Step 4. INTERPRET RESULTS

In Step 4, you interpret the information and flags you received following the initial run through the nutrient management planning model. You'll develop and assess the options to come up with the best possible decisions for your farm operation.

Here you have the opportunity to explore options, comparing the impacts of different management practices (e.g., on nutrient availability, application rates, environmental restrictions). For example, you may ask: Will some of the options result in reduced land base requirements? Or will the options result in higher application rates, and/or reduced setback distances?

Here are some of the areas you may wish to explore.

Desired outcome of Step 4 – a systems approach with the goal of maximizing the economic benefits of manure nutrients without compromising soil health, crop opportunities and other farm operations.

AREA	OPTIONS/CONSIDERATIONS	POTENTIAL IMPACT
MANURE STORAGE	type of storage – covered, concrete, earthen and management of liquids	• storage size • volume to handle • liquid loading, application rates
APPLICATION RATES	reducing or eliminating starter fertilizer	• application rate increase
	high soil test levels	• application rate limited • crop growth and quality affected • fertilizer rates reduced
CROP ROTATION	specific crop nutrient requirements	• application opportunities • acreage adjustments
MANURE NUTRIENT VALUE	method of application (e.g., incorporation vs surface application)	• available nutrients (reduced nitrogen loss) • operational concerns – workload and equipment requirement and setup • reduced P Index
PHOSPHORUS INDEX	tillage – cross-slope	• reduced P Index
	strip cropping and buffers	• reduced P Index
SEASON OF APPLICATION	late fall application	• application rates increased (compared to late summer application)
	use of cover crops with fall application	• application rate increased • nitrogen retention for spring increased
APPLICATION EQUIPMENT	time required to apply recommended rates	• feasibility with existing equipment and time
	new equipment vs. custom application	• timing of application • custom applicator flexibility and equipment selection • cost of application (what is your current cost and how does it compare?)

Size and type of manure storage will have a direct impact on the volume and nutrient value of manure to be applied.

Cross-slope tillage will reduce P Index value and allow for slightly higher application rates.

The use of cover crops will help make fall applications feasible.

The key to a workable NMP is a commonsense approach that incorporates your entire livestock or crop production system: site features, management practices, equipment types and sizes, available labour, etc. For example, a farm operation on heavy clay soils would not plan to apply all the manure in the spring, prior to planting, on fields planned for corn.

MANAGEMENT OPTIONS TO ADDRESS RED FLAGS

LIVESTOCK NUTRITION

Improve feed efficiency by reducing nutrient excretion. This can be done by decreasing feed wastage, improving feed digestibility (e.g., pelleting increases energy and protein digestibility) and improving animal productivity (e.g., genetic improvements, improving herd health status, feed additives). Consult with a livestock nutritionist to determine if your ration ingredients are being fed at rates recommended by the National Research Council.

1. If the land base required for manure application is tight or application rates are limited by high P content in manure, consider adding the enzyme phytase to the ration to improve P digestion in monogastric livestock. Adding phytase will reduce the P in manure up to 20%. However, this must be done in combination with the reduction of phosphorus supplements in feed.
2. Match the supply of available nutrient to requirements. This can be done by split-sex feeding and phase feeding.
3. Balance amino acids to help reduce the nitrogen in manure. New techniques include replacing protein with synthetic amino acids.

Reducing the nutrients in manure can often reduce the acreage requirements, since application rates often increase with reduced nutrient concentration.

Methods to reduce feed wastage:

- ▶ **use pelleted feed to reduce wastage by ~ 5%**
- ▶ **examine feeder design options that minimize waste**
  - ▷ **pigs like to eat and swallow with their heads straight**
  - ▷ **dry > wet-dry > liquid feeding systems**
- ▶ **inspect, adjust and clean feeders regularly**
  - ▷ **when feeding, only 50% of the feeder should be covered.**

MANURE AGITATION

Phosphorus is tied up with the solids, while potassium and ammonium N are highest in the liquids. So, proper manure agitation is usually recommended for uniform nutrient application on a field.

