ANIMAL WASTE MANAGEMENT PLAN

Scott Drahn
Drahnacres Farm
Strawberry Lane, Corvallis, Oregon

Mailing address:
4110 NE Pin Oak Street
Corvallis, Oregon 97330

Facility Address:
2351 NE Strawberry Lane
Corvallis, Oregon

Phone numbers:
(H) 541-758-9101
(C) 541-602-2791

As owner and operator of Drahnacres Farms, I intend to manage in accordance with the practices and operation and maintenance described in this animal waste management plan.

Signature Scott Drahn Date 8-28-06

RECEIVED
AUG 31 2006
NATURAL RESOURCES DIVISION

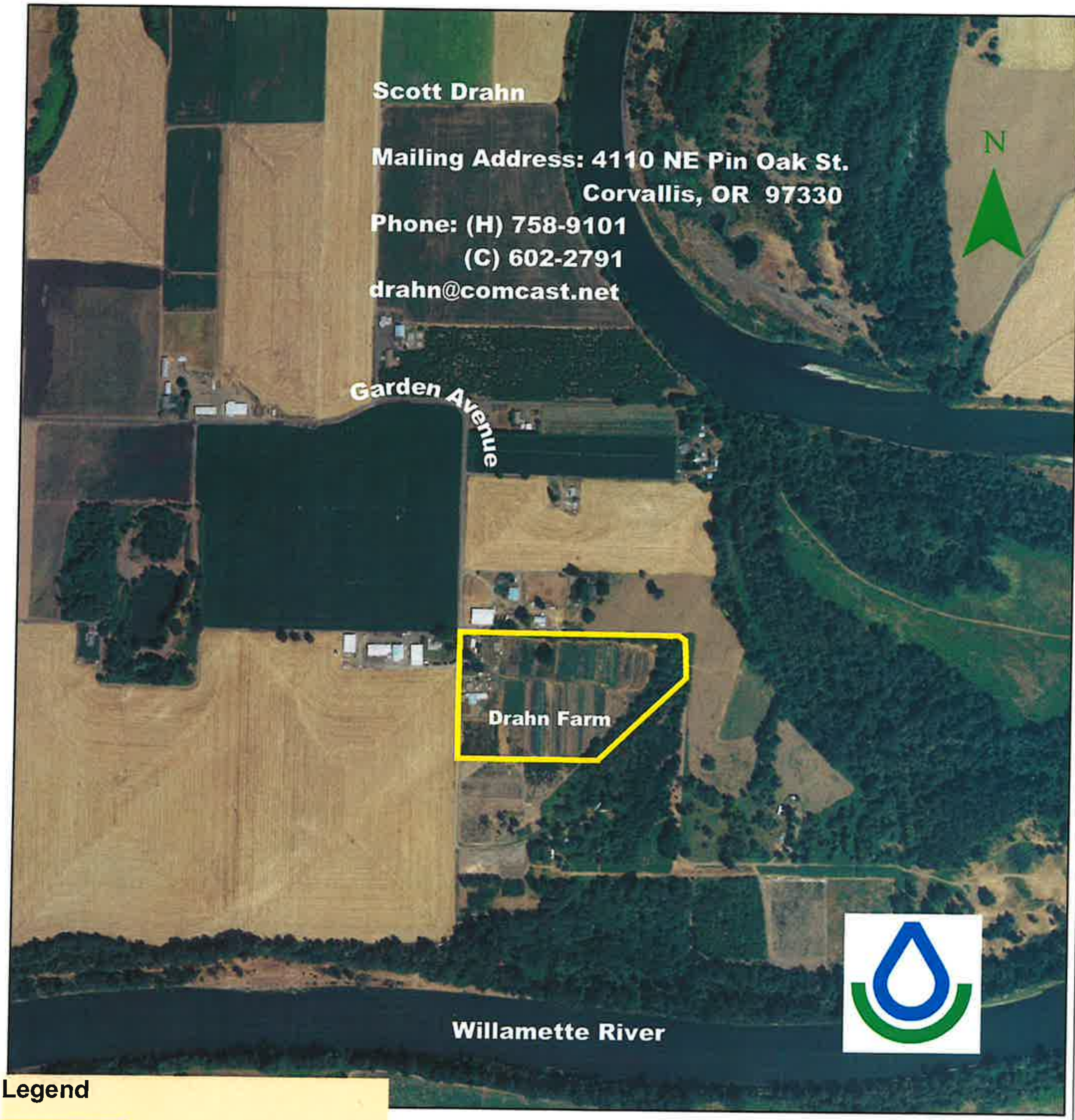
MA# 62671
AWMP# 06128
Due Date: 10/15/06
approved 9/15/06 KH

Location Map

Date: 5/18/2006

Customer(s): SCOTT DRAHN
District: BENTON SWCD
Approximate Acres: 19.5
Legal Description: T11S, R4W, S29

Field Office: TANGENT SERVICE CENTER
Agency: NRCS
Assisted By: Scott Robbins



Legend

Property Boundary

1,200 0 1,200 2,400 3,600 4,800 Feet

Emergency Response Plan

IN CASE OF A STORAGE FACILITY SPILL, LEAK, OR FAILURE

1. Stop all other activities to address the emergency.
2. Stop all flow into the storage facility.
3. If the storage facility is at maximum capacity or overtopping, draw the waste level in the facility down by making an application to the emergency application area shown on the plan map in accordance with the instructions in the Safety, Management, Operation and Maintenance section of this plan.
4. Assess the extent of the emergency and determine how much help is needed to correct the problem.
5. Call for help & excavator if needed.
6. If possible, use a skid loader or tractor with blade to contain or divert spill or leak away from environmentally sensitive areas.
7. If containment material is needed, excavate soil from appropriate areas away from the storage facility.
8. If possible, begin pumping manure and spreading in the prescribed fields at the prescribed application rates.
9. Complete the clean-up and repair the necessary components.

IN CASE OF A MANURE/WASTE DISCHARGE

1. Stop all other activities to deal with the emergency.
2. Call for help if needed.
3. Call sheriffs office if spilled on road for traffic control and clean the spill immediately from the road and roadside if needed.
4. Contain the spill or runoff from entering the stream or waterway using straw bales, sawdust, or soil material.
5. If flow is coming from a tile, plug the tile with a tile plug immediately.
6. Assess the extent of the emergency and determine how much help is needed.

CONTACTS TO BE MADE WITHIN 24 HOURS OF A DISCHARGE
(SEE NEXT PAGE FOR REQUIREMENTS FOR FILING A WRITTEN REPORT)

Oregon Department of Agriculture: 1-800-282-9378

Oregon Emergency Response System (ORES): 1-800-452-0311

Be prepared to provide the following information:

a. Your Name (See next page)
b. Farm Identification (See next page)
c. Description of emergency.
d. Estimate of the amounts, area covered, and distance traveled.
e. Has manure reached surface waters or major field drains?
f. Is there any obvious damage: employee injury, fish kill, or property damage?
g. What is currently in progress to contain situation?

EMERGENCY CONTACT INFORMATION

Farm Name	**Drahn Acres Farm**
Address	2531 NE Strawberry Lane, Corvallis, Oregon
Farm Phone	541-758-9101 or 541-602-2791 cell
CAFO Permit #	
DIRECTIONS TO FARM	**Go west on Garden Avenue from Highway 20. Garden Avenue turns into Strawberry Lane.**

Emergency Phone Numbers:	
Farm Owner	Scott Drahn
Farm Manager	**Scott Drahn**
FIRE or AMBULANCE	911
Equipment:	

IF A DISCHARGE OCCURS A WRITTEN REPORT IS TO BE MADE BY OWNER OR OPERATOR TO OREGON DEPARTMENT OF AGRICULTURE WITHIN 5 DAYS THAT CONTAINS THE FOLLOWING INFORMATION:

a. A description and cause of the discharge.
b. The period of discharge including exact dates, times and duration of discharge.
c. An estimate of discharge volume.
d. Name or location of receiving water.
e. Corrective steps taken, if appropriate, to reduce, eliminate or prevent reoccurrence of the discharge.

1. Summary of CAFO Operation:

Operation:

This is a small family farm with a swine operation and cropland. Scott runs about 40 to 50 sows and has up to about 150 piglets at a time. He usually keeps about 10 replacement sows on hand as well. The sows weigh about 400 pounds, the replacements up to 250 and the piglets up to 85 pounds. Scott sells the piglets at the farm or at a farmers market.

Additionally, sweet corn, vegetables, pears, apples and raspberries are produced. The operation consists of 19.3 acres north and east of Corvallis.

Headquarters: 2.6 ac
Raspberries, drip irrigated: 1.8 ac
Asian pear orchard: 1.3 ac
Apple Orchard: 0.8 ac
Irrigated Vegetables: 9.3 ac
Wildlife: 3.5 ac

Facilities:

There are several buildings on the farm that house the pigs. There is the old barn, the new barn, the large barn, three plastic huts for small pigs, and two sheds for farrowing.

Collection:

The Old Barn: Manure at the old barn is excreted on a concrete slab that is sloped towards a sump. Manure flows into the sump or is picked up by shovels and hauled via wheel barrows to the solid storage area. This barn does not have gutters and therefore runoff from the roof gets into the sump. Likewise, part of the slab is not covered by a roof as is the sump itself and rainwater enters the sump from these avenues as well.

The New Barn: In the new barn the flooring is concrete that slopes toward drains and pipes that take the manure into an underground tank. The tank is a 2000 gallon septic tank. Much of the solids are picked up with shovels and taken to the solid storage area which is in this building.

The Large Barn: In the large barn the pig are housed over the top of large concrete pits with a slatted floor. Some of the solid manure is picked up by shovels and taken by wheel barrow to the solids storage area. The remaining manure is stored in the pits until it is utilized.

The Plastic Huts: There are three plastic huts that house small pigs. The huts have slatted floors that allow the manure to drop into the space within each hut below the floors that stores the manure. There are pipes that carry the waste from the huts to a central collection pit, where the manure is pumped into the honey wagon. No storage occurs at the collection pit.

The farrowing sheds: The farrowing sheds also have slatted floors which allow the manure to pass into pits that are located underneath the floors. The manure is stored in the pits until it is pumped out to the honey wagon for utilization on the cropland.

Storage:

Solid Storage: Solids that are picked up by shovel and transported by wheel barrow are stored inside the new barn. This is a roofed area with a concrete floor. It measures 14 ft. by 30 ft. and will hold 1680 cubic feet of solids. According to ORAWM this will contain the solids for 365 days. Solid storage is adequate as it exists.

Liquid Storage: Liquids are stored in various places on the farm. The summary of the liquid storage sites is:

Underground storage tank	2000 gallons	267 ft^3
Sump at old barn	3375 gallons	450 ft^3
Pits underneath large barn	18,000 gallons	2400 ft^3
Pits underneath huts	1687 gallons	225 ft^3
Pits underneath farrowing sheds	2000 gallons	267 ft^3
TOTALS	27,062 gallons	3609 ft^3

Liquid storage according to ORAWM totals 56 days. This could be improved with gutters for the roof of the old barn and an extension of the roof to cover the rest of the slab and the sump. According to ORAWM the storage would increase to 80days if the improvements were made.

Transfer:

Solids Transfer: Solids are picked up by shovel in the various pens and moved to the solids storage area by wheel barrow. When enough solids accumulate in the storage area they are picked up with a front end loader and placed into the New Holland 202 manure spreader. The solids are spread on the cropland by the manure spreader.

Liquid Transfer: The liquids are transferred from the various pits/ sumps or storage tanks by pumps into the honey wagon for utilization in the crop fields.

Use:

The swine manure is utilized on the crop fields of the farm. The manure is applied to the crop areas. Manure is also applied to the permanent crops (apples, pears and raspberries) during the dormant season or early in the spring before any fruiting begins. The manure is not treated or composted before application.

SPECIFIC DESCRIPTIONS AND CALCULATIONS

Land Application Areas

Aerial photos showing field locations for all manure application acreage and surface water features, a topographic map, and headquarters sketch are included in this Animal Waste Management Plan.

Three different soil types make up the manure application acreage, as determined by the Benton County Soil Survey. Soil Types include Cloquato silt loam, 0 to 3 % slopes (46), Newberg loam 0 to 3 % slopes (127) and Pilchuck fine sandy loam, 0 to 3 % slopes (132). A soils map and soil map unit descriptions for the manure application areas are included in this Animal Waste Management Plan.

Manure and Wastewater Volumes

Calculated volumes of all manure and water have been completed using the USDA/NRCS Oregon Animal Waste Management Worksheet, Version 3.0 (ORAWM). The worksheet is included in this Animal Waste Management Plan.

Nutrient Content of Manure, Litter and Process Waste Water

ORAWM is used to estimate content and volume of nutrients in manure and waste water for nutrient balance.

Farm Nutrient Balance

A phosphorus index has been completed for this farm. The P Index shows the farm to be at low to medium risk for phosphorus. The ORAWM nutrient balance shows an over application of phosphorus to fields; however soil test results show mixed phosphorus values. The farm will monitor soil test results and adjust application if necessary. Also, more manure will be utilized on the orchards in order to spread the nutrients around.

Application Schedule and Limitations

The land to which manure is applied is more than 500' away from all surface water and consists of well drained, moderately deep soils. Storage is adequate, so that most years there will be no application between November 30 and February 1. Scott is planning on installing a roof over the slab and sump of the old barn which will increase the storage available. If weather conditions and soil moisture content permits it, applications may be made during this time period. Conditions such as non-saturated soils and a weather forecast that predicts no rain for at least 5 days must exist before any application will be attempted.

Animal Mortality Management

Animal mortalities are exported off farm. Except for small animals which are buried according to State Law.

Record Keeping and Reporting

Soil samples will be taken in fields where manure is applied every 2 years. Protocol for sampling and testing soil and manure is included in this Animal Waste Management Plan. Copies of the soil test results will be kept on file at the farm.

Records of applications of manure, litter and process waste will be kept, including the date and the amount of N and P applied during each application.
Records of any export of manure, litter and process waste will also be kept.

Reporting to the Oregon Department of Agriculture (ODA)

a) Any discharge will be reported orally to ODA within 24 hours. Within 5 days, a written statement describing this discharge will also be submitted to ODA.

b) The amount of manure, litter and process waste applied will be reported annually.

c) The amount of manure, litter and process waste exported will be reported annually.

Conservation Plan Map

Date: 6/22/2006

Customer(s): SCOTT DRAHN
District: BENTON SWCD
Approximate Acres: 19.3
Legal Description: T11S, R4W, S29

Field Office: TANGENT SERVICE CENTER
Agency: NRCS
Assisted By: Scott Robbins

Legend

Well (100 gpm)

Irrigation mainline (4")

Tract8712

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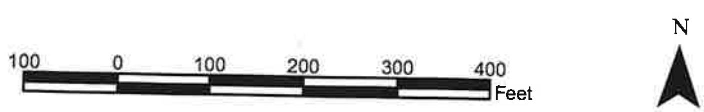


Date: 8/21/2006

Customer(s): SCOTT DRAHN
District: BENTON SWCD

Headquarters Map

Field Office: TANGENT SERVICE CENTER
Agency: NRCS
Assisted By: Scott Robbins

Legal Description: T11S, R4W, S29

Legend

Headquarters

Image: o44123e2.tif

30 0 30 60 90 120 Feet

NORTH

Emergency Manure Spreading Zone

Date: 8/28/2006

Customer(s): SCOTT DRAHN
District: BENTON SWCD
Approximate Acres: 19.3
Legal Description: T11S, R4W, S29

Field Office: TANGENT SERVICE CENTER
Agency: NRCS
Assisted By: Scott Robbins

Legend

Emergency Spreading Area

NORTH

Tract8712

Image: o44123e2.tif

Limitations to Manure Applications

There is no surface water located within 500 feet of the application areas. To protect surface and ground water, the following practices have been implemented:

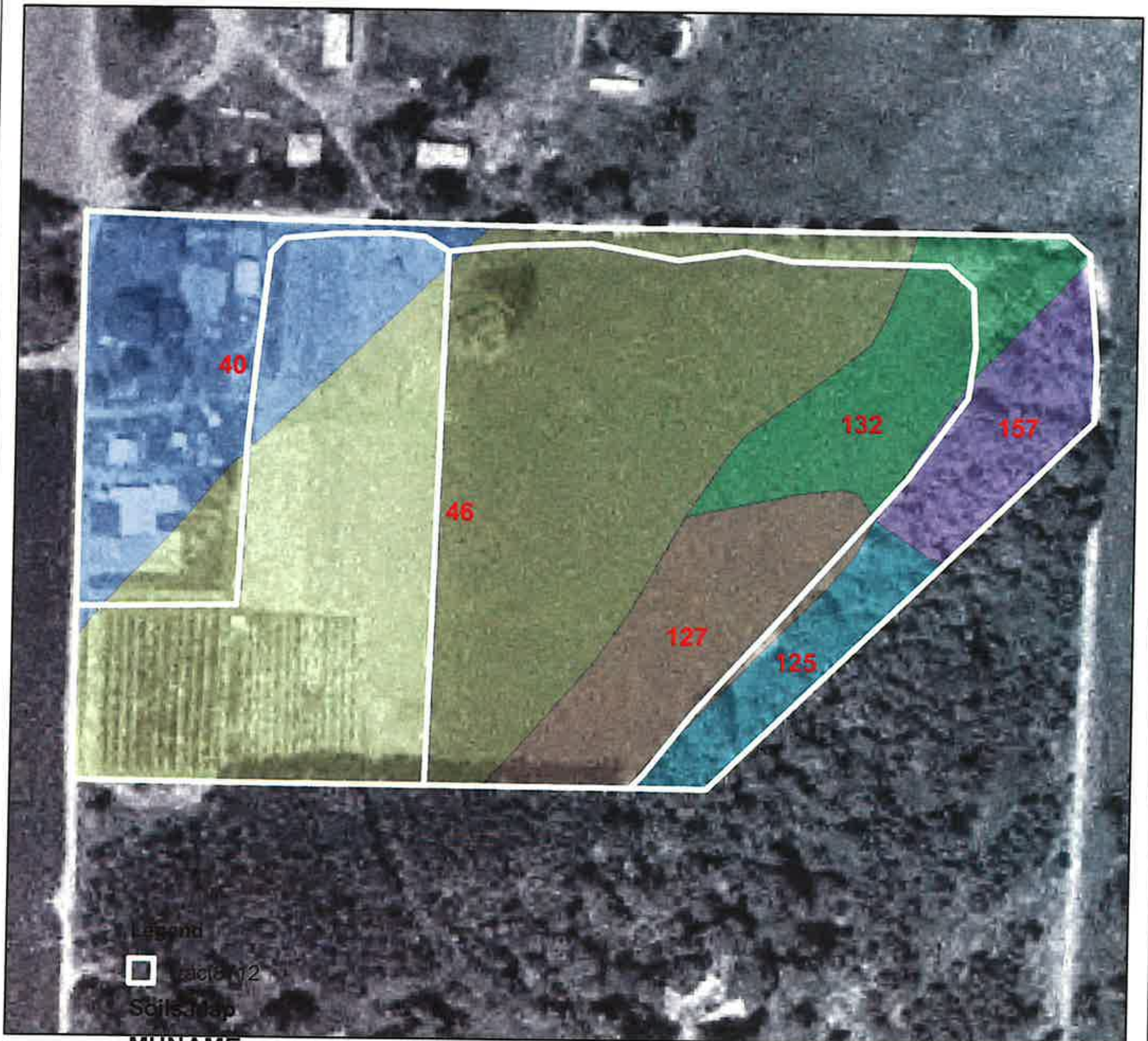
- Liquid manure applications are set back greater than 35' of open water courses and ditches.
- Liquid manure applications are set back from all roadways to avoid potential runoff into ditches.
- No manure applications are made in areas with saturated or frozen soils.
- Designated emergency winter application areas are on appropriate soil types away from surface water. Manure will not be applied on slopes great than 7% during any necessary winter application.

Soils Map

Date: 3/7/2006

Customer(s): SCOTT DRAHN
District: BENTON SWCD
Approximate Acres: 19.1
Legal Description: T11S, R4W, S29

Field Office: TANGENT SERVICE CENTER
Agency: NRCS
Assisted By: Scott Robbins



MUNAME

- Chehalis silty clay loam, 0 to 3 percent slopes
- Cloquato silt loam, 0 to 3 percent slopes
- Newberg fine sandy loam, 0 to 3 percent slopes
- Newberg loam, 0 to 3 percent slopes
- Pilchuck fine sandy loam, 0 to 3 percent slopes
- Wapato silty clay loam, 0 to 3 percent slopes

Image: ortho_e1-1_or003_1994.sid

100 0 100 200 300 400 Feet

N

Soils Inventory Report

Tue Mar 7 16:14:41 PST 2006

SCOTT DRAHN

Tract	Land Unit	Map Unit Symbol	Map Unit Name	Acres	Percent
8712		125	Newberg fine sandy loam, 0 to 3 percent slopes	0.9	5%
8712		157	Wapato silty clay loam, 0 to 3 percent slopes	1.1	6%
8712		132	Pilchuck fine sandy loam, 0 to 3 percent slopes	1.7	9%
8712		127	Newberg loam, 0 to 3 percent slopes	1.9	10%
8712		40	Chehalis silty clay loam, 0 to 3 percent slopes	3.1	16%
8712		46	Cloquato silt loam, 0 to 3 percent slopes	10.4	54%
			Total:	19.1	

Water Features

Benton County, Oregon

Map symbol and soil name	Hydrologic group	Surface runoff	Months	Water table		Ponding			Flooding	
				Upper limit	Lower limit	Surface water depth	Duration	Frequency	Duration	Frequency
				Ft	*Ft*	*Ft*				
127:										
Newberg	B	---	January	---	---	---	---	None	Brief	Occasional
			February	---	---	---	---	None	Brief	Occasional
			March	---	---	---	---	None	Brief	Occasional
			April	---	---	---	---	None	Brief	Occasional
			November	---	---	---	---	None	Brief	Occasional
			December	---	---	---	---	None	Brief	Occasional
132:										
Pilchuck	A	---	January	---	---	---	---	None	Brief	Frequent
			February	---	---	---	---	None	Brief	Frequent
			March	---	---	---	---	None	Brief	Frequent
			April	---	---	---	---	None	Brief	Frequent
			November	---	---	---	---	None	Brief	Frequent
			December	---	---	---	---	None	Brief	Frequent
157:										
Wapato	D	---	January	0.0-0.8	>6.0	0.0-1.0	Long	Frequent	Brief	Occasional
			February	0.0-0.8	>6.0	0.0-1.0	Long	Frequent	Brief	Occasional
			March	0.0-0.8	>6.0	0.0-1.0	Long	Frequent	Brief	Occasional
			April	0.0-0.8	>6.0	---	---	None	Brief	Occasional
			May	1.8-2.7	>6.0	---	---	None	---	None
			June	2.7->6.0	>6.0	---	---	None	---	None
			July	2.7->6.0	>6.0	---	---	None	---	None
			August	2.7->6.0	>6.0	---	---	None	---	None
			September	2.7->6.0	>6.0	---	---	None	---	None
			October	2.7->6.0	>6.0	---	---	None	---	None
			November	2.7->6.0	>6.0	---	---	None	Brief	Occasional
			December	0.0-0.8	>6.0	---	---	None	Brief	Occasional

Water Features

Benton County, Oregon

[Depths of layers are in feet. See text for definitions of terms used in this table. Estimates of the frequency of ponding and flooding apply to the whole year rather than to individual months. Absence of an entry indicates that the feature is not a concern or that data were not estimated. This report shows only the major soils in each map unit]

Map symbol and soil name	Hydrologic group	Surface runoff	Months	Water table		Ponding			Flooding	
				Upper limit	Lower limit	Surface water depth	Duration	Frequency	Duration	Frequency
				Ft	Ft	Ft				
10:										
Chehalis	B	---	January	---	---	---	---	None	Brief	Occasional
			February	---	---	---	---	None	Brief	Occasional
			March	---	---	---	---	None	Brief	Occasional
			April	---	---	---	---	None	Brief	Occasional
			November	---	---	---	---	None	Brief	Occasional
			December	---	---	---	---	None	Brief	Occasional
46:										
Cloquato	B	---	January	---	---	---	---	None	Brief	Occasional
			February	---	---	---	---	None	Brief	Occasional
			March	---	---	---	---	None	Brief	Occasional
			April	---	---	---	---	None	Brief	Occasional
			November	---	---	---	---	None	Brief	Occasional
			December	---	---	---	---	None	Brief	Occasional
125:										
Newberg	B	---	January	---	---	---	---	None	Brief	Occasional
			February	---	---	---	---	None	Brief	Occasional
			March	---	---	---	---	None	Brief	Occasional
			April	---	---	---	---	None	Brief	Occasional
			November	---	---	---	---	None	Brief	Occasional
			December	---	---	---	---	None	Brief	Occasional

Physical Soil Properties

Benton County, Oregon

[Entries under "Erosion Factors--T" apply to the entire profile. Entries under "Wind Erodibility Group" and "Wind Erodibility Index" apply only to the sur
data were not estimated. This report shows only the major soils in each map unit]

Map symbol and soil name	Depth	Sand	Silt	Clay	Moist bulk density	Saturated hydraulic conductivity	Available water capacity	Linear extensi-bility	Organic matter
	In	Pct	Pct	Pct	g/cc	micro m/sec	In/In	Pct	Pct
40:									
Chehalis	0-8	5-20	50-65	27-35	1.10-1.30	4.00-14.00	0.20-0.25	1.0-5.9	3.0-7.0
	8-16	5-20	50-65	27-35	1.10-1.30	4.00-14.00	0.19-0.24	3.0-5.9	2.0-5.0
	16-38	5-25	50-65	20-35	1.20-1.40	4.00-14.00	0.19-0.23	0.0-5.9	1.0-4.0
	38-45	5-25	50-65	20-35	1.20-1.40	4.00-14.00	0.18-0.23	0.0-5.9	0.5-3.0
	45-60	15-60	25-65	15-35	1.20-1.50	4.00-42.00	0.11-0.22	0.0-5.9	0.4-2.0
46:									
Cloquato	0-7	5-25	55-80	5-20	1.10-1.30	4.00-14.00	0.21-0.25	0.0-2.9	3.0-7.0
	7-12	5-25	55-80	5-20	1.20-1.40	4.00-14.00	0.20-0.24	0.0-2.9	2.0-5.0
	12-40	5-25	55-80	5-18	1.20-1.40	4.00-14.00	0.20-0.23	0.0-2.9	1.0-3.0
	40-52	30-65	25-60	5-10	1.25-1.45	14.00-42.00	0.12-0.22	0.0-2.9	0.5-1.5
	52-72	65-95	2-25	2-10	1.30-1.50	14.00-141.00	0.04-0.14	0.0-2.9	0.2-1.0
125:									
Newberg	0-7	55-75	10-35	7-20	1.20-1.40	14.00-42.00	0.13-0.17	0.0-2.9	2.0-4.0
	7-19	55-75	10-35	7-20	1.20-1.40	14.00-42.00	0.13-0.17	0.0-2.9	1.0-3.0
	19-28	55-75	10-35	5-20	1.20-1.40	14.00-42.00	0.09-0.16	0.0-2.9	0.5-1.0
	28-48	60-90	5-35	2-10	1.30-1.50	42.00-141.00	0.04-0.13	0.0-2.9	0.2-0.8
	48-64	60-90	5-35	2-10	1.30-1.50	42.00-141.00	0.04-0.13	0.0-2.9	0.1-0.7
127:									
Newberg	0-8	40-52	30-50	7-20	1.20-1.40	14.00-42.00	0.16-0.20	0.0-2.9	2.0-4.0
	8-18	55-75	10-35	7-20	1.20-1.40	14.00-42.00	0.13-0.17	0.0-2.9	1.0-3.0
	18-30	55-75	10-35	5-20	1.20-1.40	14.00-42.00	0.09-0.16	0.0-2.9	0.5-1.0
	30-46	60-90	5-35	2-10	1.30-1.50	42.00-141.00	0.04-0.13	0.0-2.0	0.2-0.8
	46-60	60-90	5-35	2-10	1.30-1.50	42.00-141.00	0.04-0.13	0.0-2.0	0.1-0.7
132:									
Pilchuck	0-7	60-75	10-35	5-15	1.20-1.40	14.00-42.00	0.12-0.17	0.0-2.9	2.0-4.0
	7-45	75-95	5-20	0-10	1.20-1.40	141.00-705.00	0.04-0.10	0.0-0.5	0.2-0.8
	45-62	75-95	5-20	0-10	1.40-1.60	141.00-705.00	0.02-0.10	0.0-0.5	0.1-0.5
157:									
Wapato	0-9	5-20	50-65	27-35	1.10-1.30	4.00-14.00	0.21-0.25	1.0-5.9	4.0-8.0
	9-16	5-20	50-65	27-35	1.10-1.30	4.00-14.00	0.20-0.24	1.0-5.9	2.0-5.0
	16-22	5-20	50-65	27-35	1.20-1.40	4.00-14.00	0.20-0.23	1.0-5.9	1.0-4.0
	22-32	5-20	50-65	27-40	1.20-1.40	4.00-14.00	0.20-0.23	1.0-5.9	1.0-3.0
	32-60	2-20	40-60	35-50	1.20-1.50	1.40-4.00	0.15-0.22	3.0-5.9	0.2-1.5

-face layer. Absence of an entry indicates that

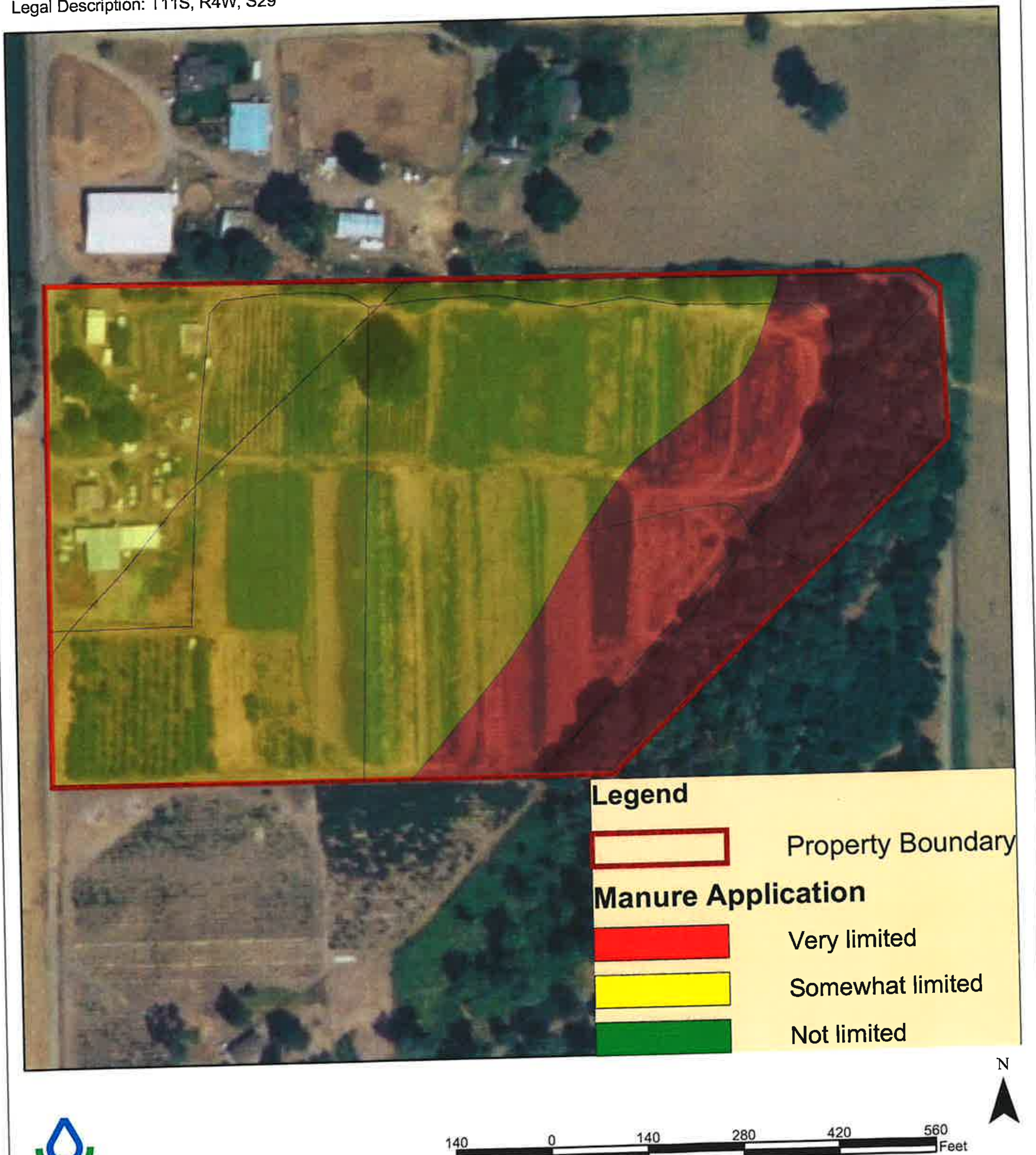
Erosion factors			Wind erodi-bility group	Wind erodi-bility index
Kw	Kf	T		
.20	.24	5	7	38
.20	.24			
.24	.28			
.32	.37			
.32	.49			
.28	.28	5	5	56
.32	.32			
.43	.43			
.32	.43			
.24	.32			
.10	.15	3	3	86
.24	.28			
.24	.32			
.20	.28			
.15	.24			
.10	.15	3	5	86
.24	.28			
.24	.32			
.20	.28			
.15	.24			
.10	.15	2	3	86
.15	.24			
.05	.24			
.24	.24	5	7	38
.24	.24			
.32	.32			
.32	.32			
.32	.32			

Manure Application Limitations

Date: 3/7/2006

Customer(s): SCOTT DRAHN
District: BENTON SWCD
Approximate Acres: 19.5
Legal Description: T11S, R4W, S29

Field Office: TANGENT SERVICE CENTER
Agency: NRCS
Assisted By: Scott Robbins



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Agricultural Disposal of Manure, Food-Processing Waste, and Sewage Sludge

Benton County, Oregon

[The information in this table indicates the dominant soil condition but does not eliminate the need for onsite investigation. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the potential limitation. The columns that identify the rating class and limiting features show no more than five limitations for any given soil. The soil may have additional limitations. This report shows only the major soils in each map unit]

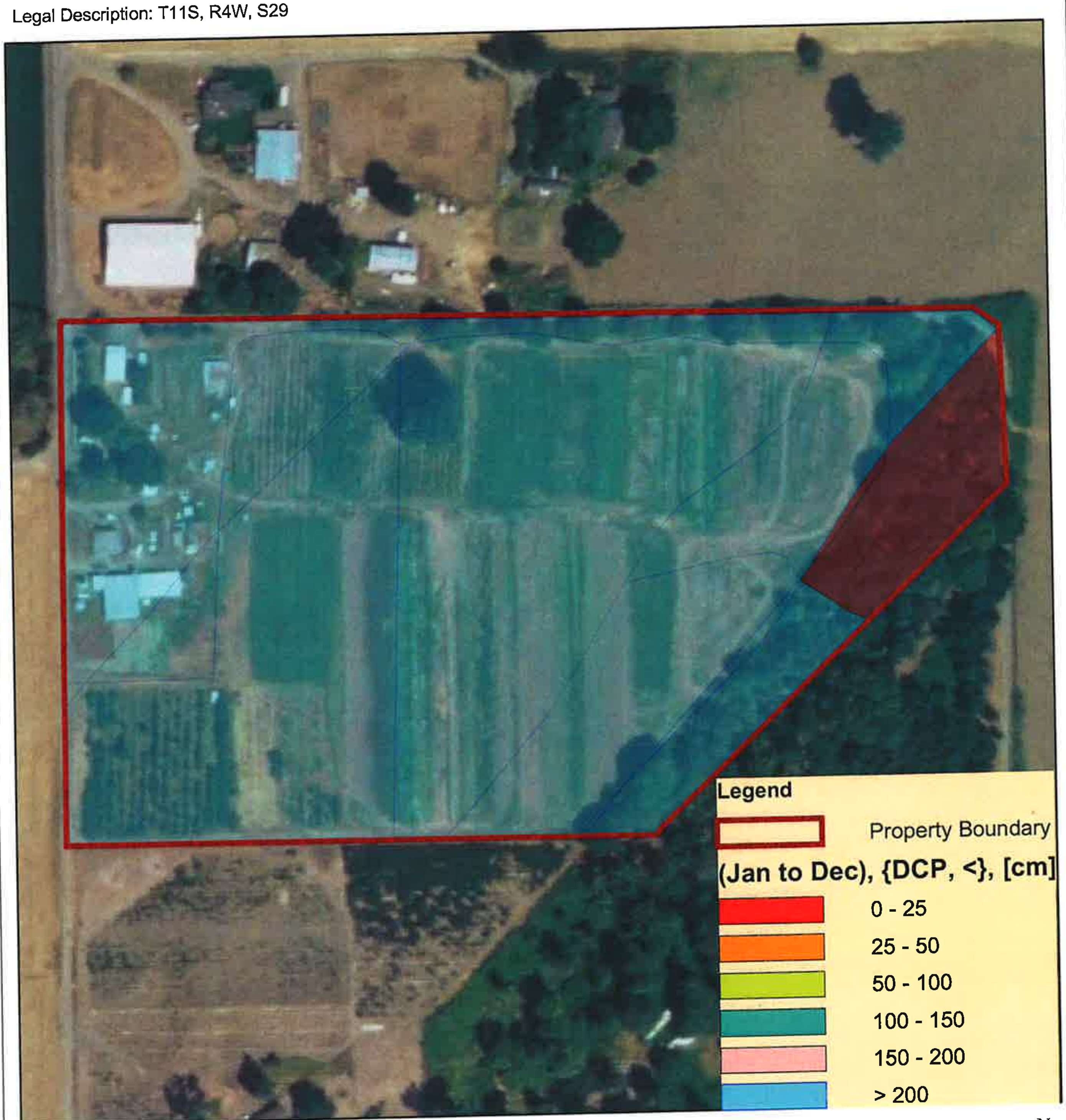
Map symbol and soil name	Pct. of map unit	Application of manure and food-processing waste		Application of sewage sludge	
		Rating class and limiting features	Value	Rating class and limiting features	Value
40:					
Chehalis	86	Somewhat limited		Very limited	
		Flooding	0.60	Flooding	1.00
		Too acid	0.02	Too acid	0.07
46:					
Cloquato	76	Somewhat limited		Very limited	
		Flooding	0.60	Flooding	1.00
		Too acid	0.05	Too acid	0.21
125:					
Newberg	84	Very limited		Very limited	
		Filtering capacity	1.00	Flooding	1.00
		Flooding	0.60	Filtering capacity	1.00
		Too acid	0.05	Too acid	0.21
127:					
Newberg	84	Very limited		Very limited	
		Filtering capacity	1.00	Flooding	1.00
		Flooding	0.60	Filtering capacity	1.00
		Too acid	0.11	Too acid	0.42
132:					
Pilchuck	73	Very limited		Very limited	
		Filtering capacity	1.00	Filtering capacity	1.00
		Flooding	1.00	Flooding	1.00
		Leaching	0.45	Droughty	0.03
		Droughty	0.03	Too acid	0.01
		Too acid	0.01		
157:					
Wapato	87	Very limited		Very limited	
		Depth to saturated zone	1.00	Depth to saturated zone	1.00
		Ponding	1.00	Flooding	1.00
		Flooding	0.60	Ponding	1.00
		Runoff	0.40	Slow water movement	0.27
		Slow water movement	0.36	Too acid	0.01

Depth to Water Table
(January to December)

Date: 3/7/2006

Customer(s): SCOTT DRAHN
District: BENTON SWCD
Approximate Acres: 19.5
Legal Description: T11S, R4W, S29

Field Office: TANGENT SERVICE CENTER
Agency: NRCS
Assisted By: Scott Robbins



N

140 0 140 280 420 560 Feet

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Drainage Class

Aggregation Method: Dominant Condition
Tie-break Rule: Higher

Benton County, Oregon
Survey Area Version and Date: 3 - 01/26/2006

Map symbol	Map unit name	Rating
40	Chehalis silty clay loam, 0 to 3 percent slopes	Well drained
46	Cloquato silt loam, 0 to 3 percent slopes	Well drained
125	Newberg fine sandy loam, 0 to 3 percent slopes	Somewhat excessively drained
127	Newberg loam, 0 to 3 percent slopes	Somewhat excessively drained
132	Pilchuck fine sandy loam, 0 to 3 percent slopes	Somewhat excessively drained
157	Wapato silty clay loam, 0 to 3 percent slopes	Poorly drained

Drainage Class

Rating Options

Attribute Name: Drainage Class

Drainage class (natural) refers to the frequency and duration of wet periods under conditions similar to those under which the soil formed. Alterations of the water regime by human activities, either through drainage or irrigation, are not a consideration unless they have significantly changed the morphology of the soil. Seven classes of natural soil drainage are recognized -- excessively drained, somewhat excessively drained, well drained, moderately well drained, somewhat poorly drained, poorly drained, and very poorly drained. These classes are defined in the "Soil Survey Manual."

