,000 tonnes, ramping up to 130,000 tonnes the following year. YK has concluded negotiations with a with a major Canadian fertilizer distributor, who will absorb 300 tonnes/ day of a granulated fortified product (100,000tonnes annually). According to YK, due to re-engineering of the plant, production costs will be lower than those for comparable facilities. This, and the low Canadian dollar will make the facility economically viable[23]. YK intends to be the market leader in manure processing in the Lower Mainland, thus tying up supply.

3.6.6 Feed Market

Poultry manure is being used as animal feed. Fish farms in the Southern US utilize poultry manure as a source of nutrients, and poultry manure has been used as a source of protein in cattle feed. The value of poultry manure as feed is several times its plant nutrient value, with dealer prices of between US$120-155 per ton[24], compared to dealer prices for fertilizer in the US$40 per ton range. The use of poultry manure as a feed (additive) could increase its value and make processing viable. Poultry manure is allowed as feed in 22 States in the US. Regulations regarding cross-feeding of animal waste may change in the near future due to "food scares".

3.6.7 Other Processes

Several other processes have been developed or are under development for treatment and handling of poultry manure or negating the effects of over-fertilization with poultry manure. Many are in the laboratory and pilot stage and cannot be evaluated thoroughly.

Phosphorus remediation

- Iron-based products to stabilise manure phosphorus into environmentally inactive form.

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[22] http://www.agaware.bc.ca/PDF/Young%20Klassen%20%20Associates%20-%20Project%20Overview%20-%20July%2023%202002.pdf
[23] Rick Klassen, Personal Communication.
[24] http://www.fertilizer.org/ifa/publicat/pdf/2001_pit_fairchild.pdf

- Phyto-remediation, or "Green Remediation", uses unusual plants that have developed the ability to concentrate high levels of elements, usually heavy metals, in plant tissue.
- A single chemical treatment of phosphorus-enriched soils would be sufficient to change the relatively mobile forms of phosphorus to stable and far less mobile mineral forms. Additions of either aluminium sulphate (Alum) or Iron Chloride to soils where phosphorus has accumulated, settling ponds, ditches, etc., might prove to be successful in precipitating phosphorus or rendering it as unavailable or in an insoluble forms.
- Treatment of phosphorus rich drain water.

Anaerobic Digestion

Anaerobic digestion is a biological process that requires stable conditions within the process, temperatures between 35C and 55C, and moisture contents above 60%. The outputs are pathogen free. Most often, a generator is used to produce electricity and the heat from the generator engine is used to maintain the temperature of the digester. Poultry litter is not well suited to anaerobic digestion because of its physical and chemical characteristics. Research has reported successful digestion operations with net energy production of 60-75% of gross carbon input. Typically, energy generation from anaerobic digestion of pre digested waste (manure) has not been proven cost effective.

Warwick Process

The Warwick Process[25] is a wet gasifiction process wherein hydrogen gas is generated from liquid waste such as sewage sludge. Produced gases are captured and filtered through a palladium coated ceramic semi permeable filter to extract hydrogen gas. As hydrogen gas concentration is a limiting factor in the reaction, its specific removal increases its generation. The University of Warwick, which developed this process, received funding from the European Community, and works together with BGT Inc in the Netherlands. BGT developed a gasification facility for poultry barns (see gasification Section below)

BIOREK Technology

Currently used in Europe in wastewater treatment, using ultrafilters to remove and concentrate nutrients. The initial filtering out of fibres leaves a purer product to run through the gas reactor. The ultrafiltration process separates N from P and leaves behind 75% clean water, 15% P-K concentrate, a liquid ammonia concentrate and composted manure. The farm-scale bio-reactor produces methane, carbon dioxide, sulfur, ammonia, some phosphate and fibre compost. The CO-generation component produces enough power to run the plant (30%) and the remainder sold into a power grid (70%). The heat generated can be used in barns and other buildings. The end products allow farmers to apply or market N separately from P and K in forms that are more readily available to plant roots[26].

Slurry Separation Treatment

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[25] http://www.spacedaily.com/news/energy-tech-02m.html
[26] http://nett21.unep.or.jp/JSIM_DATA/WASTE/WASTE_6/html/Doc_555.html

Funki, Denmark - has developed a Manura 2000 system that separates ammonia from manure slurry on-farm. Raw slurry is pumped into a decanter centrifuge where the solid particles in the slurry are separated as humus with a dry matter degree of approx. 30%, thus binding approx. 70% of the phosphorous content in the raw slurry. The thin part of the slurry is pumped into the dehydration part of the system where it is heated to approx. 100 degrees Celsius and degassed. The slurry then separates into two fractions - concentrate and nitrogen. Left over is the distilled water. The dehydration process is based on a number of patented operations ensuring optimum utilisation of the heat energy. Energy consumption is kept to a minimum. The outputs from the treatment process are 75 % distilled water; 13 % NPK-fertilizer; 10 % humus and 2 % N-fertilizer. The first Funki system was applied to hog slurry treatment in 2000 in Holland.

Fortified Organic Fertilizer Blends

Typically dried poultry manure is blended with other organic materials to balance and boost the analysis. Marketing of these products focuses on the heath of the soil and providing food sources for micro-organisms.

Sludge Treatment

N-Viro International Corp., Toledo, Ohio has experience in treating municipal sludge. Currently, the company is researching the technology application to chicken manure at Beltsville, Maryland. A patented sludge treatment technology is used to create landfill cover on acidic soils, enriched soil for strip mine reclamation, landscaping and topsoil for golf courses. The key parts of the technology application to manure are disinfecting, control of odours, and prevention of excessive P and N nutrient runoff.

Thermal Waste Treatment

The manufacturer, Sun Sgri, Inc., Lebanon, Pennsylvania, has developed a combustion and thermal process technology that has been used by heavy industry. The process (patent pending) is designed to incinerate, treat and or recover materials from manure. The system is portable, capable of handling 5,000 gallons per hour of liquid, 2 ton per hour solids drying and 2 ton per hour incineration. Manure enters the process as slurry or solids and leaves the process as heat, dry granular product, vapour, or residual ash and the final products are clean and inert. The system is modular, meaning that various components may be mixed, matched and sized for any need.

Thermo-Depolymerization and Chemical Reformer (TDP)

TDP technology produces a number of products, including the conversion of poultry offal into gas for use as fuel. Volatile chemicals are segmented from solids by a reformer reactor. The gas could be blended into gasoline or diesel. Fatty acids are produced, suitable for making cosmetics, soaps and other chemicals. The process also produces liquid and solid fertilizer. Products created from turkey offal consist of: 75% high quality oil, 15% fuel-gas, and 10% carbon and minerals. The cost of TDP technology is indicated to be about one-tenth of incinerators and also to result in valuable products.

In 2002, EPA funding is assisting in the development of a Renewable Environment Solutions plant in Carthage, Missouri, using turkey offal. There is speculation that the process is also suited to recycling poultry litter. The endeavour is a joint venture between Changing World Technologies, which owns the patent to the process and has a pilot plant in Philadelphia, and ConAgra, which licenses agricultural use of the products[27].

[27] www.ozarksnow.com/projects/stewardship/alternative072102.html
www.changingworldtech.com/

Pressure and Heat Treatment

The West Virginia University developed and tested a technology whereby poultry manure was mixed with water under application of high pressure and high temperature. Poultry manure was liquefied into diesel-like oil and ethanol using technology from the coal liquifaction field. Generated diesel fuel was tested with success in a regular diesel engine. Currently the technology is operated as a bench test with small batches. The University, funded by the South Eastern Regional Biomass Energy Program and with assistance of the National Technology Laboratory and Northco Corp., is now developing a continuous reactor and eventually an on-farm facility. As the technology produces 35% more fuel value than otherwise expected it could become profitable when oil becomes scarce. This would be a long-term solution.

Recycled Waste Paper and Chicken Manure Pellets

Research is progressing on the use of a manure-paper pellets to increase the soil moisture content of clay soils, thereby reducing the formation of cracks or macro pores that occur from shrinkage during drying. Since a proper C:N ratio in the pellet is critical for paper degradation, the research is focusing on the optimal timing of caged layer manure removal to obtain design levels of N.

3.6.8 Conclusion

Both on-farm processing and centralized processing add costs to poultry manure in the order of C$50-60 per tonne. This is the same as, or somewhat higher than, the nutrient value in poultry manure, for both macronutrients and micronutrients. Where local markets do not exist, transportation will add to the cost of processed or composted manure to the user.
Pelletized, granulated, and enriched pelletized or granulated products could be shipped over longer distances, as their sale prices appear to be much higher than of bulk pelletized product. Product prices of bagged value-added product are in the US$230/ton range, well beyond the costs of pelletizing, bagging, enrichment and transportation. Locally, the market for such products is small, and such products could not rely only on regional distribution. Value-added products produced in the Lower Mainland must be distributed well beyond the region.

Several technologies are available for processing large quantities of manure. The Agri-Recycle technology will produce manure pellets that are pathogen free. This technology is suited for large-scale operation. The technology includes drying, grinding and pelletizing. The KDS-Micromex technology produces a similar product, as the manure is also dried, ground and pelletized, although the method of processing is different. KDS dried material can be produced in small regional plants that may not attract as much public attention as the Agri-Recycle facility that was proposed for Chilliwack. A granulation facility could also be a small regional plant. In light of producing either customized fertilizer in a complete line of specialized products, one or several small operations would be rather cost effective in supplying specific markets with designed products. This is a great advantage over a bulk commodity type facility.

The Agri-Recycle facility in Delaware appears to be operating economically. However, this facility has received a State Grant and was constructed with the help of a County Bond. Operations are subsidized with the Nutrient Relocation Policy, which provides transportation cost funding for up to US$20/ton. At this time such subsidies are not available for establishing a manure processing plant in the Lower

Mainland. Economic details for any large scale or regionally based BC operation must be carefully reviewed as local markets for pelletized or granulated product are very small and margins are slim.

3.7 Incineration and Generation of Power

Poultry manure has, due to its make-up and moisture content, a significant caloric value. Therefore, it has been promoted as a fuel for power plants and for space heating. A British company, FibroWatt, operates four power stations in Britain, planning one in the Netherlands, and is proposing several facilities to be build in the United States, including in Maryland, one in Minnesota and one in Mississippi. Further, poultry manure is considered as a fuel for space heating of smaller units such as greenhouses. The caloric value of poultry litter was compared to that of wood and coal, solid fuels often used in power boilers and space heating. Table 15 provides the comparison. Disadvantages of poultry manure as fuel include the high nitrogen content, corrosion through flue gases, and fouling of equipment.

Table 15: Comparison of heating value of different solid fuels (MJ/kg dry weight)

Fuel	Heating Value Btu/Lb	Heating Value MJ/kg
Coal, Anthracite	15,000	35
Coal, Bithumus	6,800-15,000	16 - 35
Good quality charcoal	13,300	30.7
Wood	8,000 – 9,500	18.5 - 22
Dried Hog manure	8,000	28.5
Poultry litter pellets	6,000	14.0
Poultry Litter	6,200	14.6

3.7.1 Overview of Biomass Programs

Biomass programs have been developed in many areas of the world. Below we have highlighted some of the more important areas and how biomass programs are operated.[28]

United States

Currently, there are about 7,000 MW (38 billion kWh) of capacity produced at more than 500 biomass fired plants in the US (primarily wood-burning), representing about 0.5% of US electricity supply. There has been little growth in capacity in the last decade, because biomass facilities can't compete on price with other fuels, especially coal. However, biomass produced power may be destined to be a significant renewable energy resource in the future. Factors favouring this trend include homeland security concerns and the nation's energy bill, until recently expected to mandate that 10% of a supplier's power must come from renewable sources by 2020 or suppliers must pay penalties of 3 cents/kWh. However, that penalty has recently been reduced to 1.5 cents/kWh. The current production tax credit for using biomass is 1.7 cents/kWh. Biomass-fuelled facilities' generation costs are in the order of 8 to 12 cents/kWh. The federal government has paid for research on co-firing coal and biomass to reduce NOx emissions in the past. This support has been shifted toward biomass gasification-based heat and power (integrated bioenergy) systems.

[28] www.platts.com/features/biomass/

Canada

There are currently 16 biomass pants in Canada, 4 owned by utilities and the other 12 owned by non-utilities. Virtually all are fired with wood or wood waste. Raw biomass (i.e. trees, shrubs, grasses, legumes. oilseeds, cereals, rushes, and energy crops such as (hybrid) poplars, willows, switch grass and reed canary grass) is plentiful and mostly unused in Canada. Secondary biomass (materials derived form raw biomass) are essentially dumped into landfills. Virtually all agricultural biomass is returned to the soil.