However, there are times when unagitated manure can be managed to make the highest use of the N without the P. This can be achieved when the liquids are skimmed off the top before agitation, and applied to fields closest to the storage that are already testing high for P.

When using this method, it's extremely important to take regular manure samples to determine when the P level begins increasing. Also be sure to document manure nutrients at different levels in the storage for record-keeping purposes.

	NON-AGITATED MANURE		WELL-AGITATED MANURE STORAGE 3/4 EMPTY
	FINISHER HOG MANURE	(AS IS BASIS)	FINISHER HOG MANURE
DRY MATTER	1.9	%	4.7
TOTAL NITROGEN	44	lbs/1000 gallons	61
AMMONIUM NITROGEN	36.2	lbs/1000 gallons	39.2
PHOSPHORUS	1.8	lbs/1000 gallons	14.7
PHOSPHORUS (LONG TERM)	3.6	lbs/1000 gallons	29.4
POTASH	25.9	lbs/1000 gallons	30.2

Is there an opportunity to take the top portion of the liquid manure storage and apply the manure – without agitation – to the fields with the highest phosphorus soil test levels? (These are usually the fields closest to the barn.)

COMMERCIAL FERTILIZER

In most cases where manure is applied, commercial fertilizer is still required for economic crop growth. This is especially true for corn crops where with most manure types, N needs can't be met: phosphorus is the nutrient that limits application rate.

Management strategies for improving N utilization often concern starter fertilizers. Ask yourself:

- is the starter fertilizer required – is it giving any yield benefit?
  - are there opportunities to reduce the starter fertilizer, e.g., instead of 200 lbs/ac of MAP(11-52-0) through the corn planter fertilizer boxes in a 2X2 band, can MAP be applied at 25 lbs/ac in-row through the insecticide boxes?
- is there a benefit to using a low-rate liquid starter?
  - will a lower rate increase my manure application rate?
- is there an opportunity to do a side-by-side comparison to determine if there is a benefit of using starter fertilizer – especially if soil P test is greater than 30 ppm or 30 mg/L?

TILLAGE

Type and timing of tillage will have an impact on nutrient utilization. To maximize nutrients for the crop, consider:

- incorporation of manure immediately after application to minimize odour and volatilization loss
- pre-tillage to break macropores, reduce risk of preferential flow, and increase soil infiltration capacity
- injecting manure to reduce odour and maximize N utilization
  - however, depending on injection tooth design and spacing, the risk of higher volumes in a more concentrated band closer to tiles will increase the risk of preferential flow
- that reduced tillage (or no-till) practices reduce erosion potential by increasing soil residue cover – this will lower the P Index
- that tillage for liquid manure applied in early fall does increase conversion of ammonium N to nitrate, which increases the risk of nitrate moving below the root zone – less tillage will result in volatilization loss
- that direction of tillage will impact water movement across a slope
  - near surface water, tillage usually occurs parallel to the watercourse, which is generally across the slope.

Pre-tilling will break macropores, reduce risk of preferential flow, and increase soil infiltration capacity.

What's meant by "incorporation"?

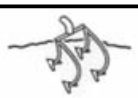
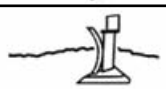
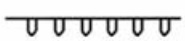
- **20–30 rule: 20–30 minutes for manure to infiltrate after application**
- **30% or less manure residue on the surface**

Does aeration tillage meet these requirements? The answer depends on application volume and setup.

MORE ABOUT NO-TILL

No-till is an excellent system and manure is an excellent resource, but using manure in a no-till system requires some compromise. Expect to do some limited tillage, or lose some nutrients.

The benefits are many, including use of natural nutrients, increased organic matter, and improved soil health and water-holding capacity. The main drawback is that you will have to pay closer attention to equipment modification, soil moisture conditions, and the potential for preferential flow. The chart below summarizes some of the advantages and disadvantages of using various forms of manure.

