Response to Comments and Questions Received at the 2011 Phosphorus Seminars

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TABLE OF CONTENTS

1. Available Information for Nutrient Concentrations 3
2. Nutrient Needs of Selected Forage Crops. 3
3. Nutrients Available from Various Nutrient Sources 4
4. Nutrient Mineralization and Expected Release Rates 4
5. Whole Farm Nutrient Balance 5
6. Effects of Water Soluble Phosphorus on Crop Up-Take 6
7. Crop Residue Effects on Water Soluble Phosphorus 6
8. Manure Spreading Guidance 6
9. Laboratory Methododology for Soil Phosphorus 7
10. Manure Separation 7
11. Reducing Phosphorus Through Manure Separation 7
12. Controlling Nutrients Through Manure Separation 8
13. Markets for Selling Separated Solids and Compost 8
14. P Index 8
15. Possible Sources of Phosphorus, Other than Farm Activities 8

List of Appendices

Appendix A Nutrient Removal Rates

Appendix B Manure Nutrient Contents, Mineralization, and Treatment Systems for Phosphorus Management

1. **What kind of information is available to assist farmers in understanding the nutrient concentrations or loading rates for agricultural wastes used on their farms? What information is available about nutrient testing these materials?**

   Several sources of reference materials including factsheets and reference guides are available on the B.C. Ministry of Agriculture, Sustainable Agriculture Management Branch web site as **Nutrient Management for BC**.

   General guidance on nutrient management:
   - *Nutrient Management Reference Guide*
   - *Choosing and Calibrating Manure Application Equipment*

   Guidance on soil, manure and crop testing:
   - *Soil Sampling for Nutrient Management*
   - *Manure Sampling for Nutrient Management*
   - *Forage Crop Sampling for Nutrient Management*
   - *Nutrient Testing Laboratories*
   - *Understanding Difference Soil Test Methods*

   Guidance on soil, manure and crop testing for phosphorus and potassium:
   - *Phosphorus Considerations in Nutrient Management*
   - *Potassium Considerations in Nutrient Management*
   - *interpretations for Soil Test Phosphorus and Potassium: Guidelines for Southern British Columbia*
   - *Soil Test Phosphorus and Potassium Converter.xls*

2. **Nutrient needs of selected forage crops (e.g., corn, grass, and alfalfa) grown in B.C.**

   Several sources of information are available to help determine the nutrient needs of forage crops including:

   - One of the most appropriate sources of information which describes farm specific plant tissue sampling and analyses is the factsheet: ***Forage Crop Sampling for Nutrient Management*****;**
   - The factsheets: ***Phosphorus Considerations in Nutrient Management*** and ***Potassium Considerations in Nutrient Management*** provide some specific information related to these two nutrients; and
   - The publications: ***Advanced Forage Management*** and ***Advanced Corn Management provide*** guidance on many aspects of forage corn and forage grass production including nutrient management.

   A series of tables using typical values for four B.C. forage crops have been generated to provide some baseline information on nutrient removal rates. Refer to Appendix A.

3. **What is the amount of N, P or K available in a given year from various nutrient sources including liquid manure, solid manure, compost, or mineral fertilizer?**

Information on manure and compost can be found below. For information on mineral fertilizer, consult with your local fertilizer supplier who should be able to address specific questions about the fertilizer products they sell.

Estimated concentrations of N, P, and K and their availability can be obtained from several sources. Due to the varying concentrations reported in these sources it is best to test the manure and/or compost to determine the actual nutrient concentration in the materials being used on the farm. A discussion of farm-specific manure sampling and analyses is described in the factsheet ***Manure Sampling for Nutrient Management***. Sampling compost should follow the solid manure guidance, but it is recommended that you collect the compost sample from 25 cm to no deeper than 1 meter into the pile. (http://www.env.gov.bc.ca/wsd/data_searches/field_sampling_manual/field_man_pdfs/part_d.pdf).

If farm specific data is not available, reference information includes:

- ***BC Environmental Farm Plan Reference Guide***, ***Chapter 6 Soil Amendments***, Table 6.7 on page 6-13.
- *Standard Characteristics of Poultry Manure* (no longer available on-line).
- ***Agricultural Waste Management Field Handbook***, Chapter 4.
- Look-up tables embedded in the B.C. Nutrient Management *Forage Calculator* provide book values of manure nutrient contents for comparison with lab reports. Refer to Table B-1.

4. **What is the amount of N, P, or K (from various nutrient sources) that gets tied up by the soil? What is the expected release rate from the soil in a given year or throughout the year?**

A definitive answer regarding nutrient availability from organic sources is difficult to provide as several factors such as soil type, climate, soil biological activity, timing and method of application, as well as source of the nutrient influence decomposition rates.

Nitrogen

Decomposition rates for nitrogen are dependent on several factors. Without site-specific measurements, book values can only provide general guidance. Table B-2 presents book values of estimated nitrogen mineralization rates over time for poultry, dairy, compost, and mechanically separated solids.