Canada does not have an extensive biomass program. Natural Resources Canada has been conducting research; a handful of private companies have been investing in biomass technology. In 2002, the federal government announced its Green Municipal Investments Fund for community-based projects in renewable energy, waste diversion and water management. A second component, the Green Municipal Enabling Fund, also provides financing to undertake feasibility studies.

Recent private initiatives are occurring in the areas of biomass heating systems, conversion into bio-oil, combustion technology and biomass-water separation, and producing dust fuel. This is further encouraged by the change in BC Hydro's energy policy. The power company wishes to drop all large projects and encourage private power generation. This has resulted in several project proposals including a potential project by Interpack Resources Ltd. that includes building a 10-30MW biomass co-generation facility in the Lower Mainland powered with poultry manure, horse manure and wood waste.

Australia

Renewable sources such as wind, solar, biomass and landfill gas account for 10% of total electricity supply. Under the federal governments' Sustainable Energy (Electricity) Act (April, 2001), power utilities are required to collectively source 9.5 GWh of additional renewable energy by 2010, while wholesale purchasers of electricity must source an additional 2% of power from renewable energy. Availability of cheap coals and natural gas is a major restraint in biomass energy development in Australia. However, government subsidies are in place and the industry is expected to become more competitive once the technologies become established and equipment costs come down.

China

China has a long history of reliance on biomass for energy. Several institutes have developed biomass energy conversion technologies that have been applied successfully in rural areas. Emphasis has been placed on the conversion of biomass into low and middle energy products such as: gas fuel, biogas, briquetting fuel, and liquid fuel. New biomass technologies developed in China in recent years include: anaerobic digestion, thermal pyrolysis, briquetting and energy saving furnaces/stoves.

Europe

Europe has the most developed biomass markets in the world, and biomass is currently the only industry in the renewables sector that has the capacity to increase energy output significantly. In 1997, the EU stated that renewable energy derived form biomass was to increase from 6% in 1995 to 12% by 2010. The EU's stated intent is to reduce reliance on imported energy (currently at 50% but likely to rise to 70-80% if no action is taken and to take bold steps to fulfil its commitments under the Kyoto Accord.

Biomass development is concentrated in 5 countries: Austria, Denmark, Finland, Germany and Sweden. Denmark is the largest contributor to renewable energy production and has been working since 1997 to reduce CO_2 emissions by 20% in 2005, resulting in 14% of energy needs supplied by renewable energy.

Finland has the most advanced biomass market in the world, with wood fuels used to produce 12% of the electricity. Finland also has a CO_2 tax, combined with subsidies toward wind and wood energy generating systems.

Biomass generated electricity accounts for 2% of Germany's total energy supply. There are 70 combined heat and power (CHP) plants at the planning stage; the overall objective is to double the share of renewable energy in the electricity market to 10% by 2010. Biomass facilities are eligible for subsidies ranging from Eur8.7 cents/kWh to Eur10.2 cents/kWh, depending on generating capacity. Soaring prices for wood biomass are reflecting a shortage of supply.

Swedish biomass to energy projects are being encouraged by policies to reduce greenhouse gases and to fulfil commitments to the Kyoto Accord. The abundant local availability of wood biomass gives these energy projects a significant advantage over fossil fuels.

Austrian biomass usage is predominantly as a heating source, although new projects to produce electricity are coming on stream. The largest sector for current biomass usage is in heating homes not connected to a heat network

3.7.2 Centralized Facilities using Poultry Manure

FibroWatt, a company from Great Britain, has designed power plants using poultry manure as a fuel. These facilities are large-scale power plants with capacity of between 10 and 50 MW. Operating facilities in Britain vary from 12.5 to 38.5 MW while a proposed facility will be located in the Netherlands with a nominal rating of 32 MW, produces 25-30 MW of electricity and an additional 20MW of waste heat for use as space heating (Apeldoorn plant). Another Dutch facility will use waste heat in up to 150 hectares of greenhouse production units[29]. Each facility will produce fertilizer as a by-product (phosphorus and potassium rich ash). The fuel can be considered as a CO_2 neutral fuel and thus counts as a fossil fuel replacement.

The FirbroShore facility, to be located in Maryland, has been the subject of detailed studies regarding its environmental effects. The facility, with a nominal capacity of 40MW, would consume between 200,000 and 300,000tons of poultry litter and 100,000 tons of forestry residual. All primary process operations would be totally enclosed and stack emission controls would be added to meet air quality control regulations. The study expected that emissions would fall between those of wood and coal fired power plants even with stringent control measures in place. The facility would avoid greenhouse gas emissions from fossil fuels. This avoidance would be 291,000 tons of CO_2 equivalents (tCO_2e) when compared to Natural Gas. The power plants need cooling water and boiler makeup water (1.1 million gallons for the FibroMinn facility in Minnesota). All supplied water will be recycled for cooling tower use, and no discharge other than domestic sewage will be discharged.The economics of the FibroShore facility was described in a report by Electrotec Concepts. The results of this report show a production cost of US$0.0365 per kWh of electricity, and a delivery cost for the area of 0.0194 per kWh. The facility received a Renewable Energy Credit of 1.7c per kWh. The Minnesota facility, FibroMinn, received air permits on October 25, 2002. Once built, this plant will generate 50MW of power from 525,000 tons of turkey manure and 175,000 tons of agricultural residual. Its output is to be purchased by Xcel Energy as part of their 129MW commitment to green energy. Xcel Energy also operates a Renewable Development

[29] http://www.nhm.ac.uk/mineralogy/phos/Nordwijkerhout/deHaan.doc

Fund, which financed 19 projects in 2001 for a total of $16Million. FibroWatt is also developing a project in Mississippi, FibroMiss, that will consume 200,000 to 300,000 tons of poultry litter.

FibroWatt facilities will provide an energy alternative in areas where power is generated from coal or other fossil fuels. FibroWatt facilities both in Europe and in North America will benefit from green energy programs and subsidies. FibroShore will benefit from a US$10/ton transport subsidy, and a 1.5c to 1.7c state or Federal energy credit. This will allow them to offer $2-5/ton to poultry producers, equivalent to the price received from land applicators in Minnesota.

Other companies have entered the power market. Eastern Shore Forest Products Inc. (ESFPI), Salisbury, Maryland recycles wood residuals from the lumber industry into mulch, bark, potting soil, compost, biomass fuel and animal bedding. ESFPI has entered into a partnership with a fertilizer company to build the granulation plant. ESFPI intends to set up boilers at processing plants to provide markets for the pellets. Composts are manufactured on-site. The company does not pay growers for the manure but does clean out the material and transport to the plant at no cost to growers. Recently, electricity generation from manure pellets has been considered too costly and unreliable, resulting in the loss of a potential state contract. ESFPI is currently experimenting with burning pellets derived from other fuels.

Based on the available amount of poultry manure in the Lower Mainland, a relatively small facility of 10MW could be sustained. Such facility would absorb about 150,000 tonnes of manure and other biomass. Costs of generated electrical power would be beyond those typical for BC. Such a plant would need significant subsidies in the form of grants and preferential power purchase plans (Green energy plans) to be viable. With its questionable finances, and the public reaction against the Sumas Energy project powered by natural gas, we do not believe that a FibroWatt type facility would be feasible in the Lower Mainland under current conditions.

3.7.2 Small Scale Facilities

While poultry barns have an energy need, no systems are commercially available to generate heat from poultry manure. Most research and product development in on-farm utilization of poultry manure have focused on gasification systems. Direct combustion for generation of heat has not been studied extensively, despite significant public support through the USDA Environmental Quality Incentives Program, and support for deployment of on-farm renewable energy systems as included in the US 2002 Farm Bill. Several hurdles stand in the way of developing on-farm systems. These include a hassle factor (natural gas is easier to use), economics, technical viability, ash management, and environmental regulations (emissions).

3.8 Gasification and generation of Power, bio-fuel, or Hydrogen gas

Several companies, including Dynamotive of Vancouver, BC, Etho Power of Kelowna, BC, and Malahat Energy Corporation have developed gasification systems to produce bio-oil/bio-gas energy, hydrogen, or heat. Etho Power installed a system in Australia and Malahat used to operate a system at a greenhouse in Chilliwack, BC. Most of these companies have focussed on gasification of clean biomass such as wood chips, wood shavings and sawdust from lumber processing facilities. Although the technology is suitable to process “dirty” poultry manure, companies prefer to work with “clean” wood in their commercialization programs. However, several gasification companies have tested with poultry manure, including JF Bioenergy and Etho Power.

3.8.1 Centralized Facilities Processing Poultry waste

Several gasification plants are currently in operation in the US. Up to 200 plants have been proposed worldwide, half of them in the US. These facilities process all kind of biomass. Some of the facilities processing poultry offal or poultry litter are listed below.

- Tyson Foods Inc., facility in Temperanceville, Virginia, converts poultry litter, hatchery waste and sludge skimmed from its poultry processing wastewater treatment plants
- Wampler Foods and Rocco Quality Foods, Virginia are reported to be building a gasification plant in the Shenandoah Valley. Wampler and Rocco are poultry producers
- Planned for completion by late 2001 in Harrisburg, VA, Duke Solutions of Charlotte, North Carolina and Harmony Products of Chesapeake, Virginia. will share ownership of the plant with Renewable Energy Corp. Ltd. of Sydney, Australia. Feed stocks to be processed will include litter and manure from poultry growers. The utility will focus on the waste-to-energy technology, while Harmony Products will operate the plants and market the fertilizer. Each ton of litter processed is expected to equal about $100 in revenue in terms of fertilizer and energy
- Several other litter to energy and fertilizer plants are planned in the US Southeast and Midwest.

One technology has been developed for the gasification of pulp mill by-products. This technology has also been tested with poultry manure and hog manure. MTCI Inc. of Baltimore MD[30], has developed a biomass energy system based on pyrolysis/steam reformation. This process, wherein dried biomass is burned with the addition of super heated steam transforms 98+% of carbonaceous material into CO and H_2. After cleaning, the gases are either used in a micro turbine or in a fuel cell to generate electrical energy. The company has operated prototypes with pulp mill waste, dried hog manure, and with poultry manure. For biomass, a facility size of 5MW appears optimum, consuming about 87tons/day of biomass waste, with an efficiency of 26.6%. Electricity production costs are US$0.068 per kWh when the feed is obtained for free, and US$0.11 with a feed cost of US$20/ton.

The Australian-based Renewable Energy technology is the patented Waterwide Heat Plant system or Close Coupled Gasification, that controls emissions during, rather than afte,r combustion in converting biomass to energy and organic fertilizer. The plants gasify poultry waste at low temperature to produce organic fertilizer and energy for sale to industrial customers in the form of steam. The ash is to be sold to fertilizer manufacturers.

This technology has great potential in areas with high energy prices, or when there is a demand for hydrogen gas for use in fuel cells. Under Fraser Valley conditions with relatively low energy costs of between C$0.03 and 0.06 per kWh, the MTCI system would not be economically feasible at this point. However, should a market develop in hydrogen fuels, the economic feasibility would change dramatically.

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[30] http://bioproducts-bioenergy.gov/pdfs/bcota/abstracts/2/z219.pdf; and Chandran, 2002. Personal Communication

3.8.2 On-farm facilities

On-farm facilities can be located on the poultry farm, where manure is transformed into heat and electricity for use on the farm, or they can be located on a user farm such as a greenhouse. Here, generated heat, CO2 or electricity is used, lowering the farm's energy dependence on outside sources. This section describes systems both for poultry farms, and for greenhouses. The poultry farm system has been developed and tested in the Netherlands by BTG Biomass Technology Group BV[31]. A demonstration plant has been built on a layer farm equipped with manure belts. This plant dries manure, runs a fluidized bed gasifier, an apparatus where fuel is burned with a low supply of oxygen, and produced gases are used in a gas turbine to produce electricity. The electricity is for on-farm uses or is sold to the power grid, and surplus heat is used on the farm. The capital cost for a production-run plant was estimated at C$800,000. Benefits include the supply of heat and electricity, and foremost, the reduction of manure disposal costs of C$53.00 per tonne. Some revenue can be expected from the sale of power to the grid. Surplus ash/charcoal (~40% of manure) would be utilized as road building material. The system contained a three-step air emission control system.

