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Idaho Environmental/Nutrient Management Program (E/NMP) Basics

Lide Chen
Waste Management Engineer, University of Idaho Department of Soil and Water Systems, Twin Falls Research and Extension Center

Mitchell Vermeer
Dairy Bureau Chief, Animal Industries, Idaho State Department of Agriculture, Boise

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University of Idaho Extension

Introduction to Developing a Nutrient Management Plan (NMP)

THE IDAHO STATE DEPARTMENT OF AGRICULTURE (ISDA), which is the regulatory agency governing most livestock-related nutrient management activities in Idaho, requires that all Grade A dairy (cow, sheep, or goat) facilities, beef farms housing more than 1,000 head for at least 45 days, and large/medium-sized poultry-concentrated animal-feeding operation (CAFO) facilities use an E/NMP to guide their nutrient management. The ISDA has adopted the Phosphorus Site Index (PSI) developed by researchers from the United States Department of Agriculture (USDA)-Agricultural Research Service station in Kimberly, Idaho (Leytem et al. 2017), as its current nutrient management standard. Only certified nutrient management planners who have attended an ISDA training class and have written two ISDA-approved E/NMPs can compile an NMP for a facility. Using the ISDA online E/NMP tool, the nutrient management planner may propose a plan from one to five years. This is based on crop rotations and the number of years the planner chooses to input into the program. E/NMPs are valid for no more than five years from the ISDA approval date.

Animal manure is a by-product of livestock operations and contains nutrients and organic components that may benefit soils and crops. Animal manure should be stored, handled, and applied with the same care given to commercial fertilizers. Managed properly, animal manure may replace part of commercial fertilizers and help improve soil health. However, if manure is overapplied, nutrients will be lost from the soil/plant system due to leaching, erosion, runoff, and/or volatilization, resulting in negative environmental impacts. An effective NMP will help both animal and crop farmers maximize their use of manure nutrients and minimize the negative impact associated with manure application.

Three Main Questions Answered by E/NMPs

Question 1: What is the total amount of nutrients produced by a facility?

Two methods provide an answer to this question. The first method is based on values that you can look up in industry-related texts. One example is part 651 of the Agricultural Waste Management Field Handbook, published by the USDA Natural Resources Conservation Service (NRCS). The second method is based on the amount and nutrient content of the manure produced on a farm. The amount is determined by farm records and the nutrient content by a certified testing laboratory. This paper focuses on the first method, because it has been adopted by the ISDA.

The information required when using the first method includes animal type and weight and the number of animals on a farm. Different animal sizes generate different amounts of manure per day; thus the book values are normalized in pounds per day-per animal unit (AU) or 1,000 pounds (lb) of an animal of any species. To use the book values, first convert the animal number and weight values to the number of AUs present.

The following equation can be used to calculate the number of AUs.

Equation 1:

$$\text{The number of AU} = \frac{\#\text{ of animals} \times \text{weight of each animal}}{1000}$$

Example 1. Dairy A has 3,000 milk cows weighing 1,400 lb each, 300 dry cows weighing 1,400 lb each, 2,000 heifers weighing 850 lb each, and 600 calves weighing 350 lb each. How many animal units does Dairy A have? Following equation 1, the numbers of AUs are shown in Table 1.

Once the number of AUs is calculated, you can calculate the total amount of nutrients produced by the facility based on book values.

Table 1. The number of AUs on Dairy A.

Type of cow	Number	Weight (lb)	Animal Unit (AU)
Milk	**3000**	**1400**	$\frac{3000\times1400}{1000} = 4200$
Dry	**300**	**1400**	$\frac{300\times1400}{1000} = 420$
Heifer	**2000**	**850**	$\frac{2000\times850}{1000} = 1700$
Calf	**600**	**350**	$\frac{600\times350}{1000} = 210$
Total	5900	Total	6530

Table 2. Dairy manure characterization-as excreted (adopted from part 651 NRCS *Agricultural Waste Management Field Handbook*).

