MANURE VALUE, COST AND TIME MANAGEMENT

TUTORIAL WORKBOOK

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Introduction

Manure is commonly used on dairy farms in New York and the Northeast as a readily-available, low-cost substitute for fertilizer. Application rates vary based on the size of the farm, the type of manure, the needs of the crops, and the environmental risk of application. This calculator provides analysis of current or proposed spreading plans and seeks to answer several questions:

1. What is the break-even hauling distance for my manure? If you spread manure but are concerned that the additional labor and machinery expense is greater than the value of the fertilizer you would otherwise buy, this calculator can help evaluate how far you can haul manure before it becomes unprofitable.
2. What are the operating and ownership costs for my manure spreading machinery? Based on parameters like fuel and labor cost, and machinery efficiency and expenses, a user can determine the net return (fertilizer replacement value less operating and/or ownership costs) for hauling and spreading manure, and evaluate the cost of hauling and spreading yourself, versus custom spreading.
3. What is the value (in terms of fertilizer replacement) and cost of exporting manure? Based on fertilizer costs and manure analysis, the user can determine the value of the manure and the cost of hauling and applying it to a particular location off the farm.
4. How much time (machinery and labor) will it take to spread manure? Based on the amount of equipment a farm owns, the number of loads spread and the efficiency of the machinery, the calculator allows the user to determine how many labor and machine hours are required to spread manure.

Using this Tutorial

In this tutorial we look at three example farm situations and run through the calculator using those values. The values in the tutorial are fabricated and should not be used as "defaults". The best values to use for making decisions on a farm business are based on data collected from that farm business. The first section of the tutorial represents a 90-cow, 250-acre dairy using a daily-spread manure system. The second scenario considers a 300-cow dairy with six months of manure storage and field application in the spring and fall with a tractor powered tank spreader. The third example represents a 1600-cow dairy with a manure storage and drag line application system. In this example five million gallons are applied direct from the storage and 10 million gallons are hauled to remote field frac tanks and applied from the frac tanks. To help with understanding the information, summary tables have been included in the Appendices. These tables are meant to be removed from this document and used while working through the scenarios.

Getting Started

The calculator can be found at (http://nmsp.cals.cornell.edu/projects/curriculum.html). Running the program requires Microsoft Excel (Microsoft Office 2003® or 2007®).

Action: Download the calculator first and then open it.

You should see a gray-backed screen, featuring several paragraphs explaining the calculator's purpose and basics of use. On the right-hand side of the screen are four buttons, each displaying

one of the four questions listed above. Above this, there is another button labeled "User's Manual". Click on a button to move directly to that sheet of the workbook; alternatively, you can navigate between sheets by clicking on the tabs at the bottom of the screen.

- If you open the calculator and do not see the introduction page, or have other errors, you may need to enable Macros on your computer. Some versions of Excel will display a pop-up message when you enter the program asking if you wish to enable Macros; select "Enable content". Other versions may not ask directly; in this case you may see a "Security Warning" banner at the top of the spreadsheet. Click on the button provided and select "Enable content" or "Enable Macros".

Information Requirements

Getting accurate calculations from this calculator will depend on entering accurate farm-specific data. To limit redundant data entries, the sheets are organized so that the same information is only entered once. While each different sheet of the workbook deals with a different question above, many values from one sheet are transferred to another. Using the sheets in the order that they appear on the opening screen will ensure that all of the required information is available.

Items Needed to Fill Out Sheets

Fertilizer Replacement Value

- Manure analysis (%, pounds of N, P_2O_5, and K_2O per gallon or per ton).
- Crop requirements (pounds per acre of N, P_2O_5, and K_2O).
- Value of fertilizer dollars per pound of N, P_2O_5, and K_2O).
- Field size (acres).
- Application rates (gallons per acre or tons per acre).
- Spreader capacity (gallons or tons).
- Operating costs: fuel price, hourly labor costs.
- Fuel efficiencies: average equipment speed (miles per hour for hauling; acres per hour for application and incorporation), fuel consumption (gallons per hour).

Whole Farm Manure Cost

- Total manure to spread for the entire year (gallons or tons).
- Total acres on which manure is spread and/or incorporated.
- Total hours required to haul, spread, and incorporate manure.
- Capital costs: purchase and salvage values of equipment, lifespan, age, repair costs, % of capital cost used by the business, equipment insurance cost, value of insured equipment.

Information taken from other sheets:

- Fuel efficiency (Fertilizer Replacement Value, Section (5).

Export

- Field size (acres).
- Application rate (gallons or tons per acre, same units as in Fertilizer Replacement Value).
- Distance from source (miles, one-way).

- Crop needs (pounds per acre of N, P_2O_5, and K_2O).

Information taken from other sheets:

- Manure analysis and density (Fertilizer Replacement Value, Section (1)).
- Fertilizer values and application cost (Fertilizer Replacement Value, Section (2)).
- Application units (Fertilizer Replacement Value, Section (4)).
- Spreader capacity (Fertilizer Replacement Value, Section (4)).
- Hauling speed (Fertilizer Replacement Value, Section (5)).
- Total gallons of manure to spread (Whole Farm Manure Costs).
- Total hours to spread manure (Whole Farm Manure Costs).
- Total per hour costs for spreading and incorporation (Whole Farm Manure Costs).
- Total equipment and machinery ownership costs (Whole Farm Manure Costs).

Time

- Total loads of manure hauled or spread.
- Time for each hauling trip (hours).
- Speed of spreaders (loads per hour).

Information for Further Understanding of Manure Nutrient Crediting

To better understand how to determine the nutrient value of manure (both in the field and in the office), read the following factsheets before proceeding in this tutorial:

- Agronomy Fact Sheet # 4: Nitrogen Credits from Manure (8/19/2005)
- Agronomy Fact Sheet # 18: Manure Spreader Calibrations (1/19/2007)
- Agronomy Fact Sheet # 38: Manure Sampling, Handling and Analysis (2/5/2008)
- Agronomy Fact Sheet # 53: Manure Cost, Value and Time Management Calculator (8/26/2010)

Tutorial 1: Daily Spread Dairy Farm

For the purpose of this initial example, we will look at the manure management of a dairy with about 170 cows (90 cows and 80 heifers) and 250 acres, spreading daily without incorporation.

Tutorial 1: Fertilizer Replacement Value

First, we look at the value of manure as a fertilizer replacement.

Open the calculator and click on the first question button, or select the "Fertilizer Replacement Value" tab at the bottom of the screen.

This sheet is where you set the basis for the rest of the calculations: the manure analysis, fertilizer prices, crop needs, and equipment use and efficiency. You will then enter (or calculate) the manure application rate to be used, which will be compared to crop needs. Final nutrient values applied and required will be calculated, along with the monetary value.

In this sheet as well as others, input cells are white in color, while non-editable cells (i.e. calculated values) are yellow or gray. Put the appropriate information in the cells where asked. Note that for some cells, namely "Animal Species", "Units" and "Method and Timing", you select the appropriate choice from a drop-down menu.

Move the cursor over the cell, and click on the downward-pointing arrow that appears on the right-hand side. Click on your choice and enter the following information:

Action 1: Section (1)

Manure nutrient content	
Animal species	cows
Units	lb/ton
Ammonium-N (lbs/ton)	4
Organic-N (lbs/ton)	6
P_2O_5 (lbs/ton)	5
K_2O (lbs/ton)	7
Total solids (%)	8
Density (lbs/gal)	8.3

Action 2: Section (2)

Fertilizer costs	
N ($/lb)	$0.50
P_2O_5 ($/lb)	$0.60
K_2O ($/lb)	$0.70
Application ($/acre)	$6.00

Action 3: Section (3)

Crop nutrient needs	
N (lbs/acre)	130
P_2O_5 (lbs/acre)	25
K_2O (lbs/acre)	20
Field size (acres)	150

Keep in mind that the calculator asks for nutrients in terms of P_2O_5 and K_2O. If the manure analysis lists nutrient contents in terms of P and K, be sure to convert the units as follows:

$P \rightarrow P_2O_5$: multiply by 2.29
$K \rightarrow K_2O$: multiply by 1.2

Notice that in Section (2), there is now a calculated value for the "cost to supply crop nutrient needs with fertilizer". This is calculated by totaling the costs of fertilizer to meet the needs of the field and the application fee. It should display $100/acre.

Action 4: Section (4): Enter the following:

Manure application	
Units	tons
Application rate (tons/acre)	10
Method and timing	Top-dressed or incorporated after 5 days
Spreader capacity (tons)	10

Now look at the Nutrient Balance Check chart. Both P_2O_5 and K_2O needs are adequately met by the manure because the "Supplied" value is greater than the "Required." However, this is not so for N, which shows a deficit of 109 lb/acre (Figure 1).