Also, refer to the ***Ammonia Loss from Applied Slurry Manure*** (web-based tool) which incorporates air temperature, wind speed, soil moisture, slurry type, method of incorporation, and application rate to determine the amount of ammonium-nitrogen lost over time (in hours). This is a very easy tool to use.

Phosphorus

Some estimates indicate 80% to 100% of the phosphorus in manure is available for plant growth (***Estimating Crop Nutrient Availability of Manure and Other Organic Nutrient Sources***). This does not imply all the available nutrients are required for plant growth. Nutrient availability of applied manure or compost should not be confused with crop uptake requirements. All manure, compost, and fertilizer applications should be agronomically balanced.

In addition, the plant availability of phosphorus depends on factors such a soil pH, soil texture and mineralogy. A soil pH of 6.0 to 7.0 is the optimum range for phosphorus availability. As soil pH increases above 7.0, or decreases below 6.0, phosphorus binds with cations (i.e., calcium, aluminum, or iron) and becomes unavailable for immediate plant uptake. Phosphorus is bound by clay particles and oxides in low pH soils.

Additional information on phosphorus can be found in the videos of the 2011 ***Phosphorus Management Seminar*** in Abbotsford.

Potassium

Some estimates indicate 80% to 100% of the potassium in manure is available for plant growth (***Estimating Crop Nutrient Availability of Manure and Other Organic Nutrient Sources***). This does not imply all the available nutrients are required for plant growth. Nutrient availability of applied manure or compost should not be confused with crop uptake requirements. All manure, compost, and fertilizer applications should be agronomically balanced.

Potassium mobility in soil is limited. Note a high proportion of potassium is found in roots, straw and corn stalks indicating that very little potassium would be removed if these residues were left on the field.

5. How can a farmer effectively create a realistic nutrient balance for their farm?

The B.C. Ministry of Agriculture is in the process of evaluating the need for a BC specific whole farm nutrient balance tool. In the meantime, there are several on-line resources and models available including the Washington State University explanation of ***Whole Farm Nutrient Management - A Dairy Example*** and ***Dairy Whole Farm Nutrient Balance Spreadsheet***. This tool is focussed on dairies and dairy forage in the Pacific Northwest, but provides some good guidance on the aspects of whole farm nutrient balance calculations.

6. What is the effect of water soluble P on crop up-take of this nutrient?

Crop uptake of water soluble P fertilizer applications can be improved if the applications are made on fields within the optimum pH range of 6.0 to 7.0. Placement must be near the root since phosphorus is not highly mobile. An application must also be timed such that root growth is active. If these circumstances are not met, the addition of water soluble P may have little to no benefit for crop growth. Over application and/or broadcast applications of water soluble P fertilizer is never recommended, especially on soils with elevated P concentrations.

7. Do crop residues from relay crops or residues from permanent grass crops increase or decrease water soluble P availability to surface water runoff?

Residues from relay crops and/or permanent grass crops would only decrease water soluble P movement into surface waters if that residue was able to effectively trap the water soluble phosphorus. If residues act to increase infiltration, loss of soluble P to surface water may be reduced as P is adsorbed into the soil. If water soluble P was applied in the manner described in the response to question 6, an actively growing relay crop or grass crop could take-up water soluble P if the P was applied near the root zone of the crop. Phosphorus bound to particles of soil or in suspension associated with small particles of organic material maybe trapped by crops or crop residue as run-off moves over the landscape.

8. What is the best guidance for deciding on how much manure to spread?

The B.C. ***Nutrient Management Reference Guide*** suggests the following:

The ratio of nitrogen to phosphorus to potassium present in manures is seldom balanced with the ratio required by most crops, especially when potential loss and availability factors are considered, so it is difficult to balance all nutrients with crop requirements using only manures. In most cases where potassium or phosphorus is selected as the '**priority nutrient'**, the farmer will be challenged to supply enough nitrogen for crop growth. Nitrogen deficits may be best managed by conserving nitrogen in manure and using supplemental nitrogen fertilizer.

The following criteria are suggested to select the **priority nutrient**:

1. **Dairy or beef operations:** manage manure application based on **potassium** if soil potassium is over 300 ppm (Kelowna soil test method, 0-15 cm sampling depth). If under 300 ppm, go to criterion 3.
2. **Non-cattle operations:** manage manure application based on **potassium** if soil potassium is over 400 ppm (Kelowna soil test method, 0-15 cm sampling depth). If under 400 ppm, go to criterion 3.

3. Manage manure application based on **phosphorus** if field runoff or erosion might enter a phosphorus sensitive environment. Generally phosphorus sensitive environments are located where runoff water enters lakes in the interior of BC. If suitable buffers are utilized and no runoff reaches the watercourse, or if not in a phosphorus sensitive environment, go to criterion 4.
4. Manage manure application based on **nitrogen**.

9. Is one laboratory test method better than another for determining soil phosphorus levels (e.g., Kelowna, vs. Mehlich 3, vs. Bray, vs. Bicarbonate)?

