Step 3. INPUT AND ANALYZE DATA

NMAN

3

Step 3 aims to:

- establish, on a field-by-field basis, the nutrients required for the planned crop
- determine land base requirements.

This analysis process accounts for the amount of nutrients left from previous crops (soil test results and credits) and nutrients available from manure based on specific management practices. The process also uses inventory information (soil and slopes) to establish potential restrictions and/or setbacks from surface water sources.

With Step 3 completed, you'll have the information from which to determine the risks as well as the opportunities within your plan. The analysis step should indicate the red and yellow flags – warnings that should be addressed – in your plan.

The analysis process requires working through the NMAN software or the *Nutrient Management Workbook* (Publication 818). This is a comprehensive field-by-field approach that incorporates site characteristics, with information about crop rotation, tillage, and timing of operations.

The result will be only as good as the information entered. Analysis depends on a thorough understanding of the cropping management on your farm. It requires a commonsense approach to timing of nutrient application, in light of the soil and cropping characteristics. Some of the information will be based on long-term knowledge of the land base, the fields, site conditions and on personal observations.

You may be confronted with a red flag if you propose to apply more manure than is needed or that the field can handle.

RED AND YELLOW FLAGS – WHAT ARE THEY?

There are several types of flags.

GREEN flags indicate that the data is within an acceptable range

YELLOW flags (identified by a yield sign containing an "i") indicate a missing information caution on the printout. Additional documentation may be required to justify missing information flags when submitting a NMS or NMP for registration or approval. The flag will show up in a printout.

YELLOW flags (identified by a yield sign containing an "!") indicate a data caution. For example, data is approaching a limit or restriction (as indicated below by a red flag). This flag will not show up in a printout.

YELLOW flags (identified by a yellow circle containing a $) indicate an economic caution. For example, nutrients could be used in another way more cost effectively. No explanation is required when submitting a NMP with an economic caution.

RED best management practice (BMP) flags (identified by a lighter red colour or by a stop sign containing an "!") represent an area of environmental concern. Changes may be needed in the nutrient planning system to eliminate these flags.

RED legislative flags (identified by a deep red colour and a stop sign) indicate a legislative infraction according to Ontario Regulation 267/03, as amended. A regulated NMS/P submitted for approval with warning flags may not be acceptable.

Red flag triggers:

Manure application rate in one application exceeds the maximum liquid loading rate.

Total amount of nitrogen applied in one crop year exceeds 200 lbs/ac and exceeds the agronomic recommendation.

The P_2O_5 crop removal balance exceeds 70 lbs/ac per year.

The nitrogen crop removal balance after crop harvest exceeds the maximum N Index value based on the field's hydrologic soil group.

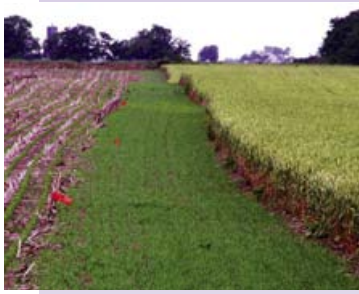
The nitrogen available for loss from fall-applied manure exceeds the lower of 120 lbs/ac or the maximum N Index value based on the field's hydrologic soil group.

The combined nitrogen crop removal balance from the harvested crop combined with the nitrogen available for loss from fall-applied manure exceeds the maximum N Index value based on the field's hydrologic soil group.

Manure and nutrients are applied within 3 m (10 ft) of surface water.

Manure and nutrients are applied within the separation distance determined by runoff potential and/or P Index.

Inadequate land base availability for the manure produced, unless manure is being transferred via broker or agreement.



Cropland buffers are a sure way to avoid red flag triggers.

Inputs in the process stem from the inventory you compiled. For example:

- soil test results will be combined with the nutrient credits to determine additional nutrient needs for the planned crop
- manure test results will be considered with planned management practices to determine approximate nutrient value and application rate for the crop
- mapping information will help determine where there could be limitations to manure and/or nutrient application
- the field-by-field nutrient application results will provide an indication of how much land base is required for the livestock base or the nutrients available.

The type of outputs include:

- application rates and timing
- additional nutrient requirements
- setbacks and separation distances
- environmental limitations (red and yellow flags)
- land base requirements
- annual manure volumes.