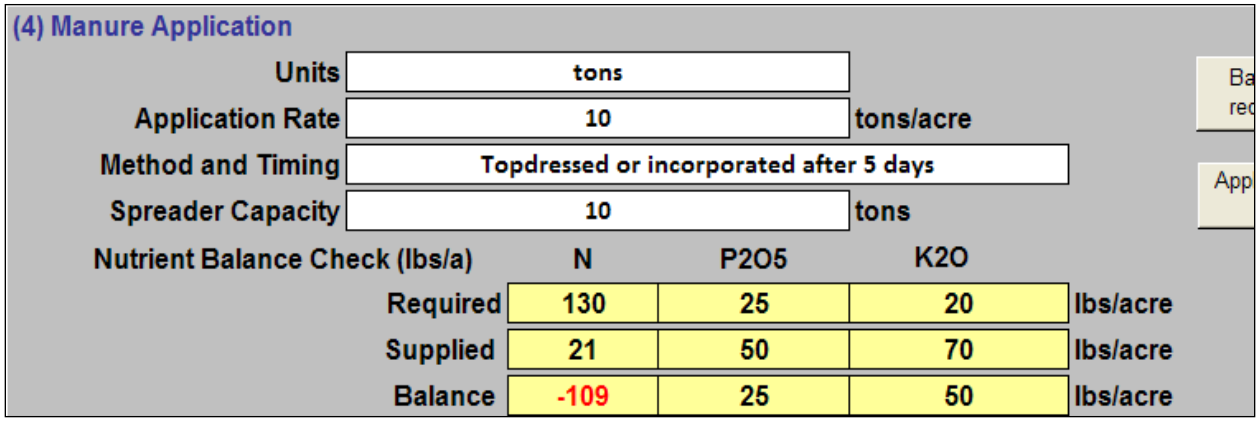

Figure 1: Section four in this tutorial shows a deficit for N while current year P_2O_5 and K_2O needs are exceeded by 25 lbs/acre for P_2O_5 and 50 lbs/acre for K_2O.

You can adjust the application rate manually or use the "Balance to N requirements" button on the right.

Action 5: Click on Balance to N requirement button to adjust the rate so that the N balance equals exactly zero. By doing so, you will notice the application rate required to meet the crop N needs is 62 tons/acre (Figure 2).

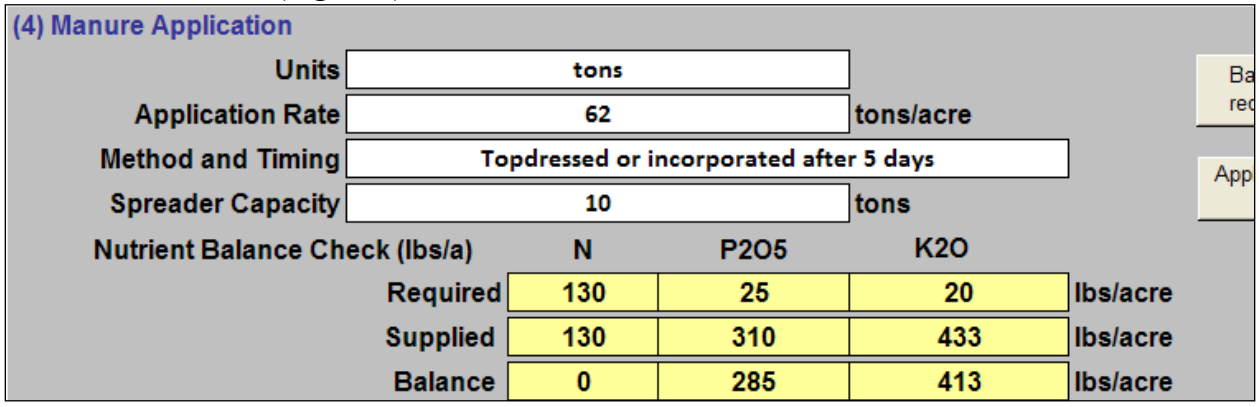

Figure 2: A surface application of 62 tons/acre will be needed to meet the crop's N needs in this example.

A 62 ton per acre application rate is exceptionally high and will result in over-application of P_2O_5 and K_2O. For example, the P_2O_5 balance of 285 is 3-4 times what an average corn silage crop can remove per year. A better solution might be to consider changing the application method. Spring or summer incorporation of manure allows for utilization of a greater fraction of the ammonium-N portion of manure. This is the fraction that would be lost to the air if manure is not incorporated. Try spring incorporating within one day and balancing to N requirements again. Note that the application rate in Figure 3 has decreased compared to the example above. The P_2O_5 and K_2O balances are now much lower, though still above the required levels. Incorporation directly after application is one way to reduce the over-application of phosphorus and potassium as it required lower rates to meet crop N needs. By lowering application rates, a farmer can reduce the risk of P and K buildup in soils far beyond crop needs, and in the case of P, reduce the risk of water quality problems caused by runoff and/or leaching losses to the environment.

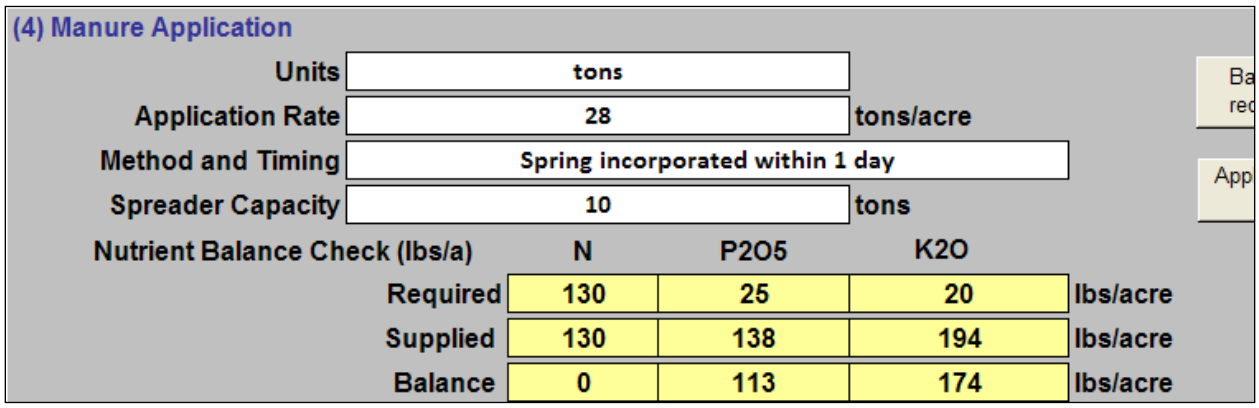

Figure 3: Incorporation of manure results in greater N credits.

Action 6: Change the application method to "Topdressed or incorporated after 5 days" and set the application rate at 25 tons/acre. The number of loads required to meet the field's nutrient needs with manure is displayed on the right-hand side. Our current method, topdressed or incorporated after 5 days, does not retain any of the ammonium-N. If you switch back to spring incorporation, 65% of the ammonium-N is conserved.

Action 7: Click on the "Application method – Ammonia Conservation Table" button next to see what is displayed in Figure 4. Click the "Return" button to go back to the Fertilizer Replacement Value Sheet.

Action 8: Click on the "Manure Nutrient Credits and Crop Nutrient Requirements" which brings you to the "Manure v Crop Chart" sheet of the workbook (Figure 5). This figure is also displayed on the screen beside the manure nutrient values (Figure 6).

Nutrients supplied by the manure are represented by solid bars, while the required nutrients are represented by striped bars. The nitrogen supplied is broken into current ammonium- and organic-N fractions, as well as future organic-N (i.e. the portion of the organic-N fraction that is not available this year but will be available the following two years). Click the "Return" button to go back to the Fertilizer Replacement Value sheet.

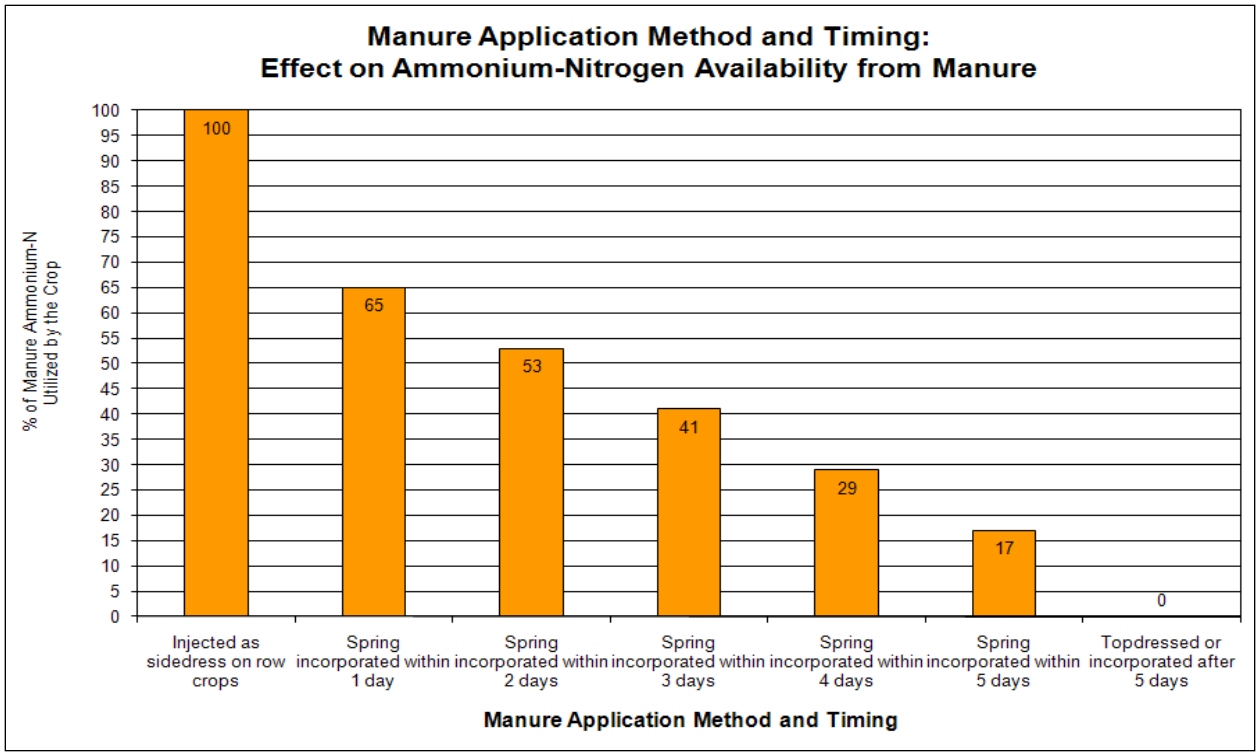

Figure 4: Manure application method and timing determined the amount of manure-N that could be available for crop uptake.