The 'Kelowna' extraction method has been the preferred test method since it was the last provincial standard publicly developed for soil phosphorus and potassium testing for agronomic purposes. It is also the method used in the B.C. Nutrient Management Plan calculators. However, if another test method was used, the ***Soil Test Phosphorus and Potassium Converter*** is available for free, on-line.

10. What are the different methods of manure separation? Is one better than others for removing P from the liquid? What is the cost-benefit analysis of separation and spreading verses spreading whole manure?

Several of the currently available manure separation or other treatment methods are shown in *Table B-3. **General Overview of Manure Treatment Systems for Phosphorus Management**.* The Ministry of Agriculture has not evaluated these options and can only make general comments on costs at this time.

11. What percent reduction of P can be expected from manure separation?

The total mass of phosphorus in manure is not reduced by separation. Research has shown that a significant portion of the phosphorus laden solids can be separated from the liquid fraction. This will allow for improved nutrient management.

12. Can manure separation be programmed to control the N, P, and K balance for a given crop?

The B.C. Ministry of Agriculture is not aware of any systems currently available that can achieve a custom separation or balancing of nutrient for specific crops. N, P and K balance is more related to the characteristic of the input material (i.e., dairy slurry) and the efficiency of the separation system.

13. What markets or other uses are there for the separated solids and compost material?

Evaluation of Options for Fraser Valley Poultry Manure Utilization introduces pros and cons of marketing poultry manure. Many concepts from this report may be transferred to the dairy industry.

14. What is the P Index?

The P index is a tool to rank the risk of phosphorus transport from crop land to surface waters. By identifying the dominant factors, it can assist farmers in developing an effective management strategy to reduce risk.

Components of the P index typically include information on soil phosphorus analyses, field erosion rates or potential, water runoff potential, and the method and rate of fertilizer and/or manure applications. They are evaluated to rank the potential risk of phosphorus movement off a field or site using a rating from very low to very high. The B.C. Ministry of Agriculture is evaluating the potential usefulness of developing a P Index tool for B.C. An example of a P-Index is at http://extension.oregonstate.edu/catalog/pdf/em/em8848-e.pdf

15. What are other possible sources of P, other than farm activities, in the Okanagan and the Fraser Valley?

Other potential sources of P that may be present in soils or surface water include:

- Geological Materials, these generally have concentrations that are considerably lower than the typical agricultural soil P levels;
- Domestic Septic Systems, these contributions are usually minimal due to the small volume of sewage and confinement to the home owner's acreage; and
- Municipal Sewage Treatment Plants, these are a small contributor due to treatment technologies designed to remove phosphorus from released water.

APPENDIX A: Nutrient Removal Rates

The information in these tables provides a basic understanding of the nitrogen (N), phosphorus (P), and potassium (K) needs of corn, grass, legume, and alfalfa forage for the growing season. The nutrient removal rates are based on yields and total crop needs using model runs of the Forage Calculator (Excel tool introduced as part of the ***Nutrient Management Reference Guide (EFP Program)***). Applications should be split based on the expected crop uptake patterns in your region.

The nutrient recommendations do not take the place of a nutrient management plan. A nutrient management plan is the preferred method of assessing the nutrient needs of a crop. Sampling and analyses of soil, manure, irrigation water, and plant tissue is further recommended. For additional information, please refer to the Environmental Farm Plan Reference Guide *BC Environmental Farm Plan Reference Guide* and the Nutrient Management Reference Guide *Nutrient Management Reference Guide*.

Assumptions

- The nutrient removal rates provided in tables A1 to A5 are for the total expected nutrient amount.
- No additional sources of nutrients such as soil, water, or manure were accounted for (except as noted).
- Yields are dependent on soil and climatic conditions and will vary between fields. Field specific yield data is preferred.

How to Use the Tables

Step 1: Work through the Flow Chart on page A-2 to determine which table to use.

Step 2: Turn to the prescribed table and determine your expected yield under the specified crop. The yield is provided in both wet and dry weights and in metric (**green**) and imperial (**blue**) forms.

Step 3: Move across the page to determine the N, P, and K removal rate for the crop. Remember that the removal rate should account for all nutrient sources including soil, manure, fertilizer, and water.

It is the responsibility of the grower to provide nutrients to their crops in an environmentally friendly manner. Please take climate conditions into consideration.

Helpful Conversions

tonnes/ha X 0.446 = tons/acre
kg/ha X 0.89 = pounds/acre
dry weight = wet weight X (100-% moisture)

tons/acre X 2.24 = tonnes/ha
pounds/acre X 1.12 = kg/ha

Nutrient Removal Rates Flow Chart

Determine your crop nutrient needs by using the flow diagram below and then referring the appropriate table.