Considerations for Step 3 will vary from farm to farm, according to the goals set for your plan and some of your farm's site characteristics. Farms with adequate land base will have more flexibility with application rates and opportunities for application, while farms with a small land base will more likely consider environmental maximums. For example, what's the maximum application rate that can be applied without triggering a red flag or "stop"?

Another consideration is the use of default information. When some of the inventory information is unavailable, then default values are used, e.g., for slope values and soil test values. The default values are generally conservative and will most often result in greater restrictions. For some nutrient management plans, it will be worth the effort to obtain the actual inventory numbers.

One of the key outputs of the NMAN program is the calculation of the land required to apply all of your manure volume.

The information entered in the inventory section will be used to develop options for application rates based on individual crop needs. Rate options are then screened through the NMAN program (software or workbook), which is pre-programmed with limits for application rates and required separation distances. This first "run" through the plan is done with proposed application rates that can be fine-tuned later. Other options are proposed by the plan developer if red or yellow flags are triggered.

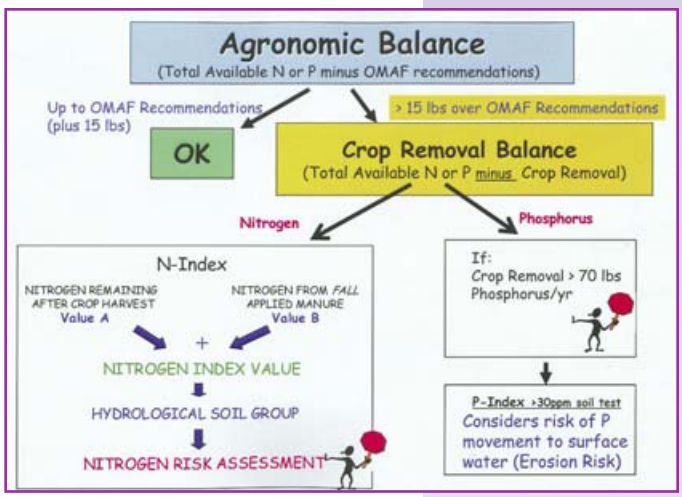
HOW THE NUTRIENT MANAGEMENT SOFTWARE/ WORKBOOK WORKS

Using livestock production data storage type and bedding information, **MSTOR** estimates manure volumes produced and typical dry matter content to calculate required manure storage size or capacity of an existing storage.

The NMAN software or workbook takes the available nutrients from manure and calculates an application rate based on crop requirements and/or on nutrients removed by the crop. Environmental risk could reduce that application rate (or require split applications).

A nutrient management planning year runs from harvest until the following harvest (generally autumn to autumn).

Agronomic balance is achieved when the macronutrients available to a crop (from all sources) is within 15 lbs/ac of the nutrients recommended for that crop. Agronomic balance takes the nitrogen and phosphorus available to a crop (from all sources) and subtracts the N and P required (based on research) for the planned crop. When the available nutrients are within 15 lbs of recommendations/requirements, then manure application rate is based on crop recommendations. When the available nutrients are more than 15 lbs over what is recommended (e.g., when a soil test is high and gives a 0 lb/ac recommendation), then the program automatically calculates crop removal balance.