Aggregation Method: Dominant Condition

Aggregation is the process by which a set of component attribute values is reduced to a single value to represent the map unit as a whole.

A map unit is typically composed of one or more "components". A component is either some type of soil or some nonsoil entity, e.g., rock outcrop. The components in the map unit name represent the major soils within a map unit delineation. Minor components make up the balance of the map unit. Great differences in soil properties can occur between map unit components and within short distances. Minor components may be very different from the major components. Such differences could significantly affect use and management of the map unit. Minor components may or may not be documented in the database. The results of aggregation do not reflect the presence or absence of limitations of the components which are not listed in the database. An on-site investigation is required to identify the location of individual map unit components.

For each of a map unit's components, a corresponding percent composition is recorded. A percent composition of 60 indicates that the corresponding component typically makes up approximately 60% of the map unit. Percent composition is a critical factor in some, but not all, aggregation methods.

For the attribute being aggregated, the first step of the aggregation process is to derive one attribute value for each of a map unit's components. From this set of component attributes, the next step of the aggregation process derives a single value that represents the map unit as a whole. Once a single value for each map unit is derived, a thematic map for soil map units can be generated. Aggregation must be done because, on any soil map, map units are delineated but components are not.The aggregation method "Dominant Condition" first groups like attribute values for the components in a map unit. For each group, percent composition is set to the sum of the percent composition of all components participating in that group. These groups now represent "conditions" rather than components. The attribute value associated with the group with the highest cumulative percent composition is returned. If more than one group shares the highest cumulative percent composition, the corresponding "tie-break" rule determines which value should be returned. The "tie-break" rule indicates whether the lower or higher group value should be returned in the case of a percent composition tie.

The result returned by this aggregation method represents the dominant condition throughout the map unit only when no tie has occurred.

Tie-break Rule: Higher

The tie-break rule indicates which value should be selected from a set of multiple candidate values, or which value should be selected in the event of a percent composition tie.

Flooding Frequency

Date: 3/7/2006

Customer(s): SCOTT DRAHN
District: BENTON SWCD
Approximate Acres: 19.5
Legal Description: T11S, R4W, S29

Field Office: TANGENT SERVICE CENTER
Agency: NRCS
Assisted By: Scott Robbins

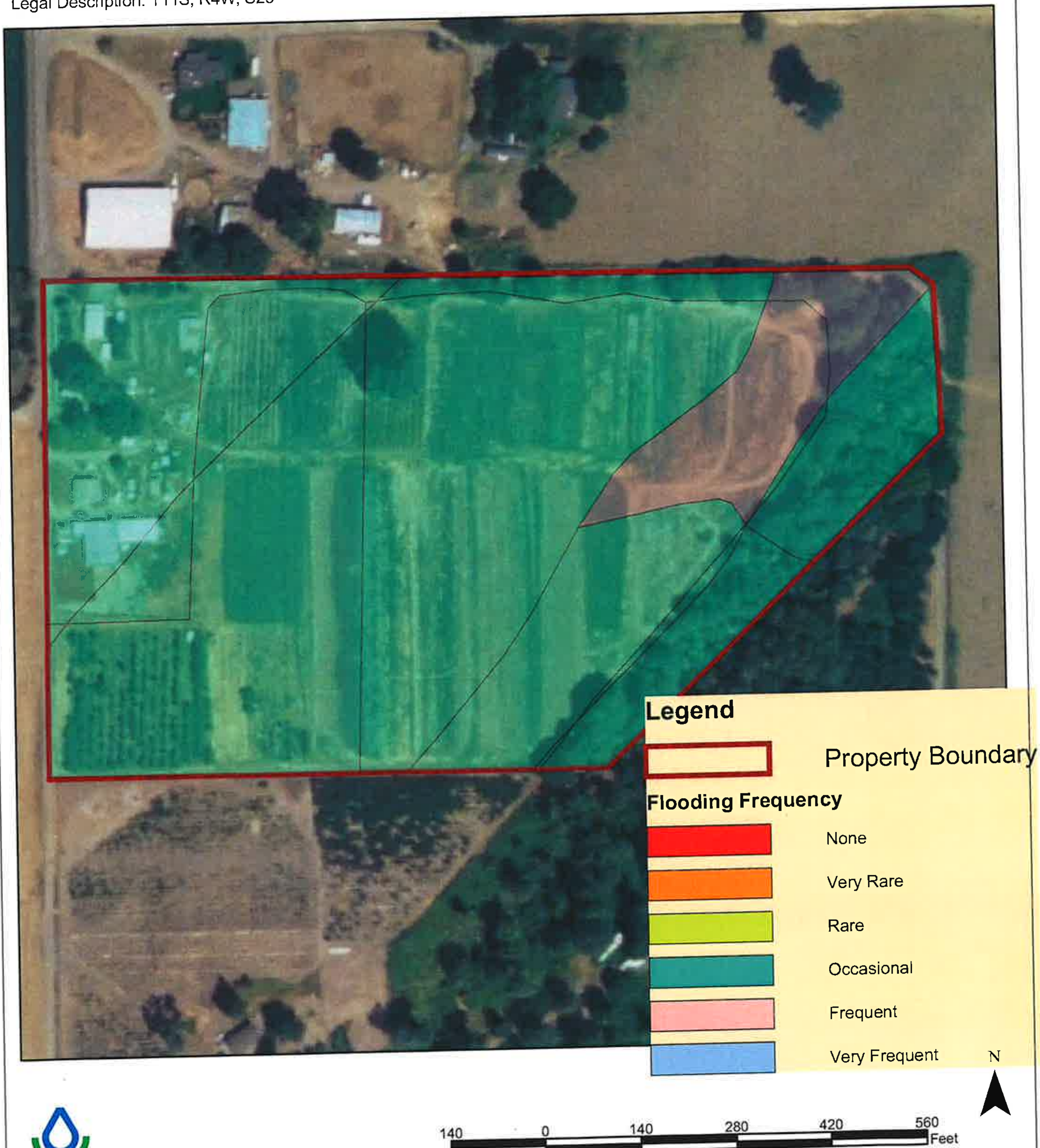


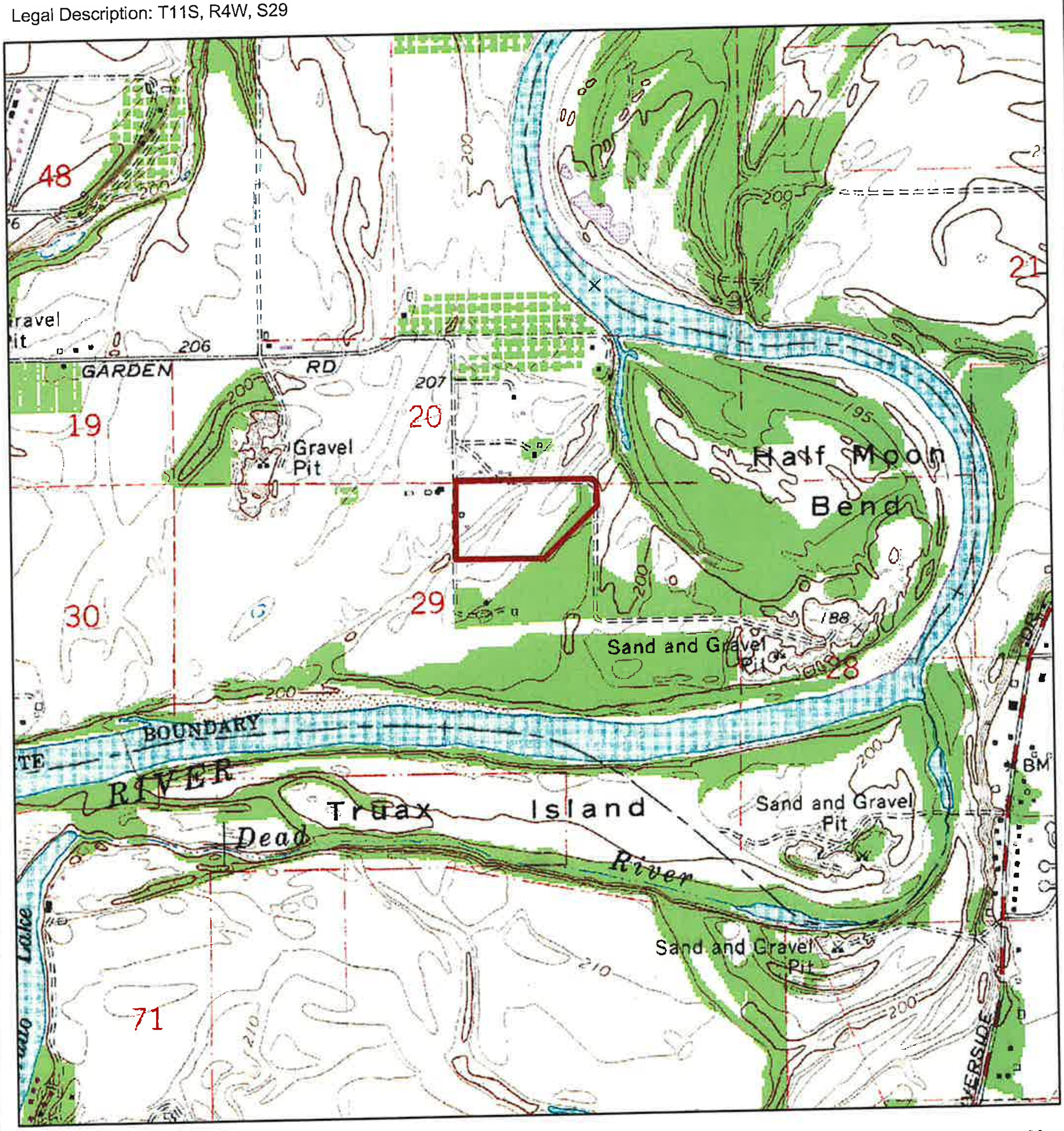
Image: o44123e2.tif

Topgraphic Map

Date: 3/7/2006

Customer(s): SCOTT DRAHN
District: BENTON SWCD
Approximate Acres: 19.5
Legal Description: T11S, R4W, S29

Field Office: TANGENT SERVICE CENTER
Agency: NRCS
Assisted By: Scott Robbins



Legend

Property Boundary

Image: o44123e2.tif

740 0 740 1,480 2,220 2,960 Feet

N

PHOSPHORUS INDEX WORKSHEET – **WESTERN** OREGON

Producer: Scott Drahn County: Benton Tract No. 8712 Field No(s). ~~#~~ 2 Date: August '06

Soil Map Unit(s): 132, 127 Soil Test P: 86 ppm Lab. Method: Bray Sample Depth: 6"

Crop Rotation: corn, veg : Nutrient Application Method(s) honey wagon / manure spreader

Planner: Robbins Notes: sample 1

TRANSPORT FACTORS	Factor Weight	PHOSPHORUS LOSS RATING: None (0)	Low (1)	Medium (2)	High (4)	Very High (8)	Weighted Rating Value: Current	Planned
Soil Erosion – tons/ac/yr (RUSLE)	1.50	< 1 (0)	1 – 3 (1.5)	4 – 6 (3.0)	7 – 15 (6.0)	> 15 (12.0)	0	0
Soil Erosion from Sprinkler Irrigation	0.75	No sprinkler irrigation (0)	Application rate < infiltration rate OR No visible runoff at field borders (0.75)	Application rate = infiltration rate OR Little to no visible runoff at field borders (1.5)	Application rate > infiltration rate OR Visible runoff at field borders (3.0)	Application rate > infiltration rate OR Excessive runoff visible at field borders. Rills and gullies present. (6.0)	0.75 ~~.56~~	0.75 ~~.56~~
Runoff Class	1.00	Negligible (0)	Very low or low (1.0)	Medium (2.0)	High (4.0)	Very High (8.0)	1	1
Flooding Frequency Class	0.75	None or very rare (0)	Rare (0.75)	Occasional (1.5)	Frequent (3.0)	Very Frequent (6.0)	1.5 ~~1.13~~	1.5 ~~1.13~~
Distance to Perennial Surface Waters / Buffer Widths	0.75	> 500 feet OR buffer > 30 ft. wide (or meets NRCS standards) next to surface waters (0)	300 – 500 feet OR buffer 20 - 30 ft. wide next to surface waters (0.75)	200 – 299 feet OR buffer 10 -19 ft. wide next to surface waters (1.5)	100 – 199 feet AND buffer < 10 ft. wide next to surface waters (3.0)	< 100 feet AND No buffer next to surface waters (6.0)	0	0
Subsurface Drainage	0.50	No Tile Drains (0)	Tile drains present Soil Test P (Bray P1) < 60 ppm (0.5)	Tile drains present Soil Test P (Bray P1) 61 - 140 ppm (1.0)	Tile drains present Soil Test P (Bray P1) 141- 190 ppm (2.0)	Tile drains present Soil Test P (Bray P1) > 190 ppm (4.0)	0	0
						Transport Factors Subtotal (TFS)	~~2.7~~ 3.25	~~2.7~~ 3.25

PHOSPHORUS INDEX WORKSHEET – **WESTERN** OREGON

Tract 8712 Fields 2

SOURCE FACTORS	Factor Weight	PHOSPHORUS LOSS RATING: None (0)	Low (1)	Medium (2)	High (4)	Very High (8)	Weighted Rating Value: Current	Planned
Soil Test P – ppm (Bray P1)	1.00	(Soil Test P – 40) x 0.10	(86 (Soil Test P) - 40) x 0.10 = 4.6		Assign 0 points if Soil Test P < 40 ppm		4.6	4.6
Commercial P Fertilizer Application Rate	1.00	lbs/ac P_2O_5 x 0.02	______ lbs/ac P_2O_5 x 0.02 = ______				0	0
Commercial P Fertilizer Application Method	1.00	None Applied (0)	Injected / banded deeper than 2 inches OR Incorporated within 5 days of application from March through September (1.0)	Incorporated within 5 days of application from October through February OR Surface applied March through August (2.0)	Incorporated more than 5 days after application OR Surface applied September through October (4.0)	Surface applied November through February (8.0)	0	0
Organic P Source Application Rate	1.00	lbs/ac P_2O_5 x 0.02	~~190~~ 243 lbs/ac P_2O_5 x 0.02 = ______				4.86 ~~3.8~~	4.86 ~~3.8~~
Organic P Source Application Method	1.00	None Applied (0)	Injected deeper than 2 inches OR Incorporated within 5 days of application from March through September (1.0)	Incorporated within 5 days of application from October through February OR Surface applied March through August (2.0)	Incorporated more than 5 days after application OR Surface applied September through October (4.0)	Surface applied November through February (8.0)	2	2

Total Rating Value TFS + SFS	Site Vulnerability Class
< 13.0	**Low**
13.0 – 25.0	**Medium**
25.1 – 50.0	**High**
> 50.0	**Very High**

	Current	Planned
Transport Factors Subtotal (TFS)	3.25 ~~2.7~~	3.25 ~~2.7~~
Source Factors Subtotal (SFS)	11.46 ~~10.4~~	11.46 ~~10.4~~
Total Rating Value (TFS + SFS)	14.71 ~~13.1~~	14.71 ~~13.1~~
Site Vulnerability Class	Medium	Medium

PHOSPHORUS INDEX WORKSHEET – **WESTERN** OREGON

Producer: Scott Drahn County: Benton Tract No. 8712 Field No(s). 2 Date: August '06

Soil Map Unit(s): 46, Soil Test P: 103 ppm Lab. Method: Bray Sample Depth: 6"

Crop Rotation: corn/veg Nutrient Application Method(s) swine, honey wagon, manure spreader

Planner: Robbins Notes: sample 3

TRANSPORT FACTORS	Factor Weight	PHOSPHORUS LOSS RATING					Weighted Rating Value	
		None (0)	Low (1)	Medium (2)	High (4)	Very High (8)	Current	Planned
Soil Erosion – tons/ac/yr (RUSLE)	1.50	< 1 (0)	1 – 3 (1.5)	4 – 6 (3.0)	7 – 15 (6.0)	> 15 (12.0)	0	0
Soil Erosion from Sprinkler Irrigation	0.75	No sprinkler irrigation (0)	Application rate < infiltration rate OR No visible runoff at field borders (0.75)	Application rate = infiltration rate OR Little to no visible runoff at field borders (1.5)	Application rate > infiltration rate OR Visible runoff at field borders (3.0)	Application rate > infiltration rate OR Excessive runoff visible at field borders. Rills and gullies present. (6.0)	0.75 ~~.56~~ ~~.37~~	0.75 ~~.56~~
Runoff Class	1.00	Negligible (0)	Very low or low (1.0)	Medium (2.0)	High (4.0)	Very High (8.0)	1	1
Flooding Frequency Class	0.75	None or very rare (0)	Rare (0.75)	Occasional (1.5)	Frequent (3.0)	Very Frequent (6.0)	1.5 ~~1.13~~	1.5 ~~1.13~~
Distance to Perennial Surface Waters / Buffer Widths	0.75	> 500 feet OR buffer > 30 ft. wide (or meets NRCS standards) next to surface waters (0)	300 – 500 feet OR buffer 20 - 30 ft. wide next to surface waters (0.75)	200 – 299 feet OR buffer 10 -19 ft. wide next to surface waters (1.5)	100 – 199 feet AND buffer < 10 ft. wide next to surface waters (3.0)	< 100 feet AND No buffer next to surface waters (6.0)	0	0
Subsurface Drainage	0.50	No Tile Drains (0)	Tile drains present Soil Test P (Bray P1) < 60 ppm (0.5)	Tile drains present Soil Test P (Bray P1) 61 - 140 ppm (1.0)	Tile drains present Soil Test P (Bray P1) 141- 190 ppm (2.0)	Tile drains present Soil Test P (Bray P1) > 190 ppm (4.0)	0	0
						Transport Factors Subtotal (TFS)	~~2.7~~ 3.25	~~2.7~~ 3.25

PHOSPHORUS INDEX WORKSHEET – **WESTERN** OREGON

Tract 8712 Fields 2

SOURCE FACTORS	Factor Weight	PHOSPHORUS LOSS RATING: None (0)	Low (1)	Medium (2)	High (4)	Very High (8)	Weighted Rating Value: Current	Planned
Soil Test P – ppm (Bray P1)	1.00	(Soil Test P – 40) x 0.10	(103 [Soil Test P] - 40) x 0.10 = ______		Assign 0 points if Soil Test P < 40 ppm		6.3	6.3
Commercial P Fertilizer Application Rate	1.00	lbs/ac P_2O_5 x 0.02	______ [lbs/ac P_2O_5] x 0.02 = ______				0	0
Commercial P Fertilizer Application Method	1.00	None Applied (0)	Injected / banded deeper than 2 inches OR Incorporated within 5 days of application from March through September (1.0)	Incorporated within 5 days of application from October through February OR Surface applied March through August (2.0)	Incorporated more than 5 days after application OR Surface applied September through October (4.0)	Surface applied November through February (8.0)	0	0
Organic P Source Application Rate	1.00	lbs/ac P_2O_5 x 0.02	243 ~~190~~ [lbs/ac P_2O_5] x 0.02 = 3.8				4.86 ~~3.8~~	4.86 ~~3.8~~
Organic P Source Application Method	1.00	None Applied (0)	Injected deeper than 2 inches OR Incorporated within 5 days of application from March through September (1.0)	Incorporated within 5 days of application from October through February OR Surface applied March through August (2.0)	Incorporated more than 5 days after application OR Surface applied September through October (4.0)	Surface applied November through February (8.0)	2	2

Total Rating Value TFS + SFS	Site Vulnerability Class
< 13.0	**Low**
13.0 – 25.0	**Medium**
25.1 – 50.0	**High**
> 50.0	**Very High**

	Current	**Planned**
Transport Factors Subtotal (TFS)	3.25 ~~2.7~~	3.25 ~~2.7~~
Source Factors Subtotal (SFS)	13.16 ~~12.7~~	13.16 ~~12.7~~
Total Rating Value (TFS + SFS)	16.41 ~~14.8~~	16.41 ~~14.8~~
Site Vulnerability Class	Medium	Medium

PHOSPHORUS INDEX WORKSHEET – **WESTERN** OREGON

Producer: Scott Drahn County: Benton Tract No. 8712 Field No(s). 2 Date: August 06

Soil Map Unit(s): 46 Soil Test P: 32 ppm Lab. Method: Bray Sample Depth: 6"

Crop Rotation: corn/veg Nutrient Application Method(s) honey wagon / manure spreader

Planner: Robbins Notes: sample 2

TRANSPORT FACTORS	Factor Weight	PHOSPHORUS LOSS RATING					Weighted Rating Value	
		None (0)	Low (1)	Medium (2)	High (4)	Very High (8)	Current	Planned
Soil Erosion – tons/ac/yr (RUSLE)	1.50	< 1 (0)	1 – 3 (1.5)	4 – 6 (3.0)	7 – 15 (6.0)	> 15 (12.0)	0	0
Soil Erosion from Sprinkler Irrigation	0.75	No sprinkler irrigation (0)	Application rate < infiltration rate OR No visible runoff at field borders (0.75)	Application rate = infiltration rate OR Little to no visible runoff at field borders (1.5)	Application rate > infiltration rate OR Visible runoff at field borders (3.0)	Application rate > infiltration rate OR Excessive runoff visible at field borders. Rills and gullies present. (6.0)	0.75 ~~.56~~	0.75 ~~.56~~
Runoff Class	1.00	Negligible (0)	Very low or low (1.0)	Medium (2.0)	High (4.0)	Very High (8.0)	1	1
Flooding Frequency Class	0.75	None or very rare (0)	Rare (0.75)	Occasional (1.5)	Frequent (3.0)	Very Frequent (6.0)	1.5 ~~1.13~~	1.5 ~~1.13~~
Distance to Perennial Surface Waters / Buffer Widths	0.75	> 500 feet OR buffer > 30 ft. wide (or meets NRCS standards) next to surface waters (0)	300 – 500 feet OR buffer 20 - 30 ft. wide next to surface waters (0.75)	200 – 299 feet OR buffer 10 -19 ft. wide next to surface waters (1.5)	100 – 199 feet AND buffer < 10 ft. wide next to surface waters (3.0)	< 100 feet AND No buffer next to surface waters (6.0)	0	0
Subsurface Drainage	0.50	No Tile Drains (0)	Tile drains present Soil Test P (Bray P1) < 60 ppm (0.5)	Tile drains present Soil Test P (Bray P1) 61 - 140 ppm (1.0)	Tile drains present Soil Test P (Bray P1) 141- 190 ppm (2.0)	Tile drains present Soil Test P (Bray P1) > 190 ppm (4.0)	0	0
						Transport Factors Subtotal (TFS)	~~2.7~~ 3.25	~~2.7~~ 3.25

PHOSPHORUS INDEX WORKSHEET – **WESTERN** OREGON

Tract 8712 Fields 2

		PHOSPHORUS LOSS RATING					Weighted Rating Value	
SOURCE FACTORS	Factor Weight	None (0)	Low (1)	Medium (2)	High (4)	Very High (8)	**Current**	**Planned**
Soil Test P – ppm (Bray P1)	1.00	(Soil Test P – 40) x 0.10	(32 [Soil Test P] - 40) x 0.10 = ____		Assign 0 points if Soil Test P < 40 ppm		0	0
Commercial P Fertilizer Application Rate	1.00	lbs/ac P_2O_5 x 0.02	____ [lbs/ac P_2O_5] x 0.02 = ____				0	0
Commercial P Fertilizer Application Method	1.00	None Applied (0)	Injected / banded deeper than 2 inches OR Incorporated within 5 days of application from March through September (1.0)	Incorporated within 5 days of application from October through February OR Surface applied March through August (2.0)	Incorporated more than 5 days after application OR Surface applied September through October (4.0)	Surface applied November through February (8.0)	0	0
Organic P Source Application Rate	1.00	lbs/ac P_2O_5 x 0.02	243 ~~190~~ [lbs/ac P_2O_5] x 0.02 = ____				4.86 ~~3.8~~	4.86 ~~3.8~~
Organic P Source Application Method	1.00	None Applied (0)	Injected deeper than 2 inches OR Incorporated within 5 days of application from March through September (1.0)	Incorporated within 5 days of application from October through February OR Surface applied March through August (2.0)	Incorporated more than 5 days after application OR Surface applied September through October (4.0)	Surface applied November through February (8.0)	2	2

Total Rating Value TFS + SFS	Site Vulnerability Class
< 13.0	**Low**
13.0 – 25.0	**Medium**
25.1 – 50.0	**High**
> 50.0	**Very High**

	Current	**Planned**
Transport Factors Subtotal (TFS)	3.25 ~~2.7~~	3.25 ~~2.7~~
Source Factors Subtotal (SFS)	6.86 ~~5.8~~	6.86 ~~5.8~~
Total Rating Value (TFS + SFS)	10.11 ~~8.5~~	10.11 ~~8.5~~
Site Vulnerability Class	Low	Low

U.S. Department of Agriculture
Natural Resources Conservation Service

CLIENT: **Drahn- existing**
ASSISTED BY: **Scott Robbins**

ANIMAL WASTE MANAGEM[illegible]
Version HRv3.[illegible]

CHECKED BY: 0

Copy of both ORAWM
sets
5-9-07 for
Lane ~~Co~~ Council + DEQ
of Gov.

ANIMAL WASTE MANAGEMEN[illegible]

NUTRIENTS AVAILABLE AFTER STORAGE

Nutrient Source	Type of Operation: Swine / Type of Storage Facility	Pounds of Nutrients Available N	P2O5
Liquids	Tank (Covered)	3,924	1,830
Solids	Solids Storage Facility (Roofed)	1,308	610
Grazing	NONE	240	172

NUTRIENTS AVAILABLE AFTER APPLICATION

Nutrient Source	Type of Application System	Pounds of Nutrients Available			Percent Nutrients Retained After Application			Pounds of Nutrients Retained After Application		
		N	P2O5	K2O	N	P2O5	K2O	N	P2O5	K2O
Liquids	Broadcast (Incorporated 7 or more days after application)	3,139	1,647	1,978	70%	100%	100%	2,197	1,647	1,978
Solids	Broadcast (Incorporated 7 or more days after application)	1,046	610	732	70%	100%	100%	732	610	732
Grazing	Grazing	240	172	199	85%	100%	100%	204	172	199

NUTRIENTS AVAILABLE AFTER DENITRIFICATION

Location: Between Coastal and Cascade Mountains

Nutrient Source	Soil Drainage Class	Pounds of Nutrients Available			Percent Nutrients Retained After Denitrification			Pounds of Nutrients Retained After Denitrification		
		N	P2O5	K2O	N	P2O5	K2O	N	P2O5	K2O
Liquids	Well Drained	2,197	1,647	1,978	90%	100%	100%	1,978	1,647	1,978
Solids	Well Drained	732	610	732	90%	100%	100%	659	610	732
Grazing	Well Drained	204	172	199	90%	100%	100%	183	172	199

PERCENT OF MANURE TO BE APPLIED TO FIELD AND UTILIZATION ACRES NEEDED BASED ON NITROGEN, N

Field Number	Acres	Crop	LIQUIDS Percent to be Applied	LIQUIDS Pounds of Nutrients to be Applied	LIQUIDS Acres Needed for Utilization of Nutrients	SOLIDS Percent to be Applied	SOLIDS Pounds of Nutrients to be Applied	SOLIDS Acres Needed for Utilization of Nutrients	GRAZING Percent to be Applied	GRAZING Pounds of Nutrients to be Applied	GRAZING Acres Needed for Utilization of Nutrients
2	9.3	Corn, Sweet	100%	1,978	7	100%	659	2	0%	0	0
HQ	1.0	Fescue Hay/Pasture	0%	0	0	0%	0	0	100%	183	1
Off-Farm			0%	0		0%	0		0%	0	
TOTALS-	10.3		100%	1,978	7	100%	659	2	100%	183	1

CLIENT: **Drahn- existing**
ASSISTED BY: **Scott Robbins**

CHECKED BY: **0**

ANIMAL WASTE MANAGEMENT SYSTEM APPLICATION

MANAGEMENT CRITERIA FOR TANK WAGON APPLICATION OF LIQUIDS

To apply **131,561** gallons of liquids generated from the operation it will take approximately **33** trips annually. Based on applying NITROGEN, N
at agronomic rates use the application depths, travel lengths, and loads per acre listed below for each crop.

Field Number	Acres	Crop	Tank Wagon Capacity Gallons	Spread Width Feet	NITROGEN, N Concentration in Storage Facility PPM	NITROGEN, N Concentration in Storage Facility Lbs/1000Gal	Pounds of Nutrients to be Applied	Number of Applications Needed to meet Crop Demand	Inches of Liquids to Apply	Travel Length per Load Needed in Feet	Loads per Acre
2	9.3	Corn, Sweet	4,000	15	2,859	23.86	267	1.00	0.26	1,647	1.8
HQ	1	Fescue Hay/Pasture	4,000	15	2,859	23.86	176	1.00	0.17	2,493	1.2
0											
0											
0											
0											
0											
0											
0											

ANIMAL WASTE MANAGEMENT WORKSHEET

Version HRv3.0

8/21/2006
STATE: OREGON

CLIENT: **Drahn- existing**
ASSISTED BY: **Scott Robbins**

CHECKED BY: **0**

ANIMAL WASTE MANAGEMENT SYSTEM APPLICATION

MANAGEMENT CRITERIA FOR TRACTOR SPREADER APPLICATION OF SOLIDS

To apply 2,389 cubic feet of solids generated from the operation it will take approximately 12 trips annually. Based on applying NITROGEN, N at agronomic rate use the application depths, travel lengths, and loads per acre listed below for each crop.

Field Number	Acres	Crop	Tractor Spreader Capacity Bushels	Tractor Spreader Capacity CF	Spread Width Feet	NITROGEN, N Concentration in Storage Facility PPM	NITROGEN, N Concentration in Storage Facility Lbs/100CF	Pounds of Nutrients to be Applied	Number of Applications Needed to meet Crop Demand	Inches of Solids to Apply	Travel Length per Load Needed in Feet	Loads per Acre
2	9.3	Corn, Sweet	160	199	15	7,019	43.80	267	1.00	0.3	597	5
HQ	1	Fescue Hay/Pasture	160	199	15	7,019	43.80	176	1.00	0.2	904	3
0												
0												
0												
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0												
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0												

MANAGEMENT CRITERIA FOR BIG GUN SPRINKLER APPLICATION OF LIQUIDS

To apply 131,561 gallons of liquids generated from the operation it will take approximately 7 hours of pumping annually. Based on applying NITROGEN, N at agronomic rate use the application depths, set times, and travel rates listed below for each crop.

Field Number	Acres	Crop	Sprinkler Flowrate GPM	Wetted Diameter Feet	Portion of Wetted Diameter Receiving Liquids	NITROGEN, N Concentration in Storage Facility PPM	NITROGEN, N Concentration in Storage Facility Lbs/1000Gal	Pounds of Nutrients to be Applied	Number of Applications Needed to meet Crop Demand	Inches of Liquids to Apply	Application Rate in Inches/Hour	Set Time Needed in Hours	Travel Rate Needed in Feet/Minute
2	9.3	Corn, Sweet	300	250	3/4 Circle	2,859	23.86	267	1.00	0.65	0.97	1.11	2.94
HQ	1	Fescue Hay/Pasture	300	250	3/4 Circle	2,859	23.86	176	1.00	0.43	0.97	0.73	4.45
0													
0													
0													
0													
0													
0													
0													

U.S. Department of Agriculture
Natural Resources Conservation Service

ANIMAL WASTE MANAGEMENT WORKSHEET

Version HRv3.0

8/21/2006
STATE: OREGON

CLIENT: **Drahn- existing**
ASSISTED BY: **Scott Robbins**
CHECKED BY: **0**

ANIMAL WASTE MANAGEMENT SYSTEM STORAGE

* Storage Period (Days) will actually be greater due to the change in solid manure storage section

TANK — MONTHLY INFLOWS INTO TANK

Tank Parameters	Value	Month	Number of days	Rain-Evap on Tank CF	Rain-Evap on Existing Storage; CF	Normal Runoff CF	Washwater CF	Manure CF	Solids CF	Waste to Store CF
* Storage Period, Days=	56	October	31	0	0	195	62	572	578	1,212
Tank Diameter, Feet=	0	November	30	0	0	460	60	553	560	1,173
		December	31	0	0	489	62	572	578	1,212
Existing Storage, Cubic Feet=	3,609	January	31	0	0	436	62	639	652	1,352
Surface Area of Existing Storage, SF=	0	February	28	0	0	368	56	577	589	1,222
25 Year-24 Hour Storm Runoff, CF=	472	March	31	0	0	282	62	639	652	1,352
Volume Needed, Cubic Feet=	3,597	April	30	0	0	174	60	618	631	1,309
Design Volume, Cubic Feet=	0	May	31	0	0	132	62	639	652	1,352
Is Tank Covered?	YES	June	30	0	0	84	60	553	560	1,173
Tank Dimensions?	Circular	July	31	0	0	30	62	572	578	1,212
		August	31	0	0	42	62	572	578	1,212
		September	30	0	0	90	60	553	560	1,173
		Annual	365	0	0	2,781	732	7,059	7,167	14,957

1.0 Feet

Depth = 0 Feet

Minimum Freeboard = 1.0 Feet

25Yr-24Hr Storm Precipitation =	4.5	Inches
25Yr-24Hr Storm Runoff =	472	Cubic Feet
56 Day Precip - Evap =	12.140666666	Inches
Runoff from Normal Precipitation =	883	Cubic Feet
Washwater =	114	Cubic Feet
Manure =	1049	Cubic Feet

Diameter = 0 Feet

U.S. Department of Agriculture
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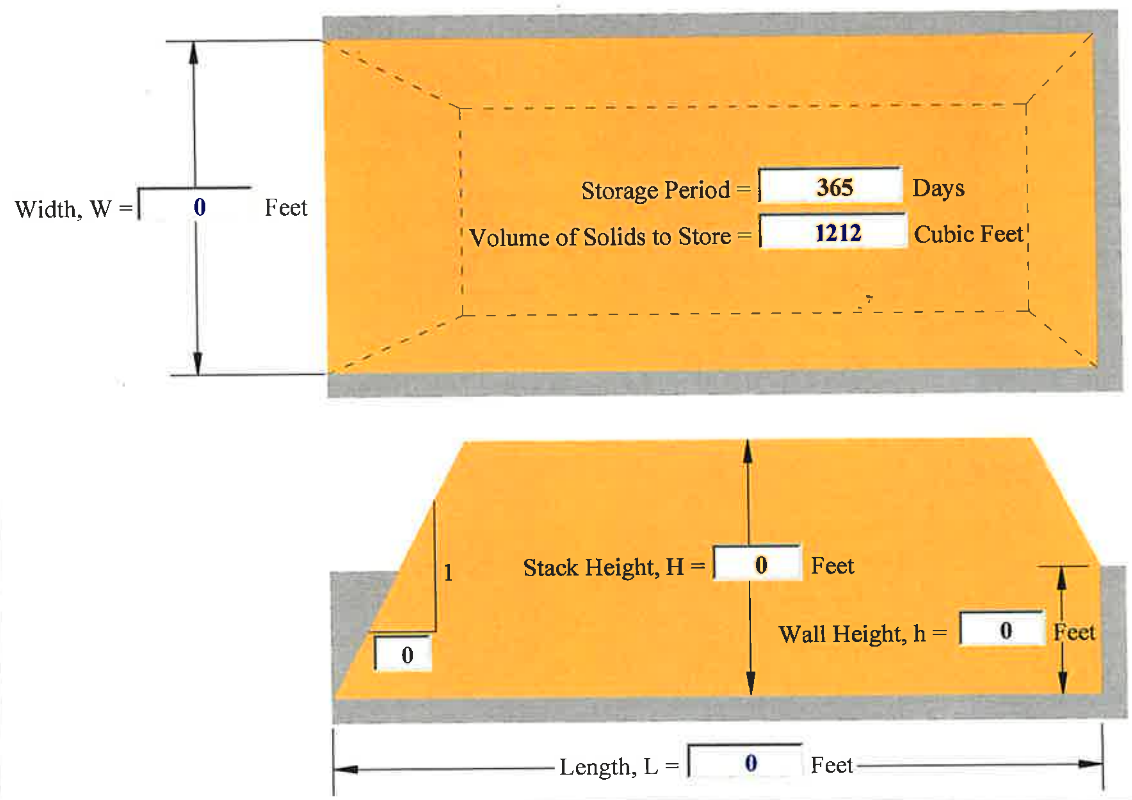
ANIMAL WASTE MANAGEMENT SYSTEM STORAGE

SOLIDS STACKING FACILITY / **MONTHLY SOLIDS VOLUME STACKED IN FACILITY**

Solids Storage Facility Parameters	Value	Month	Number of Days	Manure CF	Bedding CF	Solids to Store CF	Normal Runoff CF
Storage Period, Days=	365	October	31	191	2	96	21
Stacking Width, W in Feet=	0	November	30	184	2	93	61
Stacking Height, H in Feet=	0.00	December	31	191	2	96	52
Wall Height, h in Feet=	0.00	January	31	213	4	109	57
Stack Side Slope (X:1)=	0.00	February	28	192	4	98	40
Existing Storage, Cubic Feet=	1,680	March	31	213	4	109	24
Surface Area of Existing Storage, SF=	420	April	30	206	4	105	10
25 Year-24 Hour Storm Runoff, CF=	158	May	31	213	4	109	8
Volume Needed, Cubic Feet=	1,212	June	30	184	2	93	5
Design Volume, Cubic Feet=	0	July	31	191	2	96	0
Is Facility Covered?	YES	August	31	191	2	96	3
		September	30	184	2	93	8
		Annual	365	2,353	36	1,194	288

days of liquid storage will actually be higher
During Normal Runoff (LF) should actually be 0.