JF Bioenergy (Abbotsford, BC) has developed a gasification system that uses poultry manure as fuel for medium to large size consumers of heat such as green houses. This system dries and then gasifies poultry manure, resulting in heat, charcoal (25%) some ash (3%) and bio-oil. The system is in the pilot scale stage. Although the system produces low air emissions, the company is concerned regarding emissions of ammonia. JF Bioenergy is in the business of designing, selling and building equipment. As part of this they build teams to own and operate systems. The company envisions selling and building plants with a capacity from 120 tonnes/day to 250tonnes/day adjacent to large greenhouses. They have considerable interest from the greenhouse industry. The primary goal of operating the system would be to provide heat to the greenhouse, covering most or all of its heating requirements. Produced and pelleted charcoal could then be sold to other thermal facilities such as power boilers at pulp mills or boilers at other greenhouses. Alternatively, the charcoal can be sold to upgraders to form filter medium. Bio-oil can be sold, or used as a supply of heating oil, diesel fuel or as base for a petrochemical process. A 120t/day plant would generate about 15-20 million BTU/hour (3MW capacity) in heat and 7,500 to 8,000 tonnes of charcoal per year, as well as bio oil. Both charcoal ($150/tonne for pellets having a BTU value of 12,000 BTU, or $25/tonne bulk powder) and bio-oil (estimated at $0.45/gallon) would provide a revenue stream to the system operators. The capital outlay for such a system would be in the $2.5 million range.

This system approach may be suitable for the Fraser Valley. It is modular, and could be phased in, green houses are in need of cost effective fuel sources and are willing to invest in alternatives. Currently six or seven large greenhouses are burning wood products. Two facilities, Howeling in Delta and Rainbow in Chilliwack use wood shavings and ground wood, while several others, including Techni-gro in Chilliwack are operating on wood pellets. Manure or manure pellets and charcoal (pellets) could substitute for wood pellets as boiler fuel. Pellets, however, are not interchangeable with wood shavings or ground wood, due to the high burn temperatures. Pellets burn much hotter and boiler equipment dedicated to pellets is required.

The viability of burning alternative fuels in greenhouse boilers is based on the price of natural gas, which is the main fuel used in BC greenhouses. With natural gas prices in the order of US$4-5, excluding delivery charges, wood pellets are an economical source of fuel at $105/tonne delivered. Poultry manure pellets would be economical at $65/tonne, based on heating value, and charcoal pellets at an estimated

[31] Buffinga G.J. and HAM Knoef, 2001. Implementation and Demonstration of an Embedded Small Scale Poultry Manure CHP Process. http://www.btgworld.com/services/pdf/pei/930-sum.pdf

$150/tonne. JF Bioenergy envisions that the gasifiers would be fuelled with raw, non-pelleted poultry manure. A pelletizer is complementing their system, and produces pelleted charcoal.

Several aspects of burning poultry manure in greenhouse boiler systems must be assessed. These aspects include emissions and waste products. The emissions from poultry manure boilers are, qualitatively, between wood and coal. Stack emissions of dried wood pellets are much better than those of wood residue, and may approach those of natural gas. Components of stack emissions from poultry manure include nitrogen compounds and some particulate matter. Concerns have been raised regarding the metal content of the particulate matter. Further, concerns have been raised by boiler operators regarding corrosion due to the nitrogen oxide in flue gases which might affect the boiler's heat exchanger.

Gasification is a combustion technology. Therefore the risk of air emissions is present. It is well understood that emissions from combustion of nitrogen rich materials could contain large quantities of NOx, a potent greenhouse gas. It appears that the generation of NOx in combustion processes is temperature related. The highest levels of NOx in emissions are found in the off-gases of high temperature burners. However, in low temperature facilities such as gasifiers, ammonia, which is not a greenhouse gas, is formed instead of NOx. This has been reported for the on-farm facility in the Netherlands[32], and for the tests by MTCI[33], both using poultry manure. A monitoring program at a gasification plant in Los Angeles, which was fueled with biosolids (N content 8%) emitted only minor amounts of NOx, well below the emission standards[34]. The JF Bioenergy test facility showed NOx emissions that were lower than local standards when wood waste was processed.

It appears that the formation of NOx is quite machine, process and fuel dependent. This means that temperature and operating conditions may affect flue gas emissions. The amount of air (oxygen) allowed-in makes a difference, as well as the system configuration and temperatures for combustion. For instance the reports from BGT and MTCI show no NOx and a very high nitrogen conversion to NH_3. The LA sewage plant produced very low NOx from an N containing sewage sludge (8%). Here a multi step machine was used. In conventional combustion with full oxygen supply, NOx will be formed at medium to high temperatures. Some squelching techniques, as well as some gas cooling techniques may convert nitrogen gases to oxides. During combustion of nitrogen poor fuels such as coal and natural gas and also wood, NOx can be formed from the oxidation at high temperatures of the N_2 in air. In gasification, NOx may be formed at the higher end of the gasification temperature spectrum (750-800^oC). JF Bioenergy mentioned that their machine can operate at temperatures as low as 450^o. This would virtually eliminate the NOx production and create all nitrogen as NH_3.

Based on the reports showing results of tests with gasifiers fed with poultry manure, we believe that NH_3 will be the "emission of choice", even though combustion engineers may expect differently based on conventional combustion technology and knowledge. A test with the JF Bioenergy machine fuelled with poultry manure would be required to shed light on which gas will be produced, NOx or NH_3. Based on the results of such tests, JF Bioenergy could then investigate whether any emitted NOx could be reduced through process changes such as operating at different temperatures, or whether more engineering type of solutions would be required. Any NH_3 in the off-gases can easily be captured with a water or acid wash. Captured ammonia could then be reused in the hydroponics system of the greenhouse operating the gasifier.

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[32] Buffinga G.J. and HAM Knoef, 2001. Implementation and Demonstration of an Embedded Small Scale Poultry Manure CHP Process. http://www.btgworld.com/services/pdf/pei/930-sum.pdf

[33] http://bioproducts-bioenergy.gov/pdfs/bcota/abstracts/2/z219.pdf; and Chandran, 2002. Personal Communication

[34] Lewis and Haug, 1999. Four stage fluidized bed gasification minimizes NOx. http://www.etis.net/balpyo/15icfbc/99-0205.PDF

Ash from burned poultry manure could be used as a phosphorus and potassium rich fertilizer. This ash must then be collected as fine precipitator ash. Poultry manure precipitator ash is light in color and has a low carbon content. Samples we obtained of granulated manure ash, originated from a large facility. It needs to be assessed whether small operations generate enough ash of a quality that can be transformed in fertilizer pellets. Ash from operating wood boilers used in greenhouses was either generated in very small amounts, or was in the form of clinker ash and carbon rich precipitator ash. Neither can be used as fertilizer.

When a JF Bioenergy or similar gasification system would be installed at a large greenhouse, it would consume between 24,000 and 50,000 tonnes annually for each installation. This means that two facilities could absorb the surplus poultry manure from the Lower Mainland, and that 7 facilities could absorb all poultry manure that is currently produced.

3.9 Financial Programs

Several financial programs exist in BC and Canada to assist industry. Table 16 below, outlines programs that could be available to the poultry industry. Our evaluation of government programs led to the following results. With the possible exception of the MART market research assistance program, BC does not have programs that would assist in the uptake of new technology at the farm level. There are no federal or provincial programs that are adaptable to assist in the financing or development of on-farm manure treatment, utilization, storage, or off-farm transportation. Federal financial programs are strongly orientated toward investment in scientific and/or technological research in partnership with financially established private companies. Federal technology research programs are centered on energy efficiency in the petroleum sector, new environmental technologies and biotechnology.

The funding programs directed to climate change, such as the Climate Change Action Fund TEAM process, and the Sustainable Development Technology Canada programs could assist the poultry industry in developing and implementing manure handling technologies, where reductions in greenhouse gases can be accomplished.

Table 16: Financial Support Programs Available in Canada

Agency	Program	Details
Natural Resources Canada	Alternative Transportation Fuels	Promotes R&D in the development of alternative transportation fuels such as propane, natural gas, methanol, ethanol and electric
	CANMET Energy Diversification Laboratory	Provides R&D, commercialization and technology transfer expertise and cost sharing ventures in heat management technologies, renewable energy and hybrid systems.
	CANMET Energy Technology Branch	Promotes energy efficiency, alternative fuels and renewable energy. Provides financial assistance
	CANMET Energy Technology Centre	Creates Partnerships and strategic alliances with industry and or government to develop and commercialize new energy technologies
	CANMET Western Research Centre	Conducts industrial and environmental technologies research
	Program of Energy Research and Development	Federal Departments apply to this program to fund R&D projects within the energy field: Energy efficiency, climate change, transportation, renewable energy, hydrocarbons.
	Processing and Environmental Catalysis Program	Develops technologies for the production of renewable alternative transportation fuels, fuel additives, and petrochemicals from natural gas, light hydrocarbons and renewable sources.
	Renewable Energy Technologies Program	Supports cost-effective environmentally sound technologies such as solar, wind, small hydro and bio energy.
	Industry Energy R&D Program (IERD)	Supports development and use of technological products, processes, systems and equipment with create a cleaner environment. Focussed on those with strong

		market potential.
National Research Council Canada	Industrial Research Assistance Program	Helps firms to put their scientific and engineering expertise to work.
Industry Canada	Technology Partnerships Canada	Industry Canada partners with financially viable groups to work in areas of environmental technologies, biotech, robotics, aerospace and defence
BC Government	Technology Assistance Program	Similar to IRAP and now integrated with it.
Information Science and Technology Agnecy (ISTA)	Market Assessment of Research and Technology	BC Program to assist companies in determining the market potential of innovative scientific or technical products, processes or system (max ~$25,000)
Sustainable Development Technology Canada	Partnership to develop infra structure re greenhouse gases	Mandate to build a sustainable development technology infrastructure through partnerships between industry, government, non profit organizations www.sdtc.ca/en/funding/update
Agriculture and Agrifood Canada	CARD	Assistance in agriculture related projects
Environment Canada	Climate Change Action Fund, Technology Early Action Measures	Fund to engage government, business communities and individuals to address climate change. The TEAM brings together partners to encourage investment in innovative technologies to reduce greenhouse gases. www.climatechange.gc.ca/english/actions/action_fund/techno.shtml
Environment Canada	Eco-Action Fund	Community based program in support of healthy environment for non profit groups.
Revenue Canada	Scientific Research and Development Tax Credit	Program that reimburses 35% of a companies eligible research and development costs as a tax credit.
Western Diversification	WD Technology Assessment Services	Provides assessment services and financial aid to businesses developing technologies and processes.

One source of funding would be the sale of carbon credits. Carbon credits are part of a financial transaction between a generator of green house gases including methane, nitrous oxide and carbon dioxide, and an entity that can absorb or sequester carbon in a stable form. Through this mechanism, the permanent removal of carbon dioxide from the atmosphere lowers the effects of global warming from human activities. Different pathways exist to lower the greenhouse gas emission. These include:

- the absorption of carbon dioxide in forestry, agriculture and other land use systems,
- the transformation of highly active greenhouse gases such as methane into CO_2 (methane has the green house gas effect of 23 times that of CO_2),
- prevention of emission of nitrous oxide (310 times the greenhouse gas effect of CO_2), or
- preventing the use of fossil fuels such as coal, oil and natural gas through substituting renewable energy such as biomass fuels.

Trading carbon credits is a mechanism under the international Kyoto Accord, which was recently endorsed by the Canadian government. The mechanism allows trades between partners such as individual countries in Europe, and between developed countries and undeveloped countries. Also trades take place between parties in one country. Although the US has not ratified the Kyoto Accord, some trade takes place within the US.

Several power companies, including BC Hydro, are investigating the purchase of such credits to off-set environmental effects (and public pressure) from coal fired power plants or natural gas fired plants located in densely populated areas. For instance, BC Hydro wishes to buy the equivalent of 500,000 tonnes of CO_2 to partly offset the increased operation of the Burrard thermal facility and a new natural gas powered facility on Vancouver Island. With talk in Ottawa of capping the value of tonnes of CO_2 equivalent, and the use of carbon credits for replacement of fossil fuel, the value of carbon credits in BC is likely not large. The poultry industry, or players within the poultry industry, could benefit from carbon credits. Manure could be used as a biofuel, creating off-set credits for the substitution of fossil fuel such as is used in the greenhouse industry. Alternatively, credits could be obtained through implementation of any technology that will prevent the generation of methane.

