Animal Waste Management Plan
July 2016

Masog Mink Ranch

Operated by:

[redacted]

Main Facility
[redacted]
Linn County

[redacted]
[redacted]
Linn County

Operation:

Mink Ranch
State CAFO

As owner and operator of **Masog Mink Ranch**, I intend to manage in accordance with the practices described in this Animal Waste Management Plan.

Signature [redacted] Date 3/3/17

REC'D MAR 06 2017

AWMP#15026

GENERAL NARRATIVE DESCRIPTION

Masog Mink Ranch is comprised of two separate locations, The main facillity is located at [redacted] while the second smaller facillity is located at [redacted] both are in or [redacted] Oregon. The facillities are owned by [redacted] and his family. The operation is a State CAFO facility in Linn County. This Mink facility is in operation year round, with low animal numbers during the winter months. Animals are removed from the houses starting in October/November and finishing in early December. Only breeding animals are held during the winter. Kits Begin to arrive in late April and contiue into May. Peak waste genteration occurs during the late summer and early fall with the sesonal low from December through April.

<u>Manure Collection Methods</u>

The animals are held in pens in a roofed opensided mink house. Manure drops through the floor of the pens and is stored under the pens until the whole house is cleaned out. Bedding in the pens is used to absorb urine and any spilled water. The manure is handled as a dry solid Facillities are scraped to remove the manure during cleanouts. The liquid waste on the operations comes from the kitchen, where the animals feed is prepared. Washwater from cleaning the food preperation area and the equipment is collected by floor drains and piped to the underground storage tanks.

Manure from the grazing animals on the main facility is either directly deposited in the fields or is deposited and stored in the animal housing facillities. Animal housing facillities are cleaned out once a year with the manure scraped up and put directly into the solids spreader and applied to the manure application area.

The main facillity has a mixed waste water/ storm water system.

During the winter months the system collects the rain that falls between the houses. This rain is intended to be kept free of contamination and is pumped directly to the an application area intended to provide filtration and vegetative treatment, while preventing discharge to surface waters. This stormwater will be managed as manure only when system malfuntion has caused contamination, and during the first pumpout of the fall when the system is being cleaned after summer use.

During the spring and summer months the stormwater system will be used to collect any waste water generated from the mink pens. The volume of this water is variable as it is created by mink activity and results from spilled water. Most of this water will either evaporate or infiltrate the grass areas between the houses. If a watering system breaks the liguid will be collected by the stormwater/wastewater system and can be applied as liquid waste. Whenever sufficient wastewater is generated the system will collect it and then it can be applied to the manure application area. All pump outs after mid April will be treated as wastewater. Records of place, rate, and date, will be kept for all of these applications.

Roof runoff at the main facillity is plumbed to drainage ditches to get it off the property without contamination. Rainfall that falls between the houses is directed to two of the underground tanks and is applied to the manure application area. This water may or may not have come in contact with manure. The plan is to not allow any manure to come out from under the houses and contact any rainfall, but the water that falls between the buildings is collected and applied to the application area as a precaution.

Roof runoff at the [redacted] facillity is directed away from the houses without contamination. Rain that falls between the houses is directed away from the houses without contamination. Manure is not allowed to come out from under the houses and contact any rainfall. Solid manure collects below the pens and is managed to prevent contamination of stormwater.