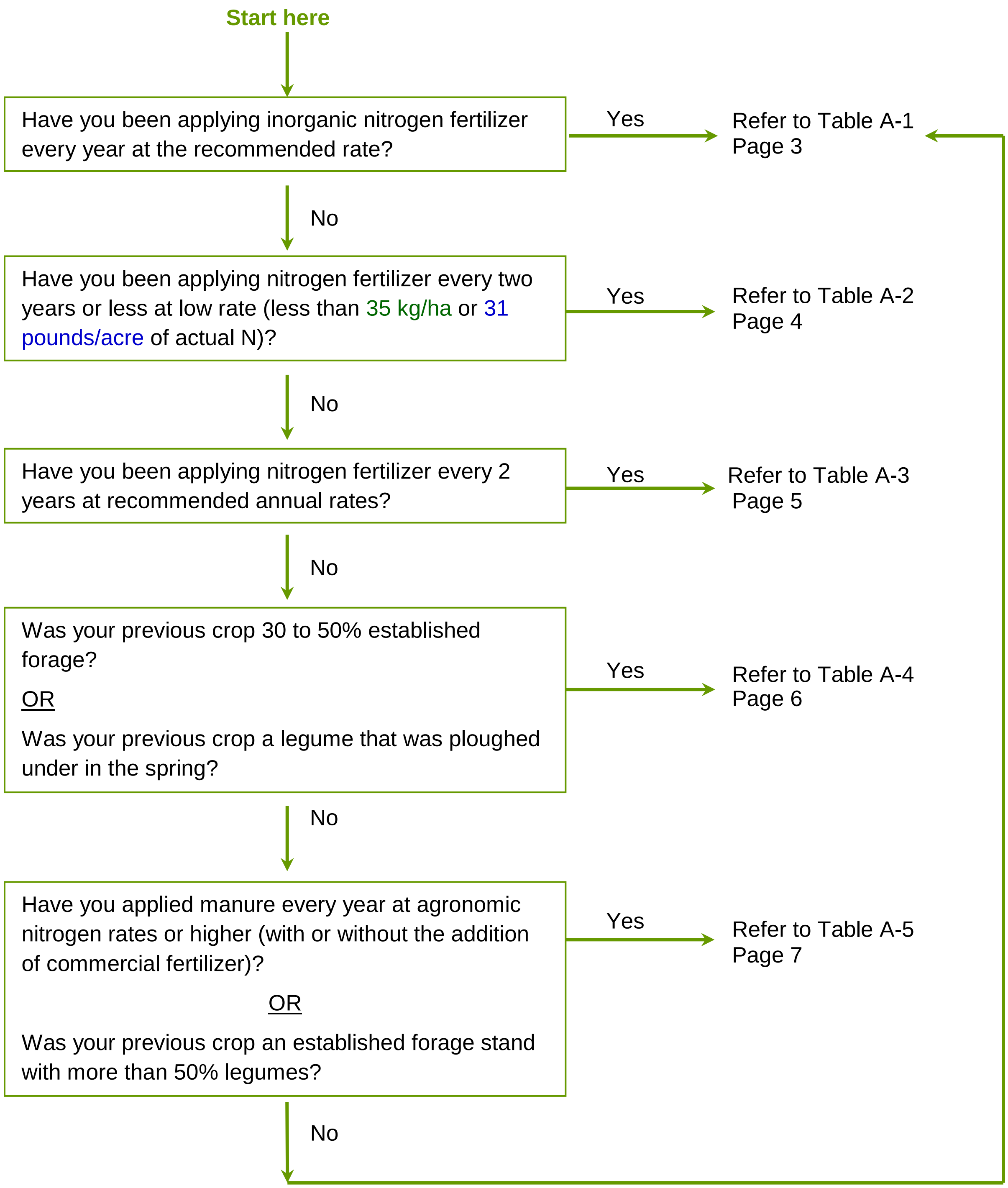

TABLE A-1: NUTRIENT RECOMMENDATIONS
Yearly Applications of Inorganic Fertilizers at Recommended Rates

Typical Yieldt tonnes/ha (tons/acre)		**Nutrient Removal Rates kg/ha (pounds/acre)**		
Wet weight	Dry weight	N	P	K
Silage Corn (at 8% protein concentration)				
35 (15.6)	10.5 (4.7)	134 (119)	48 (43)	126 (112)
45 (20.1)	13.5 (6.0)	173 (154)	62 (55)	162 (144)
55 (24.6)	16.5 (7.4)	211 (188)	76 (68)	198 (176)
65 (29.0)	19.5 (8.7)	250 (223)	90 (80)	234 (208)
75 (33.5)	22.5 (10.0)	284 (253)	104 (91)	270 (237)
Grass or <30% Legume Mix Silage (3 cuts or less with 12% protein concentration)				
20 (8.9)	6 (2.7)	115 (102)	51 (45)	144 (128)
30 (13.4)	9 (4.0)	173 (154)	77 (69)	216 (192)
40 (17.9)	12 (5.4)	230 (205)	102 (91)	288 (256)
50 (22.3)	15 (6.7)	288 (256)	128 (114)	360 (320)
60 (26.8)	18 (8.0)	346 (308)	153 (136)	432 (384)
Grass or <30% Legume Mix Silage (5 cuts or more with 16% protein concentration)				
20 (8.9)	6 (2.7)	154 (137)	51 (45)	144 (128)
30 (13.4)	9 (4.0)	230 (205)	77 (69)	216 (192)
40 (17.9)	12 (5.4)	307 (273)	102 (91)	288 (256)
50 (22.3)	15 (6.7)	384 (342)	128 (114)	360 (320)
60 (26.8)	18 (8.0)	461 (410)	153 (136)	432 (384)
Alfalfa Hay (up to 3 cuts with 20% protein concentration)				
5 (2.2)	4.3 (1.9)	138 (123)	37 (33)	103 (92)
10 (4.5)	8.5 (3.8)	272 (242)	72 (64)	204 (182)
15 (6.7)	12.8 (5.7)	410 (365)	109 (97)	307 (272)
20 (8.9)	17.0 (7.6)	544 (484)	145 (129)	408 (363)
25 (11.2)	21.3 (9.5)	682 (604)	181 (161)	511 (455)