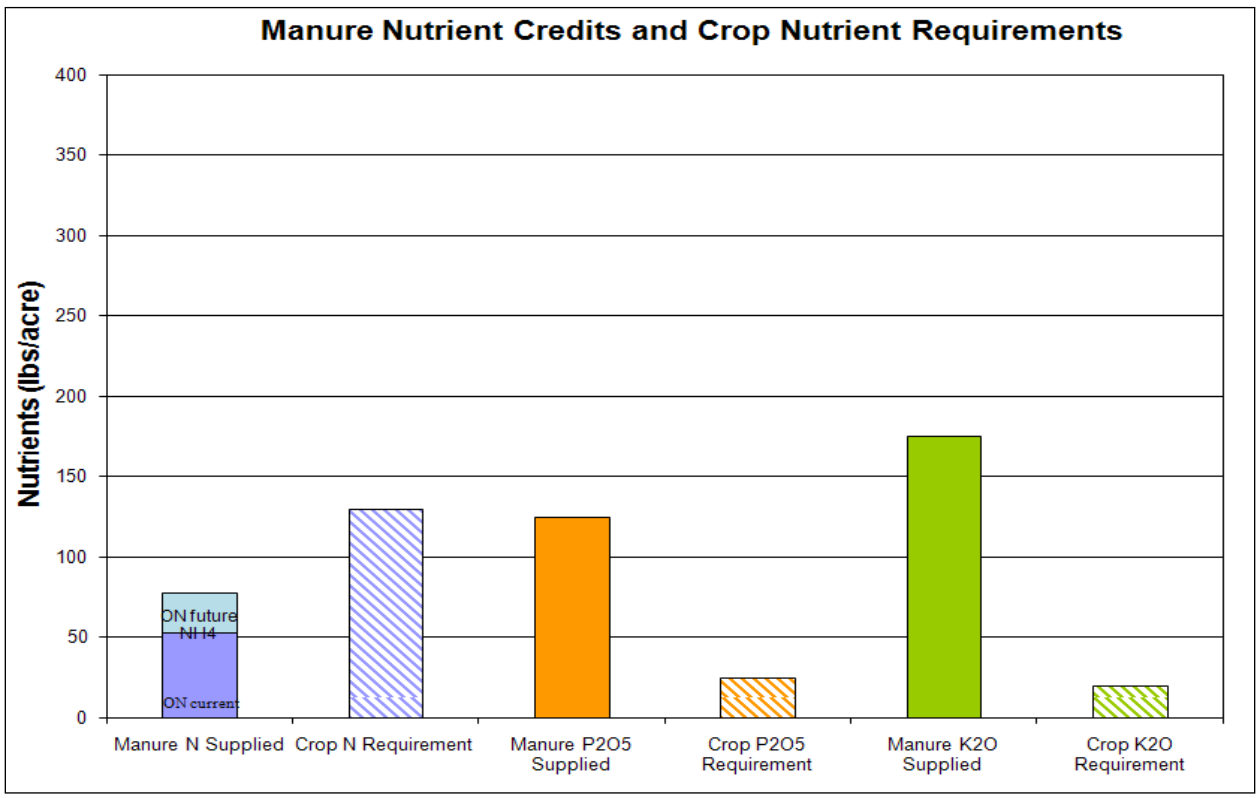

Figure 5: The nutrient credits from manure that was surface applied and not incorporated compared to crop nutrient needs in this tutorial example.

Change the application method back to "topdressed and incorporated after 5 days" again and hit the 'Balance to N" button so that the rate returns to 62 tons/acre.

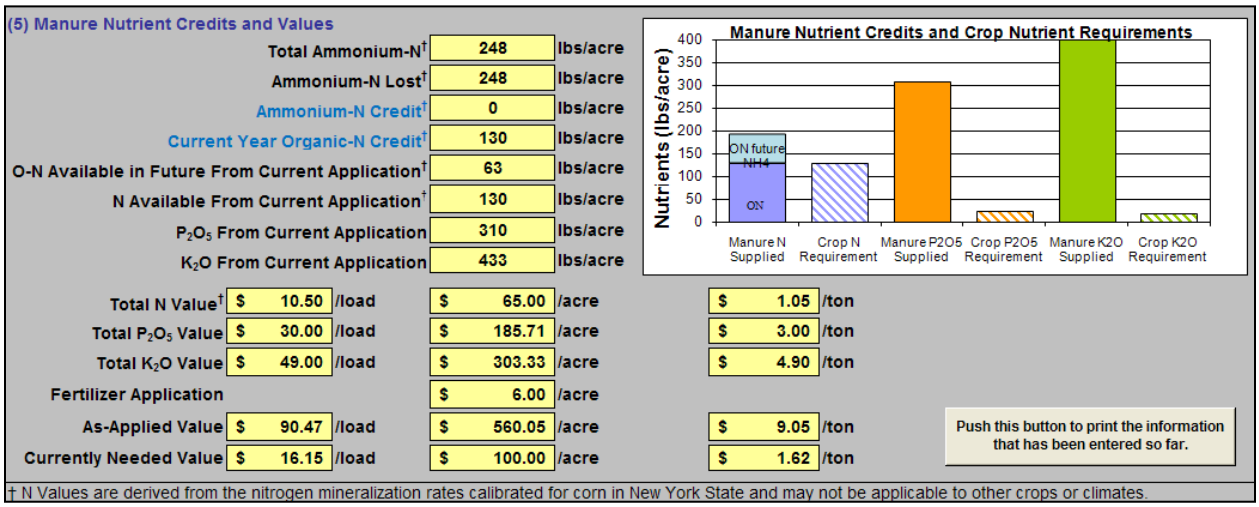

Figure 6: The calculator displays the nutrient different nutrient credits and values based on current fertilizer costs and nutrient content (As-Applied) and nutrient needs (Currently Needed).

Action 9: Section (6): Enter prices for fuel and labor as follows:

Operating costs and fuel efficiencies				
Loading	Fuel cost ($/gal)	0	Loading time (minutes/load)	30
	Labor cost ($/hour)	0	Fuel efficiency (gal/hour)	1
Hauling	Fuel cost ($/gal)	3	Speed (miles/hour)	10
	Labor cost ($/hour)	12	Fuel efficiency (gal/hour)	10
Application	Fuel cost ($/gal)	3	Speed (acres/hour)	5
	Labor cost ($/hour)	12	Fuel efficiency (gal/hour)	7
Incorporation	Fuel cost ($/gal)	0	Speed (acres/hour)	0
	Labor cost($/hour)	0	Fuel efficiency (gal/hour)	0

If you have on-farm information for the application and incorporation rates, that is the most accurate and best information to use for the above inputs. If not, the "Calculate Application and Incorporation Speed" button helps to estimate the field capacity (in acres per hour) that a given piece of machinery can cover.

Action 10: Click on the Calculate Application and Incorporation Speed button and enter the following where indicated:

Toolbar width (feet)	Speed (mph)	Field efficiency (percentage of theoretical field capacity)
13	5	63

The field efficiency varies by implement size and type, and general values are found below the input cells. The resultant field capacity should be 5.0 acres per hour. Enter this in the Application Speed cell on the original sheet, which you can get back to by clicking "Return."

That is the last of the input values for this worksheet. Section (7) is comprised entirely of calculated output values.

Most of the calculations are done two ways: "as-applied" and "as needed" (see Figure 7). "As applied" accounts for all nutrients put onto the field (subtracting ammonium-N lost to volatilization), while "as needed" only accounts for those nutrients that are applied and recommended for optimal crop growth in the current growing season. As we saw in this example, more pounds of P_2O_5 and K_2O are being applied than is necessary for the current year crop. These excess nutrients can be "banked in the soil" for future crop needs, in which case the 'as applied" value represents the true application value. If only the current year crop needs are considered, the "as needed" value should be used.

- Break-even distance is calculated on a one-way basis. The value of all the manure applied is calculated below, and then the economic (fuel, labor, efficiency) parameters are used to determine how far away a field can be before it is not profitable to haul manure there, based on the manure's N, P and K content.
- In our example, the break-even distance on an as-applied basis is 10.6 miles, while the break-even distance is only 1.8 miles if only current year nutrient needs are considered.

(7) Break-even distance	On 150 acre field, requiring 130-25-20 NPK, breakeven distance (miles one way) is					
Hauling Distance (miles)			10.6			1.8
Manure Value less Loading, Application and Incorporation Costs			as applied $ 83,010			as needed $ 14,003
Time Required (hours to spread manure)			2,471			828
Manure Value			as applied value ($/field)			as needed value ($/field)
		N	$ 9,750			$ 9,750
		P_2O_5	$ 27,857			$ 2,250
		K_2O	$ 45,500			$ 2,100
		Application	$ 900			$ 900
		Total	$ 84,007			$ 15,000
Manure Cost	**$/hour**		**$/acre**			**$/field**
Loading: Fuel	$ -					$ -
Labor	$ -					$ -
Loading Total	$ -					$ -
Hauling: Fuel	$ 30.00					
Labor	$ 12.00					
Hauling Total	$ 42.00					
Application: Fuel	$ 21.00		$ 4.23			$ 634.62
Labor	$ 12.00		$ 2.42			$ 362.64
Application Total	$ 33.00		$ 6.65			$ 997.25
Incorporation: Fuel	$ -		$ -			$ -
Labor	$ -		$ -			$ -
Incorporation Total	$ -		$ -			$ -
Total Operating	$ 75.00					$ 997.25

Figure 7: The breakeven distance for the example in this tutorial is 10.6 miles (one-way) if all nutrients are credited and 1.8 miles if only 130 lbs of N, 25 lbs of P_2O_5 and 20 lbs of K_2O are credited (current year crop needs).