	PLACEMENT OF MANURE	INCORPORATION IMPLEMENT
Shallow incorporation S-tine cultivator		
Horizontal sweep injection		
Knife injection		
Shallow incorporation concave disks		
Slot injection		
Aeration technology		

+ ADVANTAGES – DISADVANTAGES

LIQUID MANURE	SOLID MANURE	COMPOST
+ opportunity to combine with cover crops – higher risk of runoff, compaction and preferential flow (requires attention to rates or lower rates) – compromise with some tillage (to improve N utilization; reduce odour issues)	+ higher organic N content = less NH_4-N for volatilization + higher solids contribute more organic material to soil + higher solids = less risk of runoff and preferential flow – greater time and labour requirement for application – less crop-available N (short-term)	+ completed process means little environmental risk (leaching, denitrification, volatilization) + soil health benefit from increased organic matter + lower volume and less odour compared to uncomposted manure – little crop-available nitrogen, high phosphorus and potash – more labour and close attention to composting process is required

CONSERVATION PRACTICES

Several conservation practices and structures will reduce the risk of erosion, runoff and nutrient loss.

- Manage residues. Reduce tillage operations to increase the percentage of the soil's surface covered by the residue of the previous crop. This reduces risk of erosion and runoff.
- Practise contour and cross-slope tillage and planting (including strip cropping) to, in effect, reduce the impact of cropland slope.
- Use erosion control structures such as field terraces, water diversions and water and sediment control basins to reduce the energy of overland flow.
- Establish buffer strips along streams.

NUTRIENT APPLICATION

Injection methods place the nutrients in the root zone to improve availability for crop use.

The method and timing of nutrient application will reduce odours and environmental risk.

- Incorporate to reduce odour and risk for runoff.
- Inject liquid manure to place nutrients in or near the root zone.
- Side-dress with injection or dribble-bar type applicators and use pre- or post-application tillage practices to reduce odours and provide nutrients when crop requires them.

CROPPING SYSTEMS

Cover crops will help to mitigate N Index flags. Cover crops take up and hold N in organic form during a season when annual crops aren't growing. This helps reduce the N available for leaching or denitrification.

Inter-row application is the application of manure into a growing crop. This system applies the N when the crop needs are highest, and when risk of loss is lowest. When applied at a rate to meet crop needs, this is also a greenhouse gas mitigation BMP.

Crop rotation will generate more opportunities for manure application.

OTHER OPTIONS

No two farms are the same. That's why no recommendation will suit every situation. Here are some ideas for alternatives that may fit into a whole farm management program.

RECENTLY EXPANDED LIVESTOCK OPERATIONS

For many recently expanded farms, there's a large volume of manure to land apply. In the past, manure was likely applied to cornfields just prior to planting.

However, in most of Ontario, there's a narrow window of opportunity for planting corn before impacting negatively on yield. Generally, fields are wetter than ideal (compaction issue) and most farmers have a heavy workload at this time of year (i.e., time is worth more than at any other time of year). This may result in higher manure application rates to fields closest to the manure storage.

Recently expanded livestock operations may face the challenge of managing extra volume of manure during the planting season.

ALTERNATIVES

Sometimes compromises must be made between highest nutrient availability for crops and managing workload and site conditions. The following options may not be the best economic choices (e.g., manure application to legume crops) or provide the most available nutrients for the growing crop (e.g., spring vs. fall application). But they do spread out the workload and allow application to all fields over the period of the rotation.

Early spring

Winter wheat – apply liquid manure (ideally with a drag hose system) at the same time that commercial nitrogen would be applied. Compaction is reduced and natural incorporation enhanced if application is done on frozen soils that thaw during the day, and freeze again in the evening. Avoid surface application on steep slopes where runoff could be an issue. Knowing the amount of nitrogen in the manure and paying attention to application rate uniformity is critical to avoid lodging. Hard red varieties are graded by their protein levels and have a higher N requirement than soft red or white varieties. High protein is easier to achieve for fields that have had regular manure application.

Pastures – often are not regularly rejuvenated with nutrients. Applying manure to pastures with conditions similar to winter wheat is one option. When manure is applied later in the season, slot injection systems will reduce contamination of new growth.