Components	Units	Lactating cow milk production, lb/d				Milk-fed calf	Calf	Heifer	Dry cow
		50	75	100	125	125 lb	330 lb	970 lb	
Weight	lb/d/1000 lb AU	97	108	119	130		83	56	51
Volume	ft3/d/1000 lb AU	1.6	1.7	1.9	2.1		1.3	0.90	0.84
Moisture	% wet basis	87	87	87	87		83	83	87
Total solids	lb/d/1000 lb AU	12	14	15	17		9.2	8.5	6.6
VS	lb/d/1000 lb AU	9.2	11	12	13		7.7	7.3	5.6
BOD	lb/d/1000 lb AU	2.1						1.2	0.84
N	lb/d/1000 lb AU	0.66	0.71	0.76	0.81	0.11	0.42	0.27	0.30
P	lb/d/1000 lb AU	0.11	0.12	0.14	0.15		0.05	0.05	0.042
K	lb/d/1000 lb AU	0.30	0.33	0.35	0.38		0.11	0.12	0.10

Example 2. How many pounds of nitrogen (N), phosphorus (P), and potassium (K) are produced in manure yearly on Dairy A (see example 1) with an average milk production of 75 lb per day-per milking cow?

From example 1, 3,000 milk cows equal 4,200 AU, 300 dry cows equal 420 AU, 2,000 heifers equal 1,700 AU, and 600 calves equal 210 AU. Nutrient production can be estimated based on equation 2. Please notice that N, P, and K production in dairy manure also depends on the cow's milk production rate as shown in Table 2.

Equation 2: Nutrients produced in manure yearly = AU × (N, P, or K) lb/day-AU × 365 days/year

Based on Table 2 (the book values) and equation 2, see Table 3 for the amounts of excreted manure nutrients by milk cows, dry cows, heifers, calves, and the Dairy A totals.

The estimated yearly production on Dairy A is: N = 1,334,148 lb; P = 225,257 lb; and K = 604,112 lb.

Question 2: What lagoon capacity does a facility need?

Manure nutrients are typically held in the form of liquid (lagoon wastewater), solid (compost, stockpiled manure), or lagoon sludge. The ISDA requires that total containment facilities (or lagoons) must be able to hold all process wastewater for 180 days during the winter months, plus the liquid manure a farm generates, plus contaminated stormwater produced during two events (a 5-year, 24-hour winter storm and a 25-year, 24-hour precipitation event). When considering contaminated stormwater, precipitation that comes into contact with corrals, manure, and animal-housing areas must be evaluated. Divide stormwater-contaminated areas into two separate categories such as 1) concrete/asphalt-covered areas and dirt/gravel-covered areas with a slope greater than 3%, and 2) dirt/gravel-covered areas with a slope less than 3%. After registering on the ISDA online E/NMP tool (https://www.isda.idaho.gov/EnvironmentalManagement/), refer to the 100% runoff collection column for areas that qualify for condition #1; refer to the runoff curve column for areas that qualify for condition #2. **Note**: Along with registering, you must be approved by the program administrator prior to be able to use the ISDA online E/NMP tool.

Question 3: What amount of nutrients should be applied to agricultural fields?

Nutrient management in the state of Idaho is regulated based on soil test P, which will be determined using the Bray 1 method for soils with no free lime (pH <6.5) and the Olsen method for soils with free lime (pH >6.5). A complete laboratory analysis should be made of samples taken from the first foot for all NMPs. Currently, the ISDA allows producers to use either P threshold (TH) or P site index (PSI) to determine allowable manure application rates. Farmers are not allowed to divide their fields between P TH and PSI. They can only choose one method to apply to their facilities.

The P TH values are dependent on water resource concerns and site characteristics. If both surface water and groundwater concerns exist, a surface water concern takes priority. If a surface water concern is not an issue, then the NMP is based on the P TH for groundwater concerns. Concentrations

Table 3. Excreted manure nutrients on Dairy A.