Note:
- All dry weight silage values based on 70% moisture.
- Alfalfa Hay based on 15% moisture.

TABLE A-2: NUTRIENT RECOMMENDATIONS
Applications of Nitrogen Fertilizers Every Two Years or Less at Low Rates

Typical Yield tonnes/ha (tons/acre)		**Nutrient Removal Rates** kg/ha (pounds/acre)		
Wet weight	Dry weight	N	P	K
Silage Corn (at 8% protein concentration)				
35 (15.6)	10.5 (4.7)	234 (208)	48 (43)	126 (112)
45 (20.1)	13.5 (6.0)	273 (243)	62 (55)	162 (144)
55 (24.6)	16.5 (7.4)	311 (277)	76 (68)	198 (176)
65 (29.0)	19.5 (8.7)	350 (312)	90 (80)	234 (208)
75 (33.5)	22.5 (10.0)	388 (342)	102 (91)	266 (237)
Grass or <30% Legume Mix Silage (3 cuts or less with 12% protein concentration)				
20 (8.9)	6 (2.7)	215 (191)	51 (45)	144 (128)
30 (13.4)	9 (4.0)	273 (243)	77 (69)	216 (192)
40 (17.9)	12 (5.4)	330 (294)	102 (91)	288 (256)
50 (22.3)	15 (6.7)	388 (345)	128 (114)	360 (320)
60 (26.8)	18 (8.0)	446 (397)	153 (136)	432 (384)
Grass or <30% Legume Mix Silage (5 cuts or more with 16% protein concentration)				
20 (8.9)	6 (2.7)	254 (226)	51 (45)	144 (128)
30 (13.4)	9 (4.0)	330 (294)	77 (69)	216 (192)
40 (17.9)	12 (5.4)	407 (362)	102 (91)	288 (256)
50 (22.3)	15 (6.7)	484 (431)	128 (114)	360 (320)
60 (26.8)	18 (8.0)	561 (499)	153 (136)	432 (384)
Alfalfa Hay (up to 3 cuts with 20% protein concentration)				
5 (2.2)	4.3 (1.9)	238 (212)	37 (33)	103 (92)
10 (4.5)	8.5 (3.8)	372 (331)	72 (64)	204 (182)
15 (6.7)	12.8 (5.7)	510 (454)	109 (97)	307 (272)
20 (8.9)	17.0 (7.6)	644 (573)	145 (129)	408 (363)
25 (11.2)	21.3 (9.5)	782 (696)	181 (161)	511 (455)

Note:
- All dry weight silage values based on 70% moisture.
- Alfalfa Hay based on 15% moisture.

TABLE A-3: NUTRIENT RECOMMENDATIONS
Application of Nitrogen Fertilizers Every Two Years at Recommended Rates

Typical Yield tonnes/ha (tons/acre)		Nutrient Removal Rates kg/ha (pounds/acre)		
Wet weight	Dry weight	N	P	K
Silage Corn (at 8% protein concentration)				
35 (15.6)	10.5 (4.7)	184 (164)	48 (43)	126 (112)
45 (20.1)	13.5 (6.0)	223 (198)	62 (55)	162 (144)
55 (24.6)	16.5 (7.4)	261 (232)	76 (68)	198 (176)
65 (29.0)	19.5 (8.7)	300 (267)	90 (80)	234 (208)
75 (33.5)	22.5 (10.0)	338 (297)	102 (91)	266 (237)
Grass or <30% Legume Mix Silage (3 cuts or less with 12% protein concentration)				
20 (8.9)	6 (2.7)	165 (147)	51 (45)	144 (128)
30 (13.4)	9 (4.0)	223 (199)	77 (69)	216 (192)
40 (17.9)	12 (5.4)	280 (249)	102 (91)	288 (256)
50 (22.3)	15 (6.7)	338 (301)	128 (114)	360 (320)
60 (26.8)	18 (8.0)	396 (352)	153 (136)	432 (384)
Grass or <30% Legume Mix Silage (5 cuts or more with 16% protein concentration)				
20 (8.9)	6 (2.7)	204 (182)	51 (45)	144 (128)
30 (13.4)	9 (4.0)	280 (249)	77 (69)	216 (192)
40 (17.9)	12 (5.4)	357 (318)	102 (91)	288 (256)
50 (22.3)	15 (6.7)	434 (386)	128 (114)	360 (320)
60 (26.8)	18 (8.0)	511 (455)	153 (136)	432 (384)
Alfalfa Hay (up to 3 cuts with 20% protein concentration)				
5 (2.2)	4.3 (1.9)	188 (167)	37 (33)	103 (92)
10 (4.5)	8.5 (3.8)	322 (287)	72 (64)	204 (182)
15 (6.7)	12.8 (5.7)	460 (409)	109 (97)	307 (272)
20 (8.9)	17.0 (7.6)	594 (529)	145 (129)	408 (363)
25 (11.2)	21.3 (9.5)	732 (651)	181 (161)	511 (455)