Drahn-exist-ORAWM.xls

CLIENT: **Drahn- existing**
ASSISTED BY: **Scott Robbins**

CHECKED BY: **0**

ANIMAL WASTE MANAGEMENT SYSTEM PRODUCTION

MONTHLY NUTRIENT PRODUCTION

Month	Pounds of Nutrients from **LIQUIDS**			Pounds of Nutrients from **SOLIDS**			Pounds of Nutrients from **GRAZING**			Pounds of Nutrients going **OFF-FARM**			Total Pounds of Nutrients from **ALL SOURCES**		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
October	322	148	178	107	49	59	35	25	29	0	0	0	465	222	266
November	312	143	172	104	48	57	34	24	28	0	0	0	450	215	257
December	322	148	178	107	49	59	35	25	29	0	0	0	465	222	266
January	349	166	199	116	55	66	0	0	0	0	0	0	465	222	266
February	315	150	180	105	50	60	0	0	0	0	0	0	420	200	240
March	349	166	199	116	55	66	0	0	0	0	0	0	465	222	266
April	337	161	193	112	54	64	0	0	0	0	0	0	450	215	257
May	349	166	199	116	55	66	0	0	0	0	0	0	465	222	266
June	312	143	172	104	48	57	34	24	28	0	0	0	450	215	257
July	322	148	178	107	49	59	35	25	29	0	0	0	465	222	266
August	322	148	178	107	49	59	35	25	29	0	0	0	465	222	266
September	312	143	172	104	48	57	34	24	28	0	0	0	450	215	257
Annual	**3,924**	**1,830**	**2,197**	**1,308**	**610**	**732**	**240**	**172**	**199**	**0**	**0**	**0**	**5,471**	**2,611**	**3,128**

U.S. Department of Agriculture
Natural Resources Conservation Service

CLIENT: **Drahn- existing**
ASSISTED BY: **Scott Robbins**

ANIMAL WASTE MANAGEMENT WORKSHEET

Version HRv3.0

8/21/2006
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CHECKED BY: **0**

ANIMAL WASTE MANAGEMENT SYSTEM PRODUCTION

MONTHLY VOLUMES

Month	Runoff in Cubic Feet: Roof Area Square Feet 540	Runoff in Cubic Feet: Paved Slab Area Square Feet 300	Runoff in Cubic Feet: Unpaved Lot Area Square Feet 0	Runoff in Cubic Feet: Silage Pit Surface Area, SF 0	Facility Water Use Cubic Feet	Manure: Solids Cubic Feet	Manure: Liquids Cubic Feet	Bedding: Cubic Feet	Bedding: Pounds	Solids Separated: Cubic Feet	Solids Separated: Pounds	Solids in Liquids: Cubic Feet	Solids in Liquids: Pounds	Total Solids Cubic Feet	Total Liquids Cubic Feet
October	136	38	0	0	62	83	680	9	22	193	6,941	578	20,822	193	1,386
November	312	87	0	0	60	80	658	8	21	187	6,717	560	20,151	187	1,591
December	334	102	0	0	62	83	680	9	22	193	6,941	578	20,822	193	1,649
January	291	89	0	0	62	92	760	17	43	217	7,820	652	23,459	217	1,732
February	257	71	0	0	56	83	686	16	39	196	7,063	589	21,189	196	1,612
March	207	52	0	0	62	92	760	17	43	217	7,820	652	23,459	217	1,611
April	134	30	0	0	60	89	735	17	42	210	7,567	631	22,702	210	1,493
May	104	20	0	0	62	92	760	17	43	217	7,820	652	23,459	217	1,476
June	66	13	0	0	60	80	658	8	21	187	6,717	560	20,151	187	1,270
July	26	4	0	0	62	83	680	9	22	193	6,941	578	20,822	193	1,242
August	33	6	0	0	62	83	680	9	22	193	6,941	578	20,822	193	1,252
September	66	17	0	0	60	80	658	8	21	187	6,717	560	20,151	187	1,274
Annual	**1,965**	**528**	**0**	**0**	**732**	**1,016**	**8,395**	**144**	**361**	**2,389**	**86,003**	**7,167**	**258,010**	**2,389**	**17,588**

DAILY NUTRIENT PRODUCTION

Type of Animal	Pounds/Day of Nutrients from LIQUIDS: N	LIQUIDS: P_2O_5	LIQUIDS: K_2O	Pounds/Day of Nutrients from SOLIDS: N	SOLIDS: P_2O_5	SOLIDS: K_2O	Pounds/Day of Nutrients from GRAZING: N	GRAZING: P_2O_5	GRAZING: K_2O
SOW(GESTATING)	1.68	1.20	1.39	0.56	0.40	0.46	2.24	1.60	1.86
SOW(LACTATING)	2.03	1.34	1.52	0.68	0.45	0.51	0.00	0.00	0.00
GROW TO FINISH PIG	0.81	0.31	0.43	0.27	0.10	0.14	0.00	0.00	0.00
NURSERY PIG	6.73	2.51	3.08	2.24	0.84	1.03	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

ANIMAL WASTE MANAGEMENT WORKSHEET

Version HRv3.0

8/21/2006
STATE: OREGON

CLIENT: Drahn- existing
ASSISTED BY: Scott Robbins
CHECKED BY:

ANIMAL WASTE MANAGEMENT SYSTEM INVENTORY

BEDDING VOLUME

Type of Animal	Type of Bedding Facility	Bedding Material	Unit Weight Lbs/CF	Amount Needed Lbs/Day/AU	Volume CF/Day/AU	Total Volume CF/Day	Total Weight Lbs/Day
SOW(GESTATING)	Confined	Loose Straw	2.50	0.10	0.04	1	1
SOW(LACTATING)	Confined						
GROW TO FINISH PIG	Confined						
NURSERY PIG	Confined						

SOLIDS SEPARATION FACTOR

Type of Animal	Type of Separator	Separation Factor %	Volume of Solids Separated CF/Day	Volume of Solids in Liquids CF/Day	Volume of Manure in Liquids CF/Day	Volume of Manure in Solids CF/Day	Accumulated Sludge in Storage CF/Day	Density of Separated Solids Lbs/CF	Weight of Separated Solids Lbs/Day
SOW(GESTATING)	Dry Scrape System	25%	2	5	4	1	2	36	57
SOW(LACTATING)	Dry Scrape System	25%	1	4	4	1	5	36	52
GROW TO FINISH PIG	Dry Scrape System	25%	1	2	2	1	2	36	19
NURSERY PIG	Dry Scrape System	25%	3	10	10	3	22	36	124
Total Solids>>			7	21	21	7	31		252

U.S. Department of Agriculture
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ANIMAL WASTE MANAGEMENT SYSTEM INVENTORY

WEATHER STATION

CORVALLIS STATE UNIV

Month	25Yr-24Hr	4.50	Lot Runoff Factors as a Percent of Monthly Precipitation	
	Monthly Average in Inches			
	Precipitation	Evaporation	Paved	Unpaved
October	3.02	1.64	50%	20%
November	6.94	0.71	50%	25%
December	7.43	0.61	55%	20%
January	6.46	0.73	55%	25%
February	5.71	0.97	50%	20%
March	4.59	1.32	45%	15%
April	2.98	2.16	40%	10%
May	2.30	3.34	35%	10%
June	1.46	4.31	35%	10%
July	0.57	5.59	30%	0%
August	0.73	5.12	35%	10%
September	1.47	3.46	45%	15%
Annual	43.66	29.96		

AREAS CONTRIBUTING RUNOFF TO LIQUID STORAGE FACILITY

Description of Runoff Area	Area in SF
Paved Lot Area >>> Is paved lot scraped daily? (Y/N) NO	300
Unpaved Lot Area >>>	
Roof Area >>>	540
Surface Area of Silage Storage Facility>>>>>>>>>>>>>>>>>>>>>>>>>>>>> Does Silage Seepage Drain to Storage Facility? (Y/N) NO	0
Total Runoff Area Contributing to Liquid Storage Facility>>>>>>>>>>>>>>>>	840

WATER USE THAT ENTERS LIQUID STORAGE FACILITY

Type of Water Use	Number of Animals	Number of Washes per Day	Gallons of Water Used per Wash-Day	Total Water Use per Day, Gallons	Total Water Use per Day, Cubic Feet
Animal Washwater				0	0.0
Equipment Wash				0	0.0
Flushwater				0	0.0
Miscellaneous		1	15.00	15	2.0
Total>>				15	2.0

CROP DATA

Field Number	Acres	Crop	Condition	Yield Units	Target Yield	Nutrients Removed in Pounds per Acre: Nitrogen N	Phosphorous P2O5	Potassium K2O
2	9.3	Corn, Sweet	As Harvested	Ton	15.00	267	165	210
HQ	1.0	Fescue Hay/Pasture	DHM	Ton	6.00	176	85	241
Off-Farm								

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Natural Resources Conservation Service

ANIMAL WASTE MANAGEMENT WORKSHEET

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ANIMAL WASTE MANAGEMENT SYSTEM INVENTORY

ANIMAL INVENTORY

Type of Animal	Number of Animals	Average Weight (lbs.)	Animal Units (1,000 lb.)	Nutrient Production (lbs./day/1000 lb. Animal Unit) N	P	K	Nutrient Production (lbs./day) N	P	K	Manure CF/D/AU	Annual Days Confined	Annual Days Grazed
SOW(GESTATING)	35	400	14.0	0.16	0.05	0.11	2.24	0.70	1.54	0.41	258	107
SOW(LACTATING)	15	400	6.0	0.45	0.13	0.28	2.70	0.78	1.68	0.97	365	0
GROW TO FINISH PIG	10	250 200	2.0	0.54	0.09	0.24	1.08	0.18	0.48	1.08	365	0
NURSERY PIG	150	65	9.8	0.92	0.15	0.35	8.97	1.46	3.41	1.41	365	0
Totals/Averages-	210	266	31.8	0.47	0.10	0.22	15.0	3.1	7.1	0.9		

GRAZING PERIOD

Percent of Month and Number of Animals Grazing

Type of Animal	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	AU-YR.
SOW(GESTATING)	50%	50%	50%	0%	0%	0%	0%	0%	50%	50%	50%	50%	
	35	35	35	35	35	35	35	35	35	35	35	35	49
SOW(LACTATING)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
	15	15	15	15	15	15	15	15	15	15	15	15	0
GROW TO FINISH PIG	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
	10	10	10	10	10	10	10	10	10	10	10	10	0
NURSERY PIG	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
	150	150	150	150	150	150	150	150	150	150	150	150	[illegible]
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													0
													0
													0
													0
													0
Total AUM's Available>	0	0	0	0	0	0	0	0	0	0	0	0	0
Total AUM's Needed>>>	7	7	7	0	0	0	0	0	7	7	7	7	49
Total AUM's>>>>>>>>>>	-7	-7	-7	0	0	0	0	0	-7	-7	-7	-7	-49

U.S. Department of Agriculture
Natural Resources Conservation Service

ANIMAL WASTE MANAGEMENT WORKSHEET
Version HRv3.0

8/21/2006
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ASSISTED BY: **Scott Robbins**

CHECKED BY: 0

ANIMAL WASTE MANAGEMENT SYSTEM UTILIZATION

NUTRIENT BALANCE BASED ON AVAILABLE ACRES

			NUTRIENTS APPLIED			- NUTRIENTS REMOVED			= NUTRIENT BALANCE		
Field Number	Acres	Crop	Nitrogen, N Lbs/Acre	Phosphorous, P_2O_5 Lbs/Acre	Potassium, K_2O Lbs/Acre	Nitrogen, N Lbs/Acre	Phosphorous, P_2O_5 Lbs/Acre	Potassium, K_2O Lbs/Acre	Nitrogen, N Lbs/Acre	Phosphorous, P_2O_5 Lbs/Acre	Potassium, K_2O Lbs/Acre
2	9.3	Corn, Sweet	284	243	291	267	165	210	17	78	82
HQ	1.0	Fescue Hay/Pasture	183	172	199	176	85	241	7	86	-43
Off-Farm											

U.S. Department of Agriculture
Natural Resources Conservation Service

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ANIMAL WASTE MANAGEMENT SYSTEM INVENTORY

ANIMAL INVENTORY

Type of Animal	Number of Animals	Average Weight (lbs.)	Animal Units (1,000 lb.)	Nutrient Production (lbs./day/1000 lb. Animal Unit) N	P	K	Nutrient Production (lbs./day) N	P	K	Manure CF/D/AU	Annual Days Confined	Annual Days Grazed
SOW(GESTATING)	35	400	14.0	0.16	0.05	0.11	2.24	0.70	1.54	0.41	258	107
SOW(LACTATING)	15	400	6.0	0.45	0.13	0.28	2.70	0.78	1.68	0.97	365	0
GROW TO FINISH PIG	10	200	2.0	0.54	0.09	0.24	1.08	0.18	0.48	1.08	365	0
NURSERY PIG	150	65	9.8	0.92	0.15	0.35	8.97	1.46	3.41	1.41	365	0
Totals/Averages-	210	266	31.8	0.47	0.10	0.22	15.0	3.1	7.1	0.9		

GRAZING PERIOD

Type of Animal	Percent of Month and Number of Animals Grazing OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	AU-YR.
SOW(GESTATING)	50%	50%	50%	0%	0%	0%	0%	0%	50%	50%	50%	50%	
	35	35	35	35	35	35	35	35	35	35	35	35	49
SOW(LACTATING)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
	15	15	15	15	15	15	15	15	15	15	15	15	0
GROW TO FINISH PIG	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
	10	10	10	10	10	10	10	10	10	10	10	10	0
NURSERY PIG	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
	150	150	150	150	150	150	150	150	150	150	150	150	[illegible]
													0
													0
													0
													0
													0
													0
Total AUM's Available>	0	0	0	0	0	0	0	0	0	0	0	0	0
Total AUM's Needed>>>	7	7	7	0	0	0	0	0	7	7	7	7	49
Total AUM's>>>>>>>>>>	-7	-7	-7	0	0	0	0	0	-7	-7	-7	-7	-49

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ANIMAL WASTE MANAGEMENT SYSTEM INVENTORY

WEATHER STATION

CORVALLIS STATE UNIV

Month	25Yr-24Hr	4.50	Lot Runoff Factors as a Percent of Monthly Precipitation	
	Monthly Average in Inches			
	Precipitation	Evaporation	Paved	Unpaved
October	3.02	1.64	50%	20%
November	6.94	0.71	50%	25%
December	7.43	0.61	55%	20%
January	6.46	0.73	55%	25%
February	5.71	0.97	50%	20%
March	4.59	1.32	45%	15%
April	2.98	2.16	40%	10%
May	2.30	3.34	35%	10%
June	1.46	4.31	35%	10%
July	0.57	5.59	30%	0%
August	0.73	5.12	35%	10%
September	1.47	3.46	45%	15%
Annual	43.66	29.96		

AREAS CONTRIBUTING RUNOFF TO LIQUID STORAGE FACILITY

Description of Runoff Area		Area in SF
Paved Lot Area >>>		0
Is paved lot scraped daily? (Y/N)	NO	
Unpaved Lot Area >>>		
Roof Area >>>		0
Surface Area of Silage Storage Facility>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>		0
Does Silage Seepage Drain to Storage Facility? (Y/N)	NO	
Total Runoff Area Contributing to Liquid Storage Facility>>>>>>>>>>>>>>>>		0

WATER USE THAT ENTERS LIQUID STORAGE FACILITY

Type of Water Use	Number of Animals	Number of Washes per Day	Gallons of Water Used per Wash-Day	Total Water Use per Day, Gallons	Total Water Use per Day, Cubic Feet
Animal Washwater				0	0.0
Equipment Wash				0	0.0
Flushwater				0	0.0
Miscellaneous		1	15.00	15	2.0
Total>>>				15	2.0

CROP DATA

Field Number	Acres	Crop	Condition	Yield Units	Target Yield	Nutrients Removed in Pounds per Acre		
						Nitrogen N	Phosphorous P2O5	Potassium K2O
2	9.3	Corn, Sweet	As Harvested	Ton	15.00	267	165	210
HQ	1.0	Fescue Hay/Pasture	DHM	Ton	6.00	176	85	241
Off-Farm								

ANIMAL WASTE MANAGEMENT WORKSHEET

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8/21/2006
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CHECKED BY:

ANIMAL WASTE MANAGEMENT SYSTEM INVENTORY

BEDDING VOLUME

Type of Animal	Type of Bedding Facility	Bedding Material	Unit Weight Lbs/CF	Amount Needed Lbs/Day/AU	Volume CF/Day/AU	Total Volume CF/Day	Total Weight Lbs/Day
SOW(GESTATING)	Confined	Loose Straw	2.50	0.10	0.04	1	1
SOW(LACTATING)	Confined						
GROW TO FINISH PIG	Confined						
NURSERY PIG	Confined						

SOLIDS SEPARATION FACTOR

Type of Animal	Type of Separator	Separation Factor %	Volume of Solids Separated CF/Day	Volume of Solids in Liquids CF/Day	Volume of Manure in Liquids CF/Day	Volume of Manure in Solids CF/Day	Accumulated Sludge in Storage CF/Day	Density of Separated Solids Lbs/CF	Weight of Separated Solids Lbs/Day
SOW(GESTATING)	Dry Scrape System	25%	2	5	4	1	2	36	57
SOW(LACTATING)	Dry Scrape System	25%	1	4	4	1	5	36	52
GROW TO FINISH PIG	Dry Scrape System	25%	1	2	2	1	2	36	19
NURSERY PIG	Dry Scrape System	25%	3	10	10	3	22	36	124
Total Solids>>			7	21	21	7	31		252

U.S. Department of Agriculture
Natural Resources Conservation Service

ANIMAL WASTE MANAGEMENT WORKSHEET
Version HRv3.0

8/21/2006
STATE: OREGON

CLIENT: **Drahn- planned**
ASSISTED BY: **Scott Robbins**

CHECKED BY: **0**

ANIMAL WASTE MANAGEMENT SYSTEM PRODUCTION

MONTHLY VOLUMES

Month	Runoff in Cubic Feet: Roof Area Square Feet 0	Runoff in Cubic Feet: Paved Slab Area Square Feet 0	Runoff in Cubic Feet: Unpaved Lot Area Square Feet 0	Runoff in Cubic Feet: Silage Pit Surface Area, SF 0	Facility Water Use Cubic Feet	Manure Solids Cubic Feet	Manure Liquids Cubic Feet	Bedding Cubic Feet	Bedding Pounds	Solids Separated Cubic Feet	Solids Separated Pounds	Solids in Liquids Cubic Feet	Solids in Liquids Pounds	Total Solids Cubic Feet	Total Liquids Cubic Feet
October	0	0	0	0	62	83	680	9	22	193	6,941	578	20,822	193	1,212
November	0	0	0	0	60	80	658	8	21	187	6,717	560	20,151	187	1,192
December	0	0	0	0	62	83	680	9	22	193	6,941	578	20,822	193	1,212
January	0	0	0	0	62	92	760	17	43	217	7,820	652	23,459	217	1,352
February	0	0	0	0	56	83	686	16	39	196	7,063	589	21,189	196	1,283
March	0	0	0	0	62	92	760	17	43	217	7,820	652	23,459	217	1,352
April	0	0	0	0	60	89	735	17	42	210	7,567	631	22,702	210	1,329
May	0	0	0	0	62	92	760	17	43	217	7,820	652	23,459	217	1,352
June	0	0	0	0	60	80	658	8	21	187	6,717	560	20,151	187	1,192
July	0	0	0	0	62	83	680	9	22	193	6,941	578	20,822	193	1,212
August	0	0	0	0	62	83	680	9	22	193	6,941	578	20,822	193	1,212
September	0	0	0	0	60	80	658	8	21	187	6,717	560	20,151	187	1,192
Annual	**0**	**0**	**0**	**0**	**732**	**1,016**	**8,395**	**144**	**361**	**2,389**	**86,003**	**7,167**	**258,010**	**2,389**	**15,095**

DAILY NUTRIENT PRODUCTION

Type of Animal	Pounds/Day of Nutrients from **LIQUIDS**			Pounds/Day of Nutrients from **SOLIDS**			Pounds/Day of Nutrients from **GRAZING**		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
SOW(GESTATING)	1.68	1.20	1.39	0.56	0.40	0.46	2.24	1.60	1.86
SOW(LACTATING)	2.03	1.34	1.52	0.68	0.45	0.51	0.00	0.00	0.00
GROW TO FINISH PIG	0.81	0.31	0.43	0.27	0.10	0.14	0.00	0.00	0.00
NURSERY PIG	6.73	2.51	3.08	2.24	0.84	1.03	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

U.S. Department of Agriculture
Natural Resources Conservation Service

ANIMAL WASTE MANAGEMENT WORKSHEET

Version HRv3.0

8/21/2006
STATE: OREGON

CLIENT: **Drahn- planned**
ASSISTED BY: **Scott Robbins**

CHECKED BY: 0

ANIMAL WASTE MANAGEMENT SYSTEM PRODUCTION

MONTHLY NUTRIENT PRODUCTION

	Pounds of Nutrients from LIQUIDS			Pounds of Nutrients from SOLIDS			Pounds of Nutrients from GRAZING			Pounds of Nutrients going OFF-FARM			Total Pounds of Nutrients from ALL SOURCES		
Month	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
October	322	148	178	107	49	59	35	25	29	0	0	0	465	222	266
November	312	143	172	104	48	57	34	24	28	0	0	0	450	215	257
December	322	148	178	107	49	59	35	25	29	0	0	0	465	222	266
January	349	166	199	116	55	66	0	0	0	0	0	0	465	222	266
February	315	150	180	105	50	60	0	0	0	0	0	0	420	200	240
March	349	166	199	116	55	66	0	0	0	0	0	0	465	222	266
April	337	161	193	112	54	64	0	0	0	0	0	0	450	215	257
May	349	166	199	116	55	66	0	0	0	0	0	0	465	222	266
June	312	143	172	104	48	57	34	24	28	0	0	0	450	215	257
July	322	148	178	107	49	59	35	25	29	0	0	0	465	222	266
August	322	148	178	107	49	59	35	25	29	0	0	0	465	222	266
September	312	143	172	104	48	57	34	24	28	0	0	0	450	215	257
Annual	**3,924**	**1,830**	**2,197**	**1,308**	**610**	**732**	**240**	**172**	**199**	**0**	**0**	**0**	**5,471**	**2,611**	**3,128**

U.S. Department of Agriculture
Natural Resources Conservation Service

ANIMAL WASTE MANAGEMENT WORKSHEET

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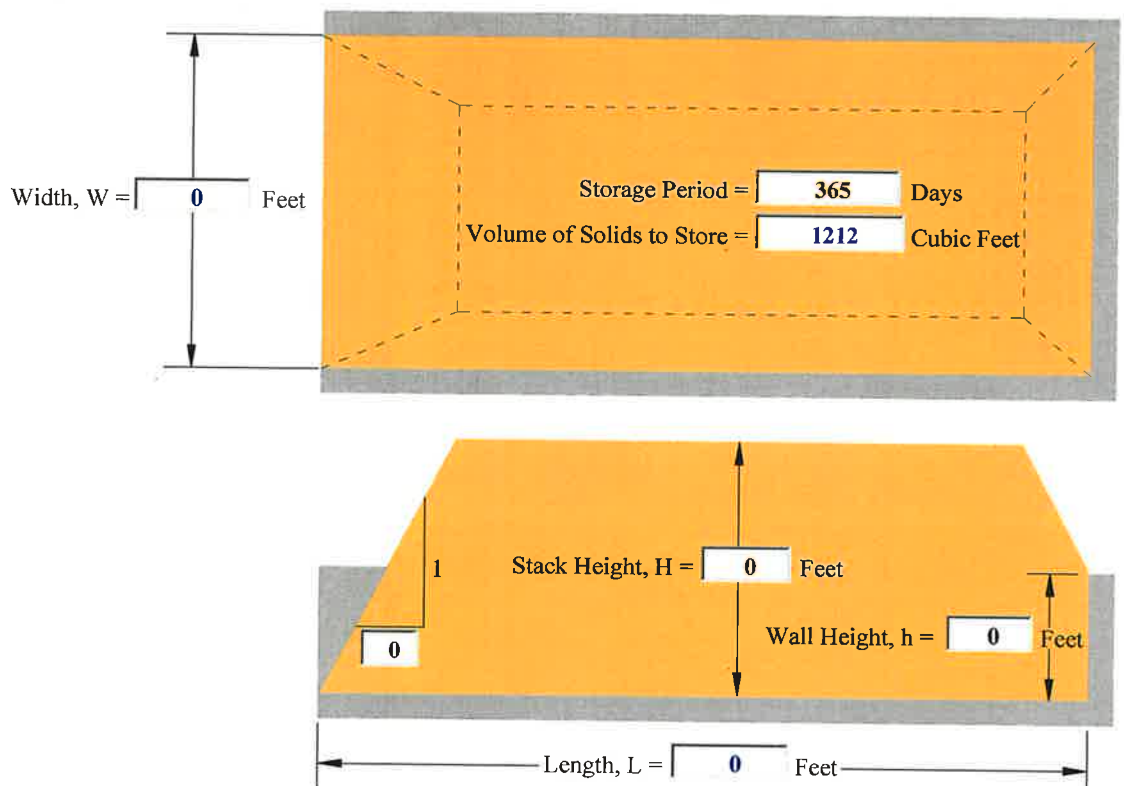
CHECKED BY: **0**

ANIMAL WASTE MANAGEMENT SYSTEM STORAGE

SOLIDS STACKING FACILITY

MONTHLY SOLIDS VOLUME STACKED IN FACILITY

Solids Storage Facility Parameters	Value	Month	Number of Days	Manure CF	Bedding CF	Solids to Store CF	Normal Runoff CF
Storage Period, Days=	365	October	31	191	2	96	21
Stacking Width, W in Feet=	0	November	30	184	2	93	61
Stacking Height, H in Feet=	0.00	December	31	191	2	96	52
Wall Height, h in Feet=	0.00	January	31	213	4	109	57
Stack Side Slope (X:1)=	0.00	February	28	192	4	98	40
Existing Storage, Cubic Feet=	1,680	March	31	213	4	109	24
Surface Area of Existing Storage, SF=	420	April	30	206	4	105	10
25 Year-24 Hour Storm Runoff, CF=	158	May	31	213	4	109	8
Volume Needed, Cubic Feet=	1,212	June	30	184	2	93	5
Design Volume, Cubic Feet=	0	July	31	191	2	96	0
Is Facility Covered?	YES	August	31	191	2	96	3
		September	30	184	2	93	8
		Annual	365	2,353	36	1,194	288



U.S. Department of Agriculture
Natural Resources Conservation Service

ANIMAL WASTE MANAGEMENT WORKSHEET

Version HRv3.0

8/21/2006
STATE: OREGON

CLIENT: **Drahn- planned**
ASSISTED BY: **Scott Robbins**

CHECKED BY: **0**

ANIMAL WASTE MANAGEMENT SYSTEM STORAGE

TANK — MONTHLY INFLOWS INTO TANK

Tank Parameters	Value	Month	Number of days	Rain-Evap on Tank CF	Rain-Evap on Existing Storage, CF	Normal Runoff CF	Washwater CF	Manure CF	Solids CF	Waste to Store CF
Storage Period, Days=	80	October	31	0	0	21	62	572	578	1,212
Tank Diameter, Feet=	80	November	30	0	0	61	60	553	560	1,173
		December	31	0	0	52	62	572	578	1,212
Existing Storage, Cubic Feet=	3,609	January	31	0	0	57	62	639	652	1,352
Surface Area of Existing Storage, SF=	0	February	28	0	0	40	56	577	589	1,222
25 Year-24 Hour Storm Runoff, CF=	157	March	31	0	0	24	62	639	652	1,352
Volume Needed, Cubic Feet=	3,613	April	30	0	0	10	60	618	631	1,309
Design Volume, Cubic Feet=	0	May	31	0	0	8	62	639	652	1,352
Is Tank Covered?	YES	June	30	0	0	5	60	553	560	1,173
Tank Dimensions?	Circular	July	31	0	0	0	62	572	578	1,212
		August	31	0	0	3	62	572	578	1,212
		September	30	0	0	8	60	553	560	1,173
		Annual	365	0	0	288	732	7,059	7,167	14,957

1.0 Feet

Minimum Freeboard = 1.0 Feet

25Yr-24Hr Storm Precipitation =	4.5	Inches
25Yr-24Hr Storm Runoff =	157	Cubic Feet
80 Day Precip - Evap =	16.87	Inches
Runoff from Normal Precipitation =	150	Cubic Feet
Washwater =	163	Cubic Feet
Manure =	1551	Cubic Feet

Depth = 0 Feet

Diameter = 80 Feet

CLIENT: **Drahn- existing**
ASSISTED BY: **Scott Robbins**

CHECKED BY: **0**

Worksheet OR10A-7--Waste storage period determination

Basic Storage Period, SPb = **213** **Days**

Enter average monthly Evapotranspiration(**ET**) from OSU Extension Publication 8530, Oregon Crop Water Use and Irrigation Requirements, and Precipitation(Ppt) Data from

Climatic Station- **CORVALLIS STATE UNIV**

Day of Year	MONTH	Crop ET, Inches	Accum ET, Inches	Ppt, Inches
1-31	January	0.39	0.39	6.46
32-59	February	0.63	1.02	5.71
60-90	March	1.46	2.48	4.59
91-120	April	3.31	5.79	2.98
121-151	May	4.53	10.32	2.30
152-181	June	5.24	15.56	1.46
182-212	July	7.13	22.69	0.57
213-243	August	6.02	28.71	0.73
244-273	September	4.02	32.73	1.47
274-304	October	2.48	35.21	3.02
305-334	November	0.43	35.64	6.94
335-365	December	0.35	35.99	7.43

a. Determine last day for the month of the year when 3/4 of Annual ET is exceeded-

3/4 of Annual ET = 0.75 x **35.99** = **26.99** Inches

L = Last Day for Month Accum ET exceeds 3/4 of Annual ET

L = **243** **Days**

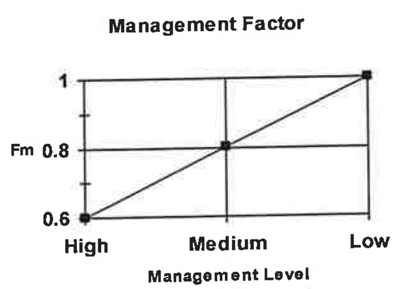
b. Determine first day for the month of the year when ET >= Ppt-

E = First Day of Month ET >= Ppt

E = **91** **Days**

c. **SPb** = 365 - (L - E) = 365 - (**243** - **91**)

Management Factor, Fm = **0.8**



Low Level, Fm = 1.0
...The operator does not utilize a waste management plan.
...Proper operation and maintenance may not be performed.

Medium Level, Fm = 0.8
...The operator utilizes an up-to-date waste management plan.
...Manure application equipment is calibrated for nutrient applications.
...Maintains adequate soil moisture for crop growth.
...Agronomic treatments which would maximize crop nutrient uptake are not fully utilized.
...Proper operation and maintenance is planned.

High Level, Fm = 0.6
...The operator utilizes an up-to-date waste management plan.
...Soil fertility testing is performed annually.
...Manure in storage is tested for nutrient concentrations.
...Records of time, rate and location of manure applications are maintained.
...Manure application equipment is calibrated for nutrient applications.
...Irrigation water management techniques are practiced.
...Crop nutrient uptake is maximized with appropriate agronomic treatments such as residue management, conservation crop rotation, crop variety selection, prescribed grazing, and pest management.
...Proper operation and maintenance is planned.

CLIENT: **Drahn- existing**
ASSISTED BY: **Scott Robbins**
CHECKED BY: **0**

Worksheet OR10A-7--Waste storage period determination

Soils Factor: Fs_{LIQUID} = **0.8** Fs_{SOLID} = **0.6**

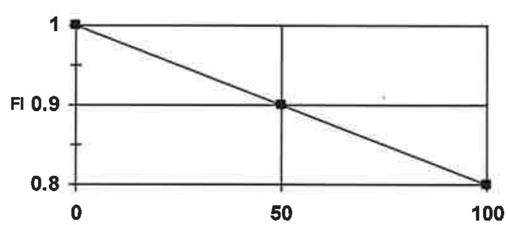
Soils must meet the following criteria for Fs to be less than 1.0-
- The average water holding capacity for the profile greater than 3.0 inches.
- A cation exchange capacity greater than 5 meq/100g of soil.
- Depth to a thin layer/cemented pan greater than 20 inches.
- Depth to high water table greater than 2 feet.
- A permeability greater than 0.06 inches/hr but less than 6 inches/hr.
- Cobbles less than 35% by weight in the surface layer.
- Stones and boulders less than 15% by weight in the surface

HSG	Soils Factor (Fs)			
	Consistency of Waste			
	Liquid	Slurry	Semi-Solid	Solid
A	1	0.95	0.9	0.8
B	0.8	0.75	0.7	0.6
C	0.9	0.85	0.8	0.7
D	1	1	0.95	0.85

HSG	Area	Fs_{LIQUID}	Wtd Fs_{LIQUID}	Fs_{SOLID}	Wtd Fs_{SOLID}
B	100	0.8	80	0.6	60
Total Weighted Fs_{LIQUID}=		0.8	Total Weighted Fs_{SOLID} =		0.6

Location Factor: Fl = **0.83**

Location Factor



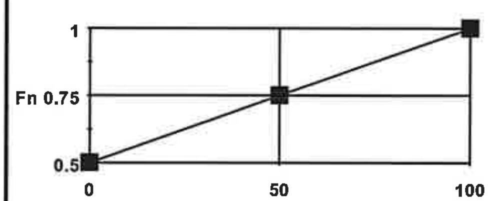
For an application area to be considered buffered there must be a 0 to 5 percent chance of flooding and the area must be at least 50 feet from water bodies, ground water sources(wells), and areas of concentrated flow. The percent buffered area(%BA) is determined by taking the total buffered area(TBA) and dividing it by the total land area(TLA) available for manure application.

$$\%BA = \frac{TBA}{TLA} \times 100\%$$

$$\%BA = \frac{9}{10} \times 100\% = \mathbf{87\%}$$

Nutrient Loading Factor: Fn = **1.10**

Nutrient Loading Factor



In order for the Nutrient Loading Factor, Fn to be less than 1, the Location Factor, Fl must be 0.95 or less.

The percent of annual nutrient requirement(%ANR) is determined by taking the total nutrients applied(TNA) annually and dividing it by the total nutrient requirements(TNR) of all of the
crops grown.

$$\%ANR = \frac{TNA}{TNR} \times 100\%$$

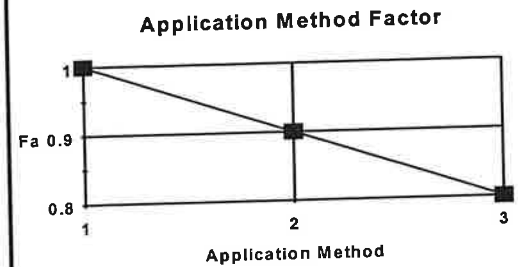
$$\%ANR = \frac{1,371}{1,145} \times 100\% = \mathbf{120\%}$$

CLIENT: Drahn- existing
ASSISTED BY: Scott Robbins

CHECKED BY: 0

Worksheet OR10A-7--Waste storage period determination

Application Method Factor: Fa_{LIQUID} = **0.90** Fa_{SOLID} = **1.00**



Method 1 - Surface applied solid manure, no incorporation.

Method 2 - Surface applied liquid manure, no incorporation.

Method 3 - Injection or immediate incorporation.

Adjusted Storage Period: ASP_{LIQUID} = **111** Days ASP_{SOLID} = **93** Days

ASP = SPb X Fm X Fs X Fl X Fn X Fa

ASP_{LIQUID} = 213 X 0.8 X 0.8 X 0.825242718446602 X 1.09886005787192 X 0.9

ASP_{SOLID} = 213 X 0.8 X 0.6 X 0.825242718446602 X 1.09886005787192 X 1

Adjusted earliest Day of Year for application, E_a = ASP - (365 - L)

$E_{a\ LIQUID}$ = -11

$E_{a\ SOLID}$ = -29

Storage Period: SP_{LIQUID} = **154** Days SP_{SOLID} = **154** Days

The storage period must span the seasonal flooding conditions and must also span frozen ground and snow conditions where the land slope exceeds 5% and a buffer strip of less than 100 feet exists next to open water courses that affect the application area-

a. Enter **L** from Sheet 1 and determine the Day of Year L_f when seasonal frozen ground, snow or flooding conditions are first anticipated for the application area-

L = **243** Days L_f = **365** Days

If L_f comes before L then $L_{sp} = L_f$
If L_f comes after L or there is no seasonal frozen ground, snow or flooding then L_{sp} = L

L_{sp} = **243** Days

b. Determine the Day of Year E_f when seasonal frozen ground, snow or flooded conditions are no longer anticipated for the application area-

E_f = **32** Days

If E_f comes after E_a then $E_{sp} = E_f$
If E_f comes before E_a or there is no seasonal frozen ground, snow or flooding then $E_{sp} = E_a$

$E_{sp\ LIQUID}$ = **32** Days $E_{sp\ SOLID}$ = **32** Days

c. SP_{LIQUID} = 365 - (Lsp - Esp LIQUID) = **154** Days

SP_{SOLID} = 365 - (L_{sp} - $E_{sp\ SOLID}$) = **154** Days

d. Earliest date (E_{sp}) for manure application (month-day):

$E_{sp\ LIQUID}$ = **February 4**

$E_{sp\ SOLID}$ = **February 1**

e. Latest date (L_{sp}) for manure application (month-day) = **September 31**

CLIENT: **Drahn- existing**
ASSISTED BY: **Scott Robbins**
CHECKED BY: **0**

Worksheet OR10A-7--Waste storage period determination

Day of Year Calendar

Day of month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	1	32	60	91	121	152	182	213	244	274	305	335
2	2	33	61	92	122	153	183	214	245	275	306	336
3	3	34	62	93	123	154	184	215	246	276	307	337
4	4	35	63	94	124	155	185	216	247	277	308	338
5	5	36	64	95	125	156	186	217	248	278	309	339
6	6	37	65	96	126	157	187	218	249	279	310	340
7	7	38	66	97	127	158	188	219	250	280	311	341
8	8	39	67	98	128	159	189	220	251	281	312	342
9	9	40	68	99	129	160	190	221	252	282	313	343
10	10	41	69	100	130	161	191	222	253	283	314	344
11	11	42	70	101	131	162	192	223	254	284	315	345
12	12	43	71	102	132	163	193	224	255	285	316	346
13	13	44	72	103	133	164	194	225	256	286	317	347
14	14	45	73	104	134	165	195	226	257	287	318	348
15	15	46	74	105	135	166	196	227	258	288	319	349
16	16	47	75	106	136	167	197	228	259	289	320	350
17	17	48	76	107	137	168	198	229	260	290	321	351
18	18	49	77	108	138	169	199	230	261	291	322	352
19	19	50	78	109	139	170	200	231	262	292	323	353
20	20	51	79	110	140	171	201	232	263	293	324	354
21	21	52	80	111	141	172	202	233	264	294	325	355
22	22	53	81	112	142	173	203	234	265	295	326	356
23	23	54	82	113	143	174	204	235	266	296	327	357
24	24	55	83	114	144	175	205	236	267	297	328	358
25	25	56	84	115	145	176	206	237	268	298	329	359
26	26	57	85	116	146	177	207	238	269	299	330	360
27	27	58	86	117	147	178	208	239	270	300	331	361
28	28	59	87	118	148	179	209	240	271	301	332	362
29	29		88	119	149	180	210	241	272	302	333	363
30	30		89	120	150	181	211	242	273	303	334	364
31	31		90		151		212	243		304		365

Irrigation Water Management for Drahnacres Farm

The Farm has a 100 gpm well and a 4" irrigation mainline to irrigate the fields. The sweet corn and vegetables are irrigated by hand move aluminum sprinkler pipe. The raspberries are drip irrigated and the apples and pears are also sprinkler irrigated. The cropland is irrigated as needed by monitoring soil moisture levels. The desired outcomes of the irrigation program are to:

- Manage soil moisture to promote the desired crop response.
- Efficiently use the water.
- Minimize irrigation induced erosion.
- Decrease non-point source pollution of surface and groundwater.
- Time irrigation applications to compliment manure applications.