<u>Manure Storage Facilities and Transfer</u>

The manure generated at the facilities is handled in a solid form. Manure is stored in the mink houses under the pens. Manure solids are stored in the animal housing areas on both facilities. The cattle and sheep have access to sheds that provide at least 2352 cubic feet of storage. The underpen storage provides aproximately 18,087 cubic feet of storage. 11,920 cubic feet of storage at the main facility and 6,167 at the [redacted] facility. The combined solids storage at the main facillity provides 14,245 cubic feet of storage. This storage provides greater than 365 days worth of storage for solids at the main facility. The 6,167 Cubic feet of solids storage at the [redacted] facility provides aproximately 240 days of solids storage. At the main facility kitchen wastewater is stored in an underground tank with a 2,000 gallon capacity this provides aproximately 195 days of liquid storage at the main facility. The kitchen waste water for the [redacted] acility is stored in a below ground tank with 1,440 gallon capacity. This tank provides approximately 143 days of liquids storage. Liquid wastes are pumped and applied through open end lines at 50 GPM on an area of 57.3 acres at the Main facility. Liquid wastes are pumped and applied through open end lines at 50 GPM on an area of 18 acres at the [redacted] road facility. All manure at the main facillity is applied to crop ground owned or leased by Masog Mink Ranch. 100% of the manure at the [redacted] facility is applied to land owned or leased by the Masog Mink Ranch. Manure solids from the facillities may be exported to other farmers in the area to help nutrients balance. The 57.3 acres at the main facility can be almost completely fertilized with the manure solids. Only 1115.5 Pounds of nitrogen can be applied in the operations wastewater while using all of the grazing and manure solids. Using the nutrient content in storage applications must be carefully tracked to assure the not to exceed application rates are not exceeded. If the not to exceed rate is approached export of solids or waste water will be used to achieve nutrient balance. The 18 acre Liguid waste application area at the [redacted] ite is limited to 136 pounds of nitrogen per acre,(or 2488.8 Pounds of nirogen for the field) the other three fields can accept another 294.8 Pounds of nitrogen. Using the nutrient content in storage applications must be carefully tracked to assure the not to exceed application rates are not exceeded. Some of the operations waste water, or manure solids may need to be exported to other farms in the area depending on the wastewater nutirent content.

Manure Utilization

All manure is spread to hay/pasture ground or exported to other farms for use as fertilizer. All wastewater is spread to hay/pasture ground or exported to other farms for use as fertilizer.

SPECIFIC DESCRIPTIONS AND CALCULATIONS

Land Application Areas

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

All fields are available for manure applications on the farm. [redacted] runs through the southern part of the Main facilities application area. [redacted] touches the south western corner of the [redacted] facilities application area.

Five different soil types make up the manure application acreage. Soil Types include Chapman Loam (19), Clackamas Variant Silt loam (24), Courtney gravelly silty clay loam (29),Holcomb silt loam (46) McBee silty clay loam (67).

Soils Maps and custom soils reports for each site are attached

Manure and Waste Volumes

Calculated volumes of all manure, bedding, have been completed using the Oregon Animal Waste Management Worksheet (ORAWM) developed using the the NRCS Agricultural Waste Field Handbook. The worksheet is included in this Animal Waste Management Plan.

Nutrient Content of Manure, Litter and Process Waste Water

Oregon Animal Waste Management Worksheet was used to estimate volume of manure, and wastewater, as well as nutrient contents.

Farm Nutrient Balance

The amount of nutrients (N, P, K) generated, lost in storage, lost during application, used by crops and exported off of the farm is supplied for this plan using the Oregon Animal Waste Management Worksheet, included with this Animal Waste Management Plan.

Masog Mink Ranch is balancing for nitrogen on the Main facility, which is the most limiting nutrient as determined by the NRCS Phosphorus Index. The index shows that fields at this location have Site Vulnerability Classes of LOW or MEDIUM.

The [redacted] Facillity is balancing for nitrogen. This is according to the most limiting nutrient determination by the NRCS Phosphorus Index. The index shows that fields at this location have Site Vulnerability Classes of MEDIUM.

Application Schedule and Limitations

Manure that is applied to the 58.4 acres of pasture and hay ground on the Main facillity is applied as weather permits and the crop can use the nutrients. Applications are typically made year round. All manure is applied to permanent grass crops. An open ended pipe system is used to apply all liquid waste. The operation is not irrigated.

There is a no-spread area along [redacted] A thirty-five foot setback will be observed in this area.

Manure that is applied to the 53.53 acres of hay ground on the [redacted] facility is applied as weather permits and the crop can use the nutrients. Applications are typically made year round. All manure is applied to permanent grass or other crops. An open ended pipe system is used to apply all liquid waste. The operation is not irrigated.