Note:
- All dry weight silage values based on 70% moisture.
- Alfalfa Hay based on 15% moisture.

TABLE A-4: NUTRIENT RECOMMENDATIONS
Previous year forage crop with 30-50% legumes or legume ploughed under

Typical Yield tonnes/ha (tons/acre)		**Nutrient Removal Rates** kg/ha (pounds/acre)		
Wet weight	Dry weight	N	P	K
Silage Corn (at 8% protein concentration)				
35 (15.6)	10.5 (4.7)	84 (75)	48 (43)	126 (112)
45 (20.1)	13.5 (6.0)	123 (109)	62 (55)	162 (144)
55 (24.6)	16.5 (7.4)	161 (413)	76 (68)	198 (176)
65 (29.0)	19.5 (8.7)	200 (178)	90 (80)	234 (208)
75 (33.5)	22.5 (10.0)	234 (208)	102 (91)	266 (237)
Grass or <30% Legume Mix Silage (3 cuts or less with 12% protein concentration)				
20 (8.9)	6 (2.7)	65 (58)	51 (45)	144 (128)
30 (13.4)	9 (4.0)	123 (109)	77 (69)	216 (192)
40 (17.9)	12 (5.4)	180 (160)	102 (91)	288 (256)
50 (22.3)	15 (6.7)	238 (212)	128 (114)	360 (320)
60 (26.8)	18 (8.0)	296 (263)	153 (136)	432 (384)
Grass or <30% Legume Mix Silage (5 cuts or more with 16% protein concentration)				
20 (8.9)	6 (2.7)	104 (93)	51 (45)	144 (128)
30 (13.4)	9 (4.0)	180 (160)	77 (69)	216 (192)
40 (17.9)	12 (5.4)	257 (229)	102 (91)	288 (256)
50 (22.3)	15 (6.7)	334 (297)	128 (114)	360 (320)
60 (26.8)	18 (8.0)	411 (366)	153 (136)	432 (384)
Alfalfa Hay (up to 3 cuts with 20% protein concentration)				
5 (2.2)	4.3 (1.9)	88 (78)	37 (33)	103 (92)
10 (4.5)	8.5 (3.8)	222 (198)	72 (64)	204 (182)
15 (6.7)	12.8 (5.7)	360 (320)	109 (97)	307 (272)
20 (8.9)	17.0 (7.6)	494 (440)	145 (129)	408 (363)
25 (11.2)	21.3 (9.5)	632 (518)	181 (161)	511 (455)

Note:
- All dry weight silage values based on 70% moisture.
- Alfalfa Hay based on 15% moisture.

TABLE A-5: NUTRIENT RECOMMENDATIONS
Annual manure application at agronomic rate or higher or previous year forage crop with more than 50% legumes

Typical Yield tonnes/ha **(tons/acre)**		**Nutrient Removal Rates** kg/ha **(pounds/acre)**		
Wet weight	Dry weight	N	P	K
Silage Corn (at 8% protein concentration)				
35 (15.6)	10.5 (4.7)	34 (30)	48 (43)	126 (112)
45 (20.1)	13.5 (6.0)	73 (65)	62 (55)	162 (144)
55 (24.6)	16.5 (7.4)	111 (99)	76 (68)	198 (176)
65 (29.0)	19.5 (8.7)	150 (134)	90 (80)	234 (208)
75 (33.5)	22.5 (10.0)	184 (164)	102 (91)	266 (237)
Grass or <30% Legume Mix Silage (3 cuts or less with 12% protein concentration)				
20 (8.9)	6 (2.7)	15 (13)	51 (45)	144 (128)
30 (13.4)	9 (4.0)	73 (65)	77 (69)	216 (192)
40 (17.9)	12 (5.4)	130 (116)	102 (91)	288 (256)
50 (22.3)	15 (6.7)	188 (167)	128 (114)	360 (320)
60 (26.8)	18 (8.0)	246 (219)	153 (136)	432 (384)
Grass or <30% Legume Mix Silage (5 cuts or more with 16% protein concentration)				
20 (8.9)	6 (2.7)	54 (48)	51 (45)	144 (128)
30 (13.4)	9 (4.0)	130 (1165)	77 (69)	216 (192)
40 (17.9)	12 (5.4)	207 (184)	102 (91)	288 (256)
50 (22.3)	15 (6.7)	284 (253)	128 (114)	360 (320)
60 (26.8)	18 (8.0)	361 (321)	153 (136)	432 (384)
Alfalfa Hay (up to 3 cuts with 20% protein concentration)				
5 (2.2)	4.3 (1.9)	38 (34)	37 (33)	103 (92)
10 (4.5)	8.5 (3.8)	172 (153)	72 (64)	204 (182)
15 (6.7)	12.8 (5.7)	310 (276)	109 (97)	307 (272)
20 (8.9)	17.0 (7.6)	444 (395)	145 (129)	408 (363)
25 (11.2)	21.3 (9.5)	582 (518)	181 (161)	511 (455)