Many sources of funding exist in the United States and Europe. Funding sources in the US include:

- Bond financing at the County level
- Operating subsidies at the State level
- Public Sector Ownership and involvement (providing land etc)
- Manure transportation subsidies
- Federal and State electricity production rebates
- Green energy purchase agreements
- Carbon Credits
- Deployment grants, and
- Environmental Quality Incentive Programs.

In Canada, there are no programs available that match the level of support for the US poultry industry. Except for carbon credit that can be obtained by selected projects, the BC poultry industry would depend on programs that are economically viable, and/or that are self financed through farmer supported transportation allowances. However, support will be available to entrepreneurs to develop the technology required such as gasification and generation of bio-oil and hydrogen, and for projects that reduce greenhouse gas emissions.

4.0 Discussion

This section will comment on some of the findings as outlined in the report. For each of the findings we have added remarks to put described solutions or findings in perspective. Each subsection discusses a topic and is indicated with a separate heading.

Accuracy of Data

The conclusions and recommendations of this report are partly based on available data for the four livestock commodities: poultry, dairy, hogs, and beef, that together account for most of the livestock in the Lower Mainland and Thompson-Okanagan regions. They are also based on estimates, rather than accurate measures, of manure production. These data may not be sufficiently accurate to produce a truly reliable manure or nutrient balance for either region. Although the Census of Agriculture provides a reasonably accurate snapshot of animal populations, no census data are available on produced manure. Therefore we relied heavily on estimates of future poultry manure production as supplied by SPFG, and on recent literature and data from North Carolina and several other jurisdictions. The literature and data from these other jurisdictions may or may not reflect the regional differences in feed, housing, climate, animal stock, and market conditions to quantitatively estimate manure supply. The results of the work should be seen as qualitative, based on best available data.

Manure Surplus in Lower Mainland

The presented data revealed that a manure nutrient surplus exist in the Lower Mainland. About twice the volume of nutrients are applied compared to what crops require. With a status quo, and accepting the current fertilizer application patterns, a manure surplus could be as low as the equivalent of 80,000 tonnes annually of poultry manure. This is the estimated increase in manure production by the poultry industry between 2001 and 2010.

With full implementation of the Environmental Farm Plan program the need for nutrients in the Lower Mainland may decrease with the equivalent of 320,000 tonnes of poultry manure, representing all of the manure production of the poultry industry. This is considered a worst case scenario. As the surplus is based on nutrients in manure from all commodities, it is plausible that not all nutrients would need to be removed from the Lower Mainland in the form of poultry manure. Considering the types of manure produced by other commodities, poultry manure may be more easily to process and remove due to its relatively low moisture content as compared to the liquid products generated by the dairy and hog industries. Further, as some commodities such as the dairy industry, have greater access to land (e.g. own more land), "none land based" commodities such as poultry and pigs, and farms where the land's absorption capacity for nutrients is exceeded, may be pressured/required to remove manure to outside the Lower Mainland. All things considered, addressing the worst case scenario may need to be a priority for the poultry industry.

Manure to the Thompson-Okanagan

The nutrient balances show that the Lower Mainland appears to have a large nutrient surplus, which, when chemical fertilizer is added into the total, is in the order of twice the demand of all crops grown in the Lower Mainland. This means that all additional poultry manure generated between 2002 and 2010 needs to be removed from the Lower Mainland, as well as a portion or all of the current supply. The Thompson-Okanagan region appears to have a nutrient deficit, especially for phosphorus and potassium. Poultry manure from the Lower Mainland could be shipped to that region and used as a nutrient supply to crops typically grown there. The largest acreage grown appears to be alfalfa or alfalfa grass mixes. Poultry manure, and especially ash from incinerated poultry manure could supply the required phosphorus and potassium, as both nutrients appear in short supply in the Thompson-Okanagan region. As farmers in the Thompson-Okanagan region primarily use chemical fertilizer, a granulated product based on poultry manure would be useful. Such product can be supplied through the existing fertilizer dealerships, and can be applied with regular farm equipment. Application of raw manure would require a separate storage and distribution system, and custom applicators. We estimate that he region could absorb between 15,000 and 125,000 tonnes of poultry manure, depending on its form and price.

Feed Additives

We have looked at how different factors in production and marketing would affect the amount of manure produced. It appears that the use of feed additives such as amino acids and phytase could lower the nutrient content of manure by as much 20 - 30% for both nitrogen and phosphorus. This would increase the amount of manure that can be applied to land in the Lower Mainland for crops restricted in either nitrogen or phosphorus. Crops where potassium is the limiting factor in application of nutrients would not benefit from these feed additives, as no information on feed additives for reducing potassium in manure could be found. A reduction in potassium would have to take place through the utilization of low potassium feed ingredients. As the Lower Mainland is saturated with nutrients to the extend that an equivalent of all manure produced by the poultry industry should be removed, large scale introduction of feed additives may not solve the manure challenge completely.

BC’s Environmental Farm Plans Program

The implementation of the BC Environmental Farm Plans Program, which will include a best nutrient management section, will greatly affect regional nutrient management. As the Environmental Farm Plan Program will encourage the balance of nutrient demands with nutrient supplies, over-fertilization as it currently occurs in the Lower Mainland, may be greatly reduced. This means that when the Environmental Farm Plan Program is fully implemented and Farm Plans are used by most or all farmers, the surplus of manure (in all forms) to be disposed of outside the Lower Mainland will grow dramatically. Although the Environmental Farm Plan Program is on a voluntary basis and will not have an enforcement mechanism, enforcement will be enacted through other (existing and future) legislation such as the Fisheries Act and the Groundwater Protection Act. We expect the impact of the Environmental Farm Plan Program to be significant in reducing the amount of nutrients that can be applied to agricultural fields

Large scale manure processing options and their markets

Large scale manure processing facilities, such as FibroWatt or Agri-Recycle, which are successfully operating in Europe and the US, may not economically solve the manure surplus in the Lower Mainland. Where these processing facilities have been, or will be established, the operations have been, or will be heavily subsidized. Subsidies include green energy buying programs (UK, Netherlands, Minnesota), manure transport subsidies of up to US$20/ton (Delaware, Maryland, Minnesota), US State and Federal green electricity production rebates of 1.7c/kWh, direct subsidies such as grants (Delaware), indirect subsidies such as relaxed regulations, providing sites, and permitting exemptions (Minnesota), and bond financing (Sussex County, Delaware). Green power from poultry manure would qualify for carbon credits as the manure is a fuel replacement for coal or other fossil fuels. The combination of financial programs allowed large scale processing and power generating facilities, trucking-in of manure free of charge, and offer poultry producers barn cleaning services. The lack of similar direct and indirect funding mechanisms in Canada and BC may exclude these large-scale processing facilities.

Agri-Recycle in Delaware ships product out-of-State. Their markets are located in the Mid-West where grain farmers use the fertilizer pellets to augment regular basic fertilizer regimen. Agri-Recycle is able to supply these distant markets due to the transportation subsidy of up to US$20/ton for processed product (including up to US$10 for raw manure). In the case of the Fraser Valley, the nearest grain growing area is Eastern Washington's Palouse region. Even in the Palouse there will be competitive pressure from poultry producers in Washington, Oregon or California. Poultry production is reasonably low in Washington State and Oregon, but California is the fifth largest egg producing State and the sixth largest producer of turkeys in the US. Depending on subsidies for transport, these areas would also ship manure to the nearest grain growing area, which also happens to be the Palouse. A similar competitive situation existed in Europe. Producers in the livestock areas in The Netherlands had identified the grain fields of Northern France as the market for their manure products, as (independently) had the livestock producers in Belgium, Germany, Switzerland, and areas of France. Due to the competition with producers from US livestock producing areas, shipments of Canadian pellets may be viewed as competition. The strong agricultural lobby in the US may quickly find ways to prevent shipments to the US, including the use of real or perceived food safety issues

The YK manure processing plant proposed for Kent, BC, has, according to company sources, low operating costs because the plant was re-engineered from the original Agri-Recycle design. YK proposes to supply one large distributor with blended and/or fortified granulated product. The product would be marketed in Canadian, US, and overseas markets. YK also envisions marketing to the organic sector. Marketing abroad will likely benefit from the low Canadian dollar, and targeting different markets would spread market risk. Our research has shown that the local market for pelleted or granulated fertilizer is small. However, this local market could be increased over time should specialty products be produced for the alfalfa-forage and for the golf course markets. A large plant may have a significant marketing risk in the first years after start-up, as large quantities of pelleted manure need to be absorbed quickly into the market.

Generation of Power

Power boilers generate large quantities of excess heat. When this heat is utilized for space heating, as will be the case with the FibroWatt facility in The Netherlands, supplying heat can be a source of income. In areas where FibroWatt is successful, such as in Britain, electricity rates are several times higher than those in BC. In Britain and other countries in Europe, green power sources with generation costs similar to or slightly higher than of those based on fossil fuel would be a source of choice due to the replacement of fossil fuel. For instance, The Netherlands required the purchase of green power and heavily subsidized its generation Other sources of income may be needed for a plant to be feasible. In the US, FibroShore is experimenting with fertilizer made from incinerated poultry manure ash. Ash (based on the sample that we have obtained) would have a nutrient value of approximately $115/ton based on N, P and K, providing an alternative source of income.

Gasification

Gasification of wood products is a technology that has been in development for a number of years. Products of gasification are flammable gases to be used for space heating and the generation of power in gas turbines, bio-oil to be used as boiler fuel or as diesel replacement, and with extra processing, hydrogen gas for use in fuel cells. Charcoal is generated as a byproduct at a rate of 25-34% of the manure input. Gasification and further processing into hydrogen gas would be a future solution, as the market for hydrogen gas is not yet established. Gasification of poultry manure to supply the heating needs of other agricultural production units such as green houses may be feasible, and should be studied further. A locally produced gasifier has been tested with poultry manure with good initial results. The company is interested in placing poultry manure fired gasifiers at large greenhouses. Each greenhouse would then absorb between 24,000 and 50,000 tonnes annually. This means that a limited number of gasifiers could absorb the complete production of poultry manure in the Lower Mainland and because each installation would absorb a small portion of the supply (10-20%), the risk would be spread. A greenhouse will adsorb the cost for the gasifier, and with a suitable deduction in fuel supply costs, such system may be cost effectively operated compared to natural gas. The greenhouse will generate value-added byproducts such as fuel oil and charcoal, each generating an additional income stream. A cooperative supply agreement between the greenhouse and several poultry producers would be cost effective.

Composting

Composting of poultry manure would be feasible for small on-farm facilities or a medium scale central facility catering to a local market. Composted poultry manure is a superior product compared to raw manure, as pathogens and weed seeds are removed, nutrients are stabilized, odour is removed, and it can be used in disease control. Compost can only be marketed within a small radius of the production unit due to cost for transportation and production. Costs of composting itself will be somewhere around $20/tonne, pelletizing or granulating is extra. This will bring the wholesale price of the final product to $60 to $65/tonne, which may be feasible in the local market. The local market for composted poultry manure could be as high as 15,000 tonnes, especially in the organic sector.

Risks to poultry producers

Several systems or technologies are available to address the manure surplus in the Lower Mainland. These systems and technologies range from small scale options combined in a basket approach to large scale options such as pelletizing/granulizing and power generation. Each of these types of options comes with risks to poultry producers and to the operators of these options. The main risk to the producers is how “durable” an option will be once it is implemented. In case of a basket approach or any combination of smaller options, this risk to the producers will be low, as failure of one of the basket options will not seriously affect the manure program as a whole. The risk to producers is much higher when a single option absorbs 40% or more of the total supply, as will be the case in the Lower Mainland with large Agri-Recycle, or a FibroWatt type of facility. Failure of such a large option would significantly affect the survival of the poultry industry itself as producers would have relinquished access to the manure handling framework currently in place.

In other jurisdictions, the effect of a typical size large facility on the total supply is smaller than it is in the Lower Mainland. For instance, relative to poultry manure produced in Delaware (900,000 tons) and neighboring Maryland (1,500,000 tons), the Agri-Recycle facility in Sussex County with a production of 80,000 tons, absorbs only a small fraction of the supply, as will Maryland’s FibroShore facility burning 200,000-300,000 tons of manure. The FibroMiss facility in Mississippi (2,900,000 tons of poultry manure) will absorb less than 10% of the supply. In Minnesota (1,400,000 tons of poultry waste) the FibroMinn facility burning 520,000 tonnes will absorb less than 40%. This will have about the same risk to poultry producers as the YK facility would have on the supply in the Lower Mainland. However, in case of production of power in a protected and subsidized market, the risk of failure is very low compared to an unsubsidized free market situation in the Lower Mainland. Producers in the Lower Mainland may wish to investigate whether risk reduction measures should be implemented in case the YK plant size facility is built. Such measures would be based on a good understanding of the market and how the supply is guaranteed.