Action 11: Click on the "How much time is required?" button. This button will estimate the amount of labor required for manure operations on this field. Based on the two break-even distances, the number of hours per field for all operations (loading, hauling, application, and incorporation) is calculated (Figure 8). Note that only the hauling values differ, as the same amount of manure is being applied in the same way each time. Click on the Return button after viewing this screen.

Hauling Distance (miles)	10.6 as applied		1.8 as needed	
Number of loads	929	Operational Cost	929	Operational Cost
	Hours per field		Hours per field	
Loading	465	$ -	465	$ -
Hauling	1976	$ 83,009.89	333	$ 14,002.75
Application	30	$ 997.25	30	$ 997.25
Incorporation				
Total (hours)	2471	$ 84,007.14	828	$ 15,000.00

Figure 8: Time required for manure allocation for the break-even distances of 10.6 miles (manure is valued as applied) versus 1.8 miles (manure is valued as currently needed only).

Action 12: Click on the "Return" button on the top of the current sheet to return to the main menu.

Tutorial 1: Whole Farm Manure Cost

Next, we will examine the second question "What are the operating and ownership costs for my machinery?"

Action 13: On the main page, click on the second question box on the list ("What are the operating and ownership costs for my machinery?").

This page allows you to estimate the ownership and operating costs (such as depreciation, equipment, fuel, and repairs) associated with manure hauling and handling.

When entering information for incorporation, only enter values if incorporation happens separately from application. Otherwise, include the time and acreage in the manure spreading section. In our first example, the farm does not incorporate manure.

Action 14: Enter the following information:

Units	tons
Total manure (tons)	3717
Manured acres (acres)	250
Spread hours (hours)	100
Incorporated acres (acres)	0
Incorporation hours (hours)	0

Hauling hours (hours)	225

There are a number of calculated values derived from this information and information on the Fertilizer Replacement Value sheet completed earlier. For instance, the Whole Farm Cost sheet fuel cost per hour is the fuel cost (from the Fertilizer Replacement Value sheet) times the fuel efficiency on the Whole Farm Cost sheet. Clicking "Print Sheet" will allow you to print the entire page; you may want to switch the orientation to landscape.

Action 15: Under the Capital Costs section (Section 5), enter information about all the manure handling equipment you use (including tractors).

Equipment name	Percent of time for manure handling	Purchase cost ($)	Salvage value ($)	Lifespan (yrs)	Age (yrs)	Yearly repairs and maintenance ($)
Manure spreader	100	35000	5000	10	4	2500
Tractor	45	65000	10000	12	2	1000

If you need more space to enter information, either scroll down or click the button labeled "Add more equipment", you will be taken to another identical chart further down the sheet.

If your equipment is insured, include that information in the next small section. Also include the cost of capital as a % of the value of the capital above. The cost of capital is the expected rate of return of a similar investment (i.e. approximately the same $ value as the equipment) in a different area – for instance, if you would have invested the equipment money in a bank account instead of equipment. For purposes such as this, the cost of capital should be about the % interest paid on equipment loans.

Action16: For this tutorial, enter the following equipment information:

Cost of capital (%)	6
Equipment insurance cost per $1000 ($)	6
Manure equipment amount insured ($)	75,000

You now have added all the inputs. The calculations are summarized on the large white chart below this last input section (see Figure 9). Output values are calculated three ways: the expense for the entire farm, per acre that received manure, and per ton (or gallon) of manure. The per-manured-acre value is simply the whole farm expense divided by the number of acres; the per-ton-cost (or per-gallon-cost) is the whole farm expense divided by the tons or gallons spread.

In our example, the whole farm accrues $6,750 in fuel expenses for manure hauling, an additional $2,700 for hauling labor, $2,100 for spreading fuel, and $1,200 for spreading labor. There are no additional incorporation costs as in this tutorial scenario the farm does not incorporate the manure. All in all, this farm spends $94.12 per acre on manure handling given the acreages, total manure quantity and equipment combinations listed. This includes $62.80 in operating costs and $31.32 in ownership costs.

- The whole farm data can be changed to represent different manure spreading equipment complements and changes in total time to spread. These different scenarios can be printed and compared to each other and compared to estimates for custom application.

- The values generated by this analysis can also be compared to the cost of fertilizer and application to evaluate the economic feasibility of utilizing manure instead of fertilizer.

Farm Manure Application Costs for 250 acres at average farm application rate						
	Whole Farm		Farm application average $/a spread		Cost per ton	
Loading (0 machinery hours)						
Fuel	$	-	$	-	$	-
Labor	$	-	$	-	$	-
Hauling (225 machinery hours)						
Fuel	$	6,750	$	27.00	$	1.816
Labor	$	2,700	$	10.80	$	0.726
Spreading (250 acres)						
Fuel	$	2,100	$	8.40	$	0.565
Labor	$	1,200	$	4.80	$	0.323
Incorporation (0 acres incorporated)						
Fuel	$	-	$	-	$	-
Labor	$	-	$	-	$	-
Manure Equipment Repairs and Maintenance	$	2,950	$	11.80	$	0.794
Total Operating Costs	$	15,700	$	62.80	$	4.224
Ownership Costs						
Depreciation	$	5,063	$	20.25	$	1.362
Interest on Equity	$	2,318	$	9.27	$	0.623
Insurance	$	450	$	1.80	$	0.121
Total Ownership Costs	$	7,830	$	31.32	$	2.107
Total Operating and Ownership Costs	$	23,530	$	94.12	$	6.330

Figure 9: Farm manure application costs for 250 acres at the average farm application rate assumed in this tutorial example.

Tutorial 1: Export

In this section we will look at similar values – fertilizer replacement value and handling costs – but for manure hauled and spread off-farm. This will allow you to determine how much you might want to charge another farmer for the manure and the service, or evaluate the cost of exporting manure. Go to the "Export" sheet, either by clicking on the tab on the bottom of the sheet, or by returning to the Main Menu and clicking the third question down, "What is the value (in terms of fertilizer replacement) and cost of exporting manure?"

This sheet allows you to input the manure application rates and acreages of off-farm locations where you spread manure. It will tell you the costs associated with the hauling, spreading, and incorporation, and the return to the operator. The first inputs deal with the fields you spread on.

Action 17: Enter the distance of the field from the manure source and the application rate used:

Application rate (tons/acre)	12
Distance one way from source (miles)	5

- Note that the rate is in the same units (gallons or tons per acre) that you used on the Fertilizer Replacement Value sheet. Based on this information, the calculator determines the "as applied nutrients" and value thereof, based on the prices from the Fertilizer Replacement Value sheet.

Action 18: Also enter in the crop nutrient needs, if known; this will calculate the "as needed" values. For both as needed and as applied, the per-acre-values are calculated using the application rate, not the field size.

Crop needs	N (lbs/acre)	125
	P_2O_5 (lbs/acre)	50
	K_2O (lbs/acre)	50

The rest of the sheet is output values. Section (3) totals the expenses of hauling, application, and incorporation. Note that, right now, the incorporation value is $0 – the spreadsheet is using information from the Whole Farm Manure Cost sheet to estimate the expenses. If your off-farm application and incorporation will differ from your on-farm work (for instance, if you apply and incorporate, or apply and incorporate separately), you will need to adjust some values on the Fertilizer Replacement Value and Whole Farm Cost sheets.

Action 19: Return to the Fertilizer Replacement Value sheet and enter labor and fuel efficiencies for incorporation:

Fuel costs ($/gallon)	$3.00
Labor costs ($/hour)	$12.00
Speed (acres/hour)	7
Fuel efficiency (gallons/hour)	10

Action 20: Enter "Fall incorporation" as the manure application method.

Action 21: Return to the Whole Farm Manure Cost page and enter the following values:

Manure spreading	Total manured acres (acres)	250
	Total hours to spread (hours)	100
Manure incorporation	Total incorporated acres (acres)	12
	Total machinery hours (hours)	2.4

Action 22: Add the investment values for a toolbar and chisel:

Equipment name	Percent of time for manure handling (%)	Purchase cost ($)	Salvage value ($)	Lifespan (yrs)	Age (yrs)	Yearly repairs and maintenance ($)
Manure spreader	100	35,000	5,000	10	4	2,500
Tractor	45	65,000	10,000	12	2	1,000
Tool bar and chisel	50	8,000	1,000	20	10	500

Action 23: Return to the Export page and notice you can see that there are values for incorporation as well as hauling and application.

Section (2) (Figure 10) calculates the fertilizer replacement values of the manure nutrients applied. The "As Applied" value of the nutrients, which includes future value from excess nutrients and future mineralization of organic-N, can be looked at or the "As Needed" value, which only includes the nutrient value of nutrients needed by the current crop, can be used.

(2) Value of manure to the field receiving manure (fertilizer replacement value)									
	Applied lbs/acre	As Applied Value $/ton		$/acre		Crop Needs lbs/acre	As Needed Value $/ton		$ /acre
N	37	$	1.56	$	18.72	N 125	$	1.56	$ 18.72
P_2O_5	60	$	3.00	$	36.00	P_2O_5 50	$	2.50	$ 30.00
K_2O	84	$	4.90	$	58.80	K_2O 50	$	2.92	$ 35.00
Fert. Application		$	0.50	$	6.00	Fert. Application	$	0.50	$ 6.00
Total		$	9.96	$	119.52	Total	$	7.48	$ 89.72

Figure 10: Fertilizer replacement value of manure for the example field in the tutorial exercise when valued for current and future year N, P_2O_5 and K_2O ("as applied") and only current year crop needs ("as needed").