There is a no-spread area alon[redacted]A thirty-five foot setback will be observed in this area.

Animal Mortality Management

Mink mortalities are either frosen and sold as crab bait, composted or sent to a rendering facility. Any other animals that die onsite are returned to there owners for them to dispose of.

Record Keeping and Reporting

Masog mink Ranch will test the soils in its manure application areas at least once every five years to monitor Nitrogen and Phosphorous levels.

Soil sample test results are supplied by a certified Labratory. Masog Mink Ranch records date and amount of manure or wastewater exported and Records the date, amount, and place for manure applied to their own crop ground. Application records showing the amount of Nitrogen and Phosphorus applied will be kept.

Masog Mink Ranch will report any discharge within 24 hours to the Oregon Department of Agriculture. Annual reports including amount of manure applied and exported will be submitted each year.

Operation and Maintenance

Above and/or Below Ground Liquid Tank

The tank serves as a collection point for effluent to drain to or be scraped from the animal feeding areas. If the tank will provide storage capacity to the waste management system it shall be completely emptied at the beginning of the storage period and the contents applied to cropland as weather and crop conditions permit. A 1-foot free board will be maintained to prevent spillage.

Continually maintain all pumps, agitators, piping valves and all other electrical and mechanical equipment in good operating condition by following manufacturer's recommendations. Float valves will be maintained in good working order. Perform daily inspections of waterlines including drinking water or cooling water lines. Repair leaking lines immediately to prevent excess water from entering the waste storage system. Depth markers are installed to assure maximum volume will be maintained and checked weekly. At least once every 5 years, the tank shall be emptied and inspected for structural damage and leakage. Any damage found shall be corrected before putting the tank back in service. Remove all foreign debris within the structure that may cause damage to pumps and agitator. If below ground, the tank lid will not be subjected to more than two, 8,000 pound wheel loads. Before entering a tank, for any reason whatever, proper ventilation shall be provided, and self-contained breathing apparatus shall be used, if required, when entering a covered tank. No one shall enter the tank unless safety ropes are used and someone else capable of providing assistance is outside of the tank. Warning: Entering Unventilated Tanks Is Extremely Dangerous.

Animal Access Lanes or Walkways

Damaged components will be repaired or replaced as needed. Debris and excess manure will be removed from roadway surfaces, road ditch and drainage areas. Maintain drainage area capacities. Maintain good vegetative cover on all slopes and watercourses.

Concrete Gutters

Floor gutters and grates will be inspected periodically. All foreign material restricting flow will be removed. Damage will be repaired as needed.

Curbs

Curbs, gutters and slabs that are used to convey effluent to the below ground tank will be inspected periodically. Broken sections will be repaired or replaced. Manure or other solids will be prevented from building up next to curbs or flowing over them. If over flow is a consistent problem the curb height should be increased.

Culverts

Inspect annually or after large rainfall event. All foreign objects restricting water flow will be removed. Damaged sections will be repaired or replaced. Erosion around inlet or outlet will be corrected.

Fencing

Fences will be inspected periodically. Broken or decayed posts will be replaced. Sagging wire will be tightened. Broken wire will be spliced or replaced. Broken or missing insulators for electric fencing will be replaced. Vegetation will be controlled under the fences.

Filter Strips

Maintain vigorous growth of vegetative covering. This includes reseeding, fertilization and application of herbicides when necessary. Periodic mowing, harvesting or grazing may also be needed to control height. Remove all foreign debris that hinders system operation. Limit the traffic from filter strip area. Limit livestock usage to vegetative growth periods when the animals will not damage vegetative root system or compact the soil. Eradicate or otherwise remove all rodents or burrowing animals. Immediately repair any damage.

Gutters and Downspouts

Gutters will be inspected annually to ensure all gutters are free of foreign materials. Broken gutters or downspouts will be replaced or repaired. Gutters will be connected to downspouts. Leaky gutters and downspouts will be repaired. Weeds and sediment will be removed from downspout outlets. All downspouts will be connected to outlets, which are kept free flowing. Outlets will be inspected for rodent guards and repaired or replaced as needed.