Canola – has a high N requirement and is planted at the same time as spring grains. Compaction is the biggest issue.

Canola has a high N requirement and will help to use manure nitrogen.

Row-crops such as corn provide an opportunity for side-dress applications.

Corn – is still the best crop to target with manure. Consider predetermining a percentage of acreage that will get manure and planting shorter-day varieties in those fields to compensate for realistic later planting, or plan manure application for corn silage fields. Surface application of manure can also take place after planting but with a compromise to some nitrogen.

Soybeans – have a longer planting window before significant yield losses. Later planting means more opportunity for better soil conditions to apply manure. Note, however, that too high a manure rate could result in taller and more dense beans that have an increased risk for lodging and white mould. Consult with a seed dealer for shorter, less bushy varieties and/or varieties that have some resistance to white mould.

Manure application on spring grains works in regions where additional nitrogen is recommended.

Spring grains – not recommended for manure application in southwestern Ontario since the amount of required N is so low (35 lbs) that a less-than-uniform application or too high a rate can result in a badly lodged crop. In other regions of Ontario where N recommendations for spring grains are higher, there is an opportunity for manure.

Late spring / early summer

Side-dress – into standing crop (i.e., liquid hog manure into corn).

Edible beans (coloured beans) – are usually planted near the beginning of June when risk of frost has passed and soil conditions are drier. Because they are a legume crop, coloured beans don't generally require nitrogen. However, where bronzing and root rots reduce yield, 40–60 lbs of nitrogen will often be recommended. Too high a rate of nitrogen from manure would delay crop maturity.

Liquid manure application following forage harvests works best with older forage stands.

Following forage harvest – after first, second or third cut, as close to harvest before regrowth. Keep rates under 4000 gal (50–75 lbs ammonium N) to minimize N burn. Applications give the greatest benefit to older forage stands with higher grass content (grasses need the N more than legumes) and where crown damage caused by wheel traffic will have less impact. Irrigation of low dry matter (<1%) liquids is an option for some that will also give a much-needed moisture benefit to the second and third cut forage crops.

Late summer / fall

After wheat harvest – on heavy clay soils prone to compaction, this time of year is the best option for application. The ability to apply manure on wheat makes wheat a good crop in the rotation since wheat allows the workload to be spread out, and makes it easier to apply manure to fields farther from the storage (sometimes once every three years at a higher application rate). Cover crops will minimize impact of nitrogen leaching (N Index).

Cover crops – are considered a benefit for fall manure application. Oats, barley, oilseed radish, turnips, oat/rye mix, red clover and red clover and/or peas are all acceptable cover crops. When spread uniformly over the field, volunteer wheat is also acceptable, as is wheat planted as a crop after soybeans. Cover crops take up the nitrogen and hold it in organic form until spring. Some cover crops will release their nutrients earlier or later than needed by the following crop. Red clover seems to release its nitrogen closest to corn crop needs.

Early fall after silage corn harvest – when soil conditions are dry, before the bulk of soybean and corn harvest. Nutrient loss and compaction can be minimized.

Alfalfa that will be plowed down – especially when the next crop will be corn. Drier soil conditions and workload flexibility make this a common practice. Keep in mind that a high percentage of legumes in the plowdown will result in a 100 lb N credit in addition to manure N, which should result in lower manure application rates.

Prior to planting winter wheat – may work better after edible bean harvest than soybean harvest since many seed drills follow the soybean combine. Manure applied after the wheat crop is emerged will often result in some tracking damage.

After corn and soybean harvest – the later that manure is applied in the fall, when conditions are cooler, the lower the likelihood of nitrogen loss from volatilization and leaching.

Apply manure in early fall after corn silage harvest to reduce the risk of compaction.

Winter application should never be part of the plan – but may be part of a contingency plan.