Section (3) (Figure 11) returns the cost of the application of the manure nutrients listed in section (2). Manure application costs are broken down into operational costs associated with the specific manure application (depends on rate and distance from source) and ownership costs associated with the manure spreading equipment. These two values may also be used as negotiating points during manure export decisions. This means that in this example a total payment of $143.81 per acre would both cover your direct costs of applying manure on the export field and would also reimburse you for future replacement of the machinery used for manure applications to this field.

(3) Cost of transporting and spreading manure to the receiving field (operating and ownership costs)						
Operating Costs	Machine hours/load		$/load		$/ton	$ /acre
Loading	0.50	$	-	$	-	$ -
Hauling	1.00	$	42.00	$	4.20	$ 50.40
Application	0.17	$	5.50	$	0.55	$ 6.60
Incorporation	0.12	$	5.00	$	0.50	$ 6.00
Total Operating Costs		$	52.50	$	5.25	$ 63.00
Ownership Costs*		$	64.92	$	6.49	$ 77.91
Operating + Ownership Costs		$	117.42	$	11.74	$ 140.91

Figure 11: On the example farm, the direct (operating) cost (total of fuel, labor and repairs) associated with exporting manure to the defined field is $63.00 per acre; the overhead (ownership) cost (total of depreciation, interest, and insurance) is $77.91.

Section (4) (Figure 12) displays the net (value – cost) of exported manure when valued as "as applied" and "as needed". In this case, when all available N, P and K are valued, the value of the manure nutrients as a replacement for fertilizer are $4.71 per ton more than the operating costs (fuel and labor). However, when capital costs associated with the equipment investment are considered, the costs are $1.78 more than the value of the displaced fertilizer.

(4) Net Income or Cost of Manure Export							
	Net (value-cost) As Applied				Net (value-cost) As Needed		
	$/ton		$/acre		$/ton		$ /acre
Return to Operating Costs	$ 4.71		$ 56.52	Return to Operating Costs	$ 2.23		$ 26.72
Return to Ownership & Operating Costs	$ (1.78)		$ (21.39)	Return to Ownership & Operating Costs	$ (4.27)		$ (51.19)

Figure 12: The net income or cost of manure export is calculated as the difference between fertilizer replacement value (as applied and as needed) and the operating only and total operating and ownership cost.

Tutorial 1: Time

This sheet converts per-trip time information into required machine and man hours for entire hauling and application workdays. From here, given the hourly rate you pay or are paid, you can determine the labor value. This sheet can also be used to calculate the time required to complete manure application work for use in planning.

In this daily-spread example, one person loads, hauls and applies the manure. The manager breaks fields receiving manure into 3 "blocks": 100 loads that require ½ hour to load, haul and apply and return to the barn (roundtrip), 100 loads that require ¾ hour roundtrip and 200 loads that will take 1 hour roundtrip (Figure 13). Since there is one person per machine and one machine used at a time, the machine, labor and clock hours are all the same in this example. In the totals row at the bottom of the chart, you can see the total number of loads hauled and spread (400), the hours logged on all machines and the labor hours. In this example, because all of the work is done consecutively, both the total clock hours and the total labor hours required to load, haul and apply manure are the same, 500 hours.

Action 24: Enter values into the Time Sheet to reflect this scenario.

Number of Loads	Hauling Equipment Number	Loading & Hauling round trip time (hours)	Application Equipment Number	Application speed loads/hr	Hauling machinery hours	Spreading machinery hours	Hauling clock hours	Application clock hours	Total clock hours	Total Labor hours
100	1	0.5			50	0	50	0	50	50
200	1	0.75			150	0	150	0	150	150
300	1	1			300	0	300	0	300	300
					0	0	0	0	0	0
					0	0	0	0	0	0
					0	0	0	0	0	0
					0	0	0	0	0	0
					0	0	0	0	0	0
					0	0	0	0	0	0
					0	0	0	0	0	0
600				TOTAL	500	0	500	0	500	500

Figure 13: The time management worksheet allows you to experiment with different numbers of operators and equipment to estimate the total time required to perform manure applications and to identify work-flow bottlenecks.

Take some time to answer the review the information you have entered into the Manure Value and Cost Calculator and answer the question in Appendix 1 of this document.

Tutorial 2: Dairy Farm with 6-month Liquid Manure Storage

In the next few sections of the tutorial, we will look at other methods of manure management and handling. First we will consider a larger farm, about 300 cows, that spreads a total of 2 million gallons of manure twice a year on 300 acres of land.

To help summarize the results of the different analyses completed in this tutorial a summary table is provided in Appendix 2 of this document for recording information.

Tutorial 2: Fertilizer Replacement Value

Enter manure nutrient composition values, fertilizer costs and crop nutrient needs in sections 1 – 3 of the Fertilizer Replacement Value Sheet:

Action 1: Section (1)

Manure nutrient content	
Animal species	cows
Units	lb/1000 gal
Ammonium-N (lbs/gal)	19
Organic-N (lbs/gal)	28.5
P_2O_5 (lbs/gal)	23.75
K_2O (lbs/gal)	33.25
Total solids (%)	8
Density (lbs/gal)	8.3

Action 2: Section (2)

Fertilizer costs	
N ($/lb)	$0.50
P_2O_5 ($/lb)	$0.60
K_2O ($/lb)	$0.70
Application ($/acre	$6.00

Action 3: Section (3)

Crop nutrient needs	
N (lbs/acre)	130
P_2O_5 (lbs/acre)	25
K_2O (lbs/acre)	20
Field size (acres)	150

Action 4: In Section (4), set the units to gallons and the application method to "topdressed or incorporated after 5 days", and the spreader capacity as 7300 gallons. Click on the "Balance for N" button. What is the application rate? What do you notice about the P_2O_5 and K_2O balances? Check the nutrient balances out graphically.

- Record the application rate on the summary sheet.
- Record the P_2O_5 balance and the K_2O balance on the summary sheet
- Record the number of loads and gallons spread.

Section (4)

Manure application	
Units	Gallons
Method and timing	Top-dressed or incorporated after 5 days
Spreader capacity (gallons)	7300

The operating costs and fuel efficiencies in Section (5) will change from the daily spread scenario looked at previously because of the different equipment being used.

Action 5: Enter new operating costs and fuel efficiencies in Section (5):

Operating Costs and Fuel Efficiencies				
Loading	Fuel cost ($/gal)	3	Loading time (minutes/load)	10
	Labor cost ($/hour)	12	Fuel efficiency (gal/hour)	7
Hauling	Fuel cost ($/gal)	3	Speed (miles/hour)	10
	Labor cost ($/hour)	12	Fuel efficiency (gal/hour)	10
Application	Fuel cost ($/gal)	3	Speed (acres/hour)	3
	Labor cost ($/hour)	12	Fuel efficiency (gal/hour)	7
Incorporation	Fuel cost ($/gal)	0	Speed (acres/hour)	0
	Labor cost ($/hour)	0	Fuel efficiency (gal/hour)	0

Scroll down to the section six and enter the following pieces of information into the summary table.

- Manure value (minus loading, spreading and incorporation)
- Break-even miles
- Operating costs for loading, spreading and incorporation)

Switch to the time sheet by clicking on the "How much time does it take?" button. Enter into the summary table;

- Hauling costs at the break-even hauling distance.
- Hauling hours needed at the break-even hauling distance.

Now let's assume that the farm uses a chisel plow to incorporate the manure spread on 150 acres in the spring.

Action 6: Change the method and timing in Section (4) to "Spring incorporated within 1 day," but keep the application rate the same. Notice that the N supplied has greatly increased over requirements – this is because the ammonium-N is not volatilizing as ammonia, but is remaining in the soil for crops to use. The Manure Nutrient Credits and Crop Requirements chart depicts this.

Click on the Balance to N requirements button.

- Record the application rate on the summary sheet.
- Record the P_2O_5 balance and the K_2O balance on the summary sheet
- Record the number of loads and gallons spread.

Action 7: Update Fertilizer Replacement Value, section (5). Set the incorporation fuel to $3.00 per gallon and the labor costs to $12.00 per hour. Enter incorporation speed at 6 acres/hour and fuel efficiency at 5 gallons/hour. Record the following pieces of information

Scroll down to the section six and enter the following pieces of information into the summary table.

- Manure value (minus loading, spreading and incorporation)
- Break-even miles
- Operating costs for loading, spreading and incorporation)

Switch to the time sheet by clicking on the "How much time does it take?" button. Enter into the summary table;

- Hauling costs at the break-even hauling distance.
- Hauling hours needed at the break-even hauling distance. **SAVE Your Data!!!**
- Take some time and answer the questions listed below Table 2 in Appendix 2.

Tutorial 2: Whole Farm Manure Cost

Switch to the Whole Farm Manure Costs sheet…..

Action 8: Enter the following data into sections 1-4 of the Whole Farm Manure Costs sheet:

Units	gallons
Total manure (gallons)	4,000,000
Manured acres (acres)	493
Spread hours (hours)	164
Incorporated acres (acres)	343
Incorporation hours (hours)	57
Hauling hours (hours)	937

Action 9: Enter the necessary machinery complement in Section (5):

Equipment name	Percent of time for manure handling (%)	Purchase cost ($)	Salvage value ($)	Lifespan (yrs)	Age (yrs)	Yearly repairs/ maintenance ($)
Tank/spreader	100	75,000	5,000	10	4	2,500
Tractor	50	95,000	10,000	12	2	1,000
Agitator pump /hardware	100	13,000	1,500	6	2	1,200
Agitator power	100	62,000	5,000	15	14	500
Tractor (incorporation)	25	85,000	14,000	15	5	1000
Chisel plow	50	8000	1000	20	8	100

Because so much more equipment is required for this operation over the daily spread operation depicted in Tutorial 1 increase the insured equipment amount to $200,000.