Manure Application Equipment

All manure application equipment (including but not limited to sprinklers, big gun irrigators, spreaders and/or tank wagons) will be operated and maintained according to the manufacturer's manual. Equipment found to be broken or worn will be replaced. Equipment will be calibrated to ensure recommended rates are applied. Liquids will be drained from sprinklers or big guns prior to freezing weather. When system is flushed, rinse water is used following waste, and liquid and sediment is applied agronomically. Nozzles will be checked periodically and if worn, nozzles will be replaced. Minimize exposure to animal and organic waters and manure gasses. Wear protective clothing when appropriate. When cleaning equipment after nutrient application, remove and save wastes in an appropriate manner. Avoid applying manure near surface water and use extreme care to avoid contaminating ground water.

Manure Effluent and Irrigation Transfer Lines.

Manure, effluent and irrigation lines shall be flushed with clean water periodically to prevent particle buildup and plugging. Manure flushed from the lines will be applied agronomically so that surface and groundwater will be protected. Manure, effluent and irrigation lines shall be inspected periodically for leaks or worn out nozzles, and repairs or replacements made as needed. Special inspection shall be done to pressure relief valves, risers and control valves. Shut off valves will be inspected annually. Avoid unnecessary travel over pipelines that will damage their integrity. Equipment found to be broken or worn will be replaced. Water will be drained during cold weather to prevent frozen or broken lines. These lines can explode if not properly maintained and may cause human injury.

Pumps

Pumps will be maintained in accordance with manufacturer's operation and maintenance manual. Effluent will be drained from pumps prior to freezing weather. Pumps will be inspected periodically to identify and remove debris wrapped around impeller or worn parts. Appropriate action will be taken to repair any worn parts. Liquids will be drained from pump prior to freezing weather to prevent breakage. It is recommended to have a spare pump or back up system in case a pump must be removed for an extended time for repair.

Roofs

Roofs will be inspected annually. Rusted sections will be replaced or repaired if needed. Loose sections will be secured. All broken trusses, beams, poles, gutters and downspouts will be repaired or replaced.

Trough or Tank

Watering facility will be inspected periodically. Damaged tank/trough will be repaired or replaced. Float valves will be maintained in good working order. Area immediately surrounding the trough/tank will be maintained in a stable condition.

Guidance for the composting process-

Take a representative sample of the raw compost mixture and have a laboratory determine the moisture content, pH, and the carbon and nitrogen content.

The carbon to nitrogen ratio should range between 25 and 40 to 1. Make adjustments as needed to the ingredients of the raw compost mixture as necessary to achieve a carbon to nitrogen ratio within the acceptable range.

The moisture content should be between 40 and 60 percent. Add water or drier material to adjust the moisture content. Care must be taken to see that the carbon to nitrogen ratio of the mix is still in the 25 – 40 to 1 range after adjusting the moisture content.

The pH preferably should range between 6.5 and 8 however composting may be achieved between a pH of 5.5 and 9.0.

Check pile temperature using thermometer probe on a daily basis. The pile temperature should be checked at a point one-third the distance from the outside of the pile to the center of the mass. Initially it will take approximately 2 to 3 days for the compost to get above 105 degrees F. Compost temperatures should peak between 130 and 140 degrees F in 5 to 7 days. When the temperature of the compost material falls below 110 degrees F the compost needs to be aerated by turning or other means. Failure to achieve the desired temperatures may result in the incomplete destruction of pathogens and weed seeds and can cause fly and odor problems.

Odors given off by the composting operation is a good indicator of how the compost operation is proceeding. Foul odors may mean that the process has turned from aerobic to anaerobic. Anaerobic conditions are the result of insufficient oxygen in the compost. This may be caused by excessive moisture in the compost or the need for turning or aerating of the compost material.