Options for Funding

Facilities in the US which handle poultry manure are provided with financial support from the county level, the state level and federal level. Support includes bond financing, operating grants, manure transportation subsidies, preferential power purchase requirements, and green power subsidies. None of these subsidies are in place in Canada. However, some support could be obtained should a project replace fossil fuel. BC Hydro and BC Gas, as well as other Canadian power suppliers are looking to buy carbon credits, and funds are available to develop energy saving technologies or for technologies that replace the use of fossil fuels.

5.0 Promising Options

The poultry industry in the Lower Mainland currently produces about 240,000 tonnes of poultry manure. This production will increase to about 320,000 tonnes in 2010. With the adoption of the Environmental Farm Plan Program and the shift in use of poultry manure in vegetable production, it is expected that not only the expected increase in production of about 80,000 tonnes must be dealt with. Arguably, all produced poultry manure must be removed from the Lower Mainland. Several options (or combination of options) exist that may have the capability to viably solve the manure challenge in the Lower Mainland. This section will briefly describe these promising options. Described options include the basket approach, supplying the alfalfa growers in the Thompson-Okanagan (and possibly the Caribou) with either raw or pelletized/granulated manure, the production use of pelleted or granulated fortified product, an use of raw manure in gasifiers located at greenhouses.

Basket Approach

One of the options is a "basket approach" wherein increases in manure production would be absorbed incrementally by the progressive phasing in of a number of the possible options. The basket would include composting (15,000 tonnes), granulating/pelletizing and supplying local markets (5,000 tonnes), growth by the mushroom industry (5,000-20,000 tonnes), and value-added designer fertilizer products (20,000 tonnes) for a possible total of 60,000 tonnes. The basket approach would probably not be sufficient to absorb all of the expected increase in poultry manure supply to 2010 and needs to be augmented with other options.

Shipment to the Thompson-Okanagan

We believe that supplying the alfalfa and forage growers in the Thompson-Okanagan with raw manure, could absorb a portion of the surplus of manure generated between now and 2010. Current data from the SPFG shows that the transport of manure to the Interior can be cost effective. When larger quantities of manure will be shipped, some of the costs for marketing, shipping, and spreading may have to be borne by the poultry producers. The increase in recovered manure supply in the Thompson-Okanagan and changes in cropping pattern would restrict the market for Lower Mainland manure somewhat, but probably not significantly. We estimate that transportation alone (no back haul), would be in the order of C$26/tonne[35]. (Based on back hauling the cost would be about C$13/tonne.) Storage and spreading would be an additional C$5/tonne each for extra handling, dedicated (constructed) storage, and dedicated equipment use. With an apparent commercial value of raw poultry manure of only about C$38/tonne, the transport of raw poultry manure to the Interior could possibly break even. With a lower perceived value and higher costs, this option may need to be subsidized up to a maximum of $22/tonne. The Thompson-Okanagan could absorb some 25,000 tonnes of raw manure.

When the product is pelletized first (pelletizing is not likely to increase the nutrient content, but will reduce the moisture content and provide an improved physical product), some or all of the storage and spreading costs would be reduced compared to the costs for raw manure. The option of pelletizing poultry manure and then marketing it to the alfalfa growers in the Thompson-Okanagan and Caribou could absorb not only the surplus generated between 2003 and 2010, but potentially a portion of the manure presently produced in the Lower Mainland. These markets are large enough to absorb a significant portion of the supply. Servicing them may not necessarily be economically viable without a transportation subsidy, unless fortified granulated product of higher value is produced and sold. The Thompson-Okanagan could absorb up to 125,000 tonnes of a specialty product.

[35] Chambers trucking, Personal communication

Gasification and use of manure as a source of energy

The option of supplying poultry manure, as a fuel to greenhouse operators could potentially absorb 75% of the manure produced by the poultry industry in 2010. In case of raw manure, the fuel would be supplied at transportation cost. This would offset the costs incurred by greenhouse operators to install a gasifier at costs that are higher than those for regular wood burning equipment. Costs to greenhouse operators could be lowered through the sale of byproduct charcoal. Agreement is required between individual poultry producers and a greenhouse operator. We estimate that 5 to 7 of individual "clusters" would be sufficient to absorb about 245,000 tonnes as gasifier fuel. Additional information would be needed to determine if this option is acceptable within emission gas requirements.

Specialty Fertilizer

The Thompson-Okanagan and the Caribou markets are potentially the largest nearby markets for pelleted or granulated poultry manure to the Lower Mainland. Markets may also exist elsewhere. The feasibility of marketing pelleted or granulated poultry manure to such markets needs to be reviewed carefully as to profitability and sustainability. Establishing a pelletizer/granulator in the Lower Mainland to produce value-added, fortified, or designer, fertilizer would be a solution generating most revenue per tonne produced. Manufacturing of "designer products" would increase the value of a poultry manure based fertilizer by selective blending with high analysis, chemical fertilizer materials. Several options exist to market designer products. The golf course market could absorb about 2,300 tonnes of poultry manure annually when it is either blended with chemical fertilizer, or when poultry manure pellets or granules are enriched with other nutrients to reach the require nutrient analysis. Certainly, other markets exist requiring "designer products", and a local, small to medium scale pelletizing or granulation unit may be required to supply this market. We estimate the local market that can be supplied from the Lower Mainland based plant to be between 10,000 and 25,000 tonnes, in addition to the demand from the Interior alfalfa growers. This means that the Lower Mainland could sustain either a small pelletizing or granulating facility (for the specialty market), or a larger one, serving the specialty market with custom pellets or granules and serving the Interior market with an alfalfa-forage custom product. The size of the required facility or the need for several facilities needs to be investigated. The proposed YK granulating facility and distribution agreement, would absorb some 100,000 tonnes of manure annually with product shipped to a fertilizer distributor. Such a facility and marketing operation, combined with other options, could form a suitable option for the disposal and reuse of poultry manure.

Feed Additives

Introduction of the use of feed additives in the poultry industry will affect the manure application in the Lower Mainland, the ability to improve or otherwise affect the quality of custom fertilizer, and the quality of emissions and ash in "manure to energy" projects. Therefore, this option of using feed additives to lower the nitrogen, phosphorus, and possibly potassium content of manure needs to be investigated. The use of feed additives could be beneficial to the poultry producers, either in production units with manure dedicated to specified beneficial reuse, or in general to increase the amounts of manure that can be used in land application.

Combination of options

Several options are available for the handling and beneficial reuse of poultry manure. Table 17 lists these promising options, the tonnage of manure they might absorb, and roughly estimated costs and revenues. As the potential tonnage indicate, several options need to be combined to reach the required result of absorbing either the 80,000 tonnes of expected increase, or the total of poultry manure of about 320,000 tonnes. When the expected increase of about 80,000 tonnes is to be absorbed, the basket approach together with shipments of raw manure to the Thompson-Okanagan would be sufficient. In case of the need for absorbing a large quantity or all of the poultry manure, a combination of pelletizing/granulating and gasification would be proper. The gasification option is the most flexible (and also the least commercialized), and can grow with the supply. Cost effective pelletizing or granulating would be less flexible as such a plant needs a minimum volume. Any combination of options will be effected by some demand from the basket approach, e.g. demand by the mushroom industry, and through composting. Not all poultry manure may be available to satisfy the larger options' needs.

Table 17: Potential Solutions, Volumes, Costs and Revenue.

Option	Potential tonnage	Estimated cost $/tonne	Estimated revenue $/tonne	Estimated cost to program ($/tonne)
Basket Approach	40,000- 60,000	12-60	12-250	0-190
Raw Manure to Okanagan	15,000 – 25,000			
Trucking		13 -26 a		
Storage		0 - 5		
Custom spreading		5		
Total		18 - 36	14-28	(22) - 10
Pelleted manure to Okanagan	25,000 – 125,000			
Pelletizing/granulating		60		
Trucking		13 - 26 b		
Storage		0 c		
Spreading		0 c		
Total		73 - 86	30- 118 g	(43)– 45
Raw manure in gasifier (clusters)	24,000 – 246,000			
Trucking		12	12	
Charcoal d)			0 -50	
Total		12	62	0 -50
Pelletized fortified manure (designer fertilizer, specialty market, markets abroad)	10,000 – 125,000			
Pelletizing/granulating		60 f		
Chemical addition		100 - 150		
Total		160 - 210	250 – 350	90 – 140

a) = estimate Chambers (no backhaul rate)
b) = estimate Chambers (assumes backhaul)
c) = assume storage and spreading through regular channels
d) = assume charcoal sold for $150/tonne
e) = assume pelleted manure sold for heating value (6000BTU/lb)
f) = based on equipment manufacturers quote and costs.
g) = see Table 2, mark-up incorporated.

6.0 Recommendation for Phase II

Options for reducing the manure loading of soils in the Lower Mainland and potential alternative fertilizer markets for Lower Mainland poultry manure have been investigated. In addition we have identified technologies, such as feed additives and pelletizing/granulating, for further study as these technologies would support the main potential alternative end use options. These options have potential for addressing poultry manure issues in the Lower Mainland. We also recommend further investigation of funding options and business strategies.

In order to implement these options, several aspects of each options should be investigated. While some of the possibilities are stand-alone options, their viability may be enhanced and other uses of manure may benefit from implementation of all options. As subsidies to support on-farm or centralized manure handling processes are essentially unavailable in BC, a system needs to be developed to generate funding within the industry. For Phase II of the project we recommend consideration of the following options:

6.1 Market to Forage Growers

We recommend investigation of alfalfa and alfalfa forage mix production in the Thompson-Okanagan and Caribou regions as a market for raw or pelleted poultry manure. This option lowers the manure pressure on soil in the Lower Mainland by removing manure from the region and provides value-added fertilizer products with high phosphorus content. Investigation should include:

- Market size for raw, pelleted, and/or granulated poultry manure
- Desired nutrient content of specialty manure product(s)
- Options for producing the desired product(s)
- Review of transportation costs and distribution systems
- Review of needs of fertilizer dealer or independent spreading programs
- Review of cost elasticity in supply and demand.

6.2 Use as Fuel and Production of Fuel Products

We recommend investigation of the use of poultry manure as a source of fuel in gasification facilities and boiler operations. This option may increase the value of poultry manure and could generate secondary income streams from created products such as oil, gas including hydrogen, charcoal, and/or high nutrient-content incinerator ash, in on-farm or centralized facilities. Such uses would remove volume from the Lower Mainland fertilizer market. The investigation should include:

- Heating value of Lower Mainland poultry manure, separated in broiler, turkey, and layer manure
- Gasification potential of each of the manure types
- Emissions from gasification plant operated with each manure type
- Assessment of quantity, quality, value, and marketability of secondary products such as charcoal and bio-oil

- Assessment of suitable technologies: dry gasification (MTCI, JF bioenergy), pressure gasification (West Virginia), or liquid gasification (Warwick), each with or without the Warwick membrane technology
- Assessment of costs and feasibility of the "cluster approach" for in the Lower Mainland, including contractual arrangements.
- Assessment of manure blends that minimize boiler emissions.

6.3 Pelletizing or Granulating

We recommend investigation of custom pelletizing and granulating to select the best options to support both fertilizer use and fuel use of poultry manure. This option could support the "marketing to alfalfa growers", and the fuel and the gasification options. It would also provide "designer fertilizer" options and production of customized products. The technology might also be useful for processing other materials such as wood waste, compost and feed. Investigations would include:

- Systems review,
- Production costs estimates
- Available equipment
- Suitability for use
- Scale of operation
- Other uses for equipment
- Markets for "designer fertilizers", regular pellets and granules, in Canada, US and overseas
- Types of products
- Emissions during processing, and potential measures to combat air emissions
- Preliminary assessment of other materials in the Lower Mainland amenable to pelletizing or granulating (including feed, wood, compost, chemicals, lime).

6.4 Feed Additives

We recommend investigation of the viability of feed additives on the reduction of manure nutrient levels in poultry manure. This option could lower the nitrogen and phosphorus pressure in land spreading programs, which might allow the application of additional volulmes of manure. It might also allow the manufacturing of "designer manures" for specific markets, including high nitrogen manure (phytase only), high phosphorus manure (amino acids only), or high caloric manure for use as fuel (phytase and amino acids). In addition, specific barn management procedures might result in optimizing the nutrient content of poultry litter. Investigations should include:

- Cost of additives
- Cost reduction in feed
- Effects on feed conversion rate
- Potential for potassium reducing additives
- Reductions in manure nutrient levels
- Estimation of benefits to manure disposal systems

- Costs to farmers
- Benefits to farmers
- Cooperation of feed producers
- Effect on land application practices
- Effect on use of manure as fuel
- Effect on “designer fertilizers”.