	AU	N (lb/year)	P (lb/year)	K (lb/year)
Milk cows	4200	$4200 \times 0.71 \times 365 = 1{,}088{,}430$	$4200 \times 0.12 \times 365 = 183{,}960$	$4200 \times 0.33 \times 365 = 505{,}890$
Dry cows	420	$420 \times 0.3 \times 365 = 45{,}990$	$420 \times 0.0042 \times 365 = 6{,}439$	$420 \times 0.1 \times 365 = 15{,}330$
Heifer	1700	$1700 \times 0.3 \times 365 = 167{,}535$	$1700 \times 0.05 \times 365 = 31{,}025$	$1700 \times 0.12 \times 365 = 74{,}460$
Calf	210	$210 \times 0.42 \times 365 = 32{,}193$	$210 \times 0.05 \times 365 = 3{,}833$	$210 \times 0.11 \times 365 = 8{,}432$
Total	6530	1,334,148	225,257	604,112

of P TH by resource concern are described in Table 4 (NRCS 1999). Use the identified primary resource concern and site characteristics to determine the P TH of the site.

Soil tests taken for comparison to the P TH will be taken at one of two depths, as described in Table 5, dependent upon on-site surface water or groundwater resource concerns.

Table 4. Phosphorus threshold concentrations by resource concern (adopted from *Idaho Nutrient Management Handbook*).

Primary Resource Concern		P Threshold Concentration	
		Olsen	Bray 1
Surface Water Runoff		40 ppm	60 ppm
Groundwater, fractured bedrock, cobbles or gravel, course-textured soils	< 5 ft	20 ppm	25 ppm
	> 5 ft	30 ppm	45 ppm

Table 5. Soil sample depth for comparison to the P threshold.

Primary Resource Concern	P Threshold Soil Sample Depth
Surface Water Runoff	0"–12"
Groundwater, fractured bedrock, cobbles or gravel, course-textured soils	18"–24"

When soil test P concentrations are above the P TH, the planner, in cooperation with the producer, should design an NMP to reduce soil test P concentrations below the P TH and to minimize potential P off-site transport. A facility operating on a P TH–based plan may only apply P at the level equal to crop uptake once a field soil test P concentration is above the allowed P TH. If two out of the next three annual soils tests show a continued trend upwards in P concentration, further regulatory action may be taken by the ISDA.

The PSI uses an integrated approach that considers soil and landscape features as well as soil conservation and P management practices in individual fields. Methods for calculating a PSI value of an individual field can be found in the *Phosphorus Site Index* (Leytem et al. 2017). The PSI helps to target critical source areas of potential P loss for greater management attention. It includes source and transport factors. Source factors address how much P is available (for example, soil test P level and P fertilizer and manure application amounts). Transport factors evaluate the potential for runoff to occur (for example, soil erosion, distance and connectivity to water, soil slope, and soil texture). When the PSI is high, recommendations are made either to apply manure based on crop P uptake or not to apply manure at all. When the PSI is low, manure can be applied on an N basis. Also, if the PSI is high, the factors that are responsible for the higher risk of P loss are identified and this information provides guidance for management practices to reduce the risk. The PSI value proposed for use in Idaho and generalized interpretations of the PSI are shown in Table 6 (Leytem et al. 2017). Facilities operating under PSI-based plans cannot apply P to any fields having a soil test P level exceeding 300 ppm.

Table 6. The P site index value and generalized interpretation of the P site index value (Leytem et al. 2017).

P *Site Index* Value	Generalized Interpretation of the P *Site Index* Value
<75	LOW potential for P movement from this site given current management practices and site characteristics. There is a low probability of an adverse impact to surface waters from P losses from this site. Nitrogen-based nutrient management planning is satisfactory for this site. Soil P levels and P loss potential may increase in the future due to N-based nutrient management planning.
75–150	MEDIUM potential for P movement from this site given current management practices and site characteristics. P applications shall be limited to the amount expected to be removed from the field by crop harvest (crop uptake) or solid test-based P application recommendations. Testing of manure P prior to application is required.
151–225	HIGH potential for P movement from this site given the current management practices and site characteristics. P applications shall be limited to 50% of crop P uptake. Testing of manure P prior to application is required.
>225	VERY HIGH potential for P movement from this site given current management practices and site characteristics. No P shall be applied to this site.

Using either the P TH or PSI, follow these steps to determine the appropriate manure application rates that will provide adequate nutrients for growing crops and also hinder the development of water-quality issues:

Step 1. Determine a nutrient application rate.

Crop-specific nutrient uptake estimates and nutrient requirements can be found from local NRCS and University of Idaho Extension publications such as *Information About Crops* (Idaho NRCS 2019) and CIS 920 (Mahler and Guy 2007), respectively. Generally, the crop target yield and typical nutrient concentration in the crop are needed to estimate crop nutrient uptake.