Note:
- All dry weight silage values based on 70% moisture.
- Alfalfa Hay based on 15% moisture.

APPENDIX B: Manure Nutrient Contents, Mineralization, and Treatment Systems for Phosphorus Management

Table B-1. Manure Nutrient Contents - book values for comparison with lab reports

Manure Type	Total N content (kg N/t)	Ammonia-N (NH_4-N) (kg N/t)	Total Phosphorus (kg P/t)	Total Potassium (kg K/t)
Liquid Dairy >98% water (very watery)	1.3	0.73	0.18	1.2
Liquid Dairy 95-98% water (quite watery)	2.0	1.11	0.36	1.6
Liquid Dairy 92-95% water (medium slurry)	2.8	1.45	0.57	2.5
Liquid Dairy <92% water (thick slurry)	4.0	1.76	0.83	3.0
Solid Dairy 77% water	3.9	0.4	1.5	7.5
Broiler 25% water	34.7	5.7	10.9	12.9
Layer (commercial egg) 50% water	21.6	4.2	12.8	10.8
Broiler breeder (hatching egg) 46% water	19.6	4.1	13.0	10.0
Turkey 33% water	29.9	7.4	12.4	9.0
Hog 93% water (covered pit)	6.3	4.5	1.4	3.3
Hog 98% water (uncovered pit)	3.5	2.6	0.66	1.4
Beef 68% water (solid)	4.2	0.2	2.1	6.8

Source: B.C. Forage NMP Calculator 2010 v2.09. Growing Forward version.
Nutrient concentrations are on a fresh or wet weight basis.

Table B-2. Estimated Nitrogen Mineralization Rate (%) Over Time

Manure Type	Year 1	Year 2	Year 3
Poultry	50	15	5
Dairy (>95% water) or Hog	35	15	5
Dairy (<95% water) or Beef	25	15	5
Finished compost or Mechanically separated solids	10	5	5

Source: B.C. Forage NMP Calculator 2010 v2.09. *Growing Forward* version.
Manure Nitrogen Mineralization. 2009. University of California Cooperative Extension. Manure Technical Bulletin series. http://manuremanagement.ucdavis.edu