For a well managed windrow or static pile composting operation, the composting time during the summer months should range from 14 days to a month. To ensure a finished compost, observe that the composted material has little or no trace of the original raw material and has little odor. The material should be black to brown in color. Particle size should be consistent and soil-like in texture.

All materials that are not considered feedstocks for the composting process (i.e. plastic ear tags, plastic gloves, etc...) are to be collected and transported to a permitted landfill by a garbage collection service or other means. It is anticipated that there will be no other material that will require offsite disposal.

Periodically inspect concrete and asphalt slabs, walls and curbs and repair or replace broken sections as needed. Cleanup any spillage of composted material from outside of the composting area and place them back in the composting facility.

Maintain all fences, railings, and/or warning signs to provide warning and/or prevent unauthorized human or livestock entry. Immediately repair vandalism, vehicular or livestock damage to the structure, earthen areas surrounding the structure, or any appurtenances.

Guidance for Animal Mortality Composting- Composting animal mortalities requires a composting plan be prepared and submitted to the Oregon Department of Agriculture, Natural Resources Division. A composting plan consists of a site plan drawing of the composting facility, a description of how any runoff from the facility will be contained, a description of the composting process to be used and how the compost will be used. The composting facility for animal mortalities must have a concrete floor or similar impervious surface to prevent nutrient leaching. A roof covering the animal mortality composting facility is recommended to control moisture added by rainfall and rainfall runoff.

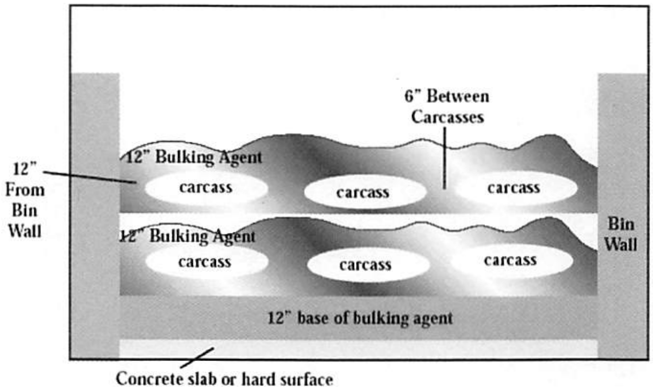
Rapid composting of dead animals occurs when the carbon to nitrogen (C:N) ratio of the compost mix ranges between 10 and 20 to 1. To achieve the recommended C:N ratio, build the initial compost pile by placing 18 inches of sawdust or other bulking agent on the floor of the composting area. The bulking agent should extend beyond the perimeter of the animal to be composted by at least 2 feet. If using a compost bin the bulking material should extend at least 1 foot beyond the perimeter of the animal being composted. Using a bulking agent such as sawdust will absorb any liquids as the animal decomposes during the composting process.

Once the bulking agent has been placed on the floor of the composting area, place the animal carcass on top. To decrease composting time and prevent bloating the body cavity should be cut open. Cover the carcass with 1 to 3 feet of separated manure solids or other material that has a moisture content between 30 to 60 percent and a C:N ratio of not more than 30 to 1. Use 1 foot of material for small carcasses and 3 feet for large carcasses such as cattle. Be careful not to add material that is to wet as it will hinder the composting process and cause odors. Small animals can be layered in a compost pile by placing 12 inches of the bulking agent between layers as shown in the figure below. Be sure the total height of the compost pile does not exceed 7 feet in height as it may spontaneously combust causing a fire.

The first heating or primary composting cycle will take approximately 15 to 90 days depending on the size of the animal being composted. Refer to the table below for estimated primary composting times. Check pile temperature using thermometer probe on a daily basis. The pile temperature should be checked at multiple points around the compost pile and at a point approximately 3 feet into the pile. The temperature of the compost pile should reach 130 degrees Fahrenheit (F) within a few days. Temperatures should peak between 130 and 150 degrees F in 3 to 4 days. When the temperature of the compost pile falls below 130 degrees F, the compost needs to be aerated by turning or other means. Be sure carcasses remain covered with the bulking agent after being aerated. It is important to maintain a temperature above 130 degrees F for at least 7 days during the primary composting cycle as failure to do so may result in the incomplete destruction of pathogens and can cause fly and odor problems. After aerating the compost pile, the secondary composting times will be similar to the first.