6.5 Funding Options

Once technical and marketing solutions are developed, funding may need to be made available to the industry as a whole, or to the entrepreneurs and technology developers. Funding might be generated from Federal and Provincial technology programs to facilitate the development of technologies and processes, from money lenders and investment funds, or solutions could be self financed or supported by the industry. The investigation should include:

- Assess generation of carbon credits from fuel replacement
- Assess use of technology and greenhouse gas funding mechanisms to finance demonstrations for cluster approach
- Assess investment funds and lenders for selected solutions
- Canvass the Industry regarding self financing of selected solutions
- Assess potential of industry support of programs through check-off(???), levies, or other instruments to support the transport of manure to areas outside the Lower Mainland;
- Assess consumer acceptance for a program of “manure eco-fee” financing.

7.0 Standard Limitations

Timmenga & Associates Inc. prepared this Report in association with Zbeetnoff Agro-Environmental Consulting and DH Lauriente Consultants Ltd. for the four "feather associations" - Broiler Hatching Egg Producers' Association, BC Chicken Growers Association, BC Turkey Association and the Fraser Valley Egg Producers' Association as coordinated by the Sustainable Poultry Farming Group. The work, the results of which are presented in this Report, followed the outline presented in our project proposal dated August 28, 2002, as well as subsequent directions by the Sustainable Poultry Farming Group. Ownership of all technical and financial information included in this report, is vested in the Poultry Environmental Steering Committee and the Agriculture Environment Partnership Initiative.

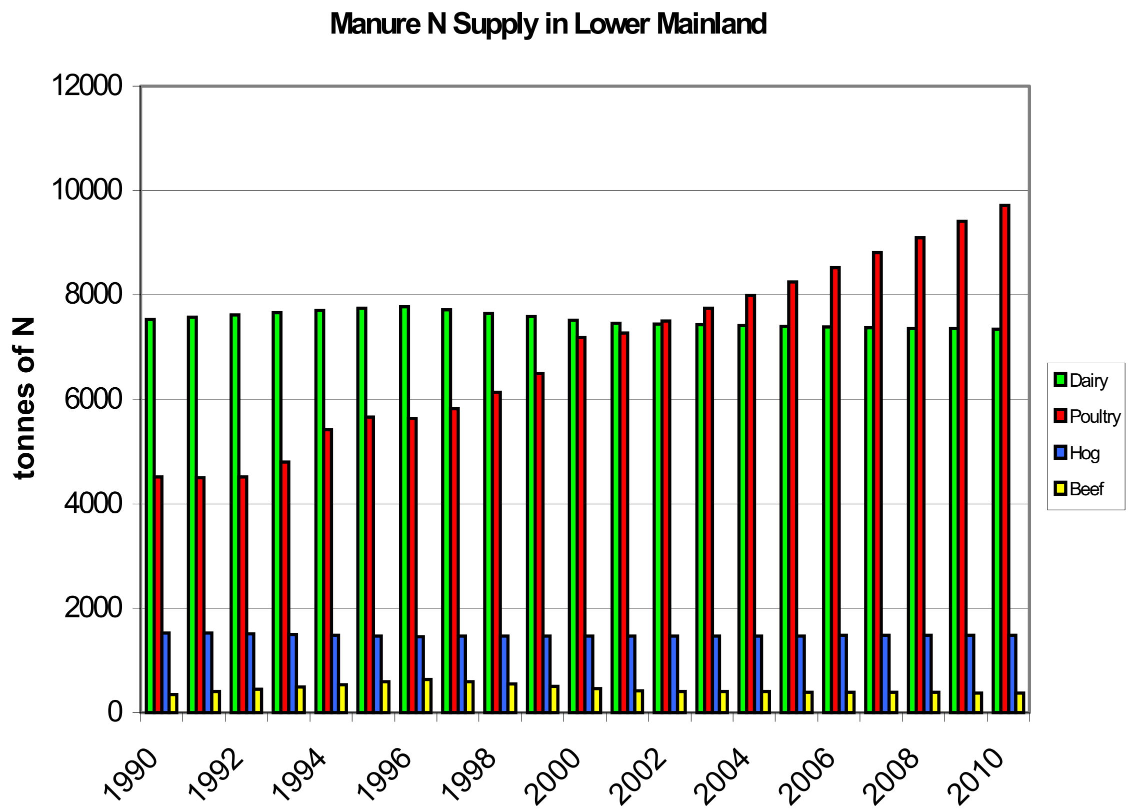
The conclusions and recommendations in this report specifically deal with aspects of handling and disposal of poultry manure generated in the Lower Mainland of BC. Conclusions and recommendations cannot arbitrarily be transferred to other jurisdictions or other industries without validation. The work has been conducted in accordance with standards and methods generally accepted in industry. Due to the nature of the work, the breath of the topic, the quality of the obtained data, the many jurisdictions involved, and the limitations of the contract, the work must be considered a screening of options rather than an all-encompassing inventory of possibilities. Additional work is recommended prior to establishing any of the presented options. No warranties, express or implied, are given. Timmenga & Associates Inc and its subcontractors and associates do not accept any liability to parties acting on the recommendations made in this report.

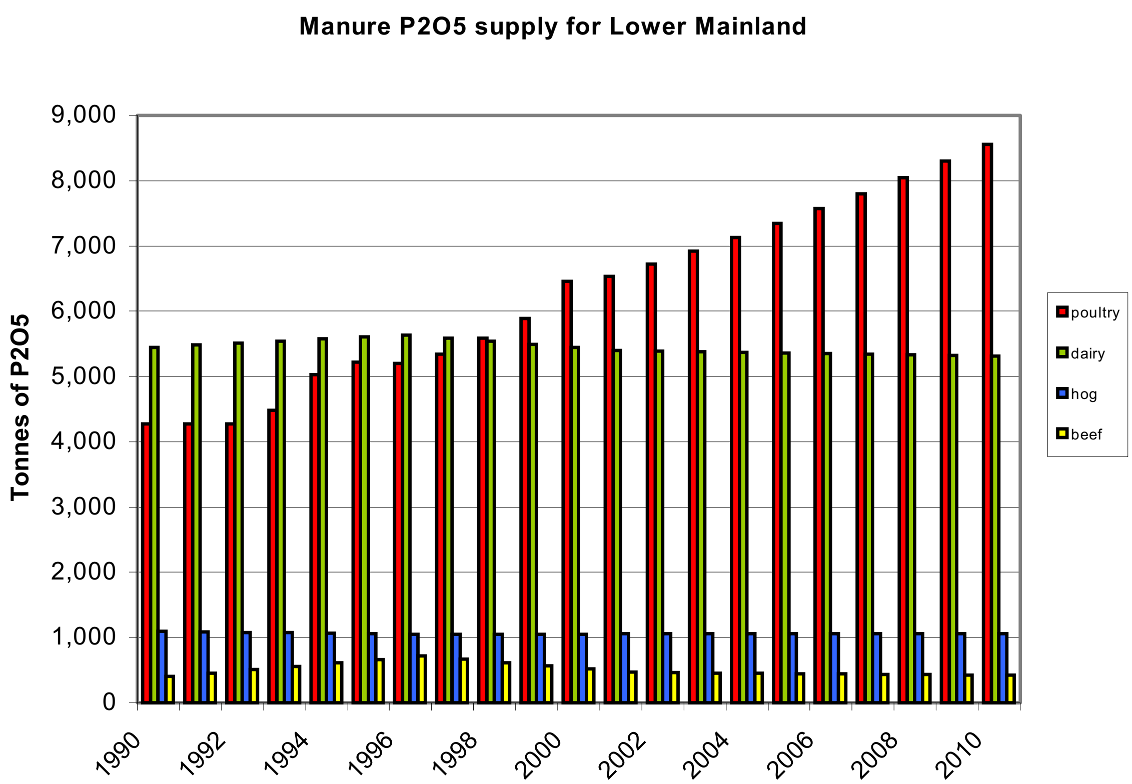
Respectfully Submitted,

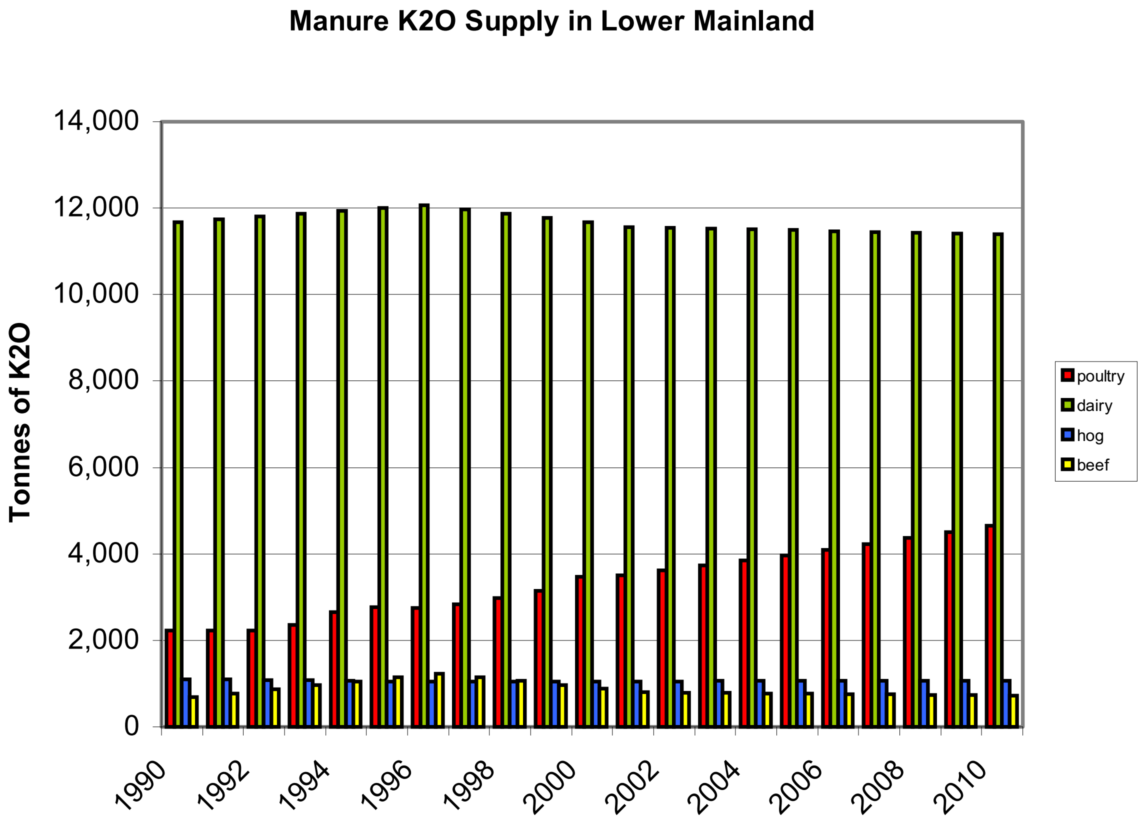
Timmenga & Associates Inc.