U.S. Department of Agriculture
Natural Resources Conservation Service

FIRI WORKSHEET
Version 1.3

9/14/06
STATE: OREGON

FARM IRRIGATION RATING INDEX

CLIENT: Scott Drahn
ASSISTED BY: Scott Robbins
TRACT: 8712
CHECKED BY:
SOIL SURVEY AREA: Benton County

FIELD DATA

Field Name/Number	Acres	Crop	Net Irrigation Requirement, Inches	Soil	Basic Intake Rate, In/Hr
Field #1	1.8	GRAPES	11.29	Ch- CHEHALIS SICL	0.35

MANAGEMENT FACTORS	PRESENT Potential	PRESENT Actual	Year 1 Potential	Year 1 Actual	Year 2 Potential	Year 2 Actual	Year 3 Potential	Year 3 Actual
Method of Irrigation	Point Source Micro		Point Source Micro					
Efficiency	90%		90%					
Md - Water Measurement	1.00	0.92	1.00	0.92				
S- Soil Moisture/Scheduling	1.00	0.96	1.00	0.96				
I- Irrigation Skill & Action	1.00	0.97	1.00	0.97				
M- Maintenance	1.00	0.98	1.00	0.98				
D- Water Delivery	1.00	0.98	1.00	0.98				
Sc- Soil Condition	1.00	0.98	1.00	0.98				

SYSTEM FACTORS	PRESENT Potential	PRESENT Actual	Year 1 Potential	Year 1 Actual	Year 2 Potential	Year 2 Actual	Year 3 Potential	Year 3 Actual
Wc- Water Distribution Control	1.00	1.00	1.00	1.00				
Ce- Conveyance Efficiency	0.99	0.99	0.99	0.99				
L- Land Leveling	0.95	0.95	0.95	0.95				
C- Climatic	1.00	1.00	1.00	1.00				
Sd- Sprinkler Design	1.00	1.00	1.00	1.00				
W- Wind	1.00	1.00	1.00	1.00				
R- Tailwater Reuse	1.00	1.00	1.00	1.00				
E- Emitter Clogging	0.96	0.96	0.96	0.96				
T- Trickle Design	0.96	0.96	0.96	0.96				
Gross Irrigation Efficiency=	78%	63%	78%	63%				
Gross Irrigation Requirement, Inches=	14.47	17.95	14.47	17.95				
Total Acre Feet Required=	2.2	2.7	2.2	2.7				
% of Potential Efficiency=		81%		81%				
Seasonal Water Loss, Ft=	0.27	0.55	0.27	0.55				
Deep Percolation, Ft=	0.27	0.17	0.27	0.55				
Runoff, Ft=	0.00	0.39	0.00	0.00				
Water Conserved, Ft/Ac=			0.00	0.00				
Total Water Conserved, Ac-Ft			0.00	0.00				

NOTES:

DrahnFIRI.xls

FIRI WORKSHEET
Version 1.3

FARM IRRIGATION RATING INDEX

CLIENT: Scott Drahn
ASSISTED BY: Scott Robbins
TRACT: 8712
CHECKED BY:
SOIL SURVEY AREA: Benton County

FIELD DATA

Field Name/Number	Acres	Crop	Net Irrigation Requirement, Inches	Soil	Basic Intake Rate, In/Hr
Field #2	9.3	SWEET CORN	12.51	Cm- CLOQUATO SIL	0.35

MANAGEMENT FACTORS	PRESENT Potential	PRESENT Actual	Year 1 Potential	Year 1 Actual	Year 2 Potential	Year 2 Actual	Year 3 Potential	Year 3 Actual
Method of Irrigation	Hand Line or Wheel Line Spri							
Efficiency	70%							
Md - Water Measurement	1.00	0.54						
S- Soil Moisture/Scheduling	1.00	0.96						
I- Irrigation Skill & Action	1.00	0.97						
M- Maintenance	1.00	0.98						
D- Water Delivery	1.00	0.98						
Sc- Soil Condition	1.00	0.98						

SYSTEM FACTORS	PRESENT Potential	PRESENT Actual	Year 1 Potential	Year 1 Actual	Year 2 Potential	Year 2 Actual	Year 3 Potential	Year 3 Actual
Wc- Water Distribution Control	1.00	1.00						
Ce- Conveyance Efficiency	0.99	0.99						
L- Land Leveling	1.00	1.00						
C- Climatic	1.00	1.00						
Sd- Sprinkler Design	1.00	0.97						
W- Wind	1.00	1.00						
R- Tailwater Reuse	1.00	1.00						
E- Emitter Clogging Factor	1.00	1.00						
T- Trickle Design	1.00	1.00						
Gross Irrigation Efficiency=	69%	55%						
Gross Irrigation Requirement, Inches=	18.05	22.59						
Total Acre Feet Required=	14.0	17.5						
% of Potential Efficiency=		80%						
Seasonal Water Loss, Ft=	0.46	0.84						
Deep Percolation, Ft=	0.14	0.25						
Runoff, Ft=	0.32	0.59						
Water Conserved, Ft/Ac=								
Total Water Conserved, Ac-Ft								

NOTES:

U.S. Department of Agriculture
Natural Resources Conservation Service

FIRI WORKSHEET
Version 1.3

9/14/06
STATE: OREGON

FARM IRRIGATION RATING INDEX

CLIENT: Scott Drahn
ASSISTED BY: Scott Robbins
TRACT: 8712
CHECKED BY:
SOIL SURVEY AREA: Benton County

FIELD DATA

Field Name/Number	Acres	Crop	Net Irrigation Requirement, Inches	Soil	Basic Intake Rate, In/Hr
Field #3 and 4	2.1	ORCHARDS (W/COVER)	19.11	Cm- CLOQUATO SIL	0.35

MANAGEMENT FACTORS	PRESENT Potential	PRESENT Actual	Year 1 Potential	Year 1 Actual	Year 2 Potential	Year 2 Actual	Year 3 Potential	Year 3 Actual
Method of Irrigation	Hand Line or Wheel Line Spri							
Efficiency	70%							
Md - Water Measurement	1.00	0.94						
S- Soil Moisture/Scheduling	1.00	0.96						
I- Irrigation Skill & Action	1.00	0.97						
M- Maintenance	1.00	0.98						
D- Water Delivery	1.00	0.98						
Sc- Soil Condition	1.00	0.98						

SYSTEM FACTORS	PRESENT Potential	PRESENT Actual	Year 1 Potential	Year 1 Actual	Year 2 Potential	Year 2 Actual	Year 3 Potential	Year 3 Actual
Wc- Water Distribution Control	1.00	1.00						
Ce- Conveyance Efficiency	0.99	0.99						
L- Land Leveling	1.00	1.00						
C- Climatic	1.00	1.00						
Sd- Sprinkler Design	1.00	0.97						
W- Wind	1.00	1.00						
R- Tailwater Reuse	1.00	1.00						
E- Emitter Clogging Factor	1.00	1.00						
T- Trickle Design	1.00	1.00						
Gross Irrigation Efficiency=	69%	55%						
Gross Irrigation Requirement, Inches=	27.58	34.51						
Total Acre Feet Required=	4.8	6.0						
% of Potential Efficiency=		80%						
Seasonal Water Loss, Ft=	0.71	1.28						
Deep Percolation, Ft=	0.21	0.38						
Runoff, Ft=	0.49	0.90						
Water Conserved, Ft/Ac=								
Total Water Conserved, Ac-Ft								

NOTES:

U.S. Department of Agriculture
Natural Resources Conservation Service

FIRI WORKSHEET
Version 1.3

9/14/06
STATE: OREGON

FARM IRRIGATION RATING INDEX

CLIENT: Scott Drahn
ASSISTED BY: Scott Robbins
TRACT: 8712
CHECKED BY:
SOIL SURVEY AREA: Benton County

FIELD DATA

Field Name/Number	Acres	Crop	Net Irrigation Requirement, Inches	Soil	Basic Intake Rate, In/Hr
Field #4	15.0	ALFALFA	19.11	AbA- ABIQUA SICL	0.35

MANAGEMENT FACTORS	PRESENT		Year 1		Year 2		Year 3	
	Potential	Actual	Potential	Actual	Potential	Actual	Potential	Actual
Method of Irrigation								
Efficiency								
Md - Water Measurement								
S- Soil Moisture/Scheduling								
I- Irrigation Skill & Action								
M- Maintenance								
D- Water Delivery								
Sc- Soil Condition								

SYSTEM FACTORS	PRESENT		Year 1		Year 2		Year 3	
	Potential	Actual	Potential	Actual	Potential	Actual	Potential	Actual
Wc- Water Distribution Control								
Ce- Conveyance Efficiency								
L- Land Leveling								
C- Climatic								
Sd- Sprinkler Design								
W- Wind								
R- Tailwater Reuse								
E- Emitter Clogging Factor								
T- Trickle Design								
Gross Irrigation Efficiency=								
Gross Irrigation Requirement, Inches=								
Total Acre Feet Required=								
% of Potential Efficiency=								
Seasonal Water Loss, Ft=								
Deep Percolation, Ft=								
Runoff, Ft=								
Water Conserved, Ft/Ac=								
Total Water Conserved, Ac-Ft								

NOTES:

FARM IRRIGATION RATING INDEX

CLIENT: Scott Drahn
ASSISTED BY: Scott Robbins
TRACT: 8712
CHECKED BY:
SOIL SURVEY AREA: Benton County

FIELD DATA

Field Name/Number	Acres	Crop	Net Irrigation Requirement, Inches	Soil	Basic Intake Rate, In/Hr
Field #5	15.0	ALFALFA	19.11	AbA- ABIQUA SICL	0.35

MANAGEMENT FACTORS	PRESENT		Year 1		Year 2		Year 3	
	Potential	Actual	Potential	Actual	Potential	Actual	Potential	Actual
Method of Irrigation								
Efficiency								
Md - Water Measurement								
S- Soil Moisture/Scheduling								
I- Irrigation Skill & Action								
M- Maintenance								
D- Water Delivery								
Sc- Soil Condition								

SYSTEM FACTORS	PRESENT		Year 1		Year 2		Year 3	
	Potential	Actual	Potential	Actual	Potential	Actual	Potential	Actual
Wc- Water Distribution Control								
Ce- Conveyance Efficiency								
L- Land Leveling								
C- Climatic								
Sd- Sprinkler Design								
W- Wind								
R- Tailwater Reuse								
E- Emitter Clogging Factor								
T- Trickle Design								
Gross Irrigation Efficiency=								
Gross Irrigation Requirement, Inches=								
Total Acre Feet Required=								
% of Potential Efficiency=								
Seasonal Water Loss, Ft=								
Deep Percolation, Ft=								
Runoff, Ft=								
Water Conserved, Ft/Ac=								
Total Water Conserved, Ac-Ft								

NOTES:

Roof Runoff Operation and Maintenance (PS 558)

The following operation and maintenance applies to buildings with gutters and downspouts:

- Periodically check gutters, downspouts and all above ground pipelines, trash guards, pumps, structures, and appurtenances for proper operation. Repair or replace if needed.
- Periodically remove debris from gutters, downspouts and outlet facilities.
- Protect downspouts from damage by livestock and equipment. Repair or replace damaged components as needed.
- Keep gutters, downspouts, pumps, conveyance pipelines and ditches and appurtenances in good operating condition with O & M performed as per site specific recommendations for each component.

Manure Transfer Operation and Maintenance (PS 634)

Liquid Waste and Irrigation Pipelines

- Flush pipelines used for liquid waste application with clean water following waste application, or as need to prevent solid buildup/

- Drain the pipeline and components in areas that are subject to freezing. If parts of the pipeline cannot be drained, a non-toxic antifreeze solution may be added.

- Check to make sure all valves and air vents are set at the proper operating condition so they can provide protection to the pipeline.

- Inspect pipelines for signs of failure. Inspect risers and valves periodically for leaks or worn gaskets. Repair or replace pipeline, risers and valves as needed.

- Eradicate or otherwise remove all rodents or burrowing animals. Immediately repair any damage cause by their activity.

Pumps and agitators

- Operate and maintain pumps in accordance with good judgment and manufacturer's manuals and recommendations.

- Drain liquid manure from pumps during cold weather to prevent freezing. If parts of the system cannon be drained, a non-toxic antifreeze solution may be added.

- Inspect pumps periodically and remove debris wrapped around shafts and impellers. Maintain foot valves and check valves for proper operation.

- For proper operation of electric motors and controls, maintain lubrication for all bearings, keep electric panel free from obstructions and debris. Maintain electrical safety devices, assure all electrical contacts are tight, and lock electrical switch to the "OFF" position during the non-use season. Maintain adequate share and ventilation for pump motors.

- For proper operation of pumps, maintain lubrication for all bearings and pump shafts, assure belts are adjusted properly, maintain safety covering devices on open shafts and belt drives, check to make sure all safety devices are set at proper operating conditions so they provide protection to the pump and power unit. For centrifugal pumps, periodically measure tolerance between pump impeller and pump casing and replace wear ring as need to help restore new pump operating characteristics.

- Use portable pressure gauge (preferably a liquid filled gauge) to monitor pump performance.

- Operate and maintain agitators in accordance with the manufacturer's manual and recommendations. Inspect all plumbing at least annually.

- Replace, tighten or repair broken or loose connections and lines as needed.

Slabs and Curbs

- Periodically inspect concrete slabs and curbs, repair or replace broken sections as needed.

- Prevent manure from building up next to the curbs or flowing over them.

WASTE UTILIZATION WORKSHEET

Waste Application Record

Name: Scott Drahn Field ID: ____________

Crop: ____________ Acres: ____________ Seeding Date: ____________

Date	Crop Stage	**Waste Type** Liquids **(L)**, Solids **(S)**, Separated Solids **(SS)**, Etc.	**Amount Applied** (Loads, Inches, Tons, Hours of Operation, Etc.)	Notes

Worksheet FD5: **Nutrient Application Equipment Description**

Equipment	*Description*	*Flow Rate (gpm)/Volume (CF or Gal)*	*Spread Area (ft)*
Big Gun Sprinkler			
Tractor Spreader			
Tank Wagon			
Other			

Worksheet FD6: **Fields and Crops Receiving Manure/Organic Application**

Field Number/ Name	*Crop*	*Acres*	*Present Yield (units/acre)*	*Target Yield (units/acre)*	*Crop Condition (Good, Fair, Poor)*

EM 8724 • January 1999 $2.00

Annual Manure Application Schedule for Western Oregon

M. Gangwer, B. Wilson, and M. Gamroth

The overall objective of manure management should be to take as many excretable manure nutrients to the soil and have them used by plants for optimal crop yield. This reduces the need to purchase feed and inorganic fertilizer. The usual outcome of manure management is finding as many acres as possible for manure application. Manure application scheduling depends on the type of manure.

Apply *liquid manure* on a schedule that provides nutrients in the soil root zone in anticipation of crop growth. Apply when soils are at field capacity or less moisture content, i.e., some air space exists in the topsoil. (See Figure 1.) There are several ways to measure soil moisture. You can squeeze a handful of soil and see whether it clumps together. If it does, it probably is at least at field capacity. If water runs out of your hands, then the soil probably is near or at complete soil saturation. You also can measure soil moisture with portable soil meters, tensiometers, watermarks, or other sensory devices.

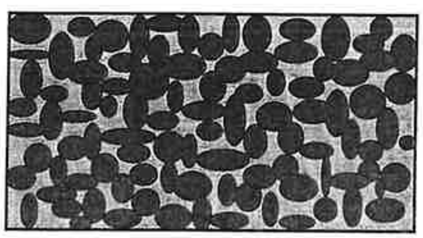
Apply *solid manure* in such a manner that it will not leave the field surface during rainfall events or flooding.

Spring and summer are the best times for manure application. Empty all storage facilities by October 1 of every year in preparation for the winter storage season.

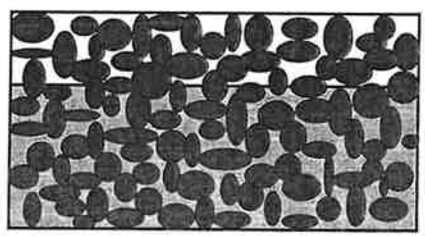
Soil testing is an important part of manure application scheduling. A fall test is especially important as it serves as a report card to evaluate crop yield during the previous growing period in relationship to plant-available nutrients, especially nitrate-N. If excessive soil nutrients (N, P, K) are measured, plan a strategy for reducing these values by reducing manure application, changing crop variety, and/or increasing yield.

Soil tests also help you decide where to apply manure. They help show whether you are distributing manure on enough crop acres to result in optimal crop yield per acre. Placing too many manure nutrients on too few acres results in excess soil concentrations and reduced nutrients used for crop growth.

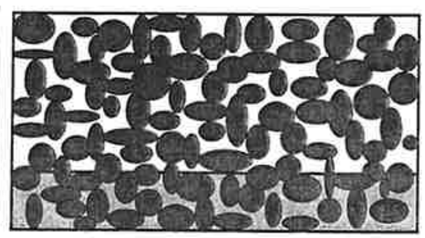
Figure 1.—*Topsoil profile:* ***blue*** *indicates soil moisture,* ***white*** *indicates air space (capacity for liquid to fill), and soil particles are* ***brown.***



Probable fall/winter soils
- 100% saturated
- Apply minimal solids.
- **Do not apply liquid.**



Probable spring/fall soils
- Typical field capacity
- Apply solids.
- **Apply minimal liquid/ application.**



Probable summer soils
- Typical wilting coefficient
- Apply solids.
- **Apply liquid.**

OREGON STATE UNIVERSITY EXTENSION SERVICE

Mike Gangwer, Extension agent, Marion County; Bruce Wilson, conservation planning engineer, USDA-NRCS; and Mike Gamroth, Extension dairy specialist; Oregon State University.

Agronomic considerations

Nitrogen (N)

Take a fall soil sample from manured fields. Any concentration of 100 lb (27 ppm) nitrate-N or higher is excessive and indicates less agronomic uptake than the sum of organic mineralization, fertilizer input, and manure application. A goal for this report card test is 55 lb (15 ppm) soil nitrate-N in the top foot. Reduce manure application the following year and increase crop yield (or change the crop) in order to reduce fall nitrate-N.

A spring nitrate-N analysis generally is not required because winter rainfall, high water tables, and denitrification leach nitrate-N out of the soil. A cover/relay/double crop or permanent grass will scavenge some of this leftover nitrate-N.

A spring application of manure-N is highly recommended due to the winter losses. This application is especially important for annual and perennial grass. In corn fields, the pre-sidedress soil nitrate test (PSNT) will indicate whether further manure is required.

Manure excretion N is half organic and half ammonium. There is no nitrate in manure.

Phosphorus (P)

You can take a soil test for P at any time. The soil test for P shows extractable P, or plant-available P. It indicates the amount of P in the soil that can be used for plant growth at a given time. Heavily manured fields usually have higher levels of soil test P than do nonmanured fields.

Any concentration of 100 ppm or higher of soil test P is excessive. Do not add P to these fields. However, storage pond supernatent contains very little manure P; applications can be made based on N or K requirement.

If soil test P is excessive, reduce manure application the following year so P can be mined out of the soil by plants. However, fields with high levels of organic matter can buffer P so that soil test P does not drop rapidly. Mining will occur slowly in these fields.

Excessive P in the soil in any form can have a negative impact on water quality if soil erosion moves topsoil into surface waters, carrying with it all forms of soil P. Excessive P in surface water increases aquatic plant growth and reduces the amount of oxygen in the water available for fish.

Potassium (K)

You can take a soil test for K at any time. The soil test for K indicates plant-available K. Heavily manured fields usually have a higher level of K, especially fields receiving liquid manure.

Any concentration of 800 ppm or higher of plant-available K is excessive. Problems with excessive K in the soil can cause high plant K concentrations that can have a negative impact on herd health, especially in fresh and early lactating cows. Excessive K, if leached into groundwater, can increase the salt concentration of water. Also, like sodium, excessive K can reduce water infiltration through soil by hanging onto water.

Therefore, managing K on the basis of ration makeup is a good strategy. If feeds low in K are needed for a particular ration, you may need to avoid applying liquid manure on one field until K is mined out.

For more information

See page 3 for ordering instructions.

Assessing the Risk of Groundwater Contamination from Livestock Manure Management Worksheet, EM 8596 (1995). $1.00

Calculating the Fertilizer Value of Manure from Livestock Operations, EC 1094 (revised 1991, reprinted 1993). $1.00

Date, Rate, and Place: The Field Book for Dairy Manure Applicators, PNW 506 (1998). $5.50

Manure Management in Small Farm Livestock Operations: Protecting Surface and Groundwater, EM 8649 (published 1996, reprinted 1997). $1.75

Manure Management Practices to Reduce Water Pollution, FS 281 (published 1982, reprinted 1993). No charge.

Nutrient Management for Dairy Production: Assessing Your Manure Management for Water Quality Risk, EM 8646 (1996). 75¢

Nutrient Management for Dairy Production: Dairy Manure as a Fertilizer Source, EM 8586 (published 1995, reprinted 1997). $1.00

Nutrient Management for Dairy Production: Manure Application Rates for Forage Production, EM 8585 (published 1996, reprinted 1997). $1.00

Nutrient Management for Dairy Production: The Pre-Sidedress Soil Nitrate Test (PSNT) for Western Oregon and Western Washington, EM 8650 (published 1996, reprinted 1997). 75¢

Nutrient Management for Dairy Production: Which Test Is Best? Customizing Dairy Manure Nutrient Testing, PNW 505 (1997). $2.00

Reducing the risk of Groundwater Contamination from Livestock Manure Management, EM 8597 (1995). $1.25

Ordering instructions

To order copies of the publications listed under "For more information," send the publication's complete title and series number, along with a check or money order for the amount listed (payable to Oregon State University), to:

Publication Orders
Extension & Station Communications
Oregon State University
422 Kerr Administration
Corvallis, OR 97331-2119
Fax: 541-737-0817

You may order up to six no-charge publications without charge. If you request seven or more no-charge publications, include 25 cents for each publication beyond six.

If you would like additional copies of this publication, *Annual Manure Application Schedule for Western Oregon*, EM 8724, send $2.00 per copy to the above address.

We offer discounts on orders of 100 or more copies of a single title. Please call 541-737-2513 for price quotes.

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Published January 1999.

Summary

- Apply liquid manure on a schedule that provides nutrients in the soil root zone in anticipation of crop growth.
- Apply liquid manure when soils are at field capacity or less moisture content, i.e., some air space exists in the topsoil. A soil moisture sensor/meter or field hand-grab sample is useful.
- Apply solid manure in such a manner that it will not leave the field surface during rainfall events or flooding.
- Empty all storage facilities of any size by October 1 of every year.
- Use soil testing, especially the fall test, as a report card to evaluate crop yield during the previous growing period in relationship to plant-available nutrients, especially nitrate-N.
- If excessive soil nutrients (N, P, K) are measured, plan a strategy for reducing these values by reducing manure application, changing crop variety, and/or increasing yield.
- Soil tests will help you decide where to apply manure. They will help show whether you are distributing manure on enough crop acres to result in optimal crop yield per acre. Placing too many manure nutrients on too few acres results in excess soil concentrations and reduced nutrients used for crop growth.
- The overall objective of manure management should be to take as many excretable manure nutrients to the soil and have them used by plants for optimal crop yield. This reduces the need to purchase feed and inorganic fertilizer. The usual outcome of manure management is finding as many acres as possible for manure application.

Example Manure Application Calendar

Sample liquid manure application dates are indicated with orange. Solids application dates are underlined. Actual application dates will be determined by weather and soil conditions.

Winter

January

1 2
3 4 5 6 7 8 9
10 11 12 13 14 15 16
17 18 19 20 21 22 23
24 25 26 27 28 29 30
31

February

1 2 3 4 5 6
7 8 9 10 11 12 13
14 15 16 17 18 19 20
21 22 23 24 25 26 27
28

March

1 2 3 4 5 6
7 8 9 10 11 12 13
14 15 16 17 18 19 20
21 22 23 24 25 26 27
28 29 30 31

- Apply liquid when soil is at field capacity or less moisture content.
- Apply solids when application will not leave the surface during heavy rainfall.
- Do not apply liquid to bare fields.
- Do not apply liquid to fields with a high or perched water table.
- Do not apply liquid to fields with soggy soils or to flooded fields.
- Identify "go-to fields" every winter that are better drained and have crop biomass.

Likely application days

	Liquid	Solid
January	6	15
February	10	18
March	15	24

Spring

April

1 2 3
4 5 6 7 8 9 10
11 12 13 14 15 16 17
18 19 20 21 22 23 24
25 26 27 28 29 30

May

1
2 3 4 5 6 7 8
9 10 11 12 13 14 15
16 17 18 19 20 21 22
23 24 25 26 27 28 29
30 31

June

1 2 3 4 5
6 7 8 9 10 11 12
13 14 15 16 17 18 19
20 21 22 23 24 25 26
27 28 29 30 31

- Apply liquid when soil is at field capacity or less moisture content.
- Apply solids any time.
- Use this season for liquid pumping on all crop ground.
- Liquids can be applied to bare ground.
- Liquids can be applied to fields with high or perched water tables and to fields that have soggy soils but have drained.
- Use this season for emptying accumulated manure fines-solids in all ponds.
- This is the season for more frequent, but light-rate, applications.

Likely application days

	Liquid	Solid
April	20	30
May	24	30
June	24	27

Summer

July

1 2 3
4 5 6 7 8 9 10
11 12 13 14 15 16 17
18 19 20 21 22 23 24
25 26 27 28 29 30 31

August

1 2 3 4 5 6 7
8 9 10 11 12 13 14
15 16 17 18 19 20 21
22 23 24 25 26 27 28
29 30 31

September

1 2 3 4
5 6 7 8 9 10 11
12 13 14 15 16 17 18
19 20 21 22 23 24 25
26 27 28 29 30

- Apply liquid when soil is at field capacity or less moisture content.
- Apply solids any time.
- Use this season for liquid pumping on grass and corn (use PSNT).
- Liquids can be applied to postharvest fields of any kind, especially nonmanured fields of grains or grass seed.
- All storage facilities should be drawn down (pumped out) in preparation for the winter storage season.

Likely application days

	Liquid	Solid
July	15	27
August	12	20
September	10	15

Fall

October

1 2
3 4 5 6 7 8 9
10 11 12 13 14 15 16
17 18 19 20 21 22 23
24 25 26 27 28 29 30
31

November

1 2 3 4 5 6
7 8 9 10 11 12 13
14 15 16 17 18 19 20
21 22 23 24 25 26 27
28 29 30

December

1 2 3 4
5 6 7 8 9 10 11
12 13 14 15 16 17 18
19 20 21 22 23 24 25
26 27 28 29 30 31

- Apply liquid when soil is at field capacity or less moisture content.
- Apply solids when application will not leave the surface during heavy rainfall.
- Do not apply liquid to bare fields.
- Do not apply liquids to fields with high or perched water tables.
- Do not apply liquids to fields with soggy soils or those that are likely to flood.
- Apply liquids to fields with plant biomass such as a double crop.
- Use this season primarily for liquid storage.

Likely application days

	Liquid	Solid
October	6	6
November	3	6
December	3	4

EM 8649 • Reprinted May 1997
$1.75

Manure Management in Small Farm Livestock Operations

Protecting surface and groundwater

D. Godwin and J.A. Moore

Clean, safe water for consumption, recreation, irrigation, manufacturing, and fish and wildlife habitat is important to Oregonians. Nonpoint source pollution is the major cause of water quality degradation in Oregon.

Nonpoint source pollution is an accumulation of small pollution sources and single pollution events that, as a whole, cause significant degradation to water quality. For example, runoff water may carry small amounts of soil particles, pesticides, nutrients, or bacteria from several land areas (Figure 1).

When combined in a water source, these small amounts of pollution add up to a large problem. Proper management of these potential pollution sources is needed to maintain clean and usable water resources.

Many Oregonians own small acreages and raise a few livestock, for example, cattle, horses, pigs, sheep, goats, llamas, or chickens. These owners can enhance their farm's productivity by managing manure as a soil amendment. Manure is a source of nitrogen,

Figure 1.—Utilizing Best Management Practices allows small farms to protect surface and groundwater.

Derek Godwin, Extension agent, Curry County; and J.A. Moore, Extension bioresource engineer; Oregon State University.

OREGON STATE UNIVERSITY EXTENSION SERVICE

phosphorus, potassium, and many micronutrients that can increase soil fertility. It also is a source of organic matter, which can improve soil water-holding capacity and tilth.

If not managed properly, however, manure can contribute significantly to pollution. Excess nutrients, disease-causing organisms, and organic matter from manure can contaminate surface and groundwater.

The following sections discuss manure as a pollution source, how its constituents can contaminate surface and groundwater, and what practices can help prevent pollution. Best management practices (BMPs) that can help you protect water quality and maintain your farm's productivity are outlined. Additional sources of information and assistance also are listed.

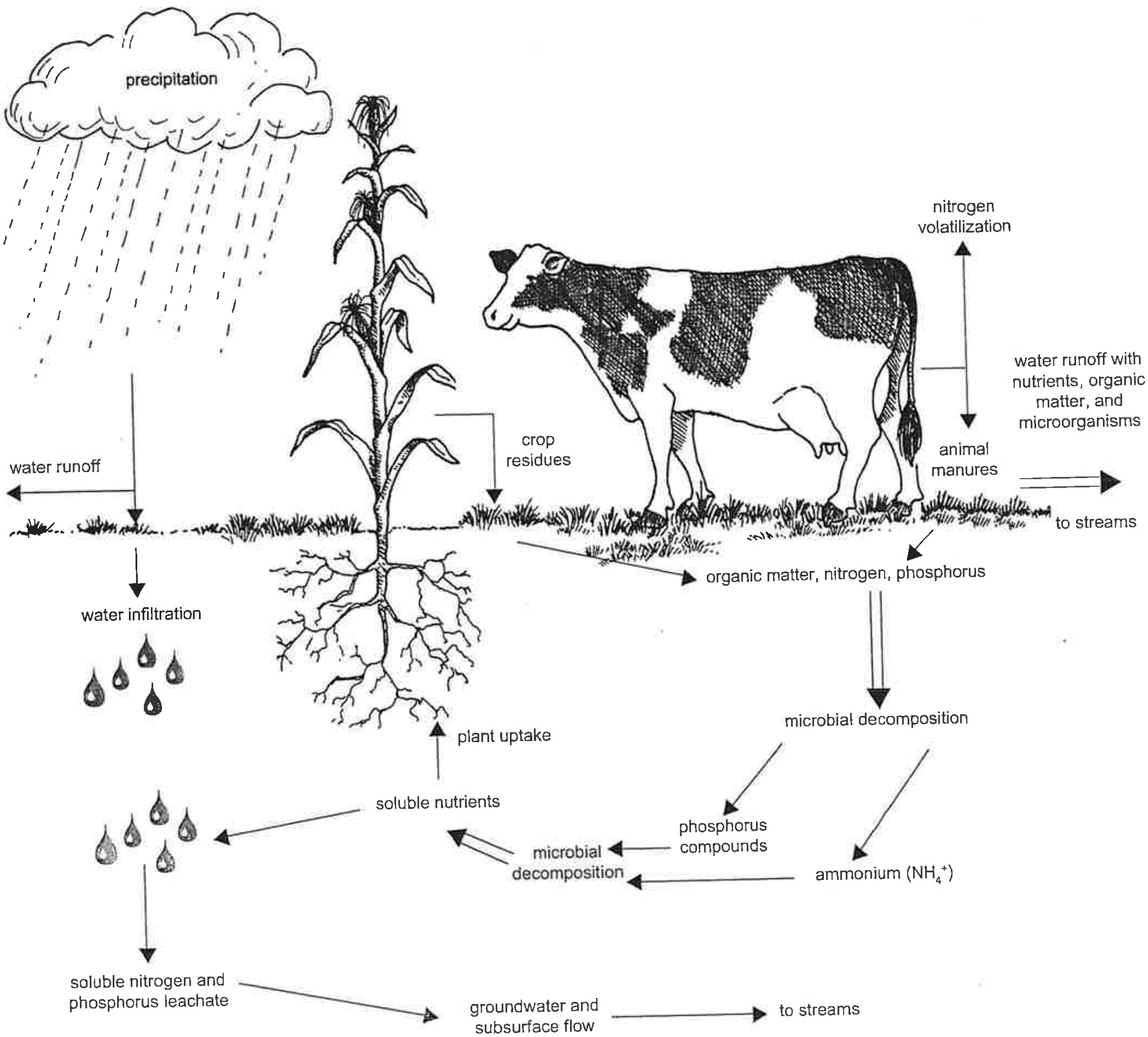

Figure 2.—Organic nitrogen and phosphorus in soil are converted through microbial decomposition to plant-available forms, which are taken up by growing plants. Nutrients also can be lost through volatilization, surface runoff, and leaching to groundwater.

Manure as a source of . . .

. . . Plant nutrients

The nitrogen in fresh manure is in the form of ammonia and organic nitrogen. The organic nitrogen is in particles such as hay and grain (organic matter).

In the soil, microorganisms convert the ammonia and organic nitrogen to nitrate (NO_3), which is readily available to plants (Figure 2). The conversion of ammonia to nitrate usually occurs quickly, providing an immediate nutrient source for plants. The conversion of organic nitrogen to nitrate occurs more slowly, providing a nutrient source over time.

Nitrate is water soluble and moves easily with water in the soil. It can move below the root zone to contaminate a water supply.

Most of the phosphorus in manure is in the form of large organic molecules. When you apply manure to soil, the organic phosphorus binds to soil particles and is immobilized. Once immobilized, it slowly becomes available to plants as phosphate (PO_4).

Phosphorus also can travel with eroded soil particles in runoff to surface waters, or can dissolve and leach to groundwater. In surface water, phosphorus stimulates the growth of algae. Excess algae growth can deplete dissolved oxygen, change the taste of the water, and cause discoloration.

. . . Microorganisms

Microorganisms abound in animal intestinal tracts, and many are excreted in manure. A few of these organisms can cause disease in humans and livestock.

These disease-causing organisms (pathogens) can live in and move with water. In surface waters, many settle into a stream's sediments, live there for extended periods of time, and are resuspended when the water is disturbed.

However, when pathogens are carried with water into the soil, they usually are filtered out and die. This natural filtering process protects groundwater.

. . . Organic matter

Manure contains organic matter, which serves as a food source for microorganisms. As microorganisms break down organic matter, they consume oxygen. When large amounts of organic matter are broken down in streams or ponds, the microorganisms use all the dissolved oxygen, and fish and other aquatic animals that need oxygen die.

Water pathways

The main concern is to keep manure out of water pathways so its constituents aren't carried to surface and groundwater. Livestock owners should pay attention to how water moves across their pasture and around buildings.

Water flows downhill over the surface toward the areas of lowest elevation, or it enters the soil and travels down toward the groundwater. Any low, wet areas or drainage-ways can be sources of both surface and groundwater.

Runoff occurs when rainfall or irrigation intensity exceeds the rate at which water can enter the soil (infiltration rate). Sandy soils have large soil particles and pore spaces and can accept water at a faster rate than clay soils (smaller particles and pore spaces).

Some areas around buildings, such as soils compacted by animal or machine traffic, have very low infiltration rates. These areas produce runoff under most storm conditions. Roofs and paved areas provide no infiltration. These areas produce runoff under all storm conditions, in turn increasing the amount and rate of water that runs off of nearby areas.

In the summer, when soils are drier, it may take several heavy rainfalls to cause surface runoff; however, in winter, when soils already are wet, a single small rain can cause runoff. The amount of rainfall necessary to cause runoff also depends on the surface slope. There is more runoff from steeper slopes.

Potential pollution problems and their Best Management Practices

Manure deposited in streams or on stream banks

Allow animal access to only small sections of streams.

You can use fences to limit access. Water gaps are fenced openings that allow animals to drink in a stream (Figure 3). However, in areas that experience high rainfall rates and flooding, such as the Oregon Coast, high maintenance demands limit the use of water gaps.

Provide alternate watering areas away from streams.

A water tank at an easily accessible location can greatly reduce the amount of time animals spend in a creek (Figure 4). Place the tank in or close to the animals' normal path toward the creek. Water can be pumped or gravity-fed to the tank.

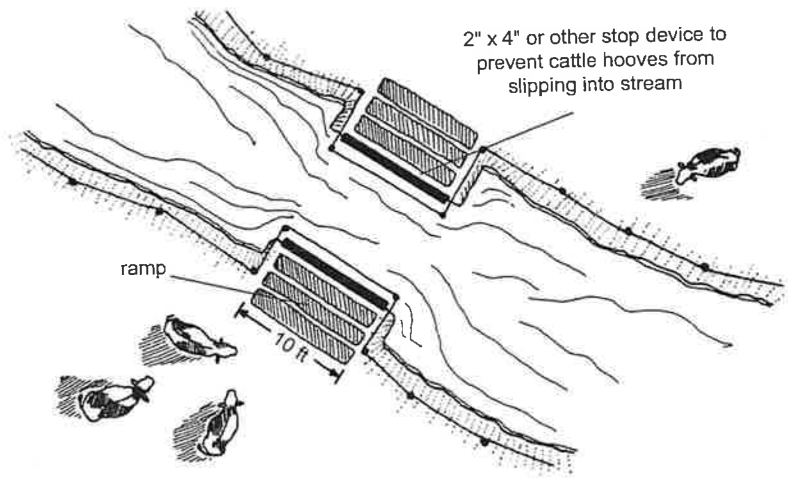

Figure 3.—Limit stream access to small areas for watering.

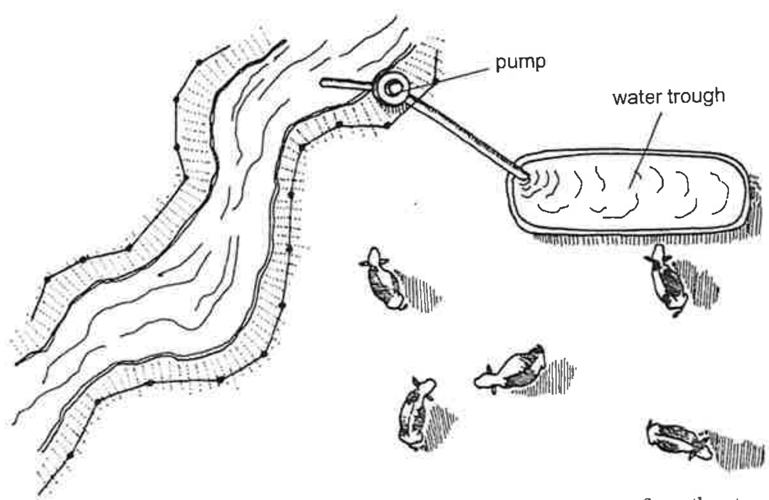

Figure 4.—Gravity flow or pumped water provides a drinking area away from the stream bank.

Overgrazing or high traffic areas next to water sources

Maintain healthy riparian vegetation and/or vegetated filter strips along streams.

The plants that grow in wet areas next to streams are called *riparian vegetation* (Figure 5). They provide shade, habitat, and food for fish and wildlife. *Vegetated filter strips* are protected areas planted to grass that are located next to creeks, winter turnout areas, impervious areas, and manure storage piles.

Riparian vegetation and vegetated strips slow runoff; increase infiltration; and filter microorganisms, nitrogen, phosphorus, organic matter, and sediment from small-volume surface runoff. When runoff volume is high, with flow depths of 2 to 3 inches, the ability to filter pollutants is greatly reduced.

Subdivide non-vegetated and impermeable areas greater than 1 acre with filter strips. The width needed for an effective filter strip varies with the size and slope of the area draining toward the strip. Recommended widths are:

- 25–50 feet for 0–3 percent slopes
- 50–100 feet for 3–8 percent slopes
- More than 100 feet for steeper slopes

The use of a vegetated earthen berm or diversion ditch greatly enhances the filtering ability of the strip. These should drain onto other vegetated areas for further filtering.