CAUTION: It is unclear whether prions that are the proteins that cause Bovine Spongiform Encephalitis (BSE or Mad Cow Disease) are destroyed in the composting process. Animals showing signs of Mad Cow Disease and those with anthrax should not be composted and must be reported to the Oregon Department of Agriculture, Animal Health and Identification Program for guidance on disposal.

After aerating the compost pile by turning or other means, be sure to check the moisture content and add water if necessary being careful not to add to much water. The compost pile should feel moist to the touch but you should not be able to squeeze any water out of it.



Primary Composting Times

Carcass Size (lb)	*Estimated Primary Composting Days*
0-10	15
10-25	22
25-300	45
300-750	60
750-1400	90

Odors given off by the composting operation is a good indicator of how the compost operation is proceeding. Foul odors may mean that the process has turned from aerobic to anaerobic. Anaerobic conditions are the result of insufficient oxygen in the compost. This may be caused by excessive moisture in the compost or the need for turning or aerating of the compost pile.

After the composting process is finished, it may be used as a bulking agent for a new compost pile. A rule of thumb is to use 50 percent of the composted material for a bulking agent but you may want to use more or less depending on how degraded the bulking agent is in the finished compost. Using finished compost in a new compost pile reduces the amount of bulking agent needed for the new pile and provides microbial inoculants to get the composting process started.

Finished compost can also be applied to crop and pasture land fields for utilization of the nutrients and organics in the composted material. Compost from animal mortalities should not be applied to crops that will be consumed directly by humans. The nutrient content of the composted material should be determined and application equipment calibrated to ensure nutrients contained in the composted material are not over applied.

1.3 [redacted]

[redacted]

In Case of an Emergency Spill, Leak or Failure During Transport or Land Application

Implement the following first containment steps:

a. Stop all other activities to deal with the emergency.
b. Call sheriff's office (See Table 3.1) if manure is spilled on road for traffic control and clean the spill immediately from the road and roadside if needed.
c. Contain the spill or runoff from entering surface waters using straw bales, saw dust, soil or other appropriate materials.
d. If flow is coming from a tile, plug the tile with a tile plug immediately.
e. Assess the extent of the emergency and request additional help if needed.
k. If a Discharge to ground or surface waters occurs, the Oregon Department of Agriculture is to be Notified within 24 hours (See Table 3.3) and a Written Report is to be made by the Owner or Operator to Oregon Department of Agriculture within 5 Days that contains the following information:
   (1) A description and cause of the discharge.
   (2) The period of discharge including exact dates, times and duration of discharge.
   (3) An estimate of discharge volume.
   (4) Name or location of receiving water.
   (5) Corrective steps taken, if appropriate, to reduce, eliminate or prevent reoccurrence of the discharge.

The land application equipment will be constantly monitored by the person conducting the land application of manure. In order to prevent an accident or spill during land application, operator should complete an inspection of the land application equipment to ensure proper function prior to performing land application. In addition, weather conditions (wind speed and direction, precipitation, etc.) and field conditions (proper setbacks noted, soil moisture, etc.) should be verified prior to land application.

Table 3-1.

Department / Agency	Phone Number
Fire Emergency Fire Non-Emergency	**911** **(541) 451-1901**
Ambulance	**911**
Sheriff Emergency Sheriff Non-Emergency	**911** **(541) 967-3911**

Table 3-2. Available equipment/supplies for responding to emergency

Equipment Type	Contact Person	Phone Number
Nearest excavation equipment		

Table 3-3. Contacts to be made by the owner or operator within 24 hours

Organization	Phone Number
Oregon Department of Agriculture Confined Animal Feeding Program 635 Capitol Street N.E. Salem, OR 97301-2532	**(503) 986-4700** **TTD (503) 986-4762**
Oregon Emergency Response System (ORES)	**(800) 452-0311**
County Environmental Health Department	**(800) 304-7468** **(541) 967-3821**

Be prepared to provide the following information:

a. Your name and contact information.
b. Farm location and other pertinent identification information.
c. Description of the emergency.
d. Estimate of the amounts, area covered, and distance traveled.
e. Whether manure has reached surface waters or major field drains.
f. Whether there is any obvious damage; i.e., employee injury, fish kill, or property damage.
g. Current status of containment efforts.