ACREAGE REQUIREMENTS BASED ON SETBACKS

If acreage is in short supply, try to keep P soil test levels under 30 ppm so that P Index doesn't become a trigger. Where soil test levels already exceed 30 ppm, treat the area near surface water as a separate section of the field to avoid lower rates to the whole field. Observe fields during rain events or snowmelt to see where water enters streams, and steer clear of those areas during manure application. Incorporate, inject or pre-till manure to allow application closer to watercourses.

CASE STUDY

For the case study farm, the chart below interprets some of the causes for the flags and seeks alternative strategies that will resolve the problems and improve the nutrient management plan. As always, the changes must be practical and fit with the overall management of the farm operation.

POTENTIAL CHANGES FOR NEXT SEASON (to resolve flags)	RESULTS
Consider not using starter fertilizer; apply additional N as carrier in herbicide	• Allows increased manure application (over 1000 gal/ac) based on P_2O_5 • Removes N Index red flag from fall manure application since N over crop balance is reduced
Reduce manure application rate for corn from 7000 to 6,000 gal/ac	• Reduces phosphorus applied over crop removal by 36 lbs and removes the red flag for P_2O_5 crop removal balance • Removes the red flag for N greater than 200 lbs/ac
Change tillage from moldboard plow to mulch till and direction from up and down slope to cross slope and measure slope length to show actual 800 ft	• Changes P Index from 36 to 22 in South field • Reduces P Index separation distance by 100 ft
Realize that more acreage is required	• Look for neighbour interested in manure agreement

Field/Section Information (Fall 2004 – Fall 2005: Farm 1, south field, All)

General | Properties | Cropping/Tillage | Fertizer | Manure/P.Mat'l | Balance | Economic | Heavy Metal

AGRONOMIC NUTRIENT BALANCE

[lb/ac]	N	P_2O_5	K_2O
Commercial Fertilizer:	0	0	0
Nitrogen Credit:	18		
This Season's Manure:	162	61	104
Production Requirements:	-165	0	0
Agronomic Balance:	15	61	104

CROP REMOVAL BALANCE

[lb/ac]	N	P_2O_5	K_2O
Field Inputs:	18	0	0
This Season's Manure:	162	122	104
Crop Removal:	-108	-55	-38
Crop Removal Balance:	73	67	66
Nutrient Indices:	4.0	22	

Add Fertilizer [to meet agronomic requirements] | N-Index | P-Index

APPLICATION RATES

Description	Applied Date	Type	Rate	Applied [N,P,K]	Surface Water
Manure App 3	20-May-2005	spring	6000 gal/ac	162,61,104 lb/ac	100 ft

Agronomic and crop removal balance after analysis (Step 3) for South field (2004–2005)

Field/Section Information (Fall 2004 – Fall 2005: Farm 1, north field, All)

General | Properties | Cropping/Tillage | Fertizer | Manure/P.Mat'l | Balance | Economic | Heavy Metal

AGRONOMIC NUTRIENT BALANCE

[lb/ac]	N	P_2O_5	K_2O
Commercial Fertilizer:	50	0	0
Nitrogen Credit:	9		
This Season's Manure:	107	61	110
Production Requirements:	-165	0	0
Agronomic Balance:	1	61	110

CROP REMOVAL BALANCE

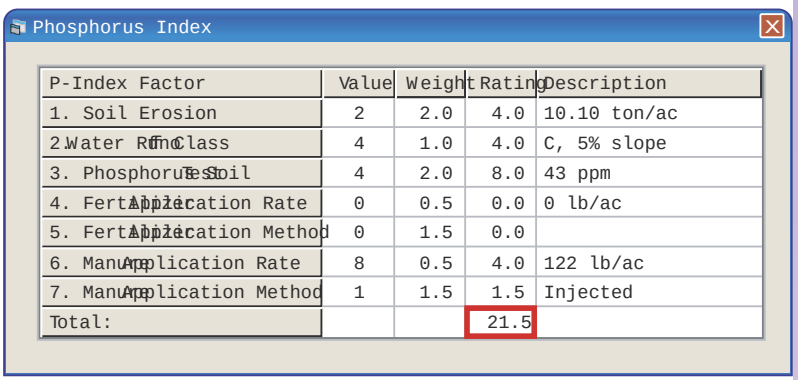
[lb/ac]	N	P_2O_5	K_2O
Field Inputs:	59	0	0
This Season's Manure:	107	122	110
Crop Removal:	-108	-55	-38
Crop Removal Balance:	58	67	73
Nutrient Indices:	5.0	23	