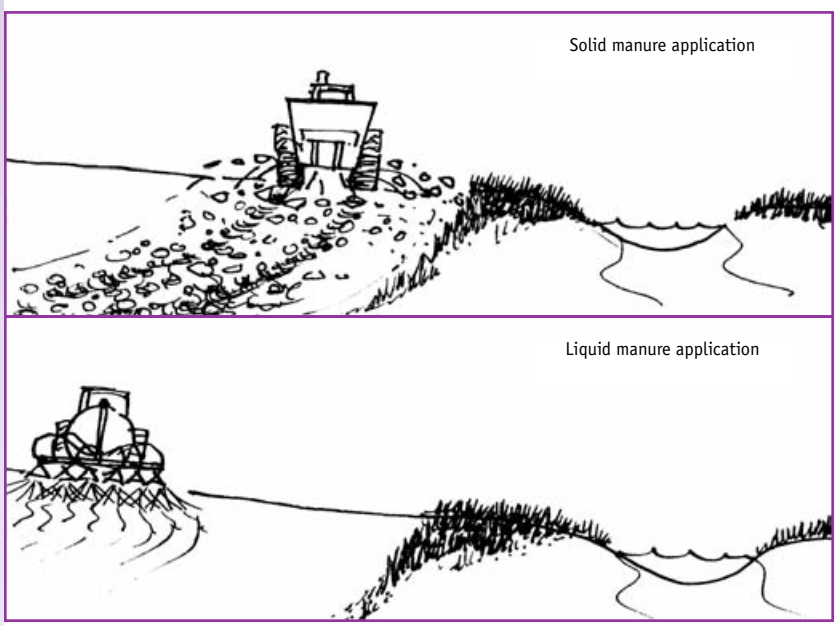
Crop removal balance is achieved when the macronutrients available to a crop (from all sources) are close to the amount of nutrients removed by that crop at harvest. Crop removal balance takes the nitrogen and phosphorus available to a crop (from all sources) and subtracts the nutrients (estimated based on average yield) to be removed by the crop at harvest. The manure application rate matches the P or N (whichever is lower) removed by the crop. Rates that match crop nutrient removal for P or K should in theory allow soil test levels to be maintained. In order to build up P levels in the soil, a phosphorus application rate of up to 70 lbs above what the crop removes per year is allowed before red flags appear. This represents approximately a 2 ppm (or mg/L) per year soil buildup for P.

If the P soil test is 30 ppm (mg /L) or higher, the P Index should be completed. The environmental impacts of P transport to surface water will be greater if the P Index is 30 ppm or higher, and significant erosion occurs. The P Index takes erosion potential and level of P in the soil to calculate a phosphorus separation distance.

When the N applied to a crop exceeds the N removed by the crop, then the N Index should be calculated to limit potential N loss by leaching during the non-growing season. When N left over at crop harvest is combined with N from manure applied in late summer or early fall, the potential loss of N from the soil through leaching or denitrification could be significant.

P and N Indexes are calculated as part of the NMAN software. They must be calculated manually when using the NMAN workbook.

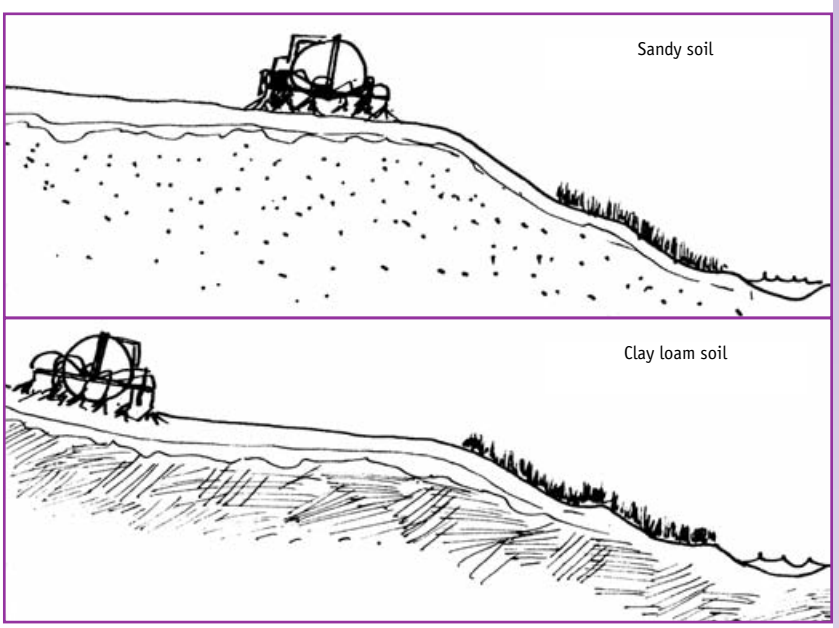
Manure separation distance is a limit set in NMAN that is based on runoff potential. The relationship is straightforward: the higher the runoff potential, the greater the distance separating manure application and surface water. Surface-applied liquid manure requires a larger distance than solid manure or liquid manure pre-tilled, injected or immediately incorporated.



Surface-applied liquid manure requires a larger distance from surface waters than surface-applied solid.