Protect all filter strips from excessive animal use, especially during wet seasons. You can mow filter strips, but don't mow them real short.

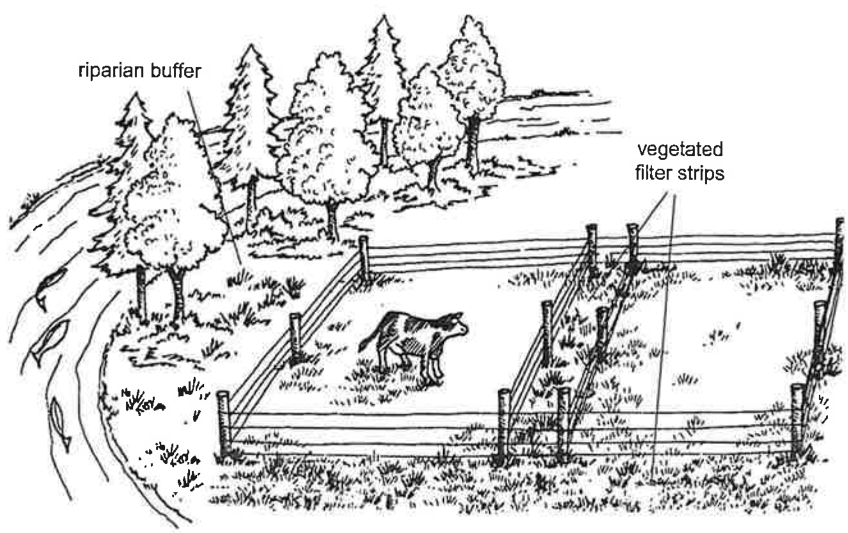

Figure 5.—Use vegetated filter strips to slow runoff, increase infiltration, and filter pollutants from runoff water.

Uncontained manure and mud in wet weather

Keep manure piles protected from rain and surface runoff.

Place the storage on high, well-drained ground away from surface water sources. Cover all manure and soiled bedding, and protect them from runoff (Figure 6). There are several ways to cover manure piles—from a simple pinned-down tarp, to a storage area with a roof and concrete floor.

Make sure your storage either contains the liquids or provides a drain to move runoff to soils and vegetation that can adequately filter leachate.

Calculate the amount of manure produced and bedding used during the storage period in order to design an adequate-size storage area. For help, refer to EC 1094, *Calculating the Fertilizer Value of Manure*. In Western Oregon, a storage length of 120 days usually is adequate to allow spreading the manure on unsaturated soil when the pasture is growing.

Keep clean runoff from flowing through livestock facilities and manure storage piles.

Reduce the amount of contaminated water to be handled by providing gutters and down spouts that move clean roof runoff away from buildings and storage areas. Create diversion ditches or earthen berms that move clean water away from livestock facilities.

Control grazing and keep livestock off pastures in the winter.

Overgrazed pastures are potential sources of surface runoff and groundwater contamination due to compacted soils and lack of filtering vegetation. Cross-fencing the pasture into smaller paddocks and controlling livestock grazing and movement can help maintain healthy, vigorous forage plants.

Because soils are wet and pasture growth is minimal during the winter, pastures will be overgrazed and physically torn up if livestock are left out. Keep livestock in small winter holding areas and collect their manure. In high rainfall areas, it is necessary to place material such as chips above the soil to keep animals out of the mud. You can use gravel, but it is difficult to keep rocks out of the pasture when you clean out the manure and haul it to your fields in the spring.

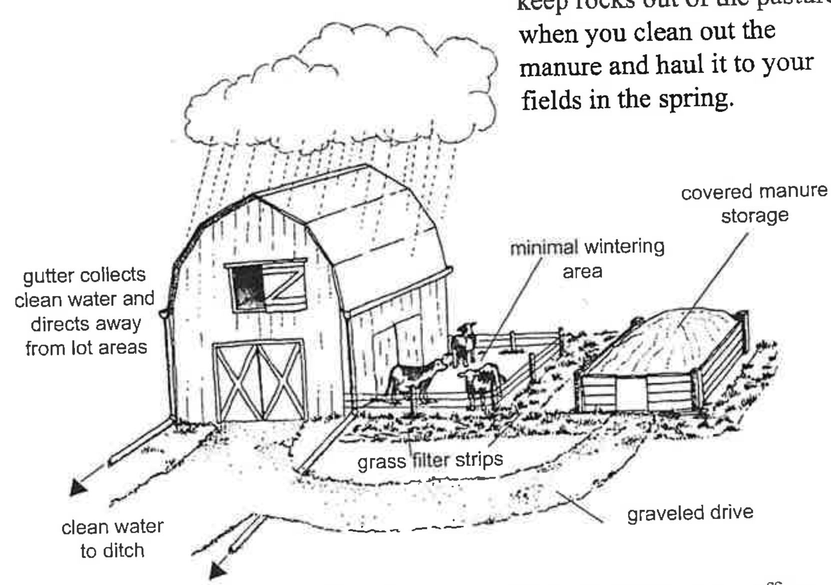

Figure 6.—Careful management of grazing, manure storage, and clean water runoff can protect surface and groundwater from contamination during wet weather.

Excessive nutrients on a pasture

Collect and store manure in winter, then spread it on pastures when plants are growing.

Spread the manure on pastures in the spring or early summer when there is little chance of runoff and growing plants can readily use nutrients.

Stored manure, with or without bedding, provides food and a place for bacteria to grow, thus making it a readily compostible material. Composting kills most disease-causing organisms, reduces the manure pile size, and provides a more stable nitrogen source that greatly reduces the possibility of leaching. Consult your county office of the OSU Extension Service for more information about composting.

Apply manure and fertilizer based on crop needs.

Spreading manure from one 1,000-lb cow, three 150-lb pigs, or twelve 100-lb sheep on 1 acre of pasture may provide the yearly phosphorus requirement for the plants (Table 1). If you apply manure based on pasture grass nitrogen needs only, you may apply excess phosphorus, which will be available for runoff and leaching. In this case, apply manure at the rate needed to supply P and purchase supplemental N fertilizer to meet crop nitrogen needs. Worksheets for calculating the fertilizer value of manure and land area required for application are available from the OSU Extension Service and other agencies.

Table 1.—Daily manure production and nutrient content of manure from various farm animals.

Animal	Animal size (lb)	Manure production (cu ft)	N (lb)	P (lb)
Dairy	150	0.19	0.06	0.011
	250	0.32	0.11	0.023
	500	0.66	0.22	0.047
	1,000	1.32	0.45	0.094
	1,400	1.85	0.59	0.131
Beef				
Cattle	500	0.50	0.17	0.051
	750	0.75	0.26	0.079
	1,000	1.0	0.34	0.109
	1,250	1.2	0.43	0.12
Cow		1.05	0.36	0.11
Swine				
Nursery pig	35	0.038	0.018	0.0052
Growing pig	65	0.070	0.034	0.0099
Finishing pig	150	0.16	0.078	0.023
	200	0.22	0.104	0.036
Gestate sow	275	0.15	0.069	0.023
Sow and litter	375	0.21	0.1	0.031
Boar	350	0.19	0.081	0.023
Sheep	100	0.062	0.045	0.0066
Poultry				
Layers	4	0.0035	0.0034	0.0012
Broilers	2	0.0024	0.0024	0.0006
Horse	1,000	0.75	0.31	0.072

The next step

Proper manure management starts with identifying existing and potential pollution problem areas. The next step is to plan and develop manure management techniques to reduce the impacts on surface and groundwater. The following agencies can help:

- Oregon State University Extension Service
- Natural Resource Conservation Service (NRCS)
- Farm Services Agency (FSA)
- Soil and Water Conservation District (SWCD)
- Oregon Department of Agriculture (ODA)

These agencies can help you select BMPs for your livestock operation. They also have information on pasture renovation and management, soil testing, and well-water testing. FSA also provides a Water Quality Incentives Program, which can offset part of the cost of these tests and improve overall farm management, as well as some cost-sharing opportunities for building livestock manure-handling facilities.

You make a difference

Proper management of livestock waste usually can be accomplished with minimum investment. Your efforts do make a difference.

For more information

OSU Extension publications

Assessing your Manure Management for Water Quality Risk, EM 8646, by M. Gamroth and J. Moore (Oregon State University, Corvallis, 1996). 75¢

Calculating the Fertilizer Value of Manure from Livestock Operations, EC 1094, by J. Moore and M. Gamroth (Oregon State University, Corvallis, reprinted 1993). $1.00

Dairy Manure as a Fertilizer Source, EM 8586, by J. Hart, M. Gangwer, M. Graham, and E. Marx (Oregon State University, Corvallis, reprinted 1996). 75¢

Livestock Manure Management Worksheet, EM 8596, by R. Miner (Oregon State University, Corvallis, 1995). $1.00

Livestock Manure Management Fact Sheet, EM 8597, by R. Miner (Oregon State University, Corvallis, 1995). $1.25

Manure Application Rates for Forage Production, EM 8585, by J. Hart, E. Marx, and M. Gangwer (Oregon State University, Corvallis, 1996). $1.00

Manure Management Practices to Reduce Water Pollution, FS 281, by J. Moore and T. Willrich (Oregon State University, Corvallis, reprinted 1993). No charge.

To order copies of the above publications, or additional copies of this publication, send the complete title and series number, along with a check or money order for the amount listed, to:

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Other publications

The Midwest Plan Service has a number of publications on livestock facilities, manure storage and treatment, etc. These publications can be purchased at OSU Extension county offices or from OSU's Bioresource Engineering Department in Corvallis.

EC 1094 Reprinted November 1993

$1.00

Calculating the fertilizer value of manure from livestock operations

J.A. Moore and M.J. Gamroth

Livestock producers know that manure can be applied to croplands as a soil amendment as well as a fertilizer. This publication outlines a method for calculating appropriate manure application rates for particular crops and soil conditions. It also identifies losses of nutrients that can occur at different stages in the management and application system—from collection, through storage, to land application.

The values represent the best available knowledge that we can suggest over a statewide area. Where you have specific values, such as from manure or soil analyses, you're encouraged to use them. A worksheet and example are included for your use (pages 6-7).

Benefits

Increased crop production can result when you add the nutrients contained in manure. A manure slurry will also provide some water to the soil. Adding manure to soil can lessen wind and water erosion, improve soil aeration and tilth, increase soil organic matter, and promote the growth of microorganisms that are beneficial to crops.

Hazards

On the other hand, excess applications of manure can be harmful to crops, soil, surface and ground water quality. In some cases (most commonly with fresh poultry manure) manure with high nitrogen content can burn crops. Heavy applications of manure also can cause excess accumulation of soluble salts in the soil, especially in some of eastern Oregon's arid regions, where little or no leaching occurs.

High salt content in soil can decrease water availability, which inhibits plant growth. In addition, a large volume of manure in one application can cause temporary soil sealing, particularly in low spots. Soil sealing increases the potential hazard of manure runoff with any subsequent rainfall.

Plant nutrient content of manure

A laboratory analysis of a representative manure sample will determine its nitrogen, phosphorus, and potassium (N-P-K) content. You can then calculate the economic value of the manure according to its plant nutrient content. Although other nutrients and trace elements in the manure are beneficial to crops, it's difficult to determine the value of that benefit.

James A. Moore, Extension agricultural engineer, and Michael J. Gamroth, Extension dairy specialist, Oregon State University, prepared this revision from a version written by Moore and the late Ted L. Willrich, professor emeritus of agricultural engineering, Oregon State University.

Sample the manure to determine the concentration of nutrients in storage. In liquid tanks, mix thoroughly before sampling or sample at different places in the storage unit to get a representative value. Mix these together and put a sample in a plastic jug or jar with a screw lid.

Keep the sample in a cool location to prevent gas buildup and rupture of the container. A local feed store, county health department, or your county Extension agent can help you locate a laboratory that will analyze the sample.

Some studies have been conducted on the production and nutrient content of fresh manures from farm animals (table 1). To find the total weight originally available, multiply the nutrient value from table 1 times the number of animals times the number of days the manure has been collected and stored.

For a portion of the year, the animals may spend part of a day in an area where the manure will be collected, and the rest of the day out on pasture. When this applies, adjust the production values accordingly. For that period when the animals are pastured, use the grazing option to account for the nutrients handled in that way. Be sure to account for the manure produced for 365 days.

Nutrient losses during collection and storage

Nutrient losses from manure occur in collection, during storage, while spreading, and after land application. These losses vary widely—under some conditions, up to 70 or 80% of the initial concentration will be lost. Table 2 lists the percentage of original nutrient concentrations retained by various collection and storage methods. These values represent a range of values, and yours could be higher or lower, depending on several factors.

In addition to the frequency and method of manure collection, the type of animal housing and handling system affects the final nutrient composition by influencing the addition of bedding, wastewater, and other materials.

The duration, type, and location of storage also affect the final concentrations of nutrients in manure. Covered storage units generally are cooler and have less biological activity than open units. This usually means smaller losses from these units. Open storage units are subjected to precipitation, resulting in leaching and runoff. Less nitrogen, for example, is lost from deep pits and roofed areas that are protected from high temperatures and rainfall.

From the animal source through field application, nitrogen is subject to the greatest losses of all the plant nutrients contained in manure. About 50% of the nitrogen in fresh manure is in the organic form and appears as partially digested feed and microorganisms. The other 50% is inorganic, usually as ammonia, and it's subject to significant losses during collection, storage, and application.

In most manure management systems, 5 to 15% of the original phosphorus and potassium is lost in handling. In open lots, however, as much as 50% of the phosphorus and 40% of the potassium can be lost through runoff, leaching, and mixing with the soil on the lot surface.

In lagoon systems, up to 80% of the phosphorus and nitrogen can be lost. Much of the phosphorus is in the sludge along the bottom—and very difficult to remove in normal emptying operations.

Table 1.—Total production and nutrient content of manure from various farm animals

Animal	Animal size (lb)	Total manure production lb/day	cu ft/day	gal/day	% water	Nutrient content N lb/day	P lb/day	K lb/day
Dairy	150	13	0.19	1.5	88	0.06	0.011	0.04
	250	22	0.32	2.4	88	0.11	0.023	0.07
	500	43	0.66	5.0	88	0.22	0.047	0.15
	1000	89	1.32	9.9	88	0.45	0.094	0.29
	1400	120	1.85	13.9	88	0.59	0.131	0.41
Beef Cattle	500	30	0.50	3.8	91	0.17	0.051	0.12
	750	45	0.75	5.6	91	0.26	0.079	0.19
	1000	60	1.0	7.5	91	0.34	0.109	0.24
	1250	65	1.2	9.4	91	0.43	0.12	0.31
Cow		63	1.05	7.9	91	0.36	0.11	0.26
Swine								
Nursery pig	35	2.9	0.038	0.27	89	0.018	0.0052	0.01
Growing pig	65	5.3	0.070	0.48	89	0.034	0.0099	0.02
Finishing pig	150	12.4	0.16	1.13	89	0.078	0.023	0.045
	200	16.6	0.22	1.5	89	0.104	0.036	0.059
Gestate sow	275	11.3	0.15	1.1	89	0.069	0.023	0.04
Sow and litter	375	15	0.21	1.4	89	0.1	0.031	0.054
Boar	350	14	0.19	1.4	89	0.081	0.023	0.051
Sheep	100	4	0.062	0.46	87	0.045	0.0066	0.032
Poultry								
Layers	4	0.26	0.0035	0.027	84	0.0034	0.0012	0.0012
Broilers	2	0.17	0.0024	0.018	78	0.0024	0.0006	0.0008
Horse	1000	51	0.75	5.6	85	0.31	0.072	0.25

Table 2.—Percentage of original nutrient content of manure retained by various storage systems

Method	Beef			Dairy			Horse			Poultry			Sheep			Swine		
	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K
Daily spread				80	90	90	75	90	90	65	90	90	75	90	90			
Dry (with roof)				70	90	90	70	90	90	60	90	90	65	90	90			
Earthen storage	65	80	85	55	60	70										60	60	70
Lagoon/flush	30	40	60	30	40	60				25	40	60				30	40	60
Open lot	60	70	60	60	70	65	60	70	65				55	70	60	60	70	65
Pits (slats)	75	95	95	75	95	95				70	95	95	75	95	95	75	95	95
Scrape/ storage tank	70	85	90	70	90	90												
None (grazing)	100% of nutrients retained																	

You'll notice that earthen storage losses of nitrogen are much less than those from a lagoon. The basic reason is that a treatment lagoon is never emptied and is constantly undergoing biological breakdown, but an earthen storage unit will be emptied several times a year and applied to land.

Nutrients removed in solids

Some operators use a liquid-solid separator to remove solids from the manure/wastewater slurry. If you remove the solids (or any other part of the manure) off farm, subtract that fraction from the amount of nutrients left to be applied to your crop land. A separator is capable of removing solids containing about 22% of the nitrogen, and 20% of both phosphorus and potassium. Don't use this calculation if you field-apply the solids to your land.

Nutrient losses during field application

Nitrogen can volatilize when manure is spread on cropland (fresh manure odor is mostly volatilized ammonia). Essentially all the phosphorus and potassium applied will be available for the crop. Runoff can remove a portion of all three nutrients; however, this type of loss is very site-specific and is not included in these calculations.

Table 3 outlines the percentage of original nutrient content delivered and available for plant use by various application methods. These figures represent both application and field losses before plant use (preutilization).

Denitrification losses in the field

Nitrogen may also be lost by denitrification (loss of inorganic nitrogen by biological conversion to nitrogen gas). Anaerobic bacteria, which work in the absence of oxygen, break down nitrate nitrogen to release nitrogen gas; thus the more oxygen in the soil, the less nitrogen that is lost. This loss is related to the soil type and the rainfall pattern.

Heavy, wet soils provide the ideal condition for maximum nitrogen loss through denitrification. Soil drainage rate is one of the factors used to calculate denitrification losses.

Table 3.—Percentage of original manure nutrient content delivered to cropland and available for plant uptake (these figures reflect application and preutilization losses)

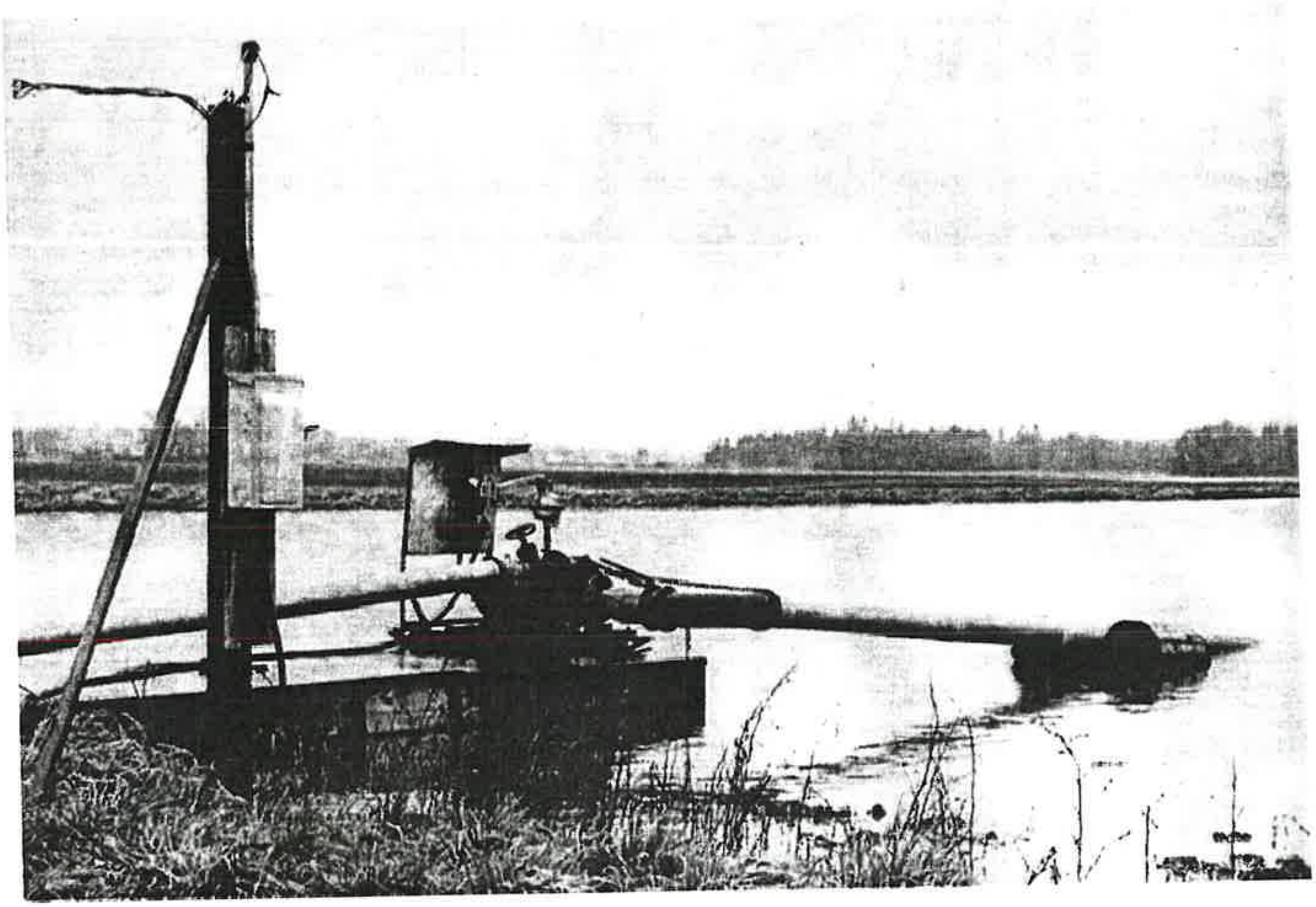
Application method	%N	%P	%K
Injection	95	100	100
Broadcast	80	100	100
Broadcast with immediate cultivation	95	100	100
Sprinkling	75	100	100
Grazing	85	100	100

For denitrification to occur, the nitrogen must first be oxidized to nitrate and then reduced to nitrogen gas or nitrous oxide gas. The rather complex processes that govern these transformations depend on the cycle of aeration and saturated (anaerobic) conditions.

Denitrification coefficients range from 5% loss in well-drained soils to 50% loss in poor drainage conditions. The wide rainfall patterns and diverse soil types make a complex set of values for Oregon. The values shown in table 4 indicate average expected nitrogen available to plants after denitrification losses.

Table 4.—Percentage of field-applied manure nitrogen available to plants after denitrification losses, by region

Location	%N available
Coast	80
Willamette Valley and southern Oregon	
Irrigated	87
Nonirrigated	92
Eastern Oregon	95



Leaching loss of nitrate nitrogen is caused by percolating water moving below the root zone. Once below the root zone, this nitrate is a potential ground water pollutant. Again, soil type and rainfall are the major influencing factors. Soil permeability can range from less than 0.06 inch per hour for clay soils to greater than 20 inches per hour for gravelly sandy soils.

The amount of nutrients (nitrogen, primarily) that are lost to deep leaching depends on physical conditions and on the rate and season of manure application.

Availability of nutrients for crops

Nitrogen is a vital nutrient, and its availability influences both microbial activity and plant growth. The carbon-nitrogen ratio (C/N) of applied wastes affects this availability and, therefore, affects plant growth.

If a material with a high C/N ratio, such as manure with a lot of bedding, is added to a soil, organisms that decompose the organic matter grow until limited by available minerals and nitrogen.

All the immediately available nitrogen may be bound by the microorganisms; for the short run, you may have to add more commercial fertilizer to the soil than before you applied the manure. The nitrogen bound by the microorganisms will become available to the plant, but it will take a longer time.

Inorganic nitrogen is the form that is taken up by the plant root system and used for growth. The organically bound nitrogen in the soil breaks down with time to form inorganic nitrogen. With enough time, the organic nitrogen present in manure will be converted to plant-usable inorganic nitrogen.

The exact percentage will vary, but researchers agree that from 4 to 25% of the nitrogen in manure will contribute to the organic matter of the soil. This means that a fraction of the added manure won't be available for plant uptake.

This nonavailable fraction is sometimes referred to as the *recalcitrant* fraction. For the calculations in this publication, we've classified a value of 10% of the manure nitrogen as recalcitrant. This means you can add 10% more nutrients than your crop will use, and we've included this value in the suggested application rates in tables 5 and 6. This fraction won't add to surface or ground water pollution problems.

The breakdown process of manure is called *mineralization*. Since livestock feeds have various particle sizes and compositions, manures have different mineralization rates, and some of the manure may be in the soil 2 years before all the organic nitrogen is converted to plant-usable inorganic nitrogen. Therefore, not all the nitrogen contained in manure that has been incorporated into the soil can be used by the plants during the first year after manure application.

Table 5.—Rates of nutrients used by NCALC

Crop	Unit	Rate (lb) N	P	K
Alfalfa hay, immature and early bloom	per ton	65.0	5.3	42.0
Alfalfa hay, midbloom to mature	per ton	45.0	4.5	36.0
Canarygrass hay	per ton	40.0	7.3	63.0
Orchardgrass	per ton	38.4	6.1	37.6
Cereal grain hay	per ton	24.0	3.4	10.0
Grass hay	per ton	25.0	3.6	19.4
Barley/oats	per ton	34.0	5.0	7.2
Alfalfa/grass silage	per ton, wet	22.0	2.9	19.0
Red clover silage	per ton, wet	14.5	2.0	12.0
Corn silage	per ton, wet	7.0	2.5	6.6
Corn earlage	per ton, wet	25.5	4.6	5.6
Grazed grass (by region, range indicated)	per acre	50-165	19-24	87-110
Harvested grass (by region, range indicated)	per acre	80-220	20-28	92-132

Table 6.—Suggested nutrient application rates for pastures, by location, harvested and grazed (lb/acre[a])

	Harvested			Grazed		
Location	N	P	K	N	P	K
Coast	220	28	132	165	24	110
NW valleys						
irrigated	200	25	120	150	22	100
nonirrigated	110	21	95	80	20	92
So. Oregon						
irrigated	180	24	110	75	20	90
nonirrigated	80	20	92	50	19	87
E. Oregon	200	25	120	120	21	96

[a]These values include a fraction of the nutrients in addition to the plant uptake values, to account for the portion that is unavailable to the plant and contributes to an increase in soil organic matter. *Note:* 1 lb P_2O_5 = 0.44 lb P; 1 lb K_2O = 0.83 lb K.

The rate of mineralization depends on the soil moisture content, organic matter level, and temperature. However, most animal manure is spread on the same fields year after year. Therefore, except for the recalcitrant component, the exact mineralization rate is unimportant because the plant will receive the same amount of nutrients each year after the first year—some from the current year's application, some from last year, and so on. This will be exactly the same amount next year.

For efficient use of nutrients, apply manure so nutrients added do not greatly exceed those removed by crops on an annual basis. Table 5 lists nutrient application rates for crops common on livestock operations in Oregon. Table 6 lists two levels of fertilization for pastures.

For example, if a beef operator grazes the animals full time on the pasture and cuts no hay, all the nutrients that leave this field must go in the beef produced. A lower fertilization rate is recommended for this type of operation.

Harvesting by cutting of hay (green chopping) is the most efficient harvest and removes all of the grass. The amount of applied fertilizer should be reflected in the nutrients that are removed from the field.

Management of the animals and crop is very important in determining proper application and use values. It's impossible to place a numerical value on the management factor, but tables 5 and 6 reflect the values suggested under a good management program.

There are also different values for four different regions in the State. Table 6 includes these to represent differences in growing degree days and general soil types.

Because moisture availability is critical to grass production, the irrigated and nonirrigated choices reflect these levels of production. Manure nutrients, especially nitrogen, are used more efficiently by grasses and cereals than by legumes. Inoculated legumes can get most of their nitrogen from the air, so additional nitrogen is not normally needed.

Get your soil tested to determine specific fertilizer requirements for your land. See EC 628 for the procedure, and ask if your county Extension office has the OSU Extension videotape, *How to Take a Soil Sample.* Adjust manure application rates for your soil conditions to balance crop nutrient needs with the soil test results.

In most cases, if you apply manure at a rate to satisfy the nitrogen requirements, you'll overapply phosphorus or potassium. Apply manure to satisfy the requirements of the least-needed nutrient and supplement the other two.

The worksheet and example on pages 6-7 will let you follow the process and insert the values for your livestock operation.

A computer program called *NCALC* has been developed using these same values and procedures. See your county Extension agent about access to this program.

For further reading

Gardner, E. Hugh, and John Hart, *How to Take a Soil Sample... and Why,* Oregon State University Extension Service Circular 628 (Corvallis, reprinted 1991). No charge for single copy.

Calculating land application rates

The following example and worksheet will help you use all the information in this publication to determine how much nitrogen, phosphorus, and potassium from manure you should use on your cropland.

Example

1. Operator in the Willamette Valley has 100 milking cows (1400 lb each) with a liquid flush/lagoon system with a separator. Annually sprinkles this on cropland to grow 31 tons of corn silage. How much land should he utilize to receive his manure?

No. animals	Animal wt.	Storage
100	1400 lb	365 days

2. Nutrient production rate (from table 1)

N: 0.59 lb/cow/day
P: 0.131 lb/cow/day
K: 0.41 lb/cow/day

3. Total nutrient production
No. animals × Days × Rate = Total produced

N: 100 × 365 × 0.59 = 21,535
P: 100 × 365 × 0.131 = 4,781
K: 100 × 365 × 0.41 = 14,965

4. Use of a separator and off-farm use of solids

Yield (lb)	×	% Held	=	Total from storage
N: 21,535	×	0.78	=	16,797
P: 4,781	×	0.80	=	3,825
K: 14,965	×	0.80	=	11,972

5. Storage losses (from table 2)

To storage	×	Retained	=	Total from storage
N: 16,797	×	0.30	=	5,039
P: 3,825	×	0.40	=	1,530
K: 11,972	×	0.60	=	7,183

1. ______________________________

No. animals	Animal wt.	Storage
______	______	______

2. Nutrient production rate (from table 1)

N: ________________
P: ________________
K: ________________

3. Total nutrient production
No. animals × Days × Rate = Total produced

N: ________________
P: ________________
K: ________________

4. Use of a separator and off-farm use of solids

Yield × % Held = Total to storage

N: ________________
P: ________________
K: ________________

5. Storage losses (from table 2)

To storage × Retained = Total from storage

N: ________________
P: ________________
K: ________________

6. Application losses (from table 3)

	From storage	×	Retained	=	Total applied
N:	5,039	×	0.75	=	3,779
P:	1,530	×	1.00	=	1,530
K:	7,183	×	1.00	=	7,183

7. Nutrient availability after denitrification

	Total lb applied	×	Retained	=	Lb available
N:	3,779	×	0.87	=	3,287
P:	1,530	×	1.00	=	1,530
K:	7,183	×	1.00	=	7,183

8. Nutrients used by crop

	Lb available	÷	Amount needed/A	=	No. of A available
N:	3,287	÷	220 lb	=	14.9
P:	1,530	÷	40 lb	=	38
K:	7,183	÷	220 lb	=	32.6

9. Largest acreage needed (from #8 above)

38 A for Phosphorus

10. Acres needing supplemental nutrients

	Acres served	–	Satisfied	=	Total
N:	38	–	14.9	=	23.1 A
P:	38	–	38	=	0 A
K:	38	–	32.6	=	5.4 A

11. Additional nutrients needed

	Area (A)	×	Rate (lb/A)	=	Bought
N:	23.1	×	220	=	5,082 lb
P:	0	×		=	0 lb
K:	5.4	×	220	=	1,188 lb

6. Application losses (from table 3)

From storage × Retained = Total applied

N: ____________________

P: ____________________

K: ____________________

7. Nutrient availability after denitrification

Total lb applied × Retained = Lb available

N: ____________________

P: ____________________

K: ____________________

8. Nutrients used by crop

Lb available ÷ Amount needed/A = No. of A available

N: ____________________

P: ____________________

K: ____________________

9. Largest acreage needed (from #8 above)

____

10. Acres needing supplemental nutrients

Acres served – Satisfied = Total

N: ____________________

P: ____________________

K: ____________________

11. Additional nutrients needed

Area (A) × Rate (lb/A) = Bought

N: ____________________

P: ____________________

K: ____________________

OSU Extension publications for livestock owners

In July, 1992, a fire in OSU's Industrial Building destroyed most of our publications. The Department of Printing and Mailing Services, which prints and distributes most of our educational materials, was badly damaged.

Since then, we have reprinted a number of titles that may be of interest to you. Some, however, are permanently out of print. For a current catalog of available publications, contact us at:

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Extension Service, Oregon State University, Corvallis, O.E. Smith, director. This publication was produced and distributed in furtherance of the Acts of Congress of May 8 and June 30, 1914. Extension work is a cooperative program of Oregon State University, the U.S. Department of Agriculture, and Oregon counties.

PNW0533

FERTILIZING WITH MANURE

Andy Bary, Craig Cogger, Dan M. Sullivan

A Pacific Northwest Extension Publication
Washington • Oregon • Idaho

Farming West of the Cascades

This publication is designed for the small to mid-sized crop producer (organic and conventional) to assist the producer in more efficiently managing nutrients from solid animal manures. The purpose of this publication is to (1) describe how to determine the appropriate manure application rate based on the type of manure and crops, and (2) describe how to apply the manure at that rate.

Manure is a good source of plant nutrients and organic matter. Properly managed manure applications recycle nutrients to crops, improve soil quality, and protect water quality. Manure is highly variable source to source, and growers must be able to understand and reduce that variability to make best agronomic and environmental use of manure.

The three main sources of variability and uncertainty when using manure are:

- Nutrient content of the manure
- Availability of manure nutrients to crops
- Application variability

If you do not account for this variability, you may apply too much or too little manure. Applying too little manure can lead to inadequate crop growth because of lack of nutrients, while applying too much manure may reduce crop quality or increase risk of plant diseases. Over-applying nutrients also may increase the risk of contaminating surface or groundwater. For more information on livestock water quality issues see *Manure Management in Small Farm Livestock Operations, Protecting Surface and Groundwater*, EM8649, available from the Oregon State University Extension Service.

Fertilizing with Manure outlines a systematic method to help you manage nutrients from manures. Even with the best methods, there is still some degree of uncertainty when using manures as nutrient sources. This publication describes how to:

- Decide if manure is a good choice for your farm.
- Determine the nutrient content of manure.
- Estimate manure nutrient availability based on manure type, handling, and nutrient content.
- Calculate the application rate.
- Calibrate manure spreaders and apply manure at thc target rate.
- Store manure.
- Test soil and monitor crops to adjust manure application rates.
- Evaluate long-term effects of manure applications on soil quality.

Three worksheets in this publication (Worksheets A, B, and C) will help you calibrate your manure spreader.

Is Manure a Good Choice for Your Farm?

Consider the following questions before applying animal manure on your farm:

- What is the local availability of manure?
- What is the quality of local manure sources?
- Where does manure fit in your crop rotation?
- Will your crops respond to added nutrients?

Local Availability of Manure

If you raise livestock, or if you have neighbors who do, you will likely have plenty of manure available nearby. If you have to import manure from more distant sources, transportation can greatly increase costs. If you are considering importing manure, you will need to decide if it makes economic sense.

Quality of Manure Sources

Manure quality varies considerably, as discussed later in this bulletin. You will need to compare the quality of available manure sources (nutrient supply, ease of handling, odor, and risk of weed seeds or pathogens) with your farming needs. See below for a comparison of composted and uncomposted manure sources.

Crop Rotations

Manure use is compatible with most crops and crop rotations. Remember that crop nutrient needs vary and manure applications should be consistent with the nutrient needs of your crops. Soil test results and

Composted Vs. Uncomposted Manure

When you are looking for organic forms of nutrients for crop production, manure and manure composts are two of the logical choices. Composting is more than just piling the material and letting it sit. Composting is the active management of manure and bedding to aid the decomposition of organic materials by microorganisms under controlled conditions.

What are the benefits or detriments of using uncomposted or composted manure? In some cases they have comparable properties and in other ways they are quite different. The table below compares the two materials.

Compost

- slow release form of nutrients
- easier to spread
- lower potential to degrade water quality
- less likely to contain weed seeds
- higher investment of time or money
- reduced pathogen levels (e.g., salmonella, *E. coli*)
- more expensive to purchase
- fewer odors (although poor composting conditions can create foul odors)
- improves soil tilth

Manure

- usually higher nutrient content
- sometimes difficult to spread
- higher potential to degrade water quality
- more likely to contain weed seeds
- lower investment of time or money
- potential for higher pathogen levels
- less expensive to purchase
- odors sometimes a problem
- improves soil tilth

extension bulletins are good sources of information on crop nutrient needs. Fresh manure is not a good choice for most salad and root crops because of food safety concerns. For more information see the section titled "Using Manure Safely."

Soil Fertility

Manure provides the most benefits on soils with deficient to adequate levels of nutrients. Soils with high to excessive levels of nutrients are not a good choice for manure use, because the nutrients in manure are less likely to benefit crops and more likely to leach into groundwater or run off into surface water. If you have excessive levels of nutrients in your soil, limit applications of those nutrients to recommended starter levels, and use an alternative source of organic matter input, such as growing cover crops.

How To Determine the Nutrient Content of Manure

Not knowing the nutrient content of manure can lead to large errors in nutrient application rate. We strongly advise you test the manure you plan to use. If you buy manure from a commercial source, they should be able to provide you with nutrient test values; you would not need to do further testing. In the absence of test values, use the published values in Table 1 as a starting point.

Laboratory Analysis

Laboratory analysis measures the nutrients in manure instead of just estimating them based on table values. Testing laboratories will charge from $30 to $60. (See the section "Deciding What To Test" for specifics on nutrient analysis of manure.) Using testing laboratories requires proper sampling techniques and timely delivery of the sample to the laboratory.

Choosing a Laboratory

It is important to use a laboratory that routinely tests animal manure as they will know the correct type of analysis to use when testing animal manures. Extension offices can provide you publications that list manure testing laboratories in the Pacific

Using Manure Safely

Fresh manure sometimes contains pathogens that can cause diseases in humans. Salmonella bacteria are among the most serious pathogens found in animal manure. Pathogenic strains of *E. coli* bacteria can be present in cattle manure. Manure from swine and carnivores can contain helminths, which are parasitic worms.

These pathogens are not taken up into plant tissue, but they can adhere to soil on plant roots, or on the leaves or fruit of low-growing crops. Cooking destroys pathogens, but raw food carries a risk of pathogen exposure. Washing and peeling raw produce removes most pathogens, but some may remain. The risk from pathogens is greatest for root crops (e.g., carrots and radishes) or leaf crops (e.g., lettuce or spinach), where the edible part touches the soil. The risk is negligible for crops such as sweet corn, which does not come in contact with the soil, or for any crop that is cooked thoroughly.

Consider any raw manure to be a potential source of pathogens, and avoid using fresh manure where you grow high-risk crops. Bacterial pathogens die off naturally during extended storage or after field application. Complete die-off of bacterial pathogens occurs in days to months depending on the pathogen and environmental conditions. Helminths in swine manure can persist in soil for years, however.

Composting manure at high temperatures will kill pathogens, including helminths, but you need careful quality control to make sure that all of the manure reaches conditions for pathogen kill. If you plan to compost manure, refer to the *On-Farm Composting Handbook* (listed in "Additional Resources") for procedures to compost manure under conditions to destroy pathogens.

If you grow certified organic crops you must follow the manure and compost practices in the National Organic Standards. These practices specify waiting periods between the application of fresh manure and the harvest of different types of crops, and time and temperature requirements for killing pathogens in manure compost.

Northwest (see the "Additional Resources" section for references).