Hubert Timmenga, Ph.D., P.Ag., CAC,
President

Appendix A: Figures


Manure N Supply in Lower Mainland
tonnes of N
12000
10000
8000
6000
4000
2000
0
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
Dairy
Poultry
Hog
Beef


Manure P2O5 supply for Lower Mainland
Tonnes of P2O5
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
poultry
dairy
hog
beef


Manure K2O Supply in Lower Mainland
Tonnes of K2O
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1990
1992
1994
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1998
2000
2002
2004
2006
2008
2010
poultry
dairy
hog
beef

Appendix B: Other technologies for "designer fertilizer products"

Manure Based Products, Companies and Concepts

Company	Global Organics
Location	Arizona www.goglobalorganics.com/
Marketing Area	California, New Mexico, Arizona, Texas
Products	BioFlora Superchicken Organic and organic-based liquid formulations
Product Concept	World's largest manufacturer of organic plant foods and soil conditioners The BioFlora system focuses on supplying the nutritional and biological needs of plants and the soil to sustain natural biological systems
Applications	Organic farming Golf, sports turf and landscaping Environmental remediation Animal supplements Home & garden Farm cropping

Company	AgriEnergy Resources
Location	Illinois www.agrienergy.net/
Marketing Area	
Products	Bio-C (OMRI listed) Organic liquid formulations made from antibiotic free chicken manure that also contains an algae complex
Product Concept	Spectrum of biological products, beneficial species, blends of microorganisms
Applications	soil applied

Company	Sustane/Natural Fertilizer of America
Location	Minnesota www.sustane.com/
Marketing Area	60% North America; 40% Hong Kong, Indonesia and Vietnam
Products	Granulated fertilizers Some certified organic products Liquid formulations Analysis range (2-18)- (1-6) - (2-10) +S +Fe Range of mesh sizes Derived from combinations of composted turkey litter, ammonium sulfate, ferrous sulfate, hydrolyzed feathermeal, leonardite, sulfate of potash, muriate of potash, ferrous sulfate, methylene urea, polymer coated sulfur coated urea (Nutralene), solubilized seaweed
Product Concept	Proprietary aerobic composting process - litter is composted in excess of 150 continuous days with temperatures greater than 145 F for no less than 15 days Guaranteed product analysis Use of compost to control thatch Presence of beneficial microorganisms Guaranteed slow release characteristics Disease suppressor Supply of humus, not undecomposed organic material Salmonella free
Applications	Golf and sports turf Nurseries and landscaping Organic crops and gardens

Company	Planet Natural
Location	Montana www.planetnatural.com/organicfertilizers1.html
Marketing Area	
Products	Sup'r Green Chicken Manure 4-4-2 Organic fertilizers
Product Concept	Ground, composted
Applications	Mulching, moisture retention
Packaging and pricing	US $3.50 per 30 lb bag

Company	Seven Springs Farm
Location	Virginia www.7springsfarm.com/
Marketing Area	
Products	Harmony Ag. Organic Fertilizer (5-5-3), all natural poultry layer manure from Clarence, NY
Product Concept	100% organic Slow release
Applications	All-purpose for vegetables, fruits, lawns and landscape
Packaging and pricing	50 lb bag - US $14.50 10 bags - $13.50 per bag 20 bags - $12.50 per bag 1 ton - $11.00 per bag 2 tons - $10.00 per bag

Company	Virginia Dehydrating Inc.
Location	Virginia 540-434-4028
Marketing Area	
Products	Valley Green All Natural Organic Plant & Turf Food
Product Concept	
Applications	
Packaging and pricing	

Company	BioScientific Products marketed through Crop Production Services
Location	Arizona www.sportturf.net/biosci.htm
Marketing Area	California and Arizona
Products	Carbonizer - a customized soil amendment derived from beef and chicken manure and leonardite Analysis (0.40%-0-0.40%) Activated Carbon Solution (ACS) - derived from beef and chicken manure- Analysis (0.40%-0-0.40%)
Product Concept	Liquid hydro-composted product - carbohydrate based fertilizer, microbial nutrient, microbial content that enhances nutrient release and carbon cycles of soil for improved productivity 72 trace elements Soluble humic acid
Applications	Field/row crops Tree/vine crops Golf and sports turf Application rate 20-40 gallons per acre during the growing season
Packaging and pricing	Available in 5 and 55 gal containers

Company	North American Organic Products, distributor of Perdue AgriRecycle products
Location	Connecticut www.naorpco.com/
Marketing Area	New England states, Florida, Arkansas, Alabama, North Carolina
Products	Sunflower Farms organic fertilizer, pelleted (3%-3%-3%-0.32%)) Three Pond Meadow organic fertilizer, granulated (3%-3%-3%-0.32%)
Product Concept	Pure processed chicken manure OMRI certified 60% organic matter Ash - 31.65% Humus - 10.54% pH - 6.5 Trace minerals
Applications	Home and garden Landscaping Organic growers Golf and sport turf
Packaging and pricing	25 and 50 lb bags 2000 lb pelletized sacks Bulk
Company	Whitney Farms www.whitneyfarms.com/

Location	Oregon
Marketing Area	Western US and Alaska
Products	Plant foods Soil amendments Fertilizer blends (2-7)-(2-6)-(2-5) may contain alfalfa meal, blood meal, bone meal, dried poultry waste, kelp meal, sunflower hull ash, sulfate of potash, feather meal, ferrous sulfate, sulfate of potash magnesia, soybean meal
Product Concept	Quick start and long term benefits Balanced ratio of N, P and K
Applications	Vegetable gardens, annual and perennial flower gardens, ornamental plantings and all type of container gardening
Packaging and pricing	4 lb. and 15 lb. bags

Company	Renaissance Fertilizers www.auri.org/clients/renaissa.htm
Location	Minnesota
Marketing Area	
Products	Plant foods Soil amendments Fertilizer blends (2-7)-(2-6)-(2-5) may contain alfalfa meal, blood meal, bone meal, dried poultry waste, kelp meal, sunflower hull ash, sulfate of potash, feather meal, ferrous sulfate, sulfate of potash magnesia, soybean meal OMRI listed
Product Concept	Quick start and long term benefits Balanced ratio of N, P and K
Applications	Vegetable gardens, annual and perennial flower gardens, ornamental plantings and all type of container gardening
Packaging and pricing	4 lb. and 15 lb. Bags

Company	Arthur Yates & Co. Ltd. www.superbrands-brands.com/volII/brand_yates.htm In 1995 Yates, an Australian Company in the packet seed business, acquired Dynamic Lifter from the Jennings family. In Australia, there are 4 million chicken producing Yates Dynamic Lifter. www.yates.co.nz/ Dynamic Lifter, Alabana www.nrrbs.com.au/fertdynlifter.htm
Location	Australia, North America
Marketing Area	Worldwide. Dynamic Lifter is made under license in the US and exported from Australian factories to Asia, Europe and the Middle East. In 1999, Yates was granted an import license by the Vietnamese government to import Dynamic Lifter organic fertilizer to Vietnam, following 2 years of field trials. Dynamic Lifter, Alabama produces a product called Nutri-Mate, some of which is exported to Australia.
Products	Composted (bio-degraded) poultry manure and blood and bone. Minimum analysis 4-3.18-0.96 plus various micronutrients. 95% fine, 55 coarse.
Product Concept	Fertilizer from dried chicken manure developed by a NSW chicken farmer & used worldwide. Dynamic Lifter was tested with help from the NSW Department of Agriculture and came on the market in the late 1970s. The product involves a method of making fertilizer from chicken manure using two Australian technologies, a drinking system for the chickens which keeps the manure dry, and a method of compressing the waste into pellets. The initial patent application for the manure (35064/70) lapsed but a later one for a dripless water trough was successful (AU 593391). In return for contracts to buy chicken manure, the company installs its watering equipment into farmers' barns Dynamic Lifter Alabama Inc. offers area growers free cleanout in exchange for their broiler litter. The company processes litter into fertilizer pellets, which it sells. The fertilizer usually carries an analysis of 3-4-2. The company also turns pelletized broiler litter into cattle feed.
Applications	The product is sold in bulk to farmers and orchardists. Bagged pellets are sold in supermarkets and nurseries to home gardeners.
Packaging and pricing	

Company	Euro-Bio Consult www.treemail.nl/eurobio/index2.htm
Location	Holland
Marketing Area	Holland, Denmark, Sweden, US
Products	Known for its BioGold soil products Chicken manure pellets - 67% organic matter content, 3-4 mm pellets, no additional enrichment Analysis (5-3-2). CaO 9.6%

Product Concept	Bio-fertilizers are microbial cultures of agronomic value, in nitrogen fixation, phosphate solubilization, and release of plant growth promoters Organic chicken manure pellets advertized not to burn crops because of excessive ammonia content www.treemail.nl/eurobio/inform/chicken.htm
Applications	All crops - particularly landscaping, grounds maintenance, tree and flower nurseries, market and home gardening
Packaging and pricing	Chicken manure pellets - 20 kg bags. NLG2.70/kg.

Company	Harmony Products Inc. www.harmonyproducts.com/
Location	Richmond, Virginia
Marketing Area	Northeast and Southeast US
Products	Harmony products include Harmony Top Coat (4-2-0), Professional Turf and Landscape (3-6-3), Bridge, AG. Organic and The Real Poop!
Product Concept	An unique patented chemical combination of organic and synthetic fertilizer components that is easier to work with than either organic or synthetic fertilizers alone. The company claims it is the first to take urea formaldehyde (SRN) technology and apply it to organics. Harmony Products Inc. uses chicken manure in as the organic base in its combination organic-synthetic fertilizers. The company has evolved through 4 generations of technology: 1)development of superfertilizers with quick and slow release characteristics; 2) development of continuous process manufacturing; 3) development of granulated technology for organic-based quick and slow release fertilizers, and 4) converting wet organic matter to high analysis mixed fertilizers in one operation. In addition, Harmony Products produces 2 lines of organic fertilizers using its special process: **Harmony AG. Organic (5-5-3)** - organically certified processed poultry manure **The Real Poop! (3-5-4)** - all-purpose, all natural, organic fertilizer from poultry manures
Applications	The Real Poop and AG. Organic are sold in consumer retail markets and recommended for shrubs, flowers and trees. However, Harmony Produts is active in four of the major fertilizer segments: professional, consumer, specialty and general agriculture Marketing efforts are to increase product use in consumer retail, professional wholesale and specialty agricultural markets Harmony Products licenses its patented fertilizer technology to companies in waste management, with applications in animal manures, municipal sewage sludge, composted refuse and landscape wastes, rumen paunch, rendering wastes, egg processing wastes, seafood wastes, and vegetable and food wastes. The process has also been licensed in the Ukraine and Australia. Most recently (2001), Harmony Products Inc. has licensed a Cargill facility (formerly Rocco Turkeys Inc.) in Dayton, Virginia to use its technology to produce an enhanced granular fertilizer product. The facility will start with 15,000 ton fertilizer output and is expected to expand to 65,000 tons per year.

Packaging and pricing	AG. Organic is available in bulk, super sacks or 50 lb. bags. Harmony Products Inc. enters into marketing arrangements with companies that license its technology. The network of harmony producers allows branded fertilizer products to penetrate regional markets without incurring high shipping costs

Company	New England Fertilizer Company (NEFCO) www.nefco.biosolids.com/
Location	Massachussets
Marketing Area	Northeast
Products	Marketed by **Harmony Products**, Blender Base Granular Organic Nutrient Source (4-3-0) is produced by New England Fertilizer Company, Mass. NEFC0 operates one of the largest sludge processing facilities in the world using Harmony Products Inc.'s technology under license.
Product Concept	**Blender Base** - advertized to be suited as a filler in inorganic fertilizers because it is free-flowing, prevents bag and bin set, does not segregate and maintains uniform spreading patterns. The product is made in a proprietary drying process using municipal sludge. An important characteristic of the product is to have a bulk density in the order of 35 to 50 lbs/ft3 to allow mixing of the product with other dry fertilizers.
Applications	Blender Base is sold to fertilizer manufacturers who use the product to differentiate their own products. NEFCO will designs, and construct waste treamtnet facilities for clients and guarantees it will take the product. Dried biosolids commonly are incorporated into finished agricultural fertilizer products at rates dependent upon final customer needs. Fertilizer blends that contain biosolids are extensively used in Florida and throughout the Southeast in non-specialty applications.
Packaging and pricing	The value of the product in this market is a function of the cost of the materials that the biosolids replace, plus some premium for the plant food and soil enrichment attributes of the biosolids. Typically, in today's marketplace, dried biosolids command $25/ton to $40/ton or more, depending on quality.