Liquid loading limit is the maximum rate that liquid manure can be applied without moving over the surface. It's determined from the runoff potential (slope and soil texture) and limits the application rate to one that can be absorbed by the soil. This loading limit can result in a requirement for split manure applications (e.g., several days apart).

The workbook version (OMAFRA Publication 818) provides the tables and calculations that are done in the background of the relatively user-friendly software. The software is available by calling the OMAFRA Nutrient Management Branch Information Line, 1-866-242-4460.



A higher application rate is possible with sandy soils that have a higher liquid loading limit, i.e., the ability for applied liquids to infiltrate and percolate into the soil.

INTERPRETING SOIL TEST RESULTS

In Ontario, crop fertilizer recommendations are based on the results of field trials conducted for each crop to determine the optimum rate for each level of soil fertility.

Agronomic nutrient requirements for P and K are based on soil test results. OMAFRA recommendations are based on the "nutrient sufficiency" approach.

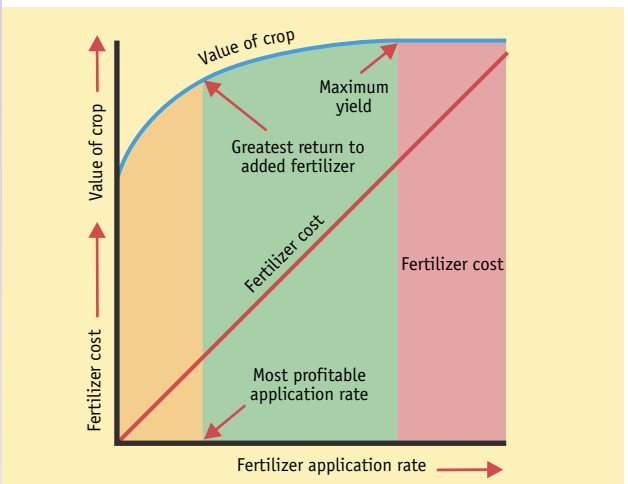
Agronomic N requirements are based on researched response curves for highest economic yield.

The recommended approach to nutrient application is applying nutrients at rates that optimize profitability while considering environmental risk. As fertility levels increase, crop response to added nutrients will decrease. When nutrients are applied in excess of crop utilization, then over time nutrient levels will gradually build up in the soil, or in the case of nitrogen, move out of the root zone.

There are two distinct goals for interpreting soil tests.

For lower-testing soils: aim to ensure adequate nutrient levels to optimize production, crop quality and returns.

For higher-testing soils: plan nutrient applications to protect water quality. For example, when planting a corn or wheat crop into soils with adequate but not extreme fertility levels, applying a liquid "pop-up" with the seed provides required nutrients closer to the seed, but at much lower volumes and incorporated into the soil.



Crop yields show a diminishing return to increasing soil fertility beyond the point of maximum economic yield.

EXAMPLE SOIL ANALYSIS RESULTS

ONTARIO ACCREDITED SOIL TEST LABORATORIES LTD.
Farm Soil Report

Report 62269
Received 07/10/05
Printed 15/10/05

Analytical values					Parts Per Million			
I.D.	Lab #	pH	BpH	O.M. %	Phosphorus $NaHCO_3$	Phosphorus Bray P	K	Mg
field 1 North half	998701	7.1		3.5	28 H		187 VH	112
field 1 South half	998702	7.2		3.2	33 VH		220 VH	167
field 2 North half	998703	6.9		4.0	35 VH		210 VH	127
field 2 South half	998704	5.9	6.8	2.8	25 H		175 VH	158
field 3 North half	998705	7.0		3.8	28 H		168 VH	118
field 3 South half	998706	7.1		3.3	26 H		160 VH	120
field 1 eroded knoll	998707	7.8		1.8	50 VH		235 VH	150

Most soil test results contain the following important information:

- **sample number** is important as a reference in case a sample needs to be re-analyzed
- **pH** is always given, and buffer pH is given when a soil sample has a pH of 6 or lower
  - buffer pH is an indication of how much lime is required to bring the pH of the soil back to 6.5 or higher – the closer the buffer pH is to 7, the less lime it will take to bring soil back to ideal pH levels
- **organic matter** can be provided for an additional cost, but is useful for establishing a baseline. Maintaining or slowly increasing organic matter levels can result in improved nutrient cycling, water-holding capacity and soil structure.
- nutrients like **P** and **K** have numbers and symbols
  - the symbols are L for low, M for medium, H for high, VH for very high and E for excessive
  - soils are considered excessive where additional nutrients will not give any economic yield return. This occurs at 60 ppm for P (for most crops) and 250 ppm for K. Soil test values over these levels could reduce crop yield or quality, e.g., phosphate applications may induce zinc deficiency on soils low in zinc and may increase the risk of water pollution.
- sometimes both the **sodium bicarbonate** and the **bray phosphorus** test numbers are given
  - some labs used the bray test until 1999
  - since there's no direct conversion (no number to multiply one result to get the other) between the two tests, the only way to compare results from previous years is to have a direct comparison of fields using both methods
  - you need the sodium bicarbonate test in order to run NMAN.

Soil nitrate levels are generally determined in May to early June by taking a soil sample from a 12-inch depth. The results can indicate how much nitrogen is present in the soil and can reduce N-inputs applied at side dress. (In Ontario, nitrate soil tests aren't routinely used for nitrogen fertilizer recommendations, but they can yield useful information.)

Testing for **micronutrients** such as zinc and manganese is sometimes done, but usually for diagnostic purposes only, i.e., comparing poor and good growing areas to identify a problem.

INTERPRETING MANURE TEST RESULTS

Manure test results will provide nutrient levels using the same numerical values as a soil test, but will **not** provide recommended rates of application. Manure test results should be used to help determine total available nutrients and overall nutrient application rates.

Several commercially available nutrient management planning tools incorporate soil and manure test results to calculate manure and other nutrient application rates.

The following principles must be addressed when interpreting manure test results:

- ▶ only a portion of the organic nitrogen is available for crop uptake (from ~5% in solid cattle manure with a high amount of bedding material to ~30% of poultry manure) in the year of application
  - ▷ organic nitrogen will build up in the soil with repeated manure applications
- ▶ residual N is derived from the organic fraction of manure, so we expect there is more from solid manure
- ▶ at least 40% of the P from manure is available as fertilizer P to crops in the year of application – at least 80% (the remaining 40%) will become available over the longer term, and adds to the total available soil P pool
- ▶ about 90% of the K is available in the year of application.

Nutrient contents of organic materials are usually reported as percentage by weight (%N, %P, %K, etc.).

Phosphorus and potassium must be converted to P_2O_5 and K_2O respectively.

Ammonium-nitrogen and micronutrient contents are usually reported in:

- **milligrams per kilogram (mg/kg) or,**
- **milligrams per litre (mg/L).**

To convert:

- **mg/kg to pounds/ton, divide mg/kg by 500**
- **mg/L to pounds/1000 gal. (imp.), divide mg/L by 100.**

Organic nitrogen is found by subtracting ammonium nitrogen from total nitrogen.

Ammonium = NH_4

Org N = Total N–NH_4

Org N (available) = Org N x available factors listed below

NH_4 (available) = NH_4 x (100–ammonium loss%)

Total (available) N = NH_4 (available) + Org N (available)

Using the inventory information from the case study farm on page 45-46, input the data into the nutrient management program (NMAN software or *Nutrient Management Workbook,* Publication 818) to come up with application rates for the planned crops. This is a first run through the plan, based on planned or normal application rates. Adjustments may have to be made if red or yellow flags are triggered.

SOIL TEST RESULTS – CASE STUDY FARM

SAMPLE MAY 2005

	PH	% OM	P (mg/L)	K (mg/L)	Mg (mg/L)
NORTH FIELD	6.8	2.8	57	300	180
SOUTH FIELD	6.7	2.6	43	258	155

MANURE TEST RESULTS – CASE STUDY FARM

MANURE SAMPLES – LIQUID HOG – FARROW TO FINISH
SAMPLED MAY 2004 TO OCTOBER 2005

AS IS BASIS	D.M.%	TOTAL N %	NH_4-N ppm	P %	K %	ZN ppm	Cu ppm
SPRING 2004	2.7	.33	2600	.11	.15	36	22
FALL 2004	3.0	.37	2350	.11	.18	37	25
SPRING 2005	2.6	.32	2550	.11	.16	34	26
FALL 2005	2.9	.36	2475	.11	.16	35	23

FROM THE MANURE ANALYSIS

Spring manure, May 2004

Nitrogen

▶ 33 lbs/1000 gallons of total nitrogen: 26 lbs/1000 gallons in the ammonium form (quickly available assuming no volatilization loss) and 7 lbs/1000 gallons in the organic (slow release) form.