Questions to ask when choosing a lab:

- Does the lab routinely analyze manure?
- How many manure samples do they analyze in a year?
- Can they perform the tests you need?
- Are the results reported in the form you need?
- How are the samples handled before analysis? Do they thoroughly mix the samples? Do they dry the samples before analysis? Drying samples prior to analyzing for ammonium nitrogen results in loss of most of the ammonium nitrogen from the sample.
- Can the laboratory supply quality control information to you? Do they participate in a regional, national, or university sample exchange program? Participation in a sample exchange program is a good indicator of a commitment to accurate results.
- How much does analysis cost? ($30–$60)

Laboratories report results on an as-received or a *dry-weight* basis. As-received results usually are reported in units of lb/ton, while dry weight results usually are reported in percent or mg/kg. The as-received results are most helpful when determining application rates. The dry-weight results can be used to compare analyses over time and from different manure sources. If you are not sure what reporting basis the lab is using, contact them for clarification. It is a good idea to ask for a sample reporting sheet before you choose a lab, to make sure you can interpret their results.

To convert manure analyses reported on a dry-weight basis (in percent) to an as-received basis (in lb/wet ton), multiply by 20 to convert the dry weight percent to lb/ton; then multiply by the decimal equivalent of the solids content.

Example:

For beef manure at 23% solids and 2.4% nitrogen (N) on a dry weight basis:

Step 1. 2.4% x 20 = 48 lb N/ton dry weight

Step 2. 48 lb N/ton dry weight x .23 = 11 lb N/ton as-is.

Deciding What To Test

The main components you should have measured are total nitrogen, ammonium nitrogen, total phosphorus, total potassium, electrical conductivity, and solids. If the manure is old or has been composted you may also want to test for nitrate-N. Total carbon (C) and pH sometimes are useful measurements. Total C can be useful for manure with bedding, so you can determine the C:N ratio. Manure with a C:N ratio greater than 25 is likely to tie up nitrogen when you apply it to the soil.

Sampling Manure

A nutrient analysis is only as good as the sample you take. Samples must be fresh and representative of the manure. Follow these steps carefully:

1. Ask the laboratory what type of containers they prefer. Also, make sure the laboratory knows when your sample is coming. Laboratories should receive samples within 48 hours of collection. Plan to collect and send your sample early in the week so the sample does not arrive at the lab on a Friday or a weekend.

2. If you have a bucket loader and a large amount of manure, use the loader to mix the manure before sampling.

3. Take 10 to 20 small samples from different parts and depths of the manure pile to form a composite sample. The composite sample should be about 5 gallons. The more heterogeneous your pile, the more samples you should take.

4. With a shovel or your hands thoroughly mix the composite sample. You may need to use your hands to ensure complete mixing. Wear rubber gloves when mixing manure samples with your hands.

5. Collect about one quart of manure from the composite sample and place in an appropriate container.

6. Freeze the sample if you are mailing it. Use rapid delivery to ensure that it arrives at the laboratory within 24 to 48 hours. You can refrigerate the sample if you are delivering it directly to the lab.

Published Values

Table 1 shows typical published values for livestock manure. These values may not accurately represent your situation. The nutrient content of manure varies widely with amount and type of bedding used, storage conditions, age of manure, manure handling, and animal diet. Nutrient values can vary by a factor of two or more from the values listed in Table 1.

For example, leaving manure piles uncovered in western Washington will reduce manure nutrient content by leaching. The use of bedding reduces manure nutrient by dilution. The amount of reduction from either of these factors is difficult to determine without laboratory testing.

Nitrogen Availability for Crop Growth

Manure application rates are usually N based, because N is usually the nutrient needed in the largest quantity for crop growth. Manure is not like commercial fertilizer in that it does not come with a guaranteed N availability. Nitrogen availability from manure varies greatly, depending on the type of animal, type and amount of bedding, and age and storage of manure.

Manure contains nitrogen in the organic and ammonium forms. The organic form releases N slowly, while ammonium-N is immediately available for crop growth. Ammonium-N can be lost to the atmosphere as ammonia gas when manure is applied to the soil surface. Most solid manures contain most of their nitrogen in the organic form, but poultry manure contains substantial ammonium-N. Poultry and other manures that contain a large proportion of ammonium-N may lose substantial N to the atmosphere if they are not tilled into the soil the same day they are spread. Ammonia loss is greater in warm, dry, and breezy conditions; less in cool, wet weather.

There is no simple test to determine N availability for an individual manure sample. Use Table 2 or Figure 1 to estimate N availability from manure.

The N availability numbers in Table 2 are approximate ranges for each type of manure. Use the lower part of the ranges if manure contains a large proportion of ammonium-N (such as poultry manure), and it is not tilled into the soil soon after application. Also, use the lower part of the ranges if the manure contains large amounts of bedding, or if the measured N content is lower than typical values. Use the higher part of the ranges if the manure contains less bedding or if the measured N content is higher than typical values.

Thorough composting generally reduces the rate of release of manure N by incorporating the N into more biologically resistant forms. Composting can reduce the amount of first-year N release by 50% or more,

Table 1. Typical nutrient content, solids content, and bulk density of uncomposted animal manures at the time of application.[1]

Type	N	P[2]	K	Solids	Bulk density
		lb per ton as-is[3]		*percent*	*lb/cu yard*
Broiler with litter	73	28	55	70	900
Laying hen	37	25	39	40	1400
Sheep	18	4.0	29	28	1400
Rabbit	15	4.2	12	25	1400
Beef	12	2.6	14	23	1400
Dry stack dairy	9	1.8	16	35	1400
Separated dairy solids	5	0.9	2.4	19	1100
Horse	9	2.6	13	37	1400

[1] Dairy manure data and some horse manure data were collected in the Pacific Northwest. Other data sources are listed in *Additional Resources.*

[2] Manure analyses are usually reported in terms of P and K, while fertilizer labels use P_2O_5 and K_2O. To convert from P to P_2O_5, multiply P by 2.3. To convert from K to K_2O, multiply K by 1.2.

[3] *As-is* is typical moisture content for manure stored under cover.

Table 2. Typical nitrogen availability for uncomposted animal manures.

Type	Typical Nitrogen Content	Nitrogen Availability[1]
	percent dry weight	*percent*
Broiler with litter	4–6	40–70
Laying hen	4–6	40–70
Sheep	2.5–4	25–50
Rabbit	2.5–3.5	20–40
Beef	2–3	20–40
Dry stack dairy	1.2–2.5	20–40
Separated dairy solids	1–2	0–20
Horse	0.8–1.6	0–20

[1] Nitrogen available in the first growing season after application.

and Table 2 will usually overestimate available N from manure composts.

This may not be the case for material sold as composted poultry litter, however. Poultry litter (from broiler production) is a mixture of manure and wood shavings. Dry stacked poultry litter will heat to high temperatures, but the composting process is often limited by insufficient moisture in the pile. Materials sold as "composted poultry litter" are frequently incompletely composted, and have similar N availability as fresh poultry litter. Incompletely composted poultry litter will have a strong ammonia odor and will have ammonium-N analyses above 2000 ppm (0.2 % ammonium-N on a dry weight basis).

Horse manure or other manures with lots of woody bedding may temporarily tie up nitrogen rather than supply nitrogen for crop growth, because the wood is still decaying, and bacteria that break down the carbon in the wood consume nitrogen. Expect first-year N tie-up from manures containing less than 1% N.

Figure 1 is an alternative way to estimate manure N availability, based on laboratory measurements of manure N content. In general, the higher the N content of manure, the higher the proportion of N that will become available to crops.

If you have been applying manure to the same field for several years, residual organic nitrogen from past applications will contribute to the supply of N available to crops. You will need to reduce the manure application rate for fields that receive repeated manure applications.

Calculating the Application Rate

Now that you have determined the nutrient content and estimated the N availability of the manure you will be using, you are ready to determine the application rate. Application rates of manure are usually based on providing adequate nitrogen for crop growth. In most cases supplying sufficient nitrogen will also provide adequate phosphorus and potassium for crop growth.

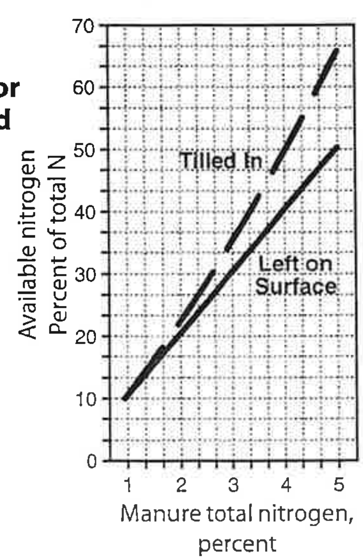
First, you will need to know the amount of nutrients your crop requires. Nutrient requirements for specific crops can be found in Cooperative Extension production guides or from soil test recommendations.

If you have your manure and soil tested at the same time at the same laboratory, the lab can provide a recommendation for the amount of manure to apply.

Once you know the amount of nitrogen needed for your crop, and the nutrient content of your manure, you can estimate the amount of manure to apply using a few simple calculations.

Observe the performance of your crops to help fine-tune your application rate. If you have a complicated

Figure 1. Nitrogen availability for uncomposted manure based on total N content.



nutrient management program, you may need to consult with a professional agronomist. See the "Additional Resources" section for publications listing laboratories and professional agronomists, or contact your local Extension office.

Applying Manure

Manure Spreaders

The best of manure application estimates will not be useful if you don't know how much you're applying once you get to the field. You will need a spreader appropriate to the size of your farm, and you will need to calibrate it so you have confidence in your application rates.

Equipment

There are several ways to spread manure. For small amounts, you can use buckets or apply it from the back of a pickup truck. Using a mechanical manure spreader is easier and more effective for spreading large amounts of manure.

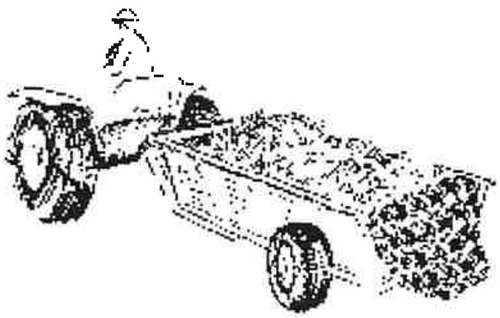
There are three general types of solid manure spreaders: rear delivery, side-delivery, and specialty spreaders. Rear delivery spreaders work best with drier materials. Side delivery spreaders handle both wet and dry

Table 3. Worksheet for calculating manure application rates.

Example: I am growing sweet corn and the nitrogen recommendation is 100 pounds N per acre. I have beef manure that has been tested by a laboratory and contains 11 pounds of N, 2.2 pounds of P, and 8.3 pounds of K per wet ton of manure.

Note: Unshaded cells in table are information about manure and crop. Shaded cells are calculations you make.

Step	Units	Example	Your Value
A. Type of manure		beef	
B. Crop		sweet corn	
C. Desired N application rate	lb N/acre	100	
D. Manure N concentration, from laboratory analysis or Table 1.	lb N/ton as-is	11	
E. Phosphorus concentration, from laboratory analysis or Table 1.	lb P/ton as-is	2.2	
F. Potassium concentration, from laboratory analysis or Table 1.	lb K/ton as-is	8.3	
G. Plant availability of N in manure from Table 2 or Figure 1.	percent	25	
H. Calculate manure available nitrogen **Line D x (line G / 100)**	lb N/ton as-is	2.75	
I. Calculate application rate **Line C / line H**	tons manure/acre as-is	36	
J. Calculate amount of phosphorus applied **Line I x line E x 2.3**	lb P_2O_5/acre	184	
K. Calculate amount of potassium applied **Line I x line F x 1.2**	lb K_2O/acre	362	



Manure Spreader

materials. Specialty spreaders have the capability of spreading material onto narrow beds found in perennial crop production. They are designed for drier materials. Prices for new equipment vary from $1,600 to $8,000. A good used spreader costs about 50–60% of a new spreader. Used spreaders are sometimes difficult to find because farmers usually wear them out before replacing them.

Calibrating Manure Applications

Calibrating your spreader will allow you to determine the actual application rate and adjust it to meet your target rate. You can calibrate your spreader by measuring a small part of the manure applied using pans or tarps. Or, you can weigh an entire spreader load and measure how much area the load covers. If you know the bulk density of the manure you can calculate the volume of a spreader load rather than the weight. These three methods are described in Worksheets A, B, and C beginning on page 10.

Calibrating your spreader will allow you to convert loads of manure applied to tons per acre. The spreader load calibration is the most accurate method, but it requires truck scales to complete. Calibration improves accuracy of the overall application rate, but there will still be variability in the actual application across your field.

If you apply manure to a small area and use buckets or a pickup truck, it is still important to know how much you are applying. You can do this by weighing the buckets or determining the weight or volume of the pickup load.

Regardless of which method you use, recheck your measurements periodically to make sure you stay on target.

Timing Manure Applications

The best time to apply manure to row crops is in the spring before planting. You also can apply manure in the fall, but some of the nutrients will be lost over the winter if you apply manure to bare ground. Environmental risks of leaching and runoff also increase. If you do apply manure in the fall, apply it early, and plant a cover crop to help capture nutrients and prevent runoff. You can apply manure to pastures from late February through mid-October in most places west of the Cascades, as long as the applications are at moderate rates.

Manure Storage

If you raise animals on your farm or import manure for crop production you may need to store manure on your farm prior to application. Proper manure storage conserves nutrients and protects surface and groundwater. Storing manure can be as elaborate as keeping it under cover in a building or as simple as covering the manure pile with a tarp. The important point is keeping the pile covered and away from drainage areas and standing water. The storage location should also be convenient to your animals and crop production. If you decide to build a manure storage structure, refer to extension bulletins that cover this subject (see "Additional Resources"), or see your nearest Natural Resources Conservation Service office.

Using Soil Testing To Adjust Application Rates

Taking soil test samples and observing your crops can help you determine if manure application rates are adequate or if they need adjusting. The report card soil test helps determine if you are applying too much manure. The report card test measures nitrate-N remaining in the soil in the fall. If you apply too much manure, nitrate N will accumulate in the soil, unused by the crop. When the fall and winter rains come, the nitrate will leach from the soil and become a potential contaminant in groundwater or surface water. Excess N can also harm some crops, delaying fruiting and increasing the risk of disease damage, freeze damage, and wind damage.

To do a report card test, sample the soil (0 to 12-inch depth) between August 15 and October 1. Timing is critical. You want to sample after most crop uptake of N has occurred, but before the fall rains leach nitrate from the soil. Take a report card sample as you would any other soil sample, collecting soil cores at multiple spots in the field, and combining the cores together into a composite sample. For details on soil sampling procedures, refer to *Soil Sampling*, Bulletin 704, available from the University of Idaho Cooperative Extension System.

If your report card nitrate-N results are greater than 15–20 mg/kg, this suggests you are supplying more N than your crop needs, and you can reduce manure application rates. Report-card nitrate-N levels greater than 30 mg/kg are excessive.

When interpreting report card results, consider the performance of your crop, too. If crop growth was poor because of drought, pests, or poor growing conditions, crop N uptake may have been less than expected, resulting in excess N remaining in the soil profile even if manure applications were on target for a normal crop.

You can use basic soil tests to evaluate the soil for sufficiency or excess of other nutrients. A basic soil test includes P, K, calcium (Ca), magnesium (Mg), boron (B), pH, and a lime recommendation. If you have consistently low levels of P and K and reduced crop growth, you can probably increase your manure application rates. If you have consistently excessive levels of P and K, you may need to decrease or eliminate manure applications, as described below.

Long-Term Effects of Manure Applications

Repeated applications of manure can increase soil organic matter content and the soil nutrient pool. Because the pool of slow-release nutrients increases in the soil with repeated manure applications, the amount of manure needed to meet crop needs will decline over time.

When manure applications are based on nitrogen need, manure usually supplies P and K in excess of crop needs. As a result, P and K can accumulate in soils with a history of manure applications, and may eventually reach excessive levels. Excess levels of soil P can increase the amount of P in runoff, increasing the risk of surface water degradation. Many crops can handle high levels of K, but livestock can be harmed by nutrient imbalances if they consume a diet of forages with high K levels.

If you apply manure repeatedly to the same fields, it is important to have a regular soil testing program to track nutrient levels. If P and K reach excessive levels, you may need to switch to a commercial fertilizer to supply N. If you are an organic farmer and do not use synthetic fertilizers, consider replacing some or all of your manure with legume cover crops. Legumes will fix N from the atmosphere, but they do not supply P or K. Reserve manure for fields that have lower P and K levels.

Summary

To reduce variability and uncertainty in manure applications, follow these four steps:

1. Determine the nutrient content of the manure you are using. Laboratory testing will give you the most reliable estimate.
2. Estimate manure N availability based on the type of manure, handling, and nitrogen content.
3. Calibrate your manure spreader so that you have confidence in the rate applied.
4. Do soil testing (report card and basic tests) and observe plant growth to evaluate the effect of manure applications on crop production and soil nutrient levels. Adjust manure rates as necessary based on your evaluations.

Worksheet A

Application Calibration Using a Tarp

You will need some tarps and a scale on which to weigh the manure. Hanging scales work well. Then follow these steps:

1. Weigh the tarp and record the weight and size of the tarp on Worksheet A.
2. Place tarps in application area.
3. Spread manure over the application area using the spreading pattern typically used in the field. Make sure the spreader is traveling at the speed it would typically travel. On Worksheet A, record tractor speed and gear, and note spreader settings.
4. Collect and weigh the manure. Record the weight on Worksheet A.
5. Calculate an average application by completing Worksheet A.
6. Repeat steps 1–4 five to nine times. Replication gives you more accurate results.
7. Adjust the application rate by changing tractor speed or gearing, or making an adjustment on the manure spreader. After adjustment, you will need to repeat the calibration procedure until you have arrived at the desired application rate.
8. Keep the calibration records for future use.

Worksheet A

Date ________________ **Field** ________________ **Spreader ID** ________________

Speed ________________ **Gear** ________________ **Operator** ________________

	Tarp ID						
	Example	A	B	C	D	E	F
1. Weight of tarp with manure (lb)	*9.2*						
2. Weight of empty tarp (lb)	*6.5*						
3. Weight of manure **(line 2 minus line 1)**	*2.7*						
4. Tarp area (sq ft)	*9.0*						
5. Manure applied (lb/ sq ft) **(line 3 / line 4)**	*0.3*						
6. Convert to tons/acre **(line 5 x 21.78)**	*6.5*						
7. Average application rate (Ave. over all locations) tons/acre							

Worksheet B

Spreader Calibration Using a Full Spreader Load and Scales

Use this method to monitor the manure application rate on the entire field. After the initial weighing to determine the capacity of the application vehicle, the only tool you need is a field-measuring wheel or long tape.

1. Determine the weight of manure the spreader will hold using a truck scale to weigh the spreader when empty and full. Record the weights on Worksheet B.

2. Spread a load on the field, using constant, even tractor speed and settings to cover field uniformly. Spread in a rectangular pattern so the area calculation will be simple. Record tractor speed and gear settings used on Worksheet B.

3. Measure the length and width covered by one full load and compute the application rate in tons per acre using Worksheet B below.

4. Adjust the application rate by changing tractor speed or gearing, or making an adjustment on the manure spreader. After adjustment, you will need to repeat the calibration procedure until you have arrived at the desired application rate.

5. Keep the calibration records for future use.

Worksheet B

Date ________________ **Field** ________________ **Spreader ID** ________________

Speed ________________ **Gear** ________________ **Operator** ________________

	Replicates				
	Example	A	B	C	D
1. Weight of loaded spreader (lb)	*12,000*				
2. Weight of empty spreader (lb)	*2,000*				
3. Weight of manure in spreader (lb) **(line 2 - line 1)**	*10,000*				
4. Length of area spread (ft)	*1,300*				
5. Width of area spread (ft)	*25*				
6. Area spread (sq ft) **(line 4 x line 5)**	*32,500*				
7. Manure applied (lb/sq ft) **(line 3 / line 6)**	*0.308*				
8. Convert to tons/acre **(line 7 x 21.78)**	*6.7*				

Worksheet C

Spreader Calibration Using Manure Bulk Density

This method can be used if you know or estimate the manure bulk density, but is not as accurate as one of the other methods. You will need a tape measure, calculator and a measurement or estimate of the manure bulk density.

1. Determine the length, width, depth, and stacking height of the manure spreader and enter values in Worksheet C. Measure or estimate manure bulk density from Table 1 and enter in the worksheet.
2. Calculate the volume and weight of manure in a spreader load using Worksheet C.
3. Spread a load on the field, using constant, even tractor speed and settings to cover field uniformly. Spread in a rectangular pattern so the area calculation will be simple. Record tractors speed and gear settings used on Worksheet C.
4. Measure the length and width covered by one full load and compute the application rate in tons per acre using Worksheet C.
5. Adjust the application rate by changing tractor speed or gearing, or making an adjustment on the manure spreader. After adjustment, you will need to repeat the calibration procedure until you have arrived at the desired application rate.

Worksheet C

Date ______________ **Field** ______________ **Spreader ID** ______________

Speed ______________ **Gear** ______________ **Operator** ______________

	Replicates			
	Example	A	B	C
1. Manure bulk density from table (lb/yd)	*1,100*			
2. Length of manure spreader (ft)	*7.0*			
3. Width of manure spreader (ft)	*3.0*			
4. Depth of manure to top of spreader side boards (ft)	*1.4*			
5. Stacking height from the top of the side boards to top of pile (ft)	*1.1*			
6. Volume of manure in spreader (ft^3) **(line 2 x line 3 x (line 4 + (line 5 x 0.8))**	*48*			
7. Weight of manure in the spreader (lb) **(line 1 x line 6) / 27**	*1,951*			
8. Length of area spread (ft)	*245*			
9. Width of area spread (ft)	*4*			
10. Area spread (sq ft) **(line 8 x line 9)**	*980*			
11. Manure applied (lb/sq ft) **(line 7 / line 10)**	*1.99*			
12. Convert to tons/acre **(line 11 x 21.78)**	*43*			

Additional Resources

Typical Nutrient Analyses of Manure

Camberato, J. J. *Land application of animal manure.* EC 673 (Clemson University Cooperative Extension, 1996).

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Godwin, D. and J, A. Moore. *Manure Management in Small Farm Livestock Operations, Protecting Surface and Groundwater.* EM8649 (Oregon State University, Cooperative Extension Service, 1997).

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Koelsch, R. *Manure applicator calibration.* G95-1267-A (University of Nebraska Cooperative Extension, 1995).

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Rynk, R. *On-Farm Composting Handbook.* NRAES-54 (Northeast Regional Agricultural Engineering Service, 1992).

Lists of Laboratories and Consultants

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Notes

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PNW0533

SOIL AND MANURE SAMPLING INSTRUCTIONS
FOR
ANIMAL WASTE MANAGEMENT SYSTEMS

SOIL SAMPLES Job Sheet 5

Spring Soil Samples

- Spring soil samples are to be collected the last 2 weeks of March or the first 2 weeks in April when soils are not saturated

- Soil samples are to be collected on fields that have not received manure applications whithin the last 30 days.

- Collect several samples (about 10 one-fourth cup samples) of soils from just below the thin sod layer to a depth of 6 to 9 inches and add to bucket.

- Mix the samples in the bucket and remove about 1 cup from the mixture and place into a sample bag.

- The bags should be labeled with;
  Farm or operator name
  Sample date
  Field and tract (see NRCS plan map)
  Sample depth (0 to 9 inches)
  Soil type if determined

- Keep soil sample cool (small cooler with some ice) in the field until sample can be put in refrigerator or into freezer. Soil can be stored in refrigerator for up to 1 week or can be stored in a freezer for longer periods.

- Ship samples to lab (see shipping instructions below).

MANURE SAMPLES

Liquid Manure Samples

- Liquid manure samples should be sampled after agitating the storage facility for the first application made in the spring (March-April) and for the last application in the fall (September-October).

- Put a bucket in the path of the gun or carefully take bucket sample of liquid manure from the liquid manure tank wagon.

- Fill a sample bottle with some of the liquid manure from the bucket and keep cool while in the field. (you can put the sample in a small cooler with some ice).

- Label the sample with the farm or operator name, date, and liquid manure sample.

- Freeze the sample until ready to ship to the lab.

added by KA

SOIL AND MANURE SAMPLING INSTRUCTIONS
FOR
ANIMAL WASTE MANAGEMENT SYSTEMS

MANURE SAMPLES

Solid Manure Samples

- Solid manure Samples should be sampled during the first application made in the spring (March-April).
- Lay a piece of tarp or plastic on the pasture and make a pass over or next to it to obtain a representative sample from the spreader.
- Scoop up enough material to fill the sample bag about half full.
- Label the sample with the farm or operator name, date, and solid manure sample.
- Keep the sample cool while in the field. (You can put the sample in a small cooler with some ice.)
- Freeze the sample until ready to ship to the lab.

SHIPPING INSTRUCTIONS

- Nitrogen is heat sensitive. Keeping the samples cool in shipping helps to improve reliability of data.
- Ship frozen soil samples in small cooler
- If shipping refrigerated soil samples, it is recommended that these be shipped in a small cooler with ice.
- Ship frozen liquid or solid manure samples in a small cooler.
- Ship frozen soil samples or refrigerated soil samples with frozen liquid and/or solid samples in a small cooler. Lab should send cooler back to you if request them to do so.
- Ship any or all samples on Monday, Tuesday, or Wednesday using any parcel post service.
- Include a note with the samples for the analysis needed

Soils Analysis Needed;

P – Phosphorus (Weak Bray)
K – Potassium
NH4-N – Ammonium
NO3-N – Nitrate

Liquid and Solid Manure Analysis Needed;

Total Nitrogen, Phosphorus & Potassium plus Ammonium and Solids

EM 8913-E • July 2006 • $1.00

Feed Management

A tool for balancing nutrients on dairies and other livestock operations

M. Gamroth, T. Downing, and P. French

Many studies have shown that dairies consistently overfeed nutrients such as phosphorus (P) and potassium (K). This practice is expensive and potentially damaging to the environment and to animal health. This publication suggests ways to improve feed management and thus avoid overfeeding P and K. Proper ration balancing is good for the environment and for the producer's bottom line.

Phosphorus

Phosphorus is an important plant nutrient for growing dairy forages. Unfortunately, on many dairies, more P is excreted and stored in manure than can be used during a crop year. Application of P to crops at rates greater than crop needs allows P to accumulate in soil. Soils have the ability to store moderate overapplications of P for future crop production, but continued over-application can lead to losses of P to surface water.

Of all the essential dietary minerals for dairy cattle, P represents the greatest potential risk for environmental damage via pollution of surface water. In Oregon, most dairy producers report that surface water borders their farm property, creating a high risk of water contamination.

The concentration of P in manure is positively correlated to the concentration of P in the diet. Therefore, feeding P in excess of requirements results in greater excretion of P. Thus, managing dietary P levels to reduce P excretion should help minimize water contamination.

Over the past decade, numerous field studies and surveys have reported overfeeding of P to lactating dairy cows. Dairy producers around the country were reported to feed as much as 40 percent above the level recommended by the National Research Council (NRC).

A recent survey of dairy herds in Virginia showed that the average P concentration in the diet was 0.49 percent, while calculated requirements averaged only 0.34 percent. In many herds, P could be reduced by 45 percent if diets were formulated to meet NRC requirements. By formulating rations more precisely, dairies in this survey could reduce the P in manure by 71 percent and save $8 to $15 per cow in feed costs each year.

Research conducted in 2003 indicated that Oregon producers were overfeeding P by 18 percent. The average dairy in this study needed 100 more acres to agronomically apply the P being overfed.

Much of the overfeeding has been attributed to a 1951 publication that reported improved conception rates in dairy cattle that consumed higher levels of P. However, this improvement

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Mike Gamroth, Extension dairy specialist; Troy Downing, district dairy agent; and Patrick French, assistant professor of dairy nutrition.

occurred in cows consuming P-deficient diets (less than 0.25 percent). Therefore, over the past 50 years, the importance of dietary P for reproductive performance has been overemphasized. Recent studies have shown no beneficial effect on reproduction or production when recommended dietary P concentrations are exceeded.

Even without overfeeding, there is potential for concentrating P on the farm. Consider a 400-cow dairy. If we assume a P requirement of 0.4 percent and animals eat 50 pounds of dry matter daily, each animal needs 0.2 pound P per day. Multiplying by 400 cows and 365 days shows that the dairy will consume 29,200 pounds of P in feeds each year. If cropping on the farm removes 35 pounds P per acre per year, the dairy needs 835 acres of cropland to utilize this P, or more than 2 acres per cow!

The good news is that not all consumed P is excreted in manure. However, a dairy cow absorbs only about 30 percent of feed P to support her body maintenance and production. Thus, she excretes 70 percent. This seems like a low absorption rate, but 45 to 60 percent of consumed P is indigestible without special extraction prior to feeding. Animals fed deficient or marginally deficient diets absorb more P, so overfeeding this nutrient reduces the absorption rate and adds more P to the manure.

Thus, it is clear that strategies to avoid excess P in the diet are essential to reducing the potential for excess P accumulation on the dairy.

Potassium

When applied in excess, some nutrients accumulate within plants instead of in the soil. One such nutrient is potassium (K); forages are able to consume K in excess of plant need. When excess K is applied to soil, it is taken up by the plant and harvested with the forage.

Although K is not an environmental concern, it has been implicated in the incidence of metabolic disease around the time of calving. Forages are the primary ingredients of the

prepartum cow's diet, and the use of high-K forages increases the incidence of milk fever, which can lead to other metabolic diseases.

In 1998, Oregon dairy producers were overfeeding K in dry cow rations by 2.5-fold. Potassium continues to be overfed in the diets of both lactating and dry cows. Of particular concern is the increase in overfeeding that has occurred in dry cow diets during the past 5 years. The ability to grow low-K forages for dry cow rations will continue to challenge the industry.

Sources of excess nutrients

Much of the P and K brought onto a dairy is in livestock feeds. Research in 1992 looked at whole-farm balances for three dairies and a beef operation in an Oregon watershed listed as water-quality-impaired due to P. The dairies each milked about 100 cows, raised their own heifers, produced part of their forages, and grew crops for sale. Not surprisingly, much of their imported P came from feeds brought onto the farm (Table 1).

Table 1. Phosphorus imported onto livestock operations, Washington County, Oregon, 1992.

	Total P (lb)	Feed P (lb)	Feed P (%)
Dairy 1	3,383	2,400	71
Dairy 2	13,321	6,500	49
Dairy 3	10,354	5,700	55
Cow/calf beef	1,040	1,000	96

Using feed management to avoid overfeeding

In 2003, the U.S. Environmental Protection Agency released new guidelines for Concentrated Animal Feeding Operations and Animal Feeding Operations (CAFOs/AFOs). Under these guidelines, CAFOs/AFOs are required to develop a Nutrient Management Plan (NMP). One type of NMP is a Comprehensive Nutrient Management Plan (CNMP) as defined by USDA's Natural Resources Conservation Service.

There are six core elements of a CNMP: (1) feed management, (2) manure and wastewater handling and storage, (3) nutrient management, (4) land treatment, (5) record keeping, and (6) other manure and wastewater utilization options.

As noted above, feed represents the largest import of nutrients to the farm (followed by commercial fertilizer). Most animal livestock and poultry operations could reduce imports of nutrients in feed, particularly nitrogen and phosphorus. Good ration balancing includes giving credit to the minerals in all feeds, developing rations to consistently meet animal requirements, and avoiding the use of "insurance" supplementation.

Some or all of the following feed management strategies can become part of a farm's NMP:

- Formulate diets closer to animal requirements. Most species require a P concentration of 0.16 to 0.4 percent of ration dry matter. Many traditional feed sources contain adequate or abundant P for supporting animal growth and milk production. Table 2 shows typical P values of feeds. (All feeds, especially by-products, vary in nutrient content. It is wise to analyze each feed ingredient to know its nutrient content, including P.)

Table 2. Typical P content of selected feeds.

Feed	% P (dry matter basis)
Almond hulls	0.13
Barley grain	0.39
Brewer's grains	0.67
Canola meal	1.10
Cereal silage	0.31
Cool-season grass	0.23
Corn grain	0.30
Corn silage	0.26
Distiller's grain	0.83
Legume hay	0.26
Oats	0.40
Soy hulls	0.17
Soybean meal	0.70
Wheat bran	1.18
Wheat midds	1.02
Whole cottonseed	0.60

- Analyze livestock drinking water to determine the mineral content and adjust the diet to account for this source of nutrients.
- Decrease crude protein levels in feed and supplement with amino acids.
- Manipulate the crude protein and energy (carbohydrate and fat) content of the diet to enhance the availability of amino acids.
- Use highly digestible feeds, as appropriate.
- Consider potential impacts of alternate feed ingredients (e.g., by-products) on the nutrient content of excreted manures.
- Use concentrates and forages grown on-farm to minimize the quantity of nutrients imported and maximize the recycling of nutrients on-farm.
- Use phytase and decrease the supplemental phosphorus content of the diet for nonruminants.
- If P is being overfed, decrease P in the diet.
- Use growth enhancers as allowed by law.
- Implement phase feeding. Consider nutrient requirements based on stage of growth, intended purpose of the animal, and type of production (e.g., meat, milk).

- Implement split-sex feeding.
- Use other feed management or diet manipulation techniques that have demonstrated the ability to decrease manure nutrient content.

Record keeping

Review farm feeding practices periodically to determine whether adjustments or modifications are needed. Records can help monitor progress in feed management. Useful records might include:

- Feed analyses and ration formulation (including formulations used before and after implementing a new feeding strategy). Routinely analyze feed to document the rates at which nitrogen and phosphorus were fed. When rates fed differ from the planned rates, records should indicate the reasons for the differences.
- Manure analyses—to determine manure nutrient content (both before and after implementing a new feeding strategy).
- Soil tests—to determine accumulation or depletion of P and K in the soil (both before and after implementing a new feeding strategy). Remember that soil composition does not change overnight; it takes years to reflect dietary changes.

Conclusion

As farms increase animal numbers relative to the acres of land managed, it becomes more important to evaluate and manage the whole-farm nutrient balance. This management involves both reducing mineral imports through a feed management program *and* increasing nutrient exports off the farm.

Reduce P and K brought onto the farm

- Test soils and target manure applications to reduce use of purchased fertilizers.
- Balance rations often to precisely meet P requirements by production stage. Don't ignore the P provided in by-product feeds. Avoid free-choice and ready-to-use minerals not matched to feeds. Supplemental K is not required on most farms.
- Plant appropriate varieties of forages or cereal grains for higher yield and quality.

Increase P and K sent off the farm

- Maintain an efficient herd or flock for best conversion of feed to animal product.
- Develop a manure management system that allows for export of manure off-farm. Composting dries the product, reduces volume, and is more acceptable to users. Lagoon sludge is rich in P; find a place for it off the farm.
- Consider planting cash crops that pull P and K out of soils.
- Prevent animal mortality. Dispose of carcasses off-farm when possible.
- Contract graze with other producers when forage exceeds farm needs.

Published July 2006.

Table 2.—Phosphorus soil test.

	West of Cascades (Bray P1 test) ppm P	East of Cascades (Olsen test) ppm P
low	<20	<10
medium	20–40	10–20
high	40–100	20–40
excessive	>100	>40

Table 4.—Extractable calcium (Ca).

	Ca
low	<1,000 ppm* <5 meq/100 g soil
medium	1,000–2,000 ppm 5–10 meq/100 g soil
high	>2,000 ppm >10 meq/100 g soil

*See Table 13 (page 7) for conversions from ppm to meq/100 g soil.

Table 3.—Extractable potassium (K).

	K
low	<150 ppm* <0.4 meq/100 g soil
medium	150–250 ppm 0.4–0.6 meq/100 g soil
high	250–800 ppm 0.6–2.0 meq/100 g soil
excessive	>800 ppm >2.0 meq/100 g soil

*See Table 13 (page 7) for conversions from ppm to meq/100 g soil.

Table 1.—Lime application rates for grass or white clover-grass pastures.

If the SMP buffer test for lime is:	Apply this amount of lime (t/a):
under 5.5	4–5
5.5–5.8	3–4
5.8–6.1	2–3
6.1–6.5	1–2
over 6.5	0–1

Table 9.—Soil pH ranges.

	pH
strongly acid	below 5.1
moderately acid	5.2–6.0
slightly acid	6.1–6.5
neutral	6.6–7.3
moderately alkaline	7.4–8.4
strongly alkaline	above 8.5

Without an SMP or similar test, there is no way to know how much lime is required to adjust soil pH to a desired level. Accurate lime recommendations cannot be made solely on the basis of soil pH.

Table 10.—SMP lime requirement—field scale.

SMP buffer	Tons/acre of 100-score lime needed to raise pH of surface 6 inches of soil to the following pH's			
	5.3	5.6	6.0	6.4
6.7	—	—	—	—
6.6	—	—	—	1.1
6.5	—	—	1.0	1.7
6.4	—	—	1.1	2.2
6.3	—	—	1.5	2.7
6.2	—	1.0	2.0	3.2
6.1	—	1.4	2.4	3.7
6.0	1.0	1.7	2.9	4.2
5.9	1.4	2.1	3.3	4.7
5.8	1.7	2.5	3.7	5.3
5.7	2.0	2.8	4.2	5.8
5.6	2.3	3.2	4.6	6.3
5.5	2.6	3.6	5.1	6.8
5.4	2.9	3.9	5.5	7.3
5.3	3.2	4.3	6.0	7.8
5.2	3.6	4.7	6.4	8.3
5.1	3.9	5.0	6.9	8.9
5.0	4.2	5.4	7.3	9.4
4.9	4.5	5.8	7.7	9.9
4.8	4.8	6.2	8.2	10.4

Example: If the "SMP buffer" value is 5.9, the amount of lime needed to raise the pH to 6.0 is 3.3 tons of 100-score lime/acre.

Table 11.—SMP lime requirement—gardens.

If the SMP lime requirement test is	Apply this amount of lime (lb/1,000 ft²)
5.4 or below	250
5.5–6.0	150–250
6.0–6.5	100–150
above 6.5	0

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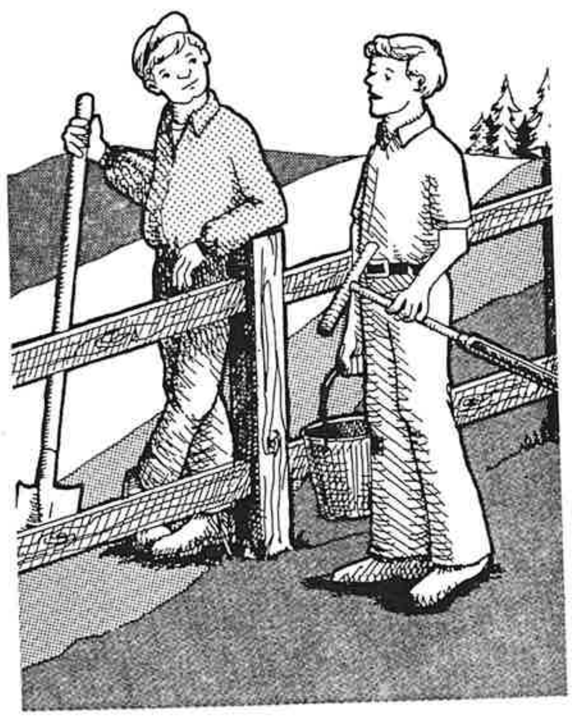
Soil Test Interpretation Guide

EC 628 • Reprinted April 2003

Soil Sampling

for Home Gardens and Small Acreages



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Laboratory soil tests will help you develop and maintain more productive soil and increase crop production by providing information on the available nutrient content of your soil. Soil testing helps you select the correct kind and amount of fertilizer and liming material. Recommendations are based on the results of fertilizer experiments, soil surveys, and results obtained by farmers.