Company	AGricultural ORganic, Inc.
Location	Houston, Texas. Factory is located in Arkansas.
Marketing Area	Northwest Arkansas, eastern Oklahoma, northern and southeastern Texas, central Louisiana, southern Alabama
Products	AG-ORG P/L Organic Fertilizer - poultry litter based (4-2-2)
Product Concept	The food-grade organic chemistry controls for odour, burning and timed release and is applied to uncomposted poultry litter The resulting product is a licensed organic fertilizer. The treatment changes the soluble N into insoluble N, while retaining the micro-nutrition inherent in poultry manure.
Applications	Retail garden centres and commercial growers
Packaging and pricing	Pellet or granular form - 40 lb bags, 1 ton totes, 22 ton truck loads

Company	Maryland Environmental Service (MES)
Location	Maryland
Marketing Area	Mid-Atlantic area
Products	fertileGRO (4-3-3) - pelletized product is purchased from Perdue AgriRecycle
Product Concept	Certified organic fertilizer
Applications	Agency is attempting to create a local and regional retail market for the product for use by nurseries, golf courses and homeowners. This market is to complement Perdue Recycling's marketing efforts.
Packaging and pricing	40 lb bags, MES specially designed bags 1 ton super sacks

Company	Perdue AgriRecycle, LLC, Micronutrient Plant
Location	Seaford, Delaware
Marketing Area	90% to the Midwest (Arkansas delta) by rail and truck 10% overseas
Products	MicroStart 60 (3-3-3) - 60% organic matter; starter fertilizer; 38-45 lbs/ft3; particle size 1.5-3.5 mm; flow characteristics similar to DAP; abrasiveness similar to limestone; dust similar to prilled products; only sold in bulk
Product Concept	The AgriRecycle technology pasteurizes, sterilizes and stabilizes the material by heating rather than composting. The heat forces the ammonia out of the manure, eliminating the fast-acting N component of the manure.
Applications	To be used by commercial row crop farmers, in conjunction with chemical fertilizers
Packaging and pricing	Product is bagged by New Earth Services, a company that packages its own composted products. the bagging plant was purchased with a grant from the US EPA to assist in the removal of nutrients from the Delmarva peninsula. The cost of transporting the product out of the area is subsidized to the tune of up to $20 ton by a government program

Company	Tropigro Pty. Ltd. www.tropigro.com.au/
Location	Northern Territory, Australia
Marketing Area	Worldwide
Products	Tropigro 10-88 (4-3.2-2) - 61.5% organic matter. Produced from densified, pelletized poultry manure. One tonne of Tropigro is equivalent to 4-6 tonnes of raw chicken manure
Product Concept	Formulation to build soil up by providing humus and stimulation to beneficial bacteria in tropical climes Supplies 16 nutrients, sterilized and weed-free Tropigro also offers consultative services on all aspects of nursery management, developmental landscaping and commercial plantations uising Tropigro's prescription farming nutrient system
Applications	New and established soils and gardens
Packaging and pricing	

Company	Northmore (UK) Limited www.northmoreuk.com/
Location	England
Marketing Area	This company designs and constructs pelletizing operations worldwide including: Australia, Malaysia, Pakistan, France, Indonesia, Saudi Arabia and the US
Products	Organic, pelletized and sterilized poultry manure based NPK fertilizer (3-4)-(5)-(3) - 10% moisture content
Product Concept	A free-flowing composted poultry manure product with reduced odour, acceptable NPK balance and controlled nutrient release characteristics. Pelletized product is inoculated with microbial colonies Utilizes an anaerobic composting system Claimed to be twice as effective a nutrient source as conventional chemical fertilizers
Applications	Modular system ranges in size from 10,000 TPA to 50,000 TPA
Packaging and pricing	

Company	Dynamic Lifter
Location	Facilities licensed in Australia, Asia and the US
Marketing Area	Worldwide
Products	100% organic poultry manure Chemical fertilizers may be added to boost the analysis for specific crops
Product Concept	Drying technology patented in Australia, allows for manure under layer cages, normally at 70-80% moisture to be 30-40% moisture, ready for pelletizing

Applications	Require about 150 HP 1 skilled labour, 2/3 unskilled per unit Capacity 3-4 tonnes/hour Capital cost US$400,000 Operational cost US$224,000 + manure purchase
Packaging and pricing	

Company	Circle One International Inc. www.circle-one.com/
Location	Spring Hill, Florida
Marketing Area	Worldwide including China, Japan, Taiwan, UAR, Turkey, Greece, Spain, Costa Rica, US, Argentina
Products	Homogenized fertilizers Prosper Poultry Gold - organic, extruded, composted manure fertilizer and soil amendment containing humus, amino acids, micronutrients and aerobic and anaerobic bacteria.
Product Concept	Advanced formulations that combine ingredients like botanicals, fish and sea plants, fermented complex sugars, organic carbons, bacteria, enzymes and minerals with chelators and catalysts. Circle One nutritional products contain a proprietary nutrient delivery system called Circle Plex System (CPS) for superior Performance
Applications	All crops, cotton in the US
Packaging and pricing	Available in liquid and dry form Liquid available iin 1, 5 and 55 gallon containers Dry available in 1, 5 and 25 lb. containers

Appendix C: Overview table of options

Markets	Volume	Product	By Products	Marketing	Stage	Benefits to Farmer	Score for volume	Discussion
Current Supply	242,000 tonnes	Raw manure	None	Farmers and Poultry Group		All manure removed from farm at cost of cleaning		Current estimate corroborated with Stats Canada data on animal numbers.
Market Trends								
Environmental Farm Plan/Enforcement	No change in volume	Raw Manure				Negative benefits, farmer need more land.	Increase by 40%	Environmental Farm Plan Program and new legislation will reduce amount of nutrients that can be used on land. Also municipal bylaws may affect the amount on certain lands.
Consumer Choice	No change in volume						0%	
Change in bedding	Likely no change in manure volume to be disposed of,	Same product, unless bedding is reused – then more nutrients					0%	Except for sand, all bedding would behave more or less similar in absorption of water and holding of nutrients. Interchanging bedding would not affect manure production significantly. In manure application, the nitrogen and phosphorus will be the limiting factors.
Change in Feed Ratio, Additives	No change in volume	Reduced strength	none		Trials and commercial in Europe, phytase in Canada	Less land needed, can make specific blends	Apparent volume reduction of 40-60%	Could reduce the pressure on land base from N and P. Will not change K balance

NAFTA /quota	Volume to increase – no decrease in the short term						0%	
Manure Market (raw)								
Lower Mainland	Cannot handle extra volume, crops are over fertilized	Raw manure					Over fertilized by 50%	Lower Mainland heavily over fertilized with Poultry N, P
Thompson Okanagan	Can take upto 125,000 tonnes tonnes on Alfalfa fields	Needs prilled or pelleted, raw is not a favorite fertilizer form		Marketing effort needed	Tested in US	Market for manure	Can take 100% of additional productio n or 25% of total.	Alfalfa is under fertilized, and needs P and K. Some beef manure used in the grazing/feeding cycle.
Relay cropping	No extra volume for poultry manure						0%	
Mushroom composting	Small increase possible, 5000 tonnes 15,000 tonnes when the industry implements their growth plan						Can take 5%	Mushroom composting will increase in future, higher demand for raw manure.
Bioremediation	No increase						0%	

Markets	**Volume**	**Product**	**By Product s**	**Marketin g**	**Stage**	**Benefits to Farmer**	**Score for volume**	**Discussion**
Organic Farming	No increase unless composted, then 15, 000 tonnes maximum, likely less	Composted manure			Commercia l, and on farm tested.		Can take 5 % of total	Organic Farming only takes composted manure. Small market
Additive to chemical Fertilizer	Small volume, some in turf grass, 3-5000 tonnes	Needs prilled or Pelleted					Can take 1-5%	
Pelleted Manure	Small market in LM increasing, 2000 – 3000 tonnes	Need prilled or Pelleted manure					Can take 1-5%	Some market for enriched products in turf grass
Forest Fertilization	No market						0%	

Markets	**Volume**	**Product**	**By Products**	**Marketing**	**Stage**	**Benefits to Farmer**	**Score for volume**	**Discussion**
On Farm Processing								
Composting	Farm's total, or from several farms	Dry compost	None, odour if not handled well.	No central market available, farmer has to do niche marketing	Commercially avavailable.	All manure processed, also mortalities and surplus litter	Can take 1-5%	Facility ~$350,000+, needs maintenace and manpower to run. Effort needed for distribution to clients. Organic markets could absorb production from small facility in LM.
Vencomatic, In barn drying of manure and litter	No change in volume.	Dried manure, can be pelletized	None	Farmer has to do marketing	Commercially available in Europe, some systems in North America	Manure is dried, providing a lighter, more voluminous product. Barn environment better due to removal of manure.	0%	Expensive system, in Netherlands it works well because of the costs of manure disposal and transportation. Added benefits are higher production in barn due to better environment to off-set some of the costs. . No ammonia or dust in barn. Birds on belts, manure further dried in drum dryer
Gasification to power BGT		Electricity, heat for own use on farm, neighbours	Ash for road bed or fertilizer	No markets	Prototype on farm in Netherlands		0%	Prototype costs ~$0.8m, can work when normal manure disposal is expensive (in Netherlands >$45/tonne)

Markets	Volume	Product	By Products	Marketing	Stage	Benefits to Farmer	Score for volume	Discussion
Large Scale Processing								
Agri-Recycle Canada	170,000 tonnes	Processed manure pellets	None, no odour as claimed	Has markets in Mexico, US, all long distance	One in operation in Delaware	Would take all manure and pay for it .	Could take 50% if economically feasible.	$10.5m investment, Facility in Delaware heavily subsidized, including transport of manure to long distance market. Closest market from LM is Palouse in Wa. Needs odour control. Do economics make sence? .
KDS Micromex	Up to 18,000 tonnes per plant	Processed manure pellets	None, no odour as claimed, no waste products	Has overseas markets for all, but not confirmed	Ready to install; new product	Co-op; free clean-out of barns; profit share.	Could take 5% per plant, up to 30% if there are markets.	Needs same market as Agri Recycle. Advantage is that it can be in clusters, surplus manure could use 5-6 plants in LM. Ease into markets and other options. Small plant allows customizing product.
Granulation	Upto 50,000 tonnes per plant	Granulated manure pellets	None, low odour product	Processing only, no market.	Technology used for other uses		Could take 15% per plant, if market available	A granulation plant only processes. Marketing is not provided. Product is of better quality than pellets, but still needs market.
Feed Market	Could be significant	Pelleted product		Market in 22 states, but will be limited in future .	Known technology		Could be 5% of supply	Needs pelleting. Market is in Southern US, so transportation is expensive. Feed product has a high value. Market will decrease due to food safety issues.

Markets	Volume	Product	By Products	Marketing	Stage	Benefits to Farmer	Score for volume	Discussion
P- remediation	No	No					0%	Will remediate the results of over fertilization with P containing fertilizer
Anaerobic digestion		Gas and energy	Sludge and water	Some application in US, Europe, Asia	Known technology, but not applied to Poultry		0%	Anaerobic Digestion is not cost effective as a source of energy due to low return on gas based electrical power.
Sludge treatment		Lime rich fertilizer		Some applications in US, no poultry	Commercialized technology in Biosolids		0%	Good for liquid sludges
Thermal Waste Treatment		Dried sludge			Pilot plant		0%	Good for liquid sludges
Thermo-Depolymerization								
Virginia Pressure and Heat		Gas and fertilizer, diesel or chemicals			Pilot project		0%	
Pellets in remediation		Diesel fuel and ethanol,	Ash		Bench scale		0%	Technology in infancy, may be suitable in future.
		Mixed pellets			Pilot scale		0%	Need a solution looking for a substrate.
Incineration, Power								

Markets	**Volume**	**Product**	**By Products**	**Marketing**	**Stage**	**Benefits to Farmer**	**Score for volume**	**Discussion**
FibroWatt, Interpack Resources Green houses	Large, can take all , depending on design/size	Electricity, Potential for carbon credits, green energy money.	Ash, is conditioned and sold as fertilizer		Commercialized, 3 in UK, board	Price to farmer? Heavily subsidized with green power credits etc.	50%+	Likely a 20MW plant for the LM, taking ~200,000 tonnes. Generates electricity at 5.5-8.8c/KWh, up to 12c/kWh. Need agreement with BC Hydro. Air pollution issues, or issues with air shed (SE2).
Bio-oil generation, Gasification	Can take up to 25,000 tonnes each	Heat for greenhouse	Ash, air emissions	Potential market in LM, depending on gas price	New technology	Green house will take for heating value	10 greenhouses can take most of manure produced.	May needs pelletizing for ease of handling. Greenhouse needs to invest in specialty equipment.
Hydrogen Generation	Potentially large	H2 gas or combustible gas, or electric power	Fly ash, bottom ash @ 36%. fertilizer.	Potential market in fuel cells,	Laboratory only, need commercialization	Depends on energy sale.	Could take 50%.	Energy to be sold in the form of hydrogen or electricity. Calculated price for electricity is US$0.05 per KWh. Need a market for Hydrogen. Need heat sink.
JF Bioenergy	Small units, each taking up to 25,000 tonnes	Heat, charcoal, diesel		Needs a market for heat, charcoal and fuel.	Commercialized, tested with poultry manure	Depends on energy price	10 facilities could take all.	May need pelletizing, for ease of handling. Clusters possible.