Example 3. Determine the N, P, and K uptake of alfalfa with a target yield of 8 ton/acre based on the values in Table 7.

Table 7. Nutrient uptake of alfalfa. More information on nutrient uptakes of other crops can be found in *Concentration of Nutrients* (Idaho NRCS 2019).

Crop	Average Concentration of Nutrients (%, dry wt basis)		
	N	P	K
Alfalfa	2.25	0.22	1.87

Based on the values in Table 7:

Nitrogen (N): 8 ton/acre × 2000 lb/ton × (2.25 ÷ 100) = 360 lb/acre

Phosphorus (P): 8 ton/acre × 2000 lb/ton × (0.22 ÷ 100) = 35.2 lb/acre

Potassium (K): 8 ton/acre × 2000 lb/ton × (1.87 ÷ 100) = 299.2 lb/acre

Example 4. Determine the N and P uptake of barley with a target yield of 100 bu/acre and straw removal of 1.5 ton/acre based on the values in Table 8.

Table 8. Nutrient uptake of barley grain and straw.

Crop	Dry Wt (lb/bu)	Average Concentration of Nutrients (%, dry wt basis)		
		N	P	K
Barley	48	1.81/0.75	0.34/0.11	0.43/1.25

100 bu/acre barley grain will uptake:

Nitrogen (N): 100 bu/acre × 48 lb/bu × (1.82 ÷ 100) = 87.4 lb/acre

Phosphorus (P): 100 bu/acre × 48 lb/bu × (0.34 ÷ 100) = 16.3 lb/acre

A removal of 1.5 ton barley straw/acre will remove:

Nitrogen (N): 1.5 ton/acre × 2,000 lb/ton × (0.75 ÷ 100) = 22.5 lb/acre

Phosphorus (P): 1.5 ton/acre × 2,000 lb/ton × (0.11 ÷ 100) = 3.3 lb/acre

Barley grain and straw together will uptake:

Nitrogen (N): 87.4 lb/acre + 22.5 lb/acre = 109.9 lb/acre

Phosphorus (P): 16.3 lb/acre + 3.3 lb/acre = 19.6 lb/acre

Example 5. Determine the N and P uptake of corn silage crop with a target yield of 30 ton/acre, based on the values in Table 9.

Table 9. Nutrient uptake of corn silage.

Crop	Nutrient Uptake Rate (lb/ton)		
	N	P_2O_5	K_2O
Corn Silage	6.8	2.51	6.91

Based on the values in Table 9, 30 ton/acre corn silage will uptake:

Nitrogen (N): 30 ton/acre × 6.8 lb/ton = 204 lb/acre

Phosphorus (P): 30 ton/acre × 2.5 lb/ton × 0.44 = 33.1 lb/acre

Note: 0.44 is a conversion factor for converting P_2O_5 to P.

Crop rotations are common practices to prevent diseases, manage weeds, maintain soil fertility, and reduce soil erosion. Two strategies can be used to make manure applications in your NMP. One strategy is to apply the same amount of manure nutrients every year regardless of the crop being grown in a specific year. The other is to apply different amounts of nutrients each year, depending on the crop grown. Regardless of the strategy used, the total amount of applied nutrients should match the total nutrient uptake for the crops grown within the planned years.

Example 6. Applying the same amount of nutrients every year.

Dairy A has planned a rotation of 3 years of alfalfa and 2 years of corn silage, with target yields of 8 ton/acre and 30 ton/acre, respectively. What is the crop average rotational P uptake?

From examples 3 and 5, 35.2 lb/acre-year P uptake by alfalfa and 33.1 lb/acre-year P uptake by corn silage:

3 years of alfalfa should take up 105.6 lb/acre of P (35.2 lb/acre-year × 3 years = 105.6 lb/acre)

2 years of corn silage should take up 66.2 lb/acre of P (33.1 lb/acre × 2 years = 66.2 lb/acre)

The crop average rotational P uptake = (105.6 lb/acre + 66.2 lb/acre)/5 years = 34.4 lb/acre-year

The dairy operator should apply 34.4 lb/acre P annually, for this five-year rotation.