A soil sample weighing about 0.5 pound represents from 2 to 40 million pounds of soil in the field. Thus, care in sampling is essential.

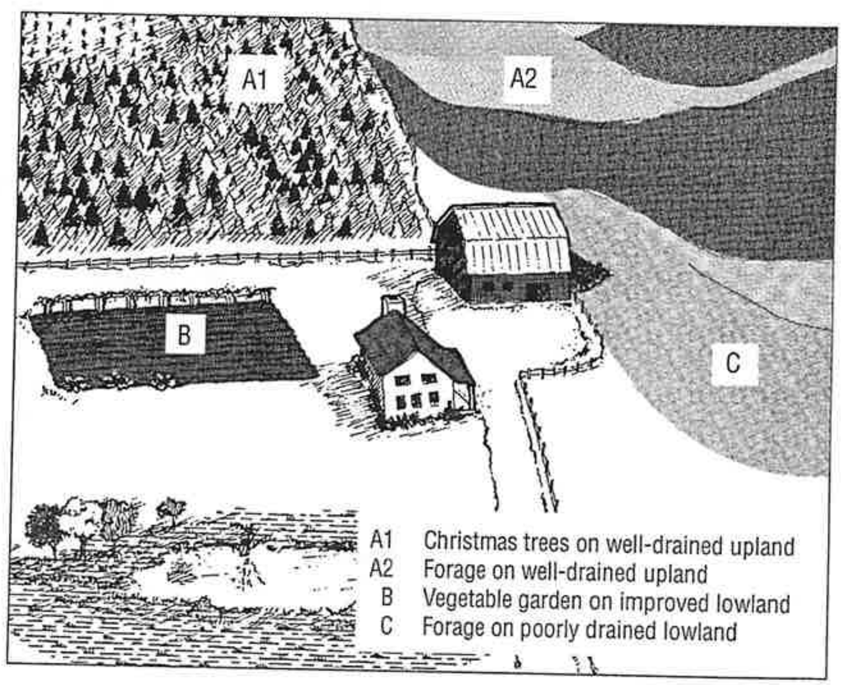
When should I test my soil?

- *For perennial crops* such as orchards, Christmas trees, alfalfa, grass seed, and permanent pasture, the most important time to test the soil is before planting so that necessary nutrients can be mixed into the soil. This test is especially important in acidic soils where liming is likely to be needed. Apply lime and mix it with the soil several months before planting (for example, in the fall for spring planting), since it reacts slowly with the soil. Then:
  - For perennial grass seed, legumes, and pastures, test soil every 3 years after planting.
  - Soil testing usually is not used for established fruit trees, berries, or grapes. Use foliar nutrient analysis instead.
  - Testing soil in timber or Christmas tree plantings usually is not necessary until replanting, unless tree growth is unsatisfactory.
- *For annual crops,* especially vegetables, test soil each year before planting. If you plant successive crops in a single season, you don't need to test before each planting.
- *Additional information* on nutrient testing methods and requirements for various crops is available in OSU Extension publications.

Each soil sample should represent only one soil type or soil condition

The farm in the illustration below has three soil types: A (upland), B (improved lowland), and C (poorly drained lowland). On the upland soil, two areas have different management histories: A1 (Christmas trees) and A2 (pasture).

Sample each soil type (A, B, and C) separately. Areas with different management histories (A1 and A2) also should be sampled separately. In this example, a separate soil sample should be taken from each of the four areas.



How to sample

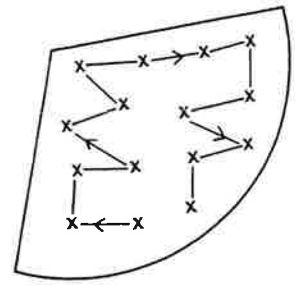
Sample where the crop will be planted

If you are using raised beds, such as for vegetable crops, take your samples in the beds, not in the areas between them.

Avoid unusual areas

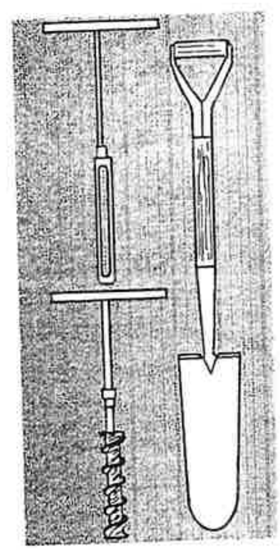
Avoid sampling in small areas where you know that conditions are different than the rest of the field (for example, former manure piles or fertilizer bands). You often can spot these areas by looking for plants growing very well or very poorly.

Take 15 to 20 subsamples



Each sample should consist of subsamples (X) taken from 15 to 20 locations within the sampling area.

Avoid contaminating the sample



- Use clean sampling tools and avoid contaminating the sample during mixing or packaging. A small amount of fertilizer residue on tools or hands, for instance, can cause serious contamination of the soil sample.
- Do not use galvanized, brass, or bronze sampling tools to collect samples that will be tested for micronutrients such as zinc.

Note: This publication is not intended to be used as guidance for obtaining soil samples for environmental testing.

Take the soil sample to the correct depth

- Sample the part of the soil where the plant roots will grow. For most annual and perennial crops, sample from the surface down to about 6 to 9 inches.

Carefully mix the soil sample

Place all of the soil subsamples from a single sampling area in a clean container and mix thoroughly.

Forwarding the soil sample

- A list of laboratories that perform soil tests is available on the Web (http://eesc.oregonstate.edu) or from your county office of the OSU Extension Service.
- Call one or more labs to determine the cost of the soil test you need.
- After choosing a lab, request any necessary paperwork (such as an information sheet), find out how you should prepare and submit the sample, and obtain the address where you should send the sample.
- Prepare and submit the sample according to the instructions. Plastic zipper bags work best; do not use a paper bag. Most laboratories ask you to label the sample bag with identifying information and to fill out and include an information sheet with the sample. Don't forget to include payment.
- Number each sample and keep a record of the fields and areas sampled.

What analysis should I request?

The standard soil test from most laboratories measures organic matter, phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sodium (Na), and soil pH (acidity). For acidic soils, the SMP buffer test is the best way to determine how much lime is needed. Certain crops might have higher requirements for specific nutrients. Consult OSU Extension publications to determine whether you should test for nutrients such as sulfur (S), boron (B), or zinc (Zn).

Special soil-sampling techniques sometimes are required

- Nitrate nitrogen soil tests are recommended only for a few crops in eastern Oregon.
- For orchards, leaf sampling is more useful than soil sampling.

religion, sex, sexual orientation, national origin, age, marital status, disability

This publication, originally prepared by E. Hugh Gardner, former Extension soil science specialist, was revised by Michael Robotham, Extension small farms faculty, Clackamas County, and John Hart, Extension soil science specialist; Oregon State University.

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FERTILIZERguide
FG 59
Reprinted June 1997

Pears

J. Hart, T. Righetti, B. Stevens, B. Stebbins, P. Lombard, D. Burkhart, and P. Van Buskirk

Fruit tree fertilization is a standard grower practice intended to supplement soil-supplied nutrients. Both soil-applied fertilizers and nutrients stored within the tree are important. Tree reserves are the major source of nutrients for developing tissues before petal fall. Current-season growth and yield are influenced by nutritional status, which in turn is affected by prior management, fertilization, and current growing conditions. The task of recommending fertilizer rates and timings therefore is complex and challenging.

Observations of annual shoot growth, crop load, size and color of leaves, and fruit size are helpful in determining fertilizer needs. In addition, leaf analysis indicates which elements are present in adequate, deficient, or excessive amounts in established orchards. Soil sampling and testing of fields before orchard planting is recommended. Apply and incorporate K, Mg, and lime before planting. Soil analysis is useful for predicting lime and fertilizer needs for both cover crop and trees.

A nutrient deficiency may be the cause of poor tree performance, if not primarily caused by lack of pruning, poor pollination, disease, winter injury, insects, physical injury to roots or trunk, limited moisture, rodents, poor weather, and/or poor soil drainage.

Apply fertilizer based on these considerations and on the probability of an economic return from the fertilizer investment. Adding inexpensive fertilizer as insurance is not economically or environmentally sound. Excess N decreases fruit skin color, soluble solids, flavor rating, and fruit density in Anjou pears. Most N fertilizers, especially ammonium sulfate, increase soil acidity.

This fertilizer guide provides information designed to help develop fertilizer recommendations. Make adjustments in fertilizer rates for specific orchard conditions such as yield potential, microclimate, cover crop, and rootstock. Consult a field representative or your county Extension agent for more information.

Nitrogen (N)

Nitrogen fertilizer recommendations in this guide differ from those in previous editions. The purpose of this publication is to present both traditional and evolving fertilizer approaches to assist in assimilating new information. Nitrogen traditionally has been applied in spring before bloom. N applications now are recommended 1 month prior to harvest, based on research at Oregon State University. Adoption of alternate N rates and timings should proceed gradually; monitor tissue N, tree vigor, and yield carefully to ensure compatibility with other management practices.

OSU research has shown uptake of 40–50 lb N/a as the total N requirement for high-yielding Comice pears (Figure 1). One-half of this N came from current-season fertilizer application; the remainder from the soil N pool (Figure 2). Other varieties may differ but probably not

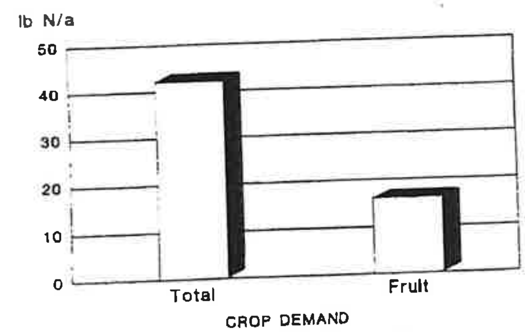

Figure 1.—Annual N demand of Comice pears.

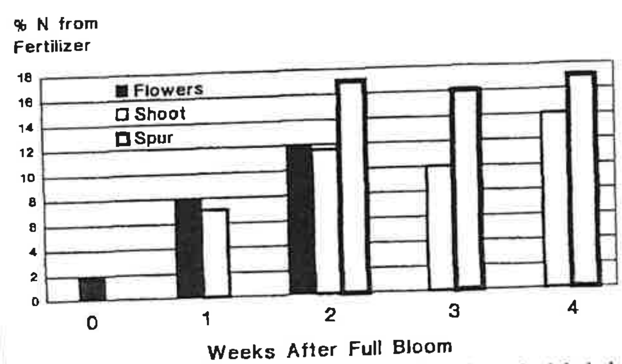

Figure 2.—Percent of the total nitrogen derived from the labeled fertilizer (NFF) in flowers, shoots, and spurs following a prebloom N application (reproduced from *Good Fruit Grower*, Oct. 15, 1990).

John Hart, Extension soil scientist, and Tim Righetti, professor of horticulture, Oregon State University; Bob Stevens, Extension soil scientist, Washington State University; Bob Stebbins, Extension tree fruit specialist emeritus, Porter Lombard, professor of horticulture emeritus, Dave Burkhart, former Extension agent, Hood River County, and Phil Van Buskirk, Extension agent, Jackson County, Oregon State University.

radically. High N rates are required because trees are inefficient in taking up N, not because N requirements are large. N uptake between leaf drop and shoot leaf emergence is minimal.

Spring growth draws N from tree reserves and only small amounts of prebloom-applied N reach newly developing tissues (Figure 2). To build reserves for the following spring while minimizing excessive vigor and fruits with high N content, late summer soil N application is suggested.

Fertilize mature trees with 100 lb N/a for normal growth and tissue N levels. Adjust this rate according to growth and tissue analysis (Table 1). The overall vigor of the tree is the best indication of nitrogen status. Pear trees more than 15 years old should make 8–10" of new growth on ends of scaffold limbs each year. Assess tree vigor to determine N concentration.

- Above-normal N and high vigor indicate over-fertilization of N.
- Below-normal N and low vigor indicate a need for additional nitrogen.
- Above-normal N and low vigor suggests another growth-limiting factor.
- Below-normal N and high vigor can occur on trees with little or no crop.

An alternative to current N fertilizer timing is to apply N to the soil 1 month before harvest. Follow with an irrigation. Reduce the soil-applied N rate accordingly if a later foliar N application is planned.

Foliar applications are helpful when tissue N is below normal. A post-harvest foliar application of 40–50 lb N/a as a 5 to 7 percent urea spray is an effective method for increasing tree N reserves. N is absorbed by leaves, then translocated to storage tissue. Either preharvest ground applications or postharvest foliar spray applications did not cause winter injury in Corvallis or Medford trials. Temperatures as low as 10°F were observed in the winter following pre- and postharvest N application.

Preharvest and foliar N fertilization are significant departures from previous spring recommendations. You may wish to test this gradually. Start with a small block of trees that is growing normally. Supplement spring fertilization with preharvest ground applications or postharvest foliar sprays. Monitor growth, tissue N, and yield. If you are satisfied with the results of this program, gradually implement new procedures in the entire orchard. Continue to monitor tree N, growth, and yield.

Table 1.—Leaf analysis guide based on % leaf N in August.

Leaf N (%)	N Status
<1.9	Shortage
1.9–2.1	Below normal
2.1–2.5	Normal
>2.5	Above normal

Apply N in the herbicide strip. If sod or grass cover is weak and you want to enhance growth, increase N rates by 40 lb/a. Apply the additional N to the sod. Additional N also may be required in orchards where weed control in tree rows is insufficient.

Young trees

Young trees should grow 18–30" annually. Apply N according to terminal growth. One- and 2-year-old trees can be injured if N is applied in a band around the tree. Spread fertilizer evenly 1–2' away from the tree trunk.

If fertilizing on a per-tree basis, divide the number of trees/a into the amount of N/a. A 6–7 year-old planting of 150 trees/a would receive $^{25}/_{150}$ x 16 (oz/lb) = 2.6 oz N/tree. To enhance vigor in young trees, spring or early summer N applications may be preferred.

N rates are on a per-acre basis, regardless of planting density. Do not increase rates for high-density plantings.

Table 2.—Pear N fertilizer recommendations based on tree age.

Tree age (years)	Apply this amount of N (lb/a)
planting–5	15–25
6–7	25–35
8–10	35–50

Phosphorus (P)

Certain P-sorbing soils of volcanic origin (for example, Parkdale, Hood River County), may require P fertilizer at planting. If the soil test P (Bray) is below 30 ppm on such soils, place ⅛ to 1 lb P_2O_5 (¼ to 2 lb, triple super phosphate, 0-45-0) in the planting hole. Cover the fertilizer with 2 to 4" of soil before planting the tree. For other soils, when the P soil test is below 15 ppm, use the same P rate and mix P fertilizer with soil as the tree is planted.

Although responses have occurred only on Parkdale soils, young trees deficient in P have responded to applications of triple super phosphate (0-45-0) at 4.5 lb/tree placed in 12"-deep holes 1' from the tree trunk. In most cases, mature pear trees deficient in phosphorus may respond to the application of mono ammonium phosphate. In cases where severe deficiency conditions exist, apply 5 to 10 lb P_2O_5/tree in a band 4 to 6" wide about halfway between the drip line and the trunk. Any water-conserving mulching material placed over the band should increase P uptake. Assess pear P status according to guidelines in Table 3.

Table 3.—Pear leaf analysis guide for P requirement, August sampling.

Leaf P in August (%)	P status
<0.10	Shortage
0.10–0.14	Below normal
>0.14	Normal

Potassium (K)

K deficiency occurs in some Oregon pear orchards. Do not apply K unless leaf analysis indicates a need for K. Low K levels can be caused by excessive crop loads and water stress, as well as by low soil K availability. Even when low levels are caused by K deficiency, K levels in the leaves often do not increase until the year following application. A single application usually is effective for 2 or more years. Preferably drill K 6–8" deep in the root zone at the drip line, or place K in a 2"-wide band for each lb K_2O per tree applied on the soil surface at the drip line. Southern Oregon orchards planted in clayey soils may require 1,000–2,000 lb/a fall injected K_2SO_4 or KCl to overcome K deficiencies.

Pear tissue K concentration, yield, and fruit size responses to K fertilization vary for variety and soil type. Figure 3 illustrates Bartlett and Anjou leaf K concentration when no fertilizer, N, and N plus K were applied. Data are from the fourth year of a trial where Bartlett trees received 50 lb/a K_2SO_4 trenched in years 1 and 2 and 25 lb/a in year 3. Anjou trees received 50 lb/a K_2SO_4 in year 1 only. Tissue K concentration responded similarly to N and K applications for both pear types. Yield and fruit size responded to fertilization in the same manner as tissue K concentration. However, even though less K was applied, Anjou trees had greater K concentrations. General guidelines to fertilization can be provided but each orchardist should consider pear cultivar and monitor growth, tissue concentration, fruit size, and crop load for every planting before deciding on a fertilizer program.

Potassium source is not critical, but salt injury can occur where muriate of potash (KCl) is used and subsequent rainfall or irrigation is inadequate to leach salts from the surface root zone. See FG 52, *Fertilizer and Lime Materials,* for more information.

K can be supplied through sprinkler systems. This method is better suited for loamy or sandy soils than clayey soils. For new plantings, K should be broadcast and plowed under during land preparation. Apply K according to Table 4.

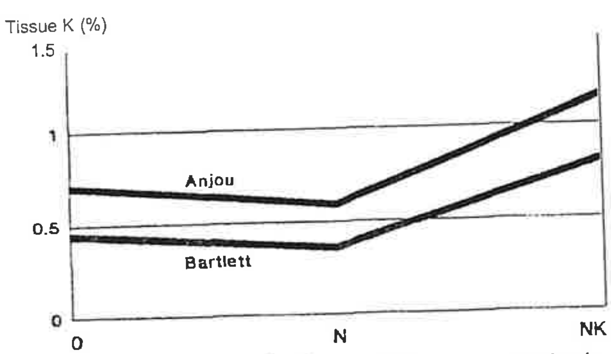

Figure 3.—Effect of K applications on K tissue concentration in Southern Oregon Bartlett and Anjou pears.

Table 4.—Pear K fertilizer recommendations using August tissue sampling or soil tests.

If acetate-extractable K is (ppm)	If leaf K is (%)	Apply K_2O this amount (lb/a)
0–75	<0.70	300–400
75–150	0.70–0.90	200–300
>150	>0.90	0

Sulfur (S)

Application of gypsum (calcium sulfate), ammonium sulfate, or other fertilizers that contain sulfur at a rate that supplies 50–100 lb of S per acre will correct a shortage of S. Anjou trees have a higher S requirement than other varieties. Applications of ammonium sulfate will depress soil pH.

Table 5.—Pear S fertilizer recommendations based on tissue concentration from August sampling.

If leaf S is (%)	Apply this amount S (lb/a)
<0.10	50–100
0.10–0.15	0–50
>0.15	0

Magnesium (Mg)

Bosc and Comice pears are more frequently deficient in Mg than other varieties. Where Mg and lime are needed, the Mg can be applied as dolomitic lime, which also reduces soil acidity. Low Mg may be related to low P; in this case, correct low P first. When lime is not required for a pH change and Mg is low, magnesium sulfate can be used.

For new plantings, an application of 1.5 T/a of dolomitic lime is recommended if the OSU soil test for Mg is less than 1.0 meq/100 g of soil.

Dolomite equals ground limestone in the correction of soil acidity, when adjusted for lime value. Apply dolomite in a similar manner to lime.

Boron (B)

B deficiencies can be treated with both foliar and soil applications in many orchards. Suggested soil application rates are listed in Table 6.

Do not apply B to nonbearing trees. Reduce rates per tree by one-half or more for young bearing trees since trees are easily injured by excessive B applications. Broadcast B when you apply it to the soil. Fertilizer rates in the following table are expressed in lb sodium pentaborate, not B. Apply no more than 20 lb/a sodium pentaborate. Annual foliar maintenance applications also are recommended, provided leaf B concentrations are not above normal.

Table 6.—Pear B fertilizer recommendations based on tissue concentration from August sampling.

B in leaves (ppm)	B status	Apply this amount Sodium pentaborate (lb/a)
<20	Shortage	15–20
<20–30	Below normal	15
<30–80	Normal	15*
>80	Above normal	0

*Maintenance application every 3 years.

For foliar applications, spray sodium pentaborate at 8 lb/a (1½ lb B/a) using 2 lb solubor/100 gal of water. Apply twice if deficiency has occurred: fall application (before leaves drop) plus prebloom application (3–4 days before blossoms open); or prebloom application plus first cover spray.

Zinc (Zn)

Zn deficiency in Oregon pear orchards is rare. Deficiency symptoms are the most reliable indication of need for Zn. If several elements are deficient, symptoms may not be clearly recognized. Symptoms occur early primarily in tops of trees. Shoots have a tuft or rosette of comparatively larger leaves at the tip with smaller, narrow, sometimes chlorotic leaves below.

If leaf Zn levels in August are below 17 ppm, suspect a deficiency. Soil and/or foliar applications will not correct Zn deficiency in 1 year. Apply Zn on a trial basis, while monitoring growth, yield, and tissue concentration.

Dormant sprays: Apply Zn sulfate at a rate of 15 lb Zn (45 lb of 32 percent Zn sulfate crystals or 13 gal liquid Zn sulfate)/a. Make the dormant application as late as possible in dormant season before any visible green appears. (Caution: Be sure all crystals have dissolved before spraying.) Other Zn materials that you can apply in oil also are available. *Afterharvest sprays*: Apply Zn sulfate spray, using about ½ lb Zn (1½ lb 32 percent crystals or ½ gal liquid/100 gal of spray). Foliage should be thoroughly wetted.

Other Micronutrients

Deficiencies of other micronutrients have not been observed in Oregon pear orchards.

Lime

Liming of orchard soils is most effective where the lime is mixed into the soil to as great a depth as feasible during the preparation of the land for planting. Use a lime requirement test to estimate the liming rate required to raise pH to 6.0.

For More Information

OSU Extension publications

Hart, J.H. 1990. *Fertilizer and Lime Materials*, FG 52 (Oregon State University, Corvallis, reprinted 1992).

To order copies of FG 52, send the title and series number to:
Publication Orders
Extension & Station Communications
Oregon State University
422 Kerr Administration
Corvallis, OR 97331-2119

You may order up to six no-charge publications without charge. If you request seven or more no-charge publications, include 25 cents for each publication beyond six.

You can obtain additional copies of this publication, *Pear Fertilizer Guide*, FG 59, from your county office of the OSU Extension Service or from the Extension and Experiment Station Communications Web site at http://wwwagcomm.ads.orst.edu/

Other publications

Dow, I.A. 1980. *Critical nutrient ranges in Northwest crops*, WREP 43 (Washington State University, Irrigated Agriculture Research and Extension Center, Prosser, WA, and the Northwest Soil and Plant Test Work Group).

Gardiner, D.T. 1989. *Phosphorus nutrition of pear seedlings with different mycorrhizae and of wheat cultivars with different efficiencies*. Ph.D. Thesis (Oregon State University, Corvallis).

Horneck, D.A., J.M. Hart, K. Topper, and B. Koepsell. 1989. *Methods of soil analysis used in the Soil Testing Laboratory at Oregon State University*, SM 89:4 (Agricultural Experiment Station, Oregon State University, Corvallis).

Lombard, P.B. 1970. Do fat K rates pay on pears? In *Better Crops with Plant Food*, No. 4 (Potash Institute of N. Am., Atlanta).

Raese, J.T. 1989. *Effect of weed control and nitrogen fertilizer rates on growth, yield, fruit quality, and mineral composition of apple and pear trees*. Proceedings 40th Annual Far West Regional Fertilizer Conference, Coeur d'Alene, ID, July 23-25, 1989.

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Sanchez, E.E., T.L. Righetti, D. Sugar and P.B. Lombard. 1990. Seasonal differences, soil texture and uptake of newly absorbed nitrogen in field-grown pear trees. *J. Hort. Sci.* 65(4):395–400.

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Stevens, R.G. and R.B. Tukey (eds.). 1983. *Tree fruit nutrition.* 1983 Shortcourse Proceedings (Washington State University Cooperative Extension).

Westwood, M.N., E.S. Degman, and J.H. Grim. 1964. *Effects of long-term fertilizer and management practices on growth and yield of pears grown in a clay adobe soil*, TB 82 (Agricultural Experiment Station, Oregon State University, Corvallis).

EM 8903-E
January 2006

Caneberries

J. Hart, B. Strik, and H. Rempel

Several types of caneberries are produced commercially in Oregon, including summer-bearing and primocane-fruiting red raspberries, black raspberries (blackcaps), and blackberries. This publication addresses nutrient assessment and application for caneberries produced in western Oregon.

In this area, caneberries typically are planted on Aloha, Jory, Newburg, Willamette, Woodburn, or Saum soils. Spacing usually is 2.5 ft x 10 ft for raspberries and 4 to 6 ft x 10 ft for blackberries. Recommendations in this publication are based on research and experience with caneberry production in this setting.

The use of fertilizer should be part of a complete management package. Nutrient application influences yield, fruit quality, fruit maturity, and sustained plant vigor. Management practices—from selection of certified plants to pre- and postharvest irrigation—must be performed in an appropriate and timely manner so that plants can benefit from applied nutrients.

Nutrient application is not a substitute for poorly timed irrigation, late harvest, or failure to control insects, diseases, rodents, or weeds. Soil properties such as low pH and/or poor drainage can be significant limiting factors in obtaining high berry yields. Increasing fertilizer rates or adding nutrients already in adequate supply will not correct these limiting factors.

Growers, with the assistance of county Extension faculty and field representatives, should consider nutrient needs of each field. Routine collection and analysis of soil and tissue samples are helpful in determining the need for nutrient applications.

To assist with interpretation of soil and tissue analysis data, keep records of weather, disease problems, nutrient application rates, and timing. Observations of annual growth (cane number, diameter, height, fruiting lateral length), yield, leaf color, and fruit quality (amount of rot and drupelet set) are also helpful in determining nutrient needs.

The goal of fertilization for any high-value crop is to remove limitations to yield and quality by supplying the crop with ample nutrition in advance of demand. Nutrient application should be based on soil and plant analyses and grower experience. Consider potential returns from your fertilizer investment, as well as environmental stewardship and governmental regulation. A fertilizer application should be "bio"logically sound and produce a measurable change in plant growth or nutrient status. The biological change caused by a fertilizer application is expected to increase fruit yield or quality and produce a return on your investment.

Caneberry plants require chemical elements from air, water, and soil to ensure adequate vegetative growth and fruit production. When levels of these nutrients in the plant are low, growth and yield may be affected. Severely reduced nutrient supply can lead to visible nutrient deficiency symptoms such as leaf discoloration and distortion (Figures 1 and 2). Routine collection and analysis of tissue

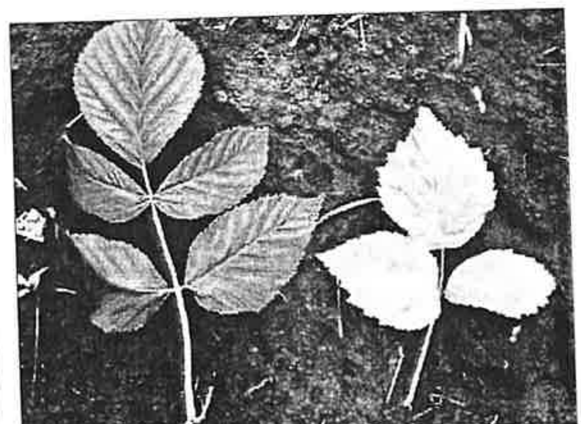

Figure 1.—Nitrogen-sufficient red raspberry (left) and nitrogen-deficient red raspberry (right).

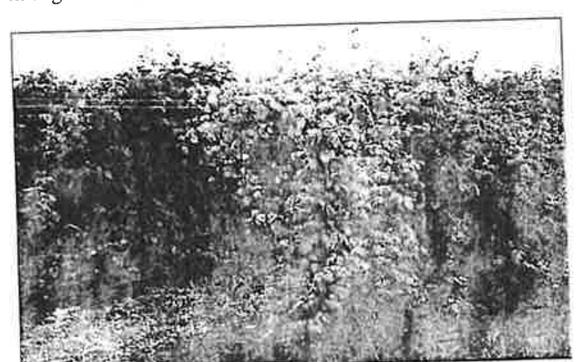

Figure 2.—Nitrogen-sufficient red raspberry (left) and nitrogen-deficient red raspberry (right).

John Hart, Extension soil scientist and Bernadine C. Strik, Extension berry crops professor, both of Oregon State University; and Hannah Rempel, research technician, USDA-ARS, Corvallis, OR. This publication replaces FG 51-E, *Caneberries Fertilizer Guide.*

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samples can detect low nutrient concentration before visible symptoms or yield reduction occurs.

Plant tissue analyses indicate which elements are accumulated in adequate, deficient, or excessive amounts. Changes in tissue analysis may not occur for 1 to 2 years after nutrient application to a perennial crop such as raspberries or blackberries, especially when immobile materials (phosphorus, potassium, and lime) are applied to the soil surface (topdressed).

Tissue testing is based on a consistent sampling time, selection of the appropriate plant part, and "standards" for comparison. The following sections provide directions for collection of soil and tissue samples.

Tissue testing

Mineral nutrients such as nitrogen (N), phosphorus (P), and potassium (K) are added through fertilizers to supplement the supply from the soil. By analyzing dried plant tissues for their nutrient content (tissue testing), you can evaluate the adequacy of mineral nutrients. This information will help you decide whether fertilizer is needed and, if so, how much and what kind to apply.

Tissue testing can be used for any of the following:

- Predicting fertilizer needs of annual crops
- Diagnosing problems
- Evaluating a fertilizer program for perennial crops

Tissue testing can be used to monitor and adjust fertilizer use during early growth stages of annual crops such as potatoes, sugar beets, or lettuce. Tissue testing can help growers anticipate fertilizer needs for these crops.

In contrast, tissue test results are not very useful for predicting current-season fertilizer needs for perennial crops such as raspberries and blackberries. In part, this is due to the minimal short-term effect of fertilizer on yield in perennial crops. Therefore, tissue testing in producing caneberries is best used for end-of-season evaluation of a fertilizer program for the next year.

If problems such as poor growth or discoloration of canes appear during the growing season, you can use a comparative tissue test to check for possible nutrient deficiencies. You can collect samples to diagnose deficiencies at any time during the season. However, if not sampling during late July or early August (see "When to sample"), you also must collect a sample from an unaffected area for comparison.

Before using tissue testing to predict or evaluate fertilizer needs, you need the following information, which is provided in this publication:

- Sampling time (stage of development)
- Plant part to sample
- Normal or sufficient concentration range for each nutrient so you can interpret results

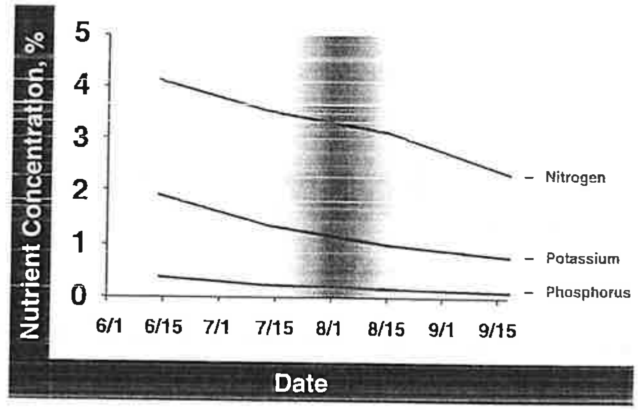

Figure 3.—The change in nitrogen (N), phosphorus (P), and potassium (K) concentration in leaves of 'Meeker' raspberries during the 2001 growing season. Tissue sampling should be done when leaf nutrient concentrations are relatively stable (shaded area).

When to sample

Tissue samples should be collected when nutrient concentration is stable. Samples collected just a few days apart during periods of rapid change in nutrient concentration can give quite different results. Changing N, P, and K concentration in leaves of 'Meeker' red raspberry primocanes is illustrated in Figure 3. Tissue concentration changes rapidly early in the growing season; compare the late-July and early-August tissue concentrations to mid-June tissue concentrations.

Tissue levels of N and K changed substantially during the season but reached a stable level in late July and early August. Samples collected during this period should produce consistent analytical results.

Figure 3 also illustrates the danger in collecting samples in late September. Nitrogen concentrations decrease as plants enter dormancy, so these samples may not give an accurate picture of the situation during the growing season.

Collect raspberry and blackberry tissue test samples during the stable period—late July to early August. Sampling raspberry tissue at any other time is not recommended except when samples are collected for comparative tissue testing to check for possible nutrient deficiencies.

Part of caneberry plant to sample

Do not mix cultivars in a tissue sample. Collect 50 of the newest fully expanded primocane leaves about 12 inches from the tip. Select only one leaf per primocane. A single sample should not represent an area of more than 5 acres or contain leaves from more than 50 primocanes.

Collect leaves that are free of disease or other damage, if possible. Pick leaves so that the petiole (stem) remains with the leaf. Do not wash the leaf samples. Put leaves in a paper bag (not plastic). Air dry them or send them to a laboratory as soon as possible. To avoid spoilage, ship fresh (moist) samples early in the week to ensure delivery before the weekend.

A list of laboratories that perform tissue analyses is available in publication EM 8677, *A List of Analytical Laboratories Serving Oregon.*

Frequency of sampling

Ideally, you should sample caneberry tissue from all fields annually. However, you may feel annual sampling is not necessary or financially feasible. Regardless of whether or not you sample every year, develop a plan for regular sampling.

Begin with fields that are not growing or yielding as desired. Annual sampling from these fields will be necessary until the problem is identified or corrected.

Divide the remainder of your acreage into two or three groups. Sample from a group of fields each year. Thus, you will sample one-half or one-third of the acreage each year.

Interpreting laboratory results

Compare laboratory results to the values in the tables found on pages 5–7 to determine whether sufficient nutrients were supplied by the soil and your fertilizer program.

Review cane growth and yield from last season. Choose the combination of tissue analysis and crop growth listed below that corresponds to your situation. Follow the instructions given for the appropriate category.

- **Low tissue analyses and abundant cane growth.** For summer-bearing red raspberries, canes should be 7 to 9 ft high and ½ inch in diameter. Cane growth of 12 to 15 ft for trailing types ('Boysen,' 'Logan,' 'Marion,' 'Kotata,' and 'Thornless Evergreen') is adequate.

  If cane growth is luxurious, don't apply additional fertilizer. This situation usually is caused by oversupply of N. Below-normal N and high vigor also can occur on canes with little or no crop. Lower-than-normal tissue nutrient concentrations are common with excessive cane growth. In this situation, low tissue nutrient concentration occurs when the tissue nutrient content is diluted by intensive growth. This condition should correct itself when growth returns to normal. Do not apply extra fertilizer, especially N, to correct low tissue concentrations when cane growth is excessive.
- **Low tissue analyses and weak cane growth.** If canes are weak, discolored, or stunted, apply fertilizer at rates recommended by your local office of the OSU Extension Service.
- **Normal tissue analyses and cane growth.** If tissue analyses and cane growth are within the normal range, continue with your current fertilizer program.
- **Above-normal tissue analyses and weak cane growth.** If canes are weak, discolored, or stunted, and the tissue analyses are above normal, look for stress from pests, drainage, drought, frost, or other factors.
- **Above-normal tissue analyses and cane growth.** If tissue analyses are above normal and cane growth is adequate or above normal, reduce the amount of fertilizer you have been applying, especially N.

Other considerations

Tissue analysis results outside the normal range cannot always be attributed to your fertilizer program. Insufficient mineral nutrient concentration can be caused by saturated or dry soils; high temperatures; frost; shade; weed, insect, or disease pressure; or herbicide injury.

Several fungicides contain plant nutrients. Because tissue samples are not washed before analysis, high copper (Cu), manganese (Mn), or zinc (Zn) might be the result of fungicide residue. High boron (B) and Zn also can occur if liquid or foliar fertilizer is used.

Collecting soil samples

Soil analysis is more useful before planting than after planting. Obtain soil samples in the summer or fall before planting to estimate amounts of nutrients and lime needed. After planting, soil analyses can be helpful in diagnosing problems, such as low soil pH or presence of excessive salts.

Fertilizer is commonly applied in a wide band centered on the caneberry rows. The band application concentrates nutrients, complicating soil sampling. Growers are well aware of the concentration of nutrients that occurs horizontally or between rows when fertilizer is placed in a band on the soil surface. However, they often neglect to think about vertical stratification. Repeated applications of N, P, and K in a band will depress soil pH and increase soil test P and K in the surface layer of soil. Neither P nor K is mobile in the soil; they will remain where placed, resulting in decreasing soil test P and K with depth.

Additional information about soil sampling is available in EC 628, *Soil Sampling for Home Gardens and Small Acreages*, and PNW 570-E, *Monitoring Soil Nutrients Using a Management Unit Approach*.

Nitrogen (N)

N requirement varies with yield, cane growth, plant age, soil type, irrigation, rainfall, and cultivar. Cane growth is an initial indicator of N sufficiency. Some caneberries are more vigorous than others and may require less N to give the desired amount of cane growth. Less N is required in the planting year than in subsequent years.

Excess N adversely affects yield and can promote vigorous vegetative growth. Excessive vegetative growth leads to longer, thinner primocanes with longer-than-normal internodes (distance between buds), thus reducing yield per cane. Excess N also can produce longer laterals on floricanes, increasing the risk of breakage during machine harvest as well as the risk of fruit diseases. When excess N is applied in late winter or early spring, fruit firmness may be reduced because a considerable portion of this fertilizer N goes to the fruit.

N fertilization should be based on tissue N concentration, cane vigor, yield, and irrigation practices. Tissue N concentration from sampling in late July or early August should be between 2.3 and 3.0 percent. See "Interpreting laboratory results" for more information.

Raspberries

In summer-bearing red raspberries, fertilizer N that is applied early (before new primocane emergence or when primocanes are less than 6 inches tall) is taken up by the new primocanes and by the fruiting laterals and fruit on the floricanes. When fertilizer N is applied when green fruit are present (approximately 1 month before first harvest), most of the fertilizer N is taken up by the primocanes and little goes to the fruit.

Research suggests that a split application of fertilizer N is best for maintaining current-season yield and good primocane growth for next season's yield. Apply half of the N about a week before primocane emergence and half about a month before first harvest.

Summer-bearing red raspberries have been shown to use about 40 percent of their stored N per year; thus, good stored reserves of N (in primocanes, crown, and roots) are important for sustaining yields.

Research suggests that delaying removal of spent floricanes after harvest can allow more time for N in the dying canes to be moved to the crown and roots, thus conserving N in the plant. In some cases, however, early "caning out" is best for disease management. Floricane prunings that are flailed and left in the field have been shown to contribute to the organic N available to the plants in subsequent years.

In general, summer-bearing red raspberries (e.g., 'Meeker,' 'Cascade Delight,' 'Coho,' 'Willamette') need 30 to 50 lb fertilizer N/acre in the establishment year and 50 to 80 lb fertilizer N/acre in subsequent years. For primocane-fruiting or fall-bearing red raspberries (e.g., 'Amity,' 'Heritage,' 'Summit'), add an additional 20 lb N/acre at bloom. For black raspberries (e.g., 'Munger'), apply 20 to 40 lb N/acre in the establishment year and 40 to 60 lb N/acre in subsequent years.

Blackberries

Trailing blackberries are produced in either an every-year (EY) or an alternate-year (AY) system. In the EY system, fruit is produced every year, with the primocanes (next year's fruiting canes) trained under the row during fruiting and trained on the wire either in late August or, more commonly, in February. In AY production, only primocanes are produced in the nonfruiting or "off year"; they are trained as they grow and fruit the following "on year" as floricanes. The primocanes are not managed in the "on year," and all canes are cut to just above crown height in October of the on-year to repeat the cycle.