Table B-3. General Overview of Manure Treatment Systems for Phosphorus Management			
Treatment	**General Description**	**Pros**	**Cons**
Separation Gravity	Solid and liquid phases of manure are separated by gravity in sedimentation basin (also referred to as solid settling basin).	• Efficient with chemical amendments.	• Dependent on manure characteristics – best with dilute wastewater. • Multi-stage settling basins and lagoons work best (additional land requirement). • Settled sludge (with high phosphorus concentration) requires cleanout (every 1, 2, etc. years).
Separation Mechanical	Screen: Manure slurry passes through a screen with solids collected on one side and liquid through another. Liquids are typically directed to settling basin or lagoon.	• Best for slurries with relatively high solids content and large particle size. • Throughput from 2 to 59 l/s (26 – 7800 gpm).	• Standard screen separators are prone to plugging but can be prevented with simple, daily maintenance. • Low separation efficiency.
	Screw press: Screw type conveyer mechanically squeezes manure against metal screens with various slot sizes to reduce the liquid portion.	• Best for slurries with higher solids content, greater than 5% up to 15%. • Has shown to remove up to 70% mass when used following anaerobic digestion.	• Improved efficiency if used as a secondary component. • Less than 25% of nitrogen and phosphorus may be removed from liquid fraction due to aqueous dissolution of nitrogen and small particle size of phosphorus. • Less efficient with swine manure. • $50,000$^+$ set-up costs plus operating and modification costs
Separation Centrifuge	Manure solids and liquids separated by force.	• High efficiencies with flocculation • Can separate particles greater than 0.025 mm so higher total phosphorus separation into solids. • Retains higher total nitrogen (compared to total phosphorus) improving agronomic value of liquid fraction.	• High energy requirements and therefore costs • High capital costs when compared to other separation methods.
Separation Chemical Additives	Coagulants (metal salts promote aggregation of small particles through charge neutralization) and flocculants (aggregation of particles by organic polymers) added prior to solid/liquid separation for larger particles that are easier to settle.	• Effective for all liquid manures (possible to remove over 80% of phosphorus from separated dairy manure). • Aluminum chloride effective on solid poultry litter (can be applied between flocks). • In hog manure, may bind phosphorus to prevent runoff. • Estimated US costs: poultry - $250/ton or $500/flock; swine - $1/133 gallons plus equipment costs.	• Used in addition to other methods of separation (works best when larger particles already removed and from primary cell). • Amount and timing needs to be optimized and carefully managed.
Precipitates	Technological and chemically induced crystallization of wastewater to form ammonium magnesium phosphate.	• Separated phosphorus is easier to manage for land application. • Low solubility. • May reduce phosphorus in wastewaters by more than 80% (20% nitrogen reduction).	• Requires proper ratios of ammonium and magnesium (1.6:1). • pH dependent. • May create blockages in supply lines (no further explanation). • High set-up and operational costs (estimated US costs: $0.035/L of manure treated slurry). • Transport costs for required off-farm treatment. • Not applicable to solid manures.
Membranes	Containment system which forces liquid (gravity or added pressure) fraction through small pores and withholds the solid particles that are larger than the pore size.	• May be possible to reuse collected water in the barn. • Replacement bags are inexpensive. • Reduces solids portion and therefore increases available space in pond. • Solids are contained.	• Requires dedicated (and engineered) space for bag placement with water collection area, liner, berms, etc. • Improved efficiency with pre-treatment. • Improved separation with smaller pores requires increased pressure. • Solids may require further post-treatment. • Cleaning of membrane required due to solids build-up. • Relatively inexpensive to set-up but pre-treatment, operational, and maintenance are additional costs.
Livestock Water Recycling **(Patented process technology)**	Multi-process system uses equalization tanks, filters, and membranes to separate manure solids and liquids.	• May remove 100% of P (unsubstantiated at this time). • Segregates material into a solid, phosphorus rich sludge, ammonium-rich liquid, and clean water. • Eliminates need for wastewater storage pond.	• Currently being tested on a dairy in BC. • Current capital investment estimated between $350,000 and $600,000CDN plus operational and maintenance costs.

Table B-3. General Overview of Manure Treatment Systems for Phosphorus Management

Treatment	General Description	Pros	Cons
Advanced Manure Treatment Plant **(proprietary)**	Developed by Osorno Enterprises Inc. as treatment strategy for the for hog manure. Uses (1) pre-treatment through aeration using a lift station, (2) flocculation, (3) wastewater treatment by biological nutrient removal, and (4) in-vessel solids composting.	• Prevents release of green house gases (Step 1). • Removal of approximately 75% biological oxygen demand during flocculation stage (Step 2). • Wastewater may be reused. • Solids composted in 14 days. • Very low pathogen count (no *E. Coli*, *Salmonella ssp*., pathogenic amoeba). • Solids volume reduction of 40%.	• Only tested in Canada for hog manure. • Would require trial studies for dairy manure. • $250,000 set-up costs plus operations for hog manure estimated at $1.10/m^3 • Actual phosphorus removal and/or phosphorus containment not provided.
Anaerobic Digestion	Biological reduction of organic matter that produces energy.	• Most used for liquid and slurry manure. • Some shift from organic to inorganic phosphorus increasing plant availability (although increased potential for leaching, runoff). • May be easier to separate out phosphorus in solid fraction with additional separation of digestate. • Slightly reduces mass/volume of waste (less than composting).	• Mass of nutrient levels generally remains unchanged. • High set-up, operational, and maintenance costs. • Management of microbial populations for digestion. • May be higher energy costs to operate in colder months.
Composting	Aerobic, thermophillic biological process to break down organic matter of manure.	• Reduces mass/volume of waste. • Reduced bulk density and therefore transport costs when compared to raw manure. • Reduces pathogens, weed seeds, and odour; stabilized nutrients. • Reduces water soluble phosphorus by approximately 50%. • Any solid or semisolid manure can be composted. • May be used with separation systems. • 2003 estimated costs $20/tonne for poultry manure (excluding pelletizing and transport).	• Does not significantly reduce total phosphorus mass. • High nitrogen loss thereby decreasing the nitrogen: phosphorus ratio. • Several composting facilities already in the Fraser Valley which may decrease marketability. • May result in high air emissions during initial stages of decomposition due to volatilization. • Complexity of system could lead to high set-up costs (requires leachate collection, liner, equipment). • Expected annual rainfall in the Fraser Valley could increase decomposition time requirements for outdoor operations. • Management and maintenance required for proper end product. • May only be financially feasible in local market. • Small scale operations financially feasible but producer has to find market compared to large operation that may increase costs to producer and purchaser.

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