Scroll down the worksheet and review the results of the Whole Farm Costs in the Results Table.

- Record results in the Tutorial 2 Whole Farm Costs summary table (Table 3) which can be found in the Appendix 2 of this document.

Action10: Change the scenario to represent a farm that had just invested in a number of new pieces of equipment for their manure management system as listed below. Record the results of this scenario in the Whole Farm Costs summary table (Appendix 2, Table 3).

Equipment name	Age (yrs)
Tank/spreader	1
Tractor	1

Agitator pump /hardware	2
Agitator power	1
Tractor (incorporation)	5
Chisel plow	8

- Record results in the Tutorial 2 Whole Farm Costs summary table (Table 3) which can be found in the Appendix 2 of this document.

Action11: Leave the new equipment ages in the spreadsheet and change the scenario to represent a farm that has more land available for manure.

Units	gallons
Total manure (gallons)	4,000,000
Manured acres (acres)	550
Spread hours (hours)	150
Incorporated acres (acres)	400
Incorporation hours (hours)	67
Hauling hours (hours)	945

- Record results in the Tutorial 2 Whole Farm Costs summary table (Table 3) which can be found in the Appendix 2 of this document.

- Change the whole farm information back to the original operational and ownership characteristics (listed under Action 8 and 9) .

Action 12: In a third scenario imagine the farm is incorporating in the spring on 200 acres and so although their farm average application rate is calculated as 10,000 gallons per acre they are actually applying 6,000 (listed as 5,823 in the calculator) gallons per acre on 200 acres and 13,000 gallons per acre on 200 acres in the fall. The spring application rate meets their crop N needs and their nutrient management plan. How much manure will they have left over?

- Enter your value in space provided on the summary worksheet.

Action 13: If the leftover manure is applied at a rate of 12,000 gallons per acre how many acres are needed?

- Enter your value in the space provided on the summary worksheet.

Tutorial 2: Export

So the farm has manure to export and a neighbor farm has 70 acres that needs nutrients. The neighbor farm application will be surface applied at 12,000 gallons per acre.

Action 14: Because the export field manure will be surface applied without immediate incorporation go to the Fertilizer Replacement Value screen and select "Topdressed or incorporated after 5 days" as the Method and Timing in Section (4) and also zero out the cost values associated with manure incorporation in section (5). To accurately reflect the costs associated with exporting manure, we must consider the farm on an annualized basis. Therefore

we will combine the whole farm costs with the export manure acres and charges must be added to the whole farm cost sheet so that the fixed costs will be allocated over both the home farm fields and the export fields.

Action 15: Enter this information into sections 1-4 of the Whole Farm Manure Costs sheet:

Units	gallons
Total manure (gallons)	4,000,000
Manured acres (acres)	470
Spread hours (hours)	170
Incorporated acres (acres)	0
Incorporation hours (hours)	0
Hauling hours (hours)	945
Equipment = tractor for incorporation	0% of time used for manure handling
Equipment = chisel plow	0% of time used for manure handling

Because the exported manure will not be incorporated, and we are only considering costs associated with the export field, we have changed Incorporation acres and hours to zero. This will change the operating expenses associated with incorporation to zero.

Action 16: Return to the Export sheet.

- Enter the following scenario:

Rate	Miles from farm
12,000 gallons/acre	1.0
Crop Needs	
N	160
P_2O_5	50
K_2O	50

Section (2) (Figure 14) calculates the fertilizer replacement values of the export manure nutrients applied. The "As Applied" value of the nutrients, which includes future value from excess nutrients and future mineralization of organic-N, can be looked at or the "As Needed" value, which only includes the nutrient value of nutrients needed by the current crop, can be used.

(2) Value of manure to the field receiving manure (fertilizer replacement value)										
	Applied	As Applied Value				Crop Needs	As Needed Value			
	lbs/acre	$/gallon		$/acre		lbs/acre	$/gallon		$ /acre	
N	120	$	0.00	$	59.85	N	160	$	0.00	$ 59.85
P_2O_5	285	$	0.01	$	171.00	P_2O_5	50	$	0.00	$ 30.00
K_2O	399	$	0.02	$	279.30	K_2O	50	$	0.00	$ 35.00
Fert. Application		$	0.00	$	6.00	Fert. Application		$	0.00	$ 6.00
Total		$	0.04	$	516.15	Total		$	0.01	$ 130.85

Figure 14: Fertilizer replacement value of manure for the example field in the tutorial exercise when valued for current and future year N, P_2O_5 and K_2O ("as applied") and only current year crop needs ("as needed").

Section (3) (Figure 15) returns the cost of the application of the manure nutrients listed in section (2). Manure application costs are broken down into operational costs associated with the specific manure application (depends on rate and distance from source) and ownership costs associated with the manure spreading equipment. These two values may also be used as negotiating points during manure export decisions.

(3) Cost of transporting and spreading manure to the receiving field (operating and ownership costs)						
Operating Costs	Machine hours/load		$/load		$/gallon	$ /acre
Loading	0.17	$	5.50	$	0.00	$ 9.04
Hauling	0.20	$	8.40	$	0.00	$ 13.81
Application	0.20	$	6.69	$	0.00	$ 11.00
Incorporation	0.10	$	-	$	-	$ -
Total Operating Costs		$	20.59	$	0.00	$ 33.85
Ownership Costs*		$	138.34	$	0.02	$ 227.42
Operating + Ownership Costs		$	158.94	$	0.02	$ 261.26

Figure 15: On the example farm, the direct (operating) cost (total of fuel, labor and repairs) associated with exporting manure to the defined field is $ 33.85 per acre; the overhead (ownership) cost (total of depreciation, interest, and insurance) is $ 261.26

Section (4) (Figure 16) displays the net (value – cost) of exported manure when values "as applied" and "as needed". In this case, when all available nutrients are valued, the value of the manure nutrients as a replacement for fertilizer and the saved fertilizer application cost are $482.30 per acre more than the operating costs (fuel and labor) used to load, haul, apply and incorporate the manure. However, when capital costs associated with the equipment investment are considered, the net value is $254.89 per acre. When only the nutrients needed in the current year are valued (perhaps a more realistic scenario), the fertilizer replacement value is $97.00 more the operational costs of spreading the manure. The total (operational + ownership) costs are $130.41 more than the fertilizer value.

(4) Net Income or Cost of Manure Export							
	Net (value-cost) As Applied				Net (value-cost) As Needed		
	$/gallon		$/acre		$/gallon		$ /acre
Return to Operating Costs	$ 0.04	$	482.30	Return to Operating Costs	$ 0.01	$	97.00
Return to Ownership & Operating Costs	$ 0.02	$	254.89	Return to Ownership & Operating Costs	$ (0.01)	$	(130.41)

Figure 16: The net income or cost of manure export is the difference between fertilizer replacement value (as applied and as needed) and operating only and total operating and ownership cost.

- Change the scenario to reflect 1.0, 2.5 and 4.0 miles from the manure source and copy the resulting values and costs to Appendix 2, Summary Table 4.

Tutorial 2: Time

The time sheet can be used to represent different scenarios to identify potential bottlenecks.

Action 17: Enter in the following scheme for spring spreading on 150 acres into the Time sheet:

Number of loads	Hauling equipment number	Loading and hauling round trip time (hours)	Application equipment number	Application speed (loads/hour)
40	1	0.25	0	0
40	1	0.50	0	0
40	1	0.75	0	0

Notice that the total number of loads is equal to 120 and that the total machinery hours amount to 60 hours. **SAVE Your Data!!!**

Tutorial 3: Dairy farm spreading from a lagoon with draghoses and frac tanks

The third and final farm we will consider is a large (1600-cow) dairy with 1500 acres on which to spread their 15.2 million gallons of manure. In the first situation, manure is pumped directly to nearby fields, where the manure is applied and incorporated simultaneously. In the second situation, two tankers haul manure to remote field frac tanks, where drag hose application and incorporation follows.

Tutorial 3: Draghose from Lagoon: Fertilizer Replacement Value

Enter manure nutrient composition values, fertilizer costs and crop nutrient needs in sections 1 – 3 of the Fertilizer Replacement Value Sheet:

Action 1: Section (1)

Manure nutrient content	
Animal species	cows
Units	lb/1000 gal
Ammonium-N (lbs/gal)	19
Organic-N (lbs/gal)	28.5
P_2O_5 (lbs/gal)	23.75
K_2O (lbs/gal)	33.25
Total solids (%)	8
Density (lbs/gal)	8.3

Action 2: Section (2)

Fertilizer costs	
N ($/lb)	$0.50
P_2O_5 ($/lb)	$0.60
K_2O ($/lb)	$0.70
Application ($/acre	$6.00

Action 3: Section (3)

Crop nutrient needs	
N (lbs/acre)	130
P_2O_5 (lbs/acre)	0
K_2O (lbs/acre)	0
Field size (acres)	500

Action 4: In Section (4), set the units to gallons and the application method to "fall incorporated or injected" at 10,000 gallons/acre.