Research has shown that trailing blackberries ('Kotata') allocate current-season fertilizer N to primocanes, fruiting laterals, and fruit. The following year, roots, the crown, and floricanes are a source of stored fertilizer N for growth of fruiting laterals and fruit.

Little stored N is used for early-season primocane growth. Thus, it is important to fertilize EY and AY trailing blackberries with N every year to sustain good growth and yield. A split application of fertilizer N is recommended. Apply half of the N about a week before primocane emergence and half about a month before first harvest.

In EY production, with February training, it is best to remove the spent floricanes in late fall or winter rather than immediately after harvest to conserve plant N. In the on-year of AY production, do not cut the plants to crown height before October; otherwise, regrowth of primocanes will deplete N reserves.

As a general rule for trailing blackberries, apply 30 to 50 lb N/acre in the establishment year and 50 to 70 lb N/acre in subsequent years. In 'Thornless Evergreen,' experience suggests mature plants can respond well to rates of 60 to 80 lb N/acre.

Little N research has been done on erect (e.g., 'Navaho,' 'Kiowa') or semierect (e.g., 'Chester Thornless,' 'Triple Crown') blackberries. However, we do know that these types of blackberries respond similarly to trailing blackberries in their use of new fertilizer N and reserves. These varieties are grown only in EY systems. As a general rule, apply 30 to 50 lb N/acre in the establishment year(s) and 50 to 80 lb N/acre in subsequent years. Use the higher rates for semierect types.

Other considerations

Nitrogen can be efficiently applied with P and K. Apply fertilizer in a wide band, about 2 feet wide and centered on the row. Nitrogen can be lost from surface-band applications if soils have been limed recently and the fertilizer is not washed into the soil by rain or irrigation within 1 or 2 days after application.

Caneberries use the nitrate form of nitrogen more readily than the ammonium form. Nitrate nitrogen is soluble in water and moves into soil or the plant rapidly, but it's also leached easily from soil.

Because nitrate nitrogen generally is more expensive than ammonium forms, many growers apply urea or other ammoniacal sources of nitrogen. Ammonium nitrogen is less easily leached because it binds to soil particles. However, it is converted into the nitrate form through a process called nitrification.

Soil pH is one factor controlling nitrification. Figure 4 illustrates relative nitrification of ammonium nitrate, ammonium sulfate, and urea. Urea and ammonium nitrate act similarly when the soil pH is 6.0 but differently at

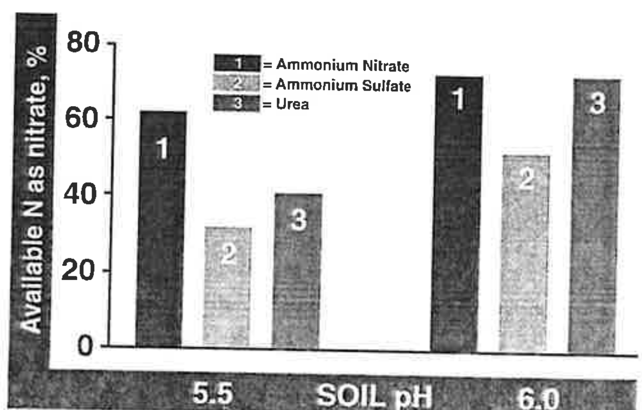

Figure 4.—Relative nitrification of N fertilizers at two levels of soil pH (Hyslop Farm, spring 1985, 140 lb N/acre applied March 7, sampled April 23).

pH 5.5. All N sources nitrify faster at pH 6.0 than 5.5. Ammoniacal N is rapidly converted to nitrate in warm, moist soil with a pH above 6.0. In the Willamette Valley, this conversion can be 50 percent complete 3 to 10 weeks after an early spring application.

Use of most common nitrogen fertilizers increases soil acidity and lime need. Table 1 shows the effect of increasing N rate on soil pH in four southern Willamette Valley soils. Urea or other ammoniacal N sources acidify the top 3 inches of soil approximately 0.1 pH unit for each 100 lb N/acre. For example, when nitrogen is applied at the rate of 140 lb/acre, the soil pH decreases by approximately 0.14 pH unit. If 140 lb N/acre is used for 3 years, soil pH will decline approximately 0.4 pH unit.

Thus, the use of nitrogen fertilizer beyond crop need has a double cost. The first cost—the N fertilizer itself—is not offset by increased yield or economic return. Second, the additional nitrogen acidifies soil, which then requires additional lime to raise the soil pH. Application of 50 lb N/acre above crop need will require an additional 0.3 to 0.6 ton lime/acre in 3 years.

Of the commonly available N sources, ammonium sulfate is the most acidifying. Urea, the most common solid or dry N source, is less acidifying than ammonium sulfate because the N in urea undergoes a different process to become plant-available. As the urea initially reacts with enzymes in the soil, the soil pH rises slightly, partially offsetting acidification produced by subsequent reactions.

Although foliar applications have been shown to be an efficient way to apply micronutrients such as zinc and boron, they have not been shown to be a very effective way of applying nitrogen. Thus, broadcast granular applications or liquid applications through drip irrigation systems are recommended .

Phosphorus (P)

Most soils in the Willamette Valley contain adequate P for caneberry production. Definitive research showing yield or growth response from P is not available for caneberries. Trial applications can be helpful in determining P need for individual fields when tissue P is below normal. See Table 2 for guidance.

Table 2.—Phosphorus recommendations for caneberries based on late-July to early-August tissue test (producing berries) or Bray soil test (preplant).

If the soil test for P reads (ppm):	If tissue P is (%):	Apply this amount of phosphate (P_2O_5) (lb/a):
0–20	<0.16	60–80
21–40	0.16–0.18	0–60
>40	>0.19	0

Although we speak and write about P, or phosphorus, the analysis on a fertilizer bag is expressed as P_2O_5. For example, the "20" in 16-20-0 represents 20 percent P_2O_5. The expression is a tradition used in the fertilizer industry. Fertilizer rates are given as P_2O_5, since this is the industry standard.

Surface application of P is less effective than subsurface banding due to lack of P mobility in soil. Rates in Table 2 are for subsurface bands. For the fastest and most efficient movement of P to caneberry roots, place bands adjacent to hills on each side of the row and 4 to 6 inches deep. Testing for 3 to 5 years may be necessary before changes are seen. Double or triple the P rate in Table 2 for a preplant, broadcast, incorporated application.

Rock phosphate can be used by growers practicing organic production. Rock phosphate material has approximately 30 percent P_2O_5 and a solubility above 50 percent. Not all rock phosphates react or release P at the same rate. Finely ground rock phosphate mined in North Carolina applied to a P-deficient soil produced wheat yields comparable to those produced by superphosphates when applied at double the rate of superphosphates.

Potassium (K)

K is essential for caneberry production. However, the amount of K fertilizer (expressed as K_2O) required is not well defined. Good fruit firmness sometimes is attributed to adequate tissue K levels. No documentation exists to support the idea that higher-than-adequate tissue concentration increases cold hardiness.

Use soil tests to determine preplant K fertilization. Plant analysis is the best indicator of K need after

Table 1.—Soil pH and lime rates required to raise the soil pH in grass seed fields after 3 years of nitrogen applications at three application rates.[a]

	Dayton silt loam		Concord silt loam		Bashaw silty clay loam			Amity silt loam	
N rate	Soil pH	Lime (ton/a)[b]	Soil pH	Lime (ton/a)[b]	Soil pH	Lime (ton/a)		Soil pH	Lime (ton/a)[b]
						4.3[c]	6.0[b]		
0	5.9	0	6.2	0	5.4			7.1	0
135	5.5	1	5.8	1.1	4.9	4.7	6.4	6.6	0
270	5.2	2	5.6	1.5	4.8	5.0	6.9	6.0	1

[a] Sampled November 2000
[b] Lime to pH 6.0
[c] Lime to pH 5.6

crop establishment. Generally, no relationship exists between soil and tissue K levels. High surface soil K and low tissue K may indicate a gravelly subsoil low in K, inadequate irrigation, diseases, or other production problems.

In fields 2 years old or older, K can be banded or broadcast, alone or in combination with N, P, and possibly other fertilizers. Table 3 indicates K fertilizer rates based on soil and tissue testing.

Table 3.—Potassium recommendations for caneberries based on late-July to early-August tissue test (producing berries) or ammonium acetate soil test (preplant).

If the soil test for K reads (ppm):	If tissue K is (%):	Apply this amount of potash (K_2O) (lb/a):
<150	<1.0	60–100
151–350	1.0–1.25	40–60
>350	>2.0	0

In new plantings, broadcast and incorporate one-half to two-thirds of the K requirement before planting and band the remaining one-half to one-third with N and P after planting. Do not include more than 40 to 60 lb K_2O/acre in N-P-K mixtures banded after planting. Excessive amounts of banded K may burn new roots, particularly in sandy soils.

Potassium is commonly supplied by potassium chloride (0-0-60, also called muriate of potash), potassium sulfate (0-0-50-18), potassium-magnesium sulfate (0-0-22-22), and potassium nitrate (14-0-45). Potassium chloride usually is less expensive than the other sources.

When using potassium chloride to supply high rates of K (more than 75 lb K_2O/a), you also apply a substantial amount of chloride. Much is said about detrimental effects of chloride on caneberry production, but no documentation exists to substantiate the comments. Even without data to support damage to caneberry production or canes from chloride, be cautious when applying more than 75 lb K_2O/acre.

One way to keep costs manageable and reduce chloride application is to mix K sources or use potassium chloride as a primary source mixed with some potassium sulfate. Potassium sulfate and potassium-magnesium sulfate also provide nutrients other than K and are most useful when sulfur and/or magnesium are needed in addition to K.

Sulfur (S)

Sulfur deficiencies in caneberry crops are not common in the Pacific Northwest. Soil S concentrations usually are adequate because S often is added with other nutrients. Fertilizer materials such as ammonium sulfate (21-0-0), potassium sulfate (0-0-50), potassium-magnesium sulfate, and gypsum contain sulfur. Use of a physical mix of urea and ammonium sulfate, urea-sul, is a common way to supply S in western Oregon.

Like nitrogen, S is a key component of proteins. Tissue S concentrations between 0.11 percent and 0.20 percent generally are adequate. The N:S ratio typically is 15:1. Sulfur is likely to be deficient if the ratio is greater than 20:1.

For example, when tissue N is 3 percent, a 15:1 N:S ratio would represent 3 percent N and 0.2 percent S. For this tissue N concentration, a tissue S concentration of 0.1 percent would be low, creating an N:S ratio of 30:1. When using the ratio approach, be sure tissue N and S are not both low.

Sulfur soil tests are difficult to use in western Oregon and Washington. Sulfur in the sulfate form, SO_4, is moderately mobile in soil; therefore, preplant application is not as critical as for lime, P, and K. A preplant application usually is not needed. If sulfur deficiency is suspected or documented, you can add S preplant, but also will need to add it regularly thereafter.

When S applications are needed, 30 to 40 lb S/acre is adequate. Sulfur can be added with N fertilizer. Gypsum is a common source of S and has little impact on soil pH.

Micronutrients

Boron (B)

Small amounts of boron are critical for bud break and fruit set of caneberries Boron deficiency results in small fruit, decreased yields, and, in severe situations, cane dieback. Table 4 provides B fertilizer recommendations based on soil or tissue tests. Note, however, that soil tests are less effective at predicting B needs for fruit crops than are tissue tests.

Boron applications without soil or tissue tests are not recommended. In an Oregon trial, continued application of B reduced yields 2 years in 5 when tissue B was adequate.

Boron should be broadcast or applied as a foliar spray. It can be added to most sprays, particularly Bordeaux mixture. Foliar boron applications in fall or spring prior to bloom are effective. Do not band apply boron.

If an analysis of a mid-July to mid-August tissue sampling is below 30 ppm B, spray sodium pentaborate (20 percent B) in fall at a concentration of 2 lb sodium pentaborate in 100 gal water. If you use dry B formulations, apply in spring before bud break.

Table 4.—Boron recommendations for caneberries based on late-July to early-August tissue test (producing berries) or hot water extractable soil test (preplant).

If the soil test for B reads (ppm):	If tissue B is (%):	Apply this amount of boron (lb/a):
<0.5	<25	2–2.5
0.5–1.5	26–30	1–2
>1.5	>30	0

Other micronutrients

No increase in growth or yield of caneberries resulting from the application of other micronutrients has been documented in western Oregon.

Lime

Acidity, or pH, is the most commonly determined chemical characteristic of soil. Acidity is a measure of the hydrogen ion concentration in soil solution. Soil solution is water held by the soil particles. Soil pH determines a soil's general suitability for root growth.

Soil acidity or alkalinity is measured and expressed as soil pH. Soil pH is measured on a scale from 0 to 14. Soil pH values below 7 indicate acidic soil, and numbers above 7 indicate basic or alkaline soil. As pH numbers decrease, soil acidity (the hydrogen ion concentration) increases. Lime is added to acidic soil to raise the pH. Amendments such as elemental sulfur are added to basic soil to reduce the pH.

Soil pH tells us the chemical condition roots will experience. As soil pH decreases, the solubility of iron, zinc, manganese, and aluminum increases. The concentration of manganese and aluminum can reach levels that are toxic or at least inhibit root growth. Crop sensitivity to manganese and aluminum varies. Caneberries are moderately sensitive.

As soil pH increases, the solubility of iron, zinc, and manganese decreases. The concentration of manganese and iron can reach levels that are deficient, causing yellowing of leaves.

For optimum caneberry production, maintain soil pH between 5.6 and 6.5. A test for soil pH determines whether lime is required. A second soil test, the lime requirement (or buffer) test (sometimes called SMP) estimates the amount of lime needed. SMP are the initials of Shoemaker, McClean, and Pratt, the creators of the test.

Lime is most effective when mixed with the soil. Therefore, lime should be applied before planting caneberries.

Lime is recommended when the soil pH is 5.6 or below, or when calcium (Ca) levels are below 5 meq Ca/100 g of soil. However, if total bases exceed 20 meq/100 g on fine-textured (clayey) soils, lime probably is not needed unless the pH is below 5.2. Estimate the rate of lime application from Table 5.

Table 5.—Preplant lime recommendations for caneberries (tons/acre of 100-score lime needed to raise pH of surface 6 inches of soil).

If the SMP is:	Apply this amount of lime (ton/a):[a]
<5.2	5
5.2–5.6	4–3[b]
5.7–5.9	3–2
6.0–6.2	2–1

[a] Rates based on 100-score lime.

[b] The higher lime rate is required for the lower SMP buffer value.

Increase the lime rates in Table 5 by 1 to 2 tons/acre before establishment of a new field. Mix lime into the soil at least several weeks before planting. A lime application is effective over several years.

Sandy soils to which fertilizers have not been recently applied sometimes record low pH and high SMP buffer values. In such cases, a light application of 1 to 2 tons lime/acre should suffice to neutralize soil acidity.

For acid soils low in magnesium (Mg) (less than 1.0 meq Mg/100 g of soil), 1 ton dolomitic lime/acre can be used as a source of Mg. Dolomite and ground limestone have about the same ability to neutralize soil acidity.

For existing plantings, monitor raspberry and blackberry leaf manganese (Mn) concentration as an indicator of declining soil pH. As soil pH declines, Mn availability increases, and leaf Mn concentration rises. If leaf Mn during late July and early August is above 300 ppm, check soil pH.

Topdressing is the logical method for lime application to established plantings. A topdress lime application should not exceed 2 tons/acre. Topdressed lime moves downward ½ to 1 inch a year until reaching a depth of 2 to 3 inches. Low soil pH below the 3-inch depth will not be corrected by topdressing lime.

Fertilizer Guide 52, *Fertilizer and Lime Materials*, available from the OSU Extension Service, provides additional information on lime, including a definition of lime score and an explanation of SMP buffer.

Manure

Manure is an excellent source of plant nutrients and serves as a soil conditioner. However, because of its variable nutrient content, increased handling requirement, and nutrient release characteristics, manure requires greater skill on the part of the grower than do commercial fertilizers. Table 6 provides average nutrient contents of manures.

Table 6.—Nutrient and water content of fresh manures.

Kind of manure	Nutrient and water content (%)			
	Water	N[a]	P_2O_5	K_2O
Dairy	87	0.50	0.16	0.44
Beef	82	0.65	0.43	0.53
Poultry	73	1.30	1.02	0.50
Hog	84	0.45	0.27	0.40
Sheep	73	1.00	0.36	1.00
Horse	60	0.70	0.25	0.60

[a] About 25 percent of the N is available the first year.

Using manure to supply plant nutrients requires handling more material compared to commercial fertilizers. Consider an application of 70 lb N/acre. For this N rate, 152 lb urea (46 percent N)/acre would be required. The same amount of N from manure, assuming 1 percent N, requires 7,000 lb/acre. Also, additional manure (5,000 to 7,000 lb/acre) would be required for the first year, as not all of the N is initially available.

The conversion of unavailable N to the available form occurs throughout the growing season. If plant demands exceed the rate of conversion, a deficiency occurs. Conversely, if conversion to available forms is high late in the season, unwanted late-season growth may result.

Losses of nitrogen exceeding 50 percent can occur during manure storage or after application to the surface of the soil. Nitrogen loss is least when fresh manure is spread and worked into the soil immediately.

Manure can serve as a source of weeds and pests. Unless livestock have been fed on weed-free feed, use aged manure that has been composted at temperatures high enough to kill seeds. Aged and composted manures contain lower nitrogen concentrations than fresh manure.

Growers report that centipede-like organisms called symphylans are introduced to western Oregon caneberry fields with manure application. This association is a puzzle since symphylans feed on germinating seeds and young roots. Therefore, weed-free or plant-free free manure should not contain symphylans. High-temperature composting should reduce problems associated with manure-introduced symphylans. If you use manure, check for symphylans before application.

For more information

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Sweet corn

Eastern Oregon—east of Cascades

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Good management practices are essential if optimum fertilizer responses are to be realized. These practices include adequate irrigation, use of recommended varieties, selection of adapted soils, weed control, disease and insect control, good seedbed preparation, proper seeding methods, and timely harvest.

Because of the influence of soil type, climatic conditions, and other cultural practices, crop response from fertilizer may not always be predicted accurately. Soil test results, field experience, and knowledge of specific crop requirements help determine the nutrients needed and the rate of application.

The fertilizer application should ensure adequate levels of all nutrients. Optimum fertilization is essential for top quality and yields.

Plant Population

The fertilizer applications suggested in this guide are based on a population of 20,000 plants/a. Where the plant population exceeds 20,000/a, increase fertilizer rates by 10 percent for each additional 5,000 plants/a. Similarly, reduce fertilizer rates for populations less than 20,000/a.

An irrigation when corn is 12–18 inches (30–45 cm) high will ensure most efficient utilization of banded fertilizer.

Follow recommended soil sampling procedures to estimate fertilizer needs. Your county Extension agent can provide you with soil sampling instructions, soil sample bags, and information sheets.

Nitrogen (N)

Sweet corn requires a good supply of available N. An optimum response to N fertilization depends on adequate irrigation.

Part (40–60 lb/a) of the N should be banded at planting time—the remainder may be applied before planting and/or during the growing season before tasseling.

If the band application of N exceeds 60 lb/a (65 kg/ha), there is danger of seeding injury from the concentration of salt.

Fertilizer salt injury can be reduced by using two rather than one fertilizer band, not banding too close to the seed, and by irrigating immediately at the first sign of crop injury. Salt injury is likely to be greater in sandy soil compared to finer textured soil and in dry soil compared to moist soil.

The urea or diammonium phosphate forms of N may cause seedling injury if banded close to the seed at planting, especially where the soil pH exceeds 7.0.

The amount of N fertilizer required depends on the following factors: the preceding crop, the N carryover from the previous crop, the amount and type of residue to be plowed under, and possible leaching losses due to over-irrigation.

The following fertilizer recommendations are for mineral soils with low organic matter content.

N fertilizer rates based on soil test

The amount of residual N in the soil varies considerably.

A soil test for nitrate-N (NO_3-N) helps in evaluating the N carryover from the previous crops in the case of mineral soils with low organic matter content.

Take soil samples for NO_3-N following a growing season and prior to the application of N fertilizer.

Take soil samples from the 0- to 2-foot (0- to 0.6-m) and 2- to 5-foot (0.6- to 1.5-m) soil depths on deep soils. The soil samples should consist of soil cores removed from the entire 0- to 2-foot and 2- to 5-foot depth of soil. On soils shallower than 5 feet, take soil samples from 0 to 2 feet and from 2 feet to the expected rooting depth.

Soil test results for N are reported in ppm. One ppm N in a 1-foot depth of soil equals about 4 lb N/acre (Table 1).

Table 1.—N quantities according to soil depth.

Soil depth		Soil test NO_3-N		
(ft)	(m)	(ppm)	(lb/a)	(kg/ha)
0–2	0–0.6	4	32	36
2–5	0.6–1.8	3	36	40
		Total	68	76

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The total NO_3-N soil test values are used to estimate the N fertilizer requirement as indicated in Table 2.

Table 2.—N fertilization rates according to total soil test values.

NO_3-N Soil test (lb/a)	N Application (lb/a)[1]		
	After nonlegume crop[2]	After beans and peas[3]	After productive alfalfa, clover
0	200	160	140
40	160	120	100
80	120	80	60
120	80	40	20
160[4]	40	0	0
200[4]	0	0	0

[1]These application rates are suggested for silt loam, loam, and clay loam soils. For sandy soils, increase the application rates by 40 lb N/a.
[2]When straw is incorporated after September 1, increase the N fertilizer rate by 30–50 lb/a.
[3]After beans and peas and low-producing alfalfa and clover.
[4]For early plantings into cool soil, apply 20–30 lb N/a in a 2-inch x 2-inch band.

If the soil test value for NO_3-N is less than 2 ppm in the 0–2' soil depth, apply a minimum of 30 lb N/a (35 kg/ha) regardless of the soil test value for N below 2'. This application is to ensure adequate initial growth of plants.

Phosphorus (P)

P is essential for vigorous early growth of seedlings. All of the P should be banded 2" to the side and 2" below the seed at planting. (See Table 3.)

Table 3.—P fertilization rates for sweet corn on mineral soils.

If the soil test for P is (ppm)	Apply this amount of phosphate (P_2O_5) lb/a	kg/ha
0–10	90	100
10–20*	0	0

*For early plantings into cool soil, apply 20–30 lb P_2O_5/a in a 2-inch x 2-inch band.

Potassium (K)

Broadcast K and plow it down before planting (Table 4).

Table 4.—K fertilization rates for sweet corn.

If the soil test for K is (ppm)	Apply this amount of potash (K_2O) (lb/a)	(kg/ha)
0–100	120–180	135–200
100–200	60–120	65–135
over 200	0	0

Sulfur (S)

S requirements will vary with soil texture, leaching losses, and the soil parent material. S frequently is contained in fertilizers used to supply other nutrients such as N, P, and K and may be present in irrigation water, which can be tested for S content.

Plants absorb S in the form of sulfate. Fertilizer materials supply S in the form of sulfate and elemental S. Elemental S must convert to sulfate in the soil before the S becomes available to plants. The conversion of elemental S to sulfate usually is rapid for fine-ground (less than 40-mesh) material in warm, moist soil. Apply elemental S the year preceding the crop using finely ground (less than 40-mesh) material.

Elemental S is a strong soil acidifier.

S in the sulfate form can be applied at planting time (Table 5).

Table 5.—S fertilization rates for sweet corn.

If the soil test for SO_4-S in the 0- to 2-ft soil depth is (ppm)	Apply this amount of S* Loamy soil	Sandy soil
	(lb/a)*	
0–2	10–20	40–60
2–5	0	20–40
5–8	0	0–20
over 8	0	0

*When the irrigation water contains more than 2 ppm of S, additional S fertilizer probably is not required.

Zinc (Zn)

Sweet corn has a relatively high requirement for Zn. An application of Zn is suggested when the Zn soil test value is below 0.8 ppm.

Where Zn is required, either 10 lb/a (10 kg/ha) of Zn should be broadcast and worked into the soil prior to planting, or 3 to 4 lb/a (3 to 4 kg/ha) of Zn should be banded with the fertilizer at planting time. An application of 10 lb Zn/a should supply Zn needs for 2 or 3 years.

To correct Zn deficiency during the growing season, thoroughly wet plants with a solution containing 1 lb (0.5 kg) Zn in 50 to 100 gal (190–380 liters) of water.

Lime

Responses of sweet corn to lime have not been observed in eastern Oregon; however, where the soil test pH value is less than 5.5, a lime application is suggested. Measure soil pH prior to application of fertilizer.

On sandy soils where soil acidity is most prevalent, 1 ton of dry 100-score lime raises the pH about 1 unit. In most instances, 1 to 1½ t/a (2.2–3.4 metric ton/ha) of lime respectively will raise soil pH about one unit.

Mix lime into the seedbed at least several weeks before seeding. A lime application is effective for several years.

The liming rate is based on 100-score dry lime.

Manure

Animal manures contain variable amounts of all plant nutrients. All of the nutrients in manure are not completely available the first year. Table 6 gives the approximate average content of some nutrients in fresh animal manures.

Table 6.—Approximate average content of some nutrients in fresh manures.

Kind of Manure	Nutrient and water content (%) Water	N*	P_2O_5	K_2O
Dairy	87	0.5	0.16	0.44
Beef	82	0.65	0.43	0.53
Poultry	73	1.30	1.02	0.50
Hog	84	0.45	0.27	0.40
Sheep	73	1.00	0.36	1.00
Horse	60	0.70	0.25	0.60

*About 50 percent of the N is available the first year.

Losses of N sometimes exceeding 50 percent can occur during manure storage or following application to the surface of the soil. N loss is least when fresh manure is spread and worked into the soil immediately.

Further information on the use of manure is available from your county Extension office.

For More Information

How to Take a Soil Sample ... and Why, EC 628, by E.H. Gardner (revised 1997). No charge.

A List of Analytical Laboratories Serving Oregon, EM 8677, by J. Hart (revised 1997). No charge.

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Fertilizer and Lime Materials, FG 52, by J. Hart (reprinted 1997). No charge.

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This guide is based largely on the results of experiments conducted by Washington State University and on observations of growers' fields.

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Apples

T. Righetti, K. Wilder, R. Stebbins, D. Burkhart, and J. Hart

Observations of annual growth and size and color of leaves and fruit are helpful in determining fertilizer needs. In addition, leaf analysis indicates which elements are present in adequate, deficient, or excessive amounts. Soil analysis is useful in predicting the need for lime applications.

Suspect a nutrient deficiency if poor tree performance is not primarily due to lack of pruning, poor pollination, disease, winter injury, deep cultivation, insects, physical injury, moisture, rodents, poor weather, or poor soil drainage.

Nitrogen (N)

Apply N according to terminal growth. Young trees should grow 18 to 30 inches annually. Injury to 1- and 2-year-old trees can occur if N is applied in a band around the tree. The rates in Table 1 are based on 108 to 218 trees/a.

Table 1.—N application rates for apples.

Tree age	Apply this amount of N (lb/tree)	(oz/tree)
1	0 to 1/8	2
2	1/4	4
3 to 5	1/4 to 1/3	4 to 5
6 to 7	1/3 to 1/2	6 to 8

The overall vigor of the tree is the best indication of nitrogen status. N concentration should be interpreted with an assessment of tree vigor (Table 2):

- Above-normal N and high vigor indicate over-fertilization of N.
- Below-normal N and low vigor indicate a need for additional nitrogen.
- Above-normal N and low vigor suggest another growth-limiting factor.
- Below-normal N and high vigor can occur on trees with little or no crop.

Table 2.—Leaf analysis guide for apples: N application based on % leaf N in August.*

Golden Delicious	Nonspur Delicious, others	Newtown	Possible interpretation
below 1.6	below 1.6	below 1.5	deficiency
1.6 to 1.8	1.6 to 2.0	1.5 to 2.3	below normal
1.8 to 2.0	2.0 to 2.3	2.3 to 2.6	normal
above 2.0	above 2.3	above 2.6	above normal

*Mature trees—in sod

Excess N produces poor-quality, bitter pit, green goldens and other yellows, and late-coloring nonspur reds. Apply little or no nitrogen to orchards where trees are crowded and pruning to restrict tree size is required.

Apply N in a 2- to 3-foot band under the drip line, or increase by 20 to 30 percent for a broadcast application. Adjust rates according to results of application in previous years. Less N is needed in clean cultivated orchards. The amount of N required ranges from none to about 2 lb/tree, assuming 108 to 218 trees/a.

Higher density plantings with dwarf trees require less N per tree but have similar per-acre requirements.

N applications should be made after leaf fall in autumn and before petal fall in spring. Early fall application can increase danger of winter freeze damage in areas in which subzero temperatures may occur.

Phosphorus (P)

Table 3.—P application rates for apples.

If % leaf P in August is	Possible interpretation	Apply this amount of P_2O_5 (lb/tree)
below 0.12	deficiency	10 to 15
0.12 to 0.14	below normal	6 to 10
above 0.14	normal	0

Tim Righetti, professor of horticulture; Kris Wilder, former research assistant in soil science; Robert Stebbins, Extension horticulture specialist emeritus; David Burkhart, former Extension agent, Hood River County; and John Hart, Extension soil scientist, Oregon State University.

Sulfur (S)

Table 4.—S application rates for apples.

If % leaf S in August is	Possible interpretation	Apply this amount of S (lb/tree)
below 0.13	deficiency	1
0.13 to 0.16	below normal	0.5
above 0.16	normal	0

Deficiencies of P and S seldom are observed in Oregon apple orchards.

Potassium (K)

K deficiency is rare in Oregon apple orchards. Since K applications tend to reduce magnesium uptake, do not apply K unless leaf analysis indicates a deficient or borderline level of K (Table 5).

Table 5.—Leaf analysis guide for K application for apples.

If % leaf K in August is	Possible interpretation	Apply this amount of K_2O (lb/tree)
below 0.9	deficiency	10 to 15
0.9 to 1.2	below normal	6 to 10
above 1.2	above normal	0

Low K levels can be caused by either excessive crop loads or water stress, and do not necessarily reflect a need to initiate K fertilization programs. Even when low levels are due to K deficiency, K levels in the leaves often do not increase until the year following application. A single application usually is effective for 2 or more years. Preferably, drill K 6 to 8 inches deep in the root zone, or place a band on the soil surface at the drip line. The band should be 2 inches wide for every pound of K_2O per tree.

Potassium source is not critical, but chloride toxicity can occur if muriate of potash (KCl) is used and subsequent rainfall or irrigation is inadequate to leach chloride out of the surface soil.

Magnesium (Mg)

Mg deficiency symptoms appear as blotchy dead areas on older leaves in late summer and fall. Where Mg is needed, broadcast 1 T/a of dolomite (Table 6). Dolomite also reduces soil acidity. Vigorous, young Newtown trees often show Mg deficiency symptoms, which may disappear in later years even without application of Mg.

Table 6.—Leaf analysis guide for Mg application for apples.

If % leaf Mg in August is	Possible interpretation
below 0.18	deficiency
0.18 to 0.22	below normal
above 0.22	normal

Lime

Liming of orchard soils is most effective if the lime is mixed into the soil to as great a depth as feasible during the preparation of the land for planting. The application of lime is not suggested if the soil pH is 5.6 or higher.

The liming rate is based on dry 100-score lime (Table 7). Mix lime into the soil at least several weeks before planting. A lime application is effective for several years.

Table 7.—Lime application rates for apples.

If the SMP buffer test for lime is	Apply this amount of lime (T/a)
below 5.2	4 to 5
5.2 to 5.5	3 to 4
5.5 to 5.8	2 to 3
5.8 to 6.2	1 to 2
above 6.2	0

Topdress rates

Monitor tissue manganese (Mn) in established orchards as an indicator of declining soil pH and the need for a soil test. Figure 1 shows leaf Mn increasing as soil pH decreases in several Hood River County apple orchards. Normal apple leaf Mn is 15 to 50 ppm. When tissue Mn exceeds 100 ppm, sample soil for determination of pH.

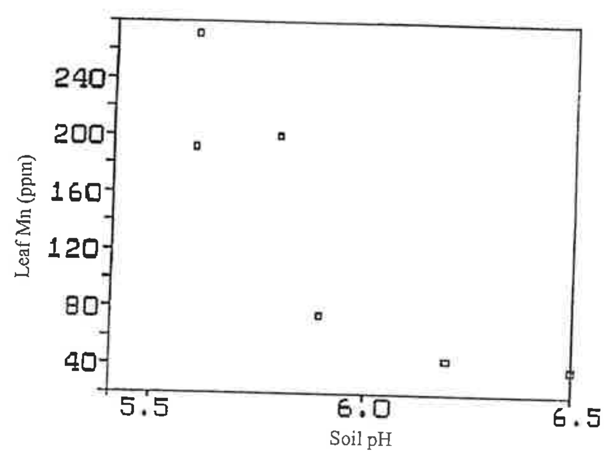

Figure 1.—Relationship between leaf Mn and soil pH in Hood River County apple orchards.

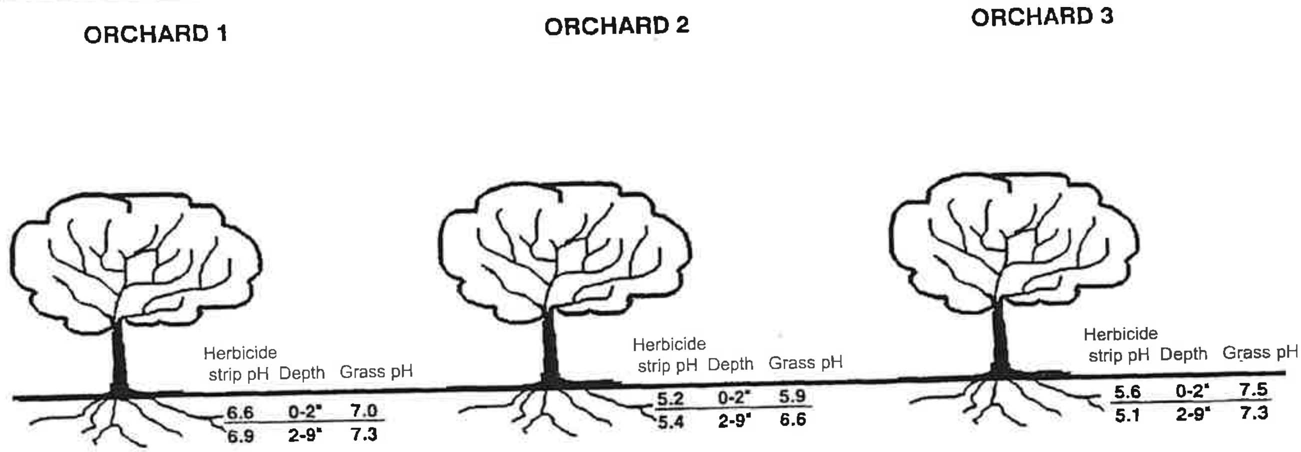

Figure 2.—Effect of soil sample depth and location on soil pH.

The soil pH value determined by a laboratory depends on the way the soil sample is obtained. Figure 2 shows the differences in orchard soil pH with soil depth and location where the sample was obtained. Soil pH in the grass area between tree rows always was higher than soil pH in the herbicide strip under the tree drip line. Soil pH in the surface 2 inches generally is lower than in the soil below this depth.

Sample soil from the area that you plan to lime, generally the herbicide strip. Use a soil sampling probe to obtain samples. Segregate soil from the upper 2 or 3 inches from soil at greater depths. Send both samples to a laboratory for determination of soil pH.

If the soil pH is below 5.6, top dress 1 to 2 tons lime/a. Lime is not soluble and will not move readily into the soil. Applications of 1 to 2 tons/a of lime will move into the soil approximately 1 inch the year following application. If your orchard has an active population of earthworms, they will mix the lime substantially deeper than 1 inch. Lime applications in filbert orchards were monitored for change in soil pH. Earthworms mixed top-dressed lime to a depth of more than 8 inches.

Soil pH changes seasonally. The lowest soil pH is found in the late summer or early fall. Samples taken in late winter or early spring have the highest pH. The average seasonal fluctuation of soil pH is 0.3 to 0.5 units, with changes of 1 pH unit not uncommon. If soil is sampled for a determination of pH, take the samples the same time each year.

Boron

Do not apply B to nonbearing trees. Reduce rates by one-half or more for young bearing trees since trees are easily injured by excessive B. (See Table 8.)

Table 8.—Leaf analysis guide for B application for apples.

If leaf B is (ppm)	Possible interpretation	Apply this amount of B* (lb/tree)
below 20	deficiency	0.10 to 0.15
20 to 30	below normal	0.10
30 to 80	normal	0.10**
80 to 100	above normal	0
above 100	excess	0

*Most commercial products are about 20% B (0.10 lb B fertilizer = 0.02 lb actual B).
**Maintenance application every 3 years

A spray application may give more rapid recovery than soil application. One preventive spray per year has been as effective as periodic soil applications. Spray at rate of 8 lb sodium pentaborate/acre. Spray twice if deficiency has occurred; fall application (before leaves drop) plus pre-bloom application (3 to 4 days before blossoms open) or pre-bloom application plus first cover spray.

Zinc (Zn)

Deficiency symptoms are helpful in diagnosing the need for Zn. Shoots have a tuft or rosette of comparatively larger leaves at the tip with smaller, narrow, sometimes chlorotic leaves below. If several elements are deficient, symptoms may not be clearly recognized. If leaf Zn levels in August are below 15 ppm, a deficiency may be more likely to occur the following spring.

Dormant sprays: Apply Zn sulfate at rate of 15 lb Zn (40 lb of 36% Zn sulfate crystals or 13 gal liquid Zn sulfate)/acre. Make the dormant application as late as possible in the dormant season before any visible green appears. *(Caution:* Be sure all crystals of Zn have dissolved before spraying.) Proprietary foliar nutrient sprays containing Zn may be used in summer. Follow recommendations on the label.

Apply after harvest when leaves are still green and active. Apply 10 lb Zn (25 lb 36% crystals or 8 gal liquid)/acre. For nonbearing trees, apply Zn sulfate spray, using approximately 0.5 lb Zn (1.5 lb 36% crystals or 0.5 gal liquid)/100 gal of spray to nonbearing trees as soon as deficiency is recognized. Thoroughly wet foliage. A spray of Zn chelate at 2 to 3 lb/100 gal 10 to 14 days following petal fall may be substituted for dormant Zn sulfate spray. In severe cases, a second spray may be required.

For More Information

OSU Extension Service publications

Fertilizer and Lime Materials, FG 52, by J. Hart (reprinted 1998). No charge.

A List of Analytical Laboratories Serving Oregon, EM 8677, by J. Hart (reprinted 1998). No charge.

Nutrient Disorders in Tree Fruits, PNW 121, by N.R. Benson, C.G. Woodbridge, and R.D. Bartram (reprinted 1994). $1.00

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Other publications

Liming for Filbert Production in Western Oregon, CI 650, by L.C. Baron and E.H. Gardner (Oregon Agricultural Experiment Station, 1975).

Tree Fruit Nutrition: A Comprehensive Manual of Deciduous Tree Fruit Nutrient Needs, A.B. Peterson and R.G. Stevens, eds. (Good Fruit Grower, Yakima, WA, 1994).

Tree Fruit Nutrition—1983 Shortcourse Proceedings , R.G. Stevens and R.B. Tukey, eds. (Washington State University Cooperative Extension, Pullman, WA, 1983).

Tissue values are based on methods used in the OSU Department of Crop and Soil Science Central Analytical Laboratory. Revised N recommendations are based on N tissue analysis groupings from Department of Horticulture Plant Analysis Laboratory data. Other recommendations are based on Extension experience and grower observation of fertilizer response.

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