Add Fertilizer [to meet agronomic requirements] | N-Index | P-Index

APPLICATION RATES

Description	Applied Date	Type	Rate	Applied [N,P,K]	Surface Water
Manure App 1	24-May-2004	fall	6000 gal/ac	107,61,110 lb/ac	N/A
Fert App 2	01-May-2005	28-0-0	14.0 gal/ac	50,0,0 lb/ac	N/A

Agronomic and crop removal balance after analysis (Step 3) for North field (2004–2005)


Phosphorus Index

P-Index Factor	Value	Weight	Rating	Description
1. Soil Erosion	2	2.0	4.0	10.10 ton/ac
2. Water Runoff Class	4	1.0	4.0	C, 5% slope
3. Phosphorus Test Soil	4	2.0	8.0	43 ppm
4. Fertilizer Application Rate	0	0.5	0.0	0 lb/ac
5. Fertilizer Application Method	0	1.5	0.0	
6. Manure Application Rate	8	0.5	4.0	122 lb/ac
7. Manure Application Method	1	1.5	1.5	Injected
Total:			21.5	

South field (2004-2005) after analysis (Step 3)

Reducing P Index results

P Index can be reduced by making several changes:

- ▶ changing tillage from moldboard plow to mulch till
- ▶ changing direction from up and down slope to cross slope
- ▶ measuring slope length to show actual 800 ft (instead of guessing)
- ▶ reducing application rate from 7000 to 6000 gal/ac
- ▶ eliminating the starter fertilizer.

The result of these changes is a reduction in the P Index from 37 to 21.5. This means a 43-ft manure setback from the surface water, and a $P_2 0_5$ setback distance of 100 ft. To meet the crop removal rate of $P_2 0_5$, just under 3,000 gal/ac of manure could be applied from 43 to 100 ft from surface water.

The land base owned by the farm is not sufficient to handle the manure produced. Alternative arrangements include:

- ▶ land purchase
- ▶ land rental
- ▶ manure agreements (or transfer out – as with NMAN terms)
- ▶ manure broker agreement to take manure to alternative location (more common with solid manure).

When land base requirements exceed owned acres, you must consider additional factors, including:

travel distance and route to alternative land base

- ▶ additional time, fuel, cost of transporting water in manure, road wear, odour issues
- ▶ whether manure can be managed so that the more concentrated manure is transported the farthest distance – this would lower the handling cost per unit of nutrient

competition for land rentals and/or manure agreements.

The owner of the case study farm approached his neighbours. They agreed to enter into a manure agreement.

MANURE APPLICATION AGREEMENT

MANURE GENERATOR INFORMATION:

Generator Farm Name: M & M Farms Ltd
Generator Owner Name: Mr. I. C. Money
Address: R.R. #2, 540 Concession 10
Anytown ON. NON ONO
Telephone: (555) 555-1234

LAND OWNER/RECEIVER OF MANURE INFORMATION:

Farm Name of Receiver: Green Acres Farm Ltd.
Legal Name of Receiver: Mr. U. B. Green
Address: R.R. #2, 555 Concession 10
Anytown ON. NON ONO
Telephone: (555) 555-9876

AGREEMENT INFORMATION:

Term of Agreement: 3 years
Agreement commences on: September 1, 2006
Agreement ceases on: August 31, 2009

This agreement between the parties named above, allows for the following fields to be included in the farm unit operator's 'Farm Unit Declaration' and for application of manure to these fields under the farm unit's nutrient management plan.