When manure is not incorporated, then some of the ammonium nitrogen will disappear (volatilize) into the atmosphere. When manure is applied in fall, some of the N will be lost through leaching or denitrification.

Phosphorus

The phosphorus portion of the manure provides about 20 lbs/1000 gallons of P_2O_5. However, not all of the 20 lbs will be available in the year of application.

Potash

Almost 17 lbs/1000 gallons of K_20 will be provided from the manure.

Copper and zinc

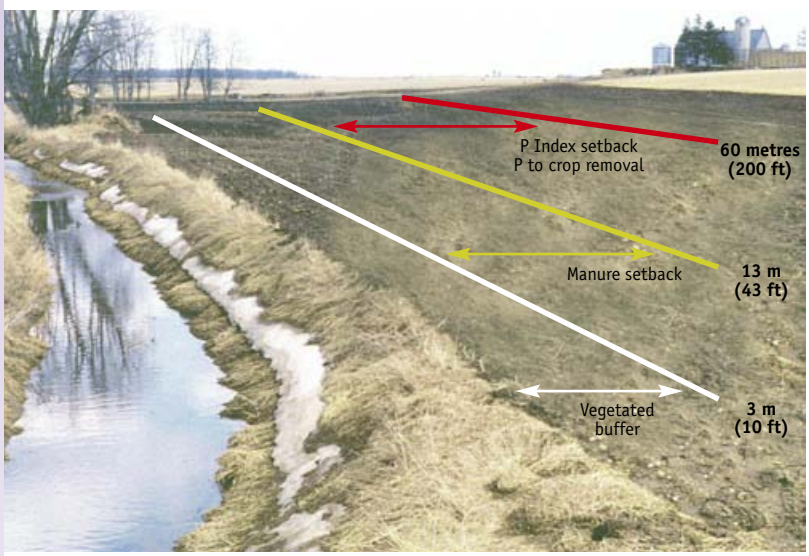
Some analyses will provide copper, zinc and other micronutrients found in the manure. These numbers normally reflect ration and supplements. If a micronutrient number is high, then a livestock nutritionist should be consulted to determine if the micronutrient is required at the rate being fed.

SOME OF THE ANALYSIS INFORMATION FOR THE CASE STUDY FARM

MANURE DESTINATION SUMMARY

TYPE	DATE	FIELD	DETAILS	AREA	CROP	RATE	SETBACK
FALL	Nov 2004	North	Drag hose – surface – incorp. 24 hrs	20	Corn	7000 gal/ac	n/a
SPRING	May 2005	South	Drag hose – surface – pre-tilled	23	Soybeans	5000 gal/ac	200 ft
FALL	Nov 2005	North	Drag Hose – surface – incorp. 24 hrs	20	Corn	7000 gal/ac	n/a
SPRING	May 2006	South	Drag hose – injected	23	Corn	7000 gal/ac	200 ft

The manure destination summary shows when application is planned to designated fields and at what rate. Setback distances are also determined from the slope and runoff potential information, and can be found in the Minimum Distance Separation Table on page 83.



A high P Index result will mean that a minimum separation distance of 60 metres (200 ft) will be required for manure application.

A Phosphorus Index of "37" for South field results in a restriction on application rate to phosphorus crop removal up to 200 ft from surface water.