Manure application	
Units	Gallons
Application rate (gallons)	10,000
Method and timing	Fall incorporated or injected
Spreader capacity (gallons)	9000

Action 5: Enter new operating costs and fuel efficiencies in Section (5):

Operating costs and fuel efficiencies				
Loading	Fuel cost ($/gal)	3	Loading time (minutes/load)	10
	Labor cost ($/hour)	12	Fuel efficiency (gal/hour)	6
Hauling	Fuel cost ($/gal)	0	Speed (miles/hour)	0
	Labor cost ($/hour)	0	Fuel efficiency (gal/hour)	0
Application	Fuel cost ($/gal)	3	Speed (acres/hour)	6.6
	Labor cost ($/hour)	12	Fuel efficiency (gal/hour)	7
Incorporation	Fuel cost ($/gal)	0	Speed (acres/hour)	0
	Labor cost ($/hour)	0	Fuel efficiency (gal/hour)	0

Because there is no hauling requirement, set hauling costs in Section (5) to zero; because incorporation is done simultaneous with application, the incorporation costs are also zero. The

application speed is 6.6 acres/hour, at 7 gallons/hour fuel efficiency. Loading time and costs reflect the cost of the labor and fuel required to setup and pump from the lagoon. Because there is no hauling done, no break-even distance is calculated.

- Use Table 1 in Appendix: Tutorial 3 Summary Worksheet to record the results.
- Use the "How much time is required?" button to view and record the hours required for spreading and loading and the operational costs to the farm for these activities.

Tutorial 3: Transport to Frac Tanks: Fertilizer Replacement Value

The remaining 10 million gallons are transported by 9000-gal tankers to frac tanks at distant fields, where the manure is again spread with incorporation on 1,000 acres. The two tankers are hired at $75/hour with gas included. On these 1,000 acres the nutrient needs are 130 lbs of N, 25 lbs of P_2O_5 and 20 lbs of K_2O per acre.

Section (3)

Crop nutrient needs	
N (lbs/acre)	130
P_2O_5 (lbs/acre)	25
K_2O (lbs/acre)	20
Field size (acres)	1000

Section (5):

Operating Costs and Fuel Efficiencies				
Loading	Fuel cost ($/gal)	3	Loading time (minutes/load)	20
	Labor cost ($/hour)	12	Fuel efficiency (gal/hour)	6
Hauling	Fuel cost ($/gal)	0	Speed (miles/hour)	15
	Labor cost ($/hour)	75	Fuel efficiency (gal/hour)	5
Application	Fuel cost ($/gal)	3	Speed (acres/hour)	6.6
	Labor cost ($/hour)	12	Fuel efficiency (gal/hour)	7
Incorporation	Fuel cost ($/gal)	0	Speed (acres/hour)	0
	Labor cost ($/hour)	0	Fuel efficiency (gal/hour)	0

The breakeven distance for this setup is 37.3 miles for as-applied, and 6.2 miles as-needed.

- Use Table 1 in Appendix 3 to record the results.
- Use the "How much time is required?" button to view and record the hours required for spreading and loading and the operational costs to the farm for these activities.

Tutorial 3: Whole Farm Manure Cost

Go to the Whole Farm Costs sheet.

Action 7: Enter the quantity of manure to be handled across the whole farm (1.3 million gallons). Adjust the hauling and spreading acres and hours to reflect fall application into sections 1-4 of the Whole Farm Manure Costs sheet:

Units	gallons
Total manure (gallons)	15,000,000
Total manured acres (acres)	1500
Spread hours (hours)	Determine by adding together the hours spent spreading in Scenario 1 and 2 (Table 1, Appendix: Tutorial 3 Summary Worksheet).
Hauling hours (hours)	

Because we are considering the whole farm – go back to the Fertilizer replacement screen and enter in a whole farm average loading time as 16.68 minutes per load (a weighted average of 500 acres with 10 minutes and 1000 acres at 20 minutes).

Action 8: Section (5) requires the following updates:

Equipment Name	Percent of Time for Manure Handling	Purchase Cost ($)	Salvage Value ($)	Life-span (yrs)	Age (yrs)	Yearly Repairs and Maintenance ($)
Tractor (hose)	50	75,000	5,000	10	4	2,500
Hose/reel/meter/couplers	100	95,000	5,000	8	2	1,000
Agitator pump/hardware	100	3,000	500	6	2	200
Agitator tractor	100	62,000	5,000	15	14	500
Lagoon agitator	100	10,000	1,000	6	2	1,000
Tractor (drag/incorporation)	50	85,000	14,000	15	5	1,000
Toolbar/incorporation unit	100	55,000	1,000	20	8	2,500
Cost of capital (%)	6.00					
Equipment insurance cost per $ 1000	6.00					
Manure equipment amount insured ($)	200,000					

Now scroll down to check the whole farm costs section.

- Use Table 1 in Appendix: Tutorial 3 Summary Worksheet to record the results.
- Determine Whole farm fore-gone fertilizer purchase value by adding together these values from scenario #1 and #2 (Table 1, Appendix 3).

Tutorial 3: Export

You are considering exporting 200,000 gallons of manure, which will be drag-hose applied and incorporated (one operation, fall incorporated or injected)

- Go to the Fertilizer Replacement Value Sheet and double check that the manure application method is "fall incorporated or injected.

The manure will be transported to a frac tank onto a neighbor's 20 acre field at a rate of 10,000 gallons/acre on a field which is 5 miles from the manure source. The export field crop nutrient needs are 125 lbs N, 50 lbs P_2O_5, 50 lbs K_2O /acre.

- Enter this information into the Export Sheet.

Section (2) (Figure 17) calculates the fertilizer replacement values of the export manure nutrients applied. The "As Applied" value of the nutrients, which includes future value from excess nutrients and future mineralization of organic-N, can be looked at or the "As Needed" value, which only includes the nutrient value of nutrients needed by the current crop, can be used.

(2) Value of manure to the field receiving manure (fertilizer replacement value)									
	Applied lbs/acre	As Applied Value $/gallon	$/acre		Crop Needs lbs/acre	As Needed Value $/gallon	$ /acre		
N	100	$ 0.00	$ 49.88		N	125	$ 0.00	$ 49.88	
P_2O_5	238	$ 0.01	$ 142.50		P_2O_5	50	$ 0.00	$ 30.00	
K_2O	333	$ 0.02	$ 232.75		K_2O	50	$ 0.00	$ 35.00	
Fert. Application		$ 0.00	$ 6.00		Fert. Application		$ 0.00	$ 6.00	
Total		$ 0.04	$ 431.13		Total		$ 0.01	$ 120.88	

Figure 17: Fertilizer replacement value of manure for the example field in the tutorial exercise when valued for current and future year N, P_2O_5 and K_2O ("as applied") and only current year crop needs ("as needed").

Section (3) (Figure 18) returns the cost of the application of the manure nutrients listed in section (2). Manure application costs are broken down into operational costs associated with the specific manure application (depends on rate and distance from source) and ownership costs associated with the manure spreading equipment. These two values may also be used as negotiating points during manure export decisions.

(3) Cost of transporting and spreading manure to the receiving field (operating and ownership costs)						
Operating Costs	Machine hours/load	$/load	$/gallon	$ /acre
Loading	0.28	$ 8.34	$ 0.00	$ 9.27
Hauling	0.67	$ 50.00	$ 0.01	$ 55.56
Application	0.14	$ 4.50	$ 0.00	$ 5.00
Incorporation	0.00	$ -	$ -	$ -
Total Operating Costs		$ 62.84	$ 0.01	$ 69.82
Ownership Costs*		$ 79.95	$ 0.01	$ 88.83
Operating + Ownership Costs		$ 142.79	$ 0.02	$ 158.65

Figure 18: On the example farm, the direct (operating) cost associated with exporting manure to the field is $69.82 per acre; the overhead (ownership) cost is $88.83 per acre.

This means that in this example a total payment $158.65 per acre would both cover your direct per unit costs of applying manure on the export field and would also reimburse you for future

replacement of the machinery used for manure applications to this field. From the previous section we saw that the cost to apply fertilizer to that field would be $120.88.

(4) Net Income or Cost of Manure Export							
	Net (value-cost) As Applied				Net (value-cost) As Needed		
	$/gallon		$/acre		$/gallon		$ /acre
Return to Operating Costs	$ 0.04	$	361.30	Return to Operating Costs	$ 0.01	$	51.05
Return to Ownership & Operating Costs	$ 0.03	$	272.47	Return to Ownership & Operating Costs	$ (0.00)	$	(37.78)

Figure 19: The net income or cost of manure export is calculated as the difference between fertilizer replacement value (as applied and as needed) and the operating and total operating and ownership costs.

- Go to the Tutorial 3 Appendix and answer question #2.

Tutorial 3: Time

Time savings is an important consideration for producers considering a drag-hose system. Go to the time sheet. The 10 million gallons of manure can be moved in (10,000,000 gal /9000 gal trucks) 1,111 loads. Assume that 500 loads require 1/2 hour roundtrip and 600 loads take 1 hour/ roundtrip. Three tractor/tankers run from the lagoon to a field frac tank simultaneously, while an additional operator runs the tractor/draghose pumping from the frac tank at a rate of 1500 gallons/minute or 6 minutes per load.

Theoretically, the draghose can apply 90,000 gallons per hour. However, even with three trucks running, only 54,000 gallons per hour is delivered to the frac tank (assuming ½ hour round trip for first 500 acres).

Hauling machinery hours = 500 loads * ½ hour/load = 250 (Figure 18). However since the 3 machines are working at the same time and each piece hauls about 166 loads, the clock time is 83 hours (166 * ½ hr). Since the application equipment and hauling equipment are working at the same time, the one with the great time requirement will be the value used to calculate the total clock hours.

Action 9: Enter values into the Time Sheet so that the result matches Figure 20.