List each field/section under this agreement:

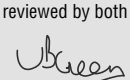
Field/Section	Lot	Concession	Township	County	Tillable Acres	Roll Number
North Field	13	10	Anywhere	Somewhere	25	355335555003555
South Field	13	10	Anywhere	Somewhere	35	355335555003555

I, U. B. Green (land owner) give permission to I. C. Money (manure generator) to declare the above lands as part of the farm unit covered by the nutrient management strategy/plan for the period covered by this agreement.

I also give permission to the farm unit operator to do soil sampling on the properties listed to determine the condition of the soil. I also agree that the land identified in this agreement will not be used for the application of any other prescribed material, originating from any other operation, including my own during the term of this agreement.

I also agree that the manure covered in this agreement will be applied in accordance to the nutrient management plan that applies to the farm unit into which these lands are incorporated.

A spill contingency plan was developed and fully reviewed by both parties.

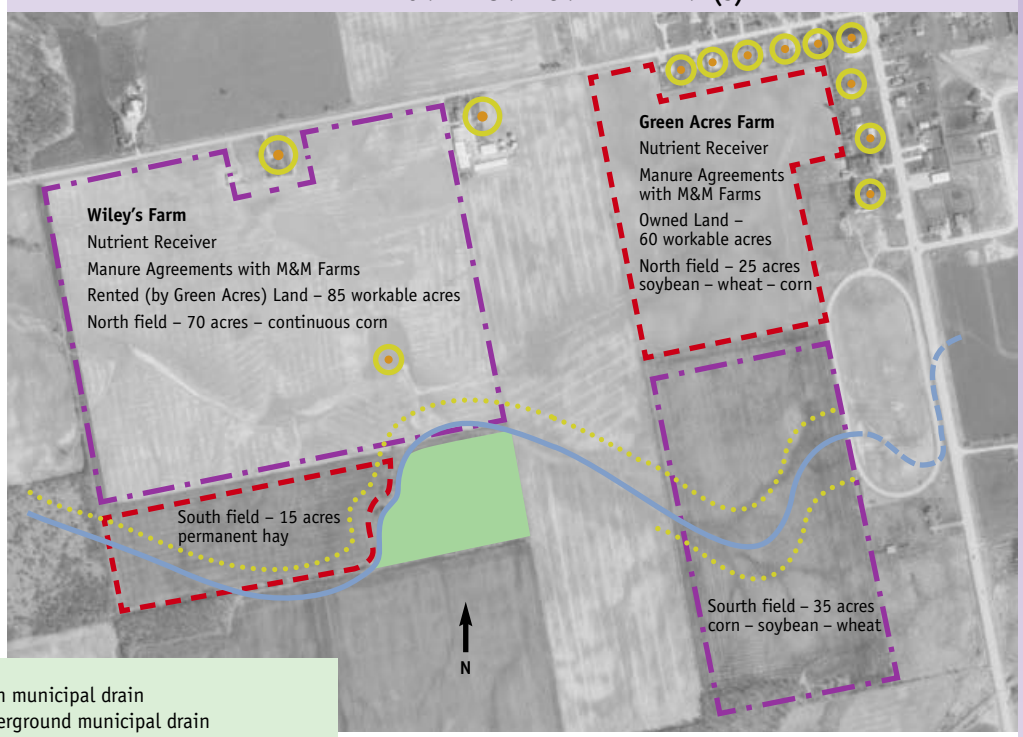
U. B. Green **Land Owner (print)**	 **Signature**	March 31, 2006 **Date**
I. C. Money **Manure Generator (print)**	 **Signature**	March 31, 2006 **Date**
C. M. Ecry **Witness (print)**	 **Signature**	March 31, 2006 **Date**

Note: Permission to use these lands is required from all property owners listed on title to the land.

For further information about and examples of manure agreements with brokers and neighbours, see factsheet Order No. 06-041 (April 2006) AGDEX 720/538.

Below is a field map for both neighbouring farms. The Green Acres field is to the east of the case study farm; Wiley's Farm is directly west.

FIELD MAP FOR MANURE AGREEMENT FARM(S)



Manure agreement details to handle remaining manure from case study farm.