Phosphorus Index South Field 2004-2005

P-Index Factor	Value	Weight	Rating	Description
1. Soil Erosion	8	2.0	16.0	31.74 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	4	0.5	2.0	64 lb/ac
5. Fertilizer Application Method	1	1.5	1.5	Placed with planter
6. Manure Application Rate	8	0.5	4.0	101 lb/ac
7. Manure Application Method	1	1.5	1.5	Injected
Total:			37.0	

P Index for South field

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:	4	16	4
Nitrogen Credit:	18		
This Season's Manure:	189	71	121
Production Requirements:	-165	0	0
Agronomic Balance:	46	87	125

CROP REMOVAL BALANCE

[lb/ac]	N	P_2O_5	K_2O
Field Inputs:	22	16	4
This Season's Manure:	189	142	121
Crop Removal:	-108	-55	-38
Crop Removal Balance:	104	103	88
Nutrient Indices:	5.0	36	

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

APPLICATION RATES

Description	Applied Date	Type	Rate	Applied [N,P,K]	Surface Water
Fert App 1	01-May-2005	6-24-6	5.0 gal/ac	4,16,4 lb/ac	200 ft
Manure App 3	20-May-2005	spring	7000 gal/ac	189,71,121 lb/ac	200 ft

Agronomic and crop removal balance summary, South field 2004–2005

Field/Section Information (Fall 2005 – Fall 2006: 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:	4	16	4
Nitrogen Credit:	14		
This Season's Manure:	125	71	129
Production Requirements:	-165	0	0
Agronomic Balance:	-23	87	133

CROP REMOVAL BALANCE

[lb/ac]	N	P_2O_5	K_2O
Field Inputs:	18	16	4
This Season's Manure:	125	142	129
Crop Removal:	-108	-55	-38
Crop Removal Balance:	35	103	95
Nutrient Indices:	5.0	21	

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	21-May-2005	fall	7000 gal/ac	125,71,129 lb/ac	N/A
Fert App 3	01-May-2006	6-24-6	5.0 gal/ac	4,16,4 lb/ac	N/A

Agronomic and crop removal balance summary, North field 2004–2005

SUMMARY OF FLAGS AFTER COMPLETING STEP 4: INTERPRET RESULTS (USING NMAN SOFTWARE)	FLAG
1. greater than 200 lbs/ac nitrogen applied to crop	
2. application rate is greater than 6700 gallons (maximum rate on silt loam soil with a 5% slope)	
3. P_2O_5 and K_2O are applied above agronomic requirements (economic)	
4. additional nitrogen is required to meet agronomic recommendation (economic)	
5. manure remaining (maximum of 52% of manure produced yearly is utilized)	
6. projected land base requirement of 105 acres (yellow flag)	
7. P_2O_5 is applied above crop removal limit (applied 87 lbs where limit is 70 lbs)	
8. N over agronomic rate + fall application = N Index trigger	

The farmer will have to adjust the planned nutrient application to eliminate the risks triggered by the red flags.

Using the inventory information and the soil test and manure analysis results, a number of red flags and caution flags have been triggered.

1. South field has 189 lbs in manure N and 22 lbs in starter N applied to a corn crop. This exceeds the 200 lbs N allowed per acre unless recommended (as per *Agronomy Guide*).

2. Application rate is greater than 6700 gallons. The proposed 7000 gal/ac to the South field exceeds the liquid loading limit for surface-applied manure to a 5% slope, with silt loam soil.

3. P_2O_5 and K_2O are applied above agronomic guidelines, which could have a negative yield/economic impact. If the additional nutrients will not boost yield, then the use of starter fertilizer could be re-evaluated.

4. For North field, additional N is required to meet the recommendations. 165 lbs/ac N is recommended, while 142 lbs/ac N is planned for application.

5. The amount of manure produced is greater than what can be utilized in the current year (just over half) on the planned fields. This would become a red flag if there were no available rented land or manure agreements.

6. A land base of 104 acres is required, based on the crop rotation, manure rate and frequency of application on the owned 44 acres. This would become a red flag if there were no available rented land or manure agreements.

7. P_2O_5 is applied at a rate higher than what the crop removes plus the allowed soil buildup. At this application rate, the soil phosphorus levels would rise quickly, resulting in increased environmental risk and higher separation distances.

8. Nitrogen Index is triggered for North field. The amount of N applied to harvested corn crop exceeded the recommended rate by over 15 lbs/ac, plus the amount of N supplied in the application of liquid hog manure in fall adds up to a potential loss that exceeds N Index limits for a hydrologic soil group C.