Example 7. Applying different amounts of nutrient each year.

Dairy A chooses not to apply manure to the alfalfa crop because it is impossible to incorporate the nutrients into the soil, which would lead to nutrient loss and poor nutrient use efficiency. What P application rate should be used for corn silage for two years?

Example 6 shows that

3 years of alfalfa will take up 105.6 lb/acre of P and

2 years of corn silage will take up 66.2 lb/acre of P.

Dividing the five-year total uptake of P (105.6 lb/acre + 66.2 lb/acre) by two years results in 85.9 lb/acre-year. Dairy A should apply 85.9 lb/acre P to corn silage annually for two years.

Step 2. Calculating manure application rates.

Nutrient application rates are determined based on crop uptake. To match manure application rates with crop uptake, the correlation between nutrient application rate and the weight or volume of solid and liquid manure must be known. Thus, manure must be sampled and analyzed for nutrient content. Estimating nutrient concentration in solid and liquid manure is grossly inaccurate and is of no value for developing NMPs. It is recommended to sample and analyze manure immediately prior to manure application to have accurate manure nutrient information. Information on sampling dairy manure and compost for nutrient analysis can be found in UI Extension publication PNW 673 (PDF available here).

Example 8. Calculating the annual manure compost application rate for the five-year rotations, based on example 6. Dairy A's manure compost contains 9.5 lb/ton of P.

Based on the five-year rotations, crop rotation P uptake was 34.4 lb/acre; dividing 34.4 lb P/acre-year by 9.5 lb/ton dairy manure compost equals 3.6 tons of dairy manure compost/acre-year.

Example 9. Calculating the annual stockpiled dairy manure application rate for two years of corn silage, based on example 7. Dairy A's stockpiled dairy manure contains 7 lb/ton of P.

Based on the five-year rotations, the two-year corn silage P application rate is 85.9 lb/acre-year; dividing 85.9 lb/acre-year by 7 lb/ton stockpiled dairy manure results in 12.3 tons stockpiled dairy manure annually for two years during the five-year rotation.

Example 10. Calculate the amount of the lagoon wastewater adequate to meet the crop P uptake of 42 lb/acre-year without it impacting soil P levels. A dairy lagoon wastewater contains 44 lb of P/1,000 gal of wastewater.

Dividing 42 lb/acre-year by 44 lb/1,000 gal results in an application rate of 955 gal of lagoon wastewater/acre-year.

Record Keeping

Producers should maintain detailed records for each field for a minimum of five years. Manure operations should keep complete and accurate records of the following:

- **Crop rotation and yield**. Crop rotation is required to develop an annual budget for nutrient application.
- **Land application**. The dates and amounts of nutrients (manure, process wastewater, and commercial fertilizer) applied on land owned or operated by the facility (includes rented or leased land).

- **Soil samples**. Representative soil samples with soil-sampling depths must be taken by a certified soil sampler and analyzed by a certified laboratory. Samples must have testing dates, field ID, N, P, and K results, and a certified soil sampler ID.
- **Manure transferred to a third party**. Provide the name and address of any third party that received manure or process wastewater from the operation, including the dates of the transfer and the amount of manure or process wastewater transferred.
- **Records retention**. Maintain all records for a minimum of five years. You must present them to the administrator upon request.

Summary

Nutrient management is a balancing act between nutrients produced and nutrient applied. It is not a game. Nutrient planners should not try to make the numbers work in lieu of recommending that a facility change its practices.

An Idaho E/NMP should include

1. facility information,
2. source of nutrients,
3. storage of nutrients,
4. and application of nutrients.

Remember, an E/NMP is a living and working document. That is, once completed, it needs to be reviewed annually by your ISDA inspector and it must be an accurate representation of the operation—which means it must be updated when a facility experiences significant change, such as a 10% livestock increase, major water-usage changes, installation of a waste-handling and storage system, a 10% increase or decrease in application area, a crop or crop rotation change, an irrigation system change, or redesignating a sensitive area.

An E/NMP Update Report is used to update NMPs when changes to practices are made. Compliance dates will be given if a significant change occurs on the facility. If NMPs are not followed, growers will not benefit from the maximum value of the manure nutrients produced on the facility, thus placing natural resources at risk.

Further Reading

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