Number of Loads	Hauling Equipment Number	Loading & Hauling round trip time (hours)	Application Equipment Number	Application speed loads/hr	Hauling machinery hours	Spreading machinery hours	Hauling clock hours	Application clock hours	Total clock hours	Total Labor hours
500	3	0.5	1	10	250	50	83	50	83	333
600	3	1	1	10	600	60	200	60	200	800
					0	0	0	0	0	0
					0	0	0	0	0	0
					0	0	0	0	0	0
					0	0	0	0	0	0
					0	0	0	0	0	0
					0	0	0	0	0	0
					0	0	0	0	0	0
					0	0	0	0	0	0
1100				TOTAL	850	110	283	110	283	1133

Figure 20: The Time Management sheet allows you to experiment with different machinery and labor complements to determine work-flow bottlenecks.

This concludes the third and last section of this tutorial. At this point you should have a good understanding for how the calculator can be used to generate useful information for farm decisions-making.

Appendix 1: Tutorial 1 Summary Questions

Question (1):

- Why might it not always be appropriate to use a manure analysis for total N, P_2O_5 and K_2O together with spreader capacity to determine the value of the nutrients trucked to a field? (HINT: As-Applied vs As-Needed nutrient values).

Answer (1):

Question (2):

- Under what circumstances might it be appropriate to consider the As-Applied value for manure?

Answer (2):

Question (3):

- The Manure Value, Cost and Time Management calculator sets the costs of hauling equal to the cost of purchasing and application of equivalent fertilizer nutrients to determine a breakeven distance. What might be a reason that it does not include the cost of field application and incorporation to determine the break-even hauling distance?

Answer (3):

Question (4):

- Farm equipment costs are not considered in the break-even hauling distance analysis but they are in the whole farm analysis, why?

Answer (4):

Question (5):

- The Export page provides information that could be used to negotiate payments for manure exports. Which values would you use if you were negotiating a payment for manure that you were exporting?

Answer (5):

Appendix 2: Tutorial 2 Summary Tables & Questions

Table 1: Fertilizer Replacement Value Summary.

	Fall application, surface applied to meet nutrient needs		Spring application with incorporation to meet nutrient needs	
Manure available				
Application rate needed to meet N needs (130 lbs/ac)				
P_2O_5 balance				
K_2O balance				
Total gallons needed				
Total loads to the field				
	As-Applied	**As-Needed**	**As-Applied**	**As-Needed**
Value of manure nutrients (less loading, application, and incorporation costs)				
Hauling break-even distance (one way) (miles)				
Operating costs for loading, spreading, and incorporation				
Hauling costs at the break-even distance?				
Hauling hours				

Question (1):

- What other value does the hauling cost at the break-even distance represent?

Answer (1):

Question (2):

- What might be some reasons for not including the loading, application and incorporation costs when balancing the fertilizer replacement value of the manure with hauling costs to determine a break-even distance?

Answer (2):

Question (3):

- What also needs to be considered for the cost comparison between the fall, non-incorporated and spring, incorporated applications to be more complete?

Answer (3):

Before going back to the Tutorial Workbook exercises, take a minute to work through the following scenario:

Question (4a):

- Consider how many additional acres would have to be spread if the application rate is 5,823 gallons per acre in the spring.

Answer (4a):

Question (4b):

- If the farm has the above listed number of acres of similar cropland (same nutrient needs) in a twelve mile radius from the farm. What would be the cost to the farm to spread manure at the 5,823 gal/ac application rate in the spring and still empty the manure from their pit? Use the calculator to revise the values in Table 2 below and to make them more comparable.

Answer (4b)

In the last scenario the incorporation was completed as a separate operation. Change the scenario to represent manure application and incorporation as a single pass over the same acres.

- Remove the incorporation costs of $3.00 per gallon and the labor costs of $12.00 per hour.
- Scroll down and click the "Times and Costs" button, then sum on a separate sheet of paper (or the margins of the page) the costs of just 'Loading' and 'Application'.
- Keeping all other factors the same enter this new value into the Appendix 2, Table 2. NOTE: the calculator will automatically re-calculate costs for hauling to a new break-even distance based on the lower-cost application/incorporation information. ONLY use the new Loading and Application numbers for Appendix 2, Table 2.

Table 2: Fertilizer Replacement Value Summary Table with complete manure application.

	Fall application, surface applied to meet nutrient needs		Spring application with second-pass incorporation to meet nutrient needs		Spring application with same-pass incorporation to meet nutrient needs	
Manure available	**2.0 million gallons**		**2.0 million gallons**		**2.0 million gallons**	
Application rate needed to meet N needs (130 lbs/acre)	**13,033**				**5,823**	
P_2O_5 balance	**284**				**113**	
K_2O balance	**412**				**174**	
Total gallons needed	**1,956,400**				**2,000,200**	
Total loads to the field	**268**				**274**	
	As-Applied	**As-Needed**	As-Applied	As-Needed	As-Applied	As-Needed
Value of manure nutrients (less loading, application, and incorporation costs)	**$85,619**	**$11,876**			**$97,317**	**$27,477**
Hauling break-even distance (one way) (miles)	**38**	**5.3**			----	-----
Operating costs for loading, spreading, and incorporation	**$3,124.00**					
Hauling costs at the break-even distance?	---	**$11,852**	-----		-----	**$27,476**
Hauling hours	----	**282**	-----		----	**654**

Question (5a):

- (a) What is the value of the manure applied to the acres in each scenario compared to the hauling costs?

Answer (5):

Question (5b)

- Based on your answer to (5a) what is the cost of manure incorporation?

Answer (5b):

Table 3: Whole Farm Cost Summary Table.

	Scenario #1			**Scenario #2**			**Scenario #3**		
	Enough land to spread 2.0 million in fall at 13,000 gal/acre and 2.0 million gallons in spring at 6,000 gal/acre.			**Same as #1 but with new equipment.**			**New equipment (scenario #2) but less land to spread on and less land available for incorporation.**		
Total Acres	**493**			**493**			**400**		
Total manure	**4,000,000**			**4,000,000**			**4,000,000**		
Average application rate									
	Whole Farm	**$/acre**	**$/gallon**	**Whole Farm**	**$/acre**	**$/gallon**	**Whole Farm**	**$/acre**	**$/gallon**
Manure handling operating costs									
Manure handling ownership costs									
operating and ownership costs									

Question (6):

- What types of costs does investing in new manure equipment impact?

Answer (6):

Question (7):

- How could the additional costs of new equipment be off-set with operational costs?

Answer (7):

Question (8):

- In the third scenario the farm is still incorporating in the spring on 250 acres and so although the farm average application rate is calculated as 10,000 gallons per acre they are actually applying 6,000 gallons per acre on 250 acres. This application rate meets their crop N needs and their nutrient management plan. How much manure will they have left over?

Answer (8):

Question (9):

- If the leftover manure is applied at a rate of 12,000 gallons per acre how many acres are needed?

Question (9):

Table 4: Manure Export Values and Costs.

Rate	Acres needed	Miles from farm	As-needed Value	Operation Costs	Ownership Costs
	acres	miles	$/acre		
12,000 gallons/acre	70	1.0			
		2.5			
		4.0			

Question (10):

- What price should the farmer try to negotiate for the spreading of their manure nutrients on the neighboring cropland that ranges from 1-4 miles from the manure storage? Why?

Answer (10):

- At least $131.00 per acre because that is how much the crop farm would have had to pay to put equivalent amount of fertilizer nutrients on. I would definitely use that as a last stand though and try to go even higher to cover more of the operational costs. Additional benefits of manure beyond nutrients (organic matter, building soil P and K banks, improve moisture holding capacity of soil….) might help to negotiate a price higher than just straight fertilizer replacement. But really the going rate is what the market will bear and if there is a lot of excess manure around it may be difficult to negotiate a price or if the crop farmer does not value manure there may be some educational time before he/she will be willing to pay for it.

Appendix 3: Tutorial 3 Summary Worksheet and Questions

Table 1: Spreading Event and Whole Farm Spreading Costs

	Event #1	Event#2	Whole Farm
	Manure draglined straight from storage	Manure hauled to and spread from frac tank	Combined
Gallons spread			**15,000,000**
Acres covered	**500**	**1000**	**1500**
Application Rate	**10,000**	**10,000**	**10,000**
As-needed break-even distance			**6.2**
Time spent spreading (hrs)			**228**
Spreading Costs			
Time spent loading (hrs)			***463***
Loading Costs			
Time spent hauling (hrs)			**917**
Hauling Costs			
Time spent incorporating (separately)			
Equipment repairs and maintenance	------	--------	
Operational costs (total)			
Ownership costs	------	-------	
Ownership + operational costs	------	-------	
Replaced current year fertilizer expenses (as-needed)			

[§]*There is a slight difference ($24 and $20 respectively) based on how the calculator rounds numbers between the two spreadsheets.*

Question (1)

- How would you evaluate and describe the cost of spreading manure on this farm on the fields that are characterized (ie: up to 6.2 miles from the source, need 130 lbsN/ac, 0-25lbs P_2O_5/acre and 0-20lbs K_2O/ac)?

Answer (1)

Question (2)

- What manure characteristics in addition to fertilizer N, P and K replacement could be considered when negotiating a payment for exported manure?

Answer (2)

Additional material for understanding benefits of manure for crop production beyond N, P and K replacement can be found at:

- Sulfur: Agronomy Fact Sheet # 34: http://nmsp.cals.cornell.edu/publications/factsheets/factsheet34.pdf
- Agronomy Fact Sheet # 41: Organic Matter http://nmsp.cals.cornell.edu/publications/factsheets/factsheet41.pdf
- Look for more information to be published soon on the benefits of manure at: http://nmsp.cals.cornell.edu/