Masog Fur Ranch Farm Fields Overview Map

[redacted]

0 500 1000 1500 Feet

N
W E
S

Field Name
Subfield Name (Optional)
Acres
Spreadable Acres

Farm Fields Map
for
Masog Fur Ranch

[redacted]

[redacted] Hay and Pasture, 58.4 Acres

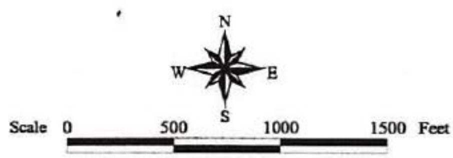
Acres Spreadable Acres - Field Label and Boundary

- Emergency Application Area

- 35 Foot Vegetated Setback Buffer

- Wastewater Transfer Pipeline

- Well



Masog Fur Ranch Farm Topographic Map

[redacted]

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NATURAL RESOURCES

Oregon Department of Agriculture
ANIMAL INCREASE REQUEST
National Pollutant Discharge Elimination System
(NPDES PERMIT)

Statutory Authority
Oregon Revised Statutes (ORS) 468B.050 When permit required
ORS 468B.210 Maximum number of animals based on ability to contain, treat, hold and dispose of wastes as necessary to comply with all conditions of the permit.

A. General Information **Master Address #**

Name or Business Name Masog Ranch LLC

Facility Location Address [redacted]

City [redacted] Zip Code [redacted] County Linn

B. Livestock Type: Circle the item that best represents your operation.

1. Beef Feedlot (Fattening) 2. Beef Cattle (Cow/calf) 3. Hogs 4. Sheep and Goats
5. Dairy Farm, Heifer Replacement Farm 6. Poultry/Broiler 7. Poultry/Eggs
7. Mink/Rabbits 8. Horses and Other Equine 9. Other

C. Current Permitted Animal Numbers: In the space below pleas[redacted] **animals by herd composition or class.**

[redacted] 20,000 Young + 5,000 Adult 10,000 Young + 4,000 Adult

D. Current Permitted CAFO Designation: Circle one. See reverse side for table.

Large Federal CAFO Medium Federal CAFO State CAFO

E. Proposed increase in permitted animal numbers: In the space below please describe your increased animal numbers by herd composition or class.

The numbers at [redacted] are: 4,000 Adult + 10,000 Young Animal

F. New CAFO Designation based on increased animal numbers. Circle one. See reverse side for table.

Large Federal CAFO Medium Federal CAFO State CAFO

G. Certification:
I understand that an approved animal waste management plan is required prior to permit increase. I agree to prepare and implement an animal waste management plan in accordance with the requirements and timelines specified in the permit.

[redacted] 9/28/15
Date
9/28/15
Date [redacted]

ANIMAL WASTE MANAGEMENT PLAN AMENDMENT

Masog Ranch LLC
Confined Animal Feeding Operation

[redacted]

[redacted] [redacted]
Facility Street Address, City, State, Zip **Phone Number**

Submitted to the Oregon Dept. Of Agriculture are the following modifications to Animal Waste Management Plan (AWMP) # 63030.

I would like to apply the following modifications to this AWMP:

I would like to add the [redacted] facility to the Masog Ranch LLC facility located at [redacted]
added Soils, info Maps and P-index For New Ground, irrigation guidance is in original AWMP
added New Drawing For New facility
O+M To Be the Same On Both Sites

[redacted]

9/28/15
Date

__________ Approved __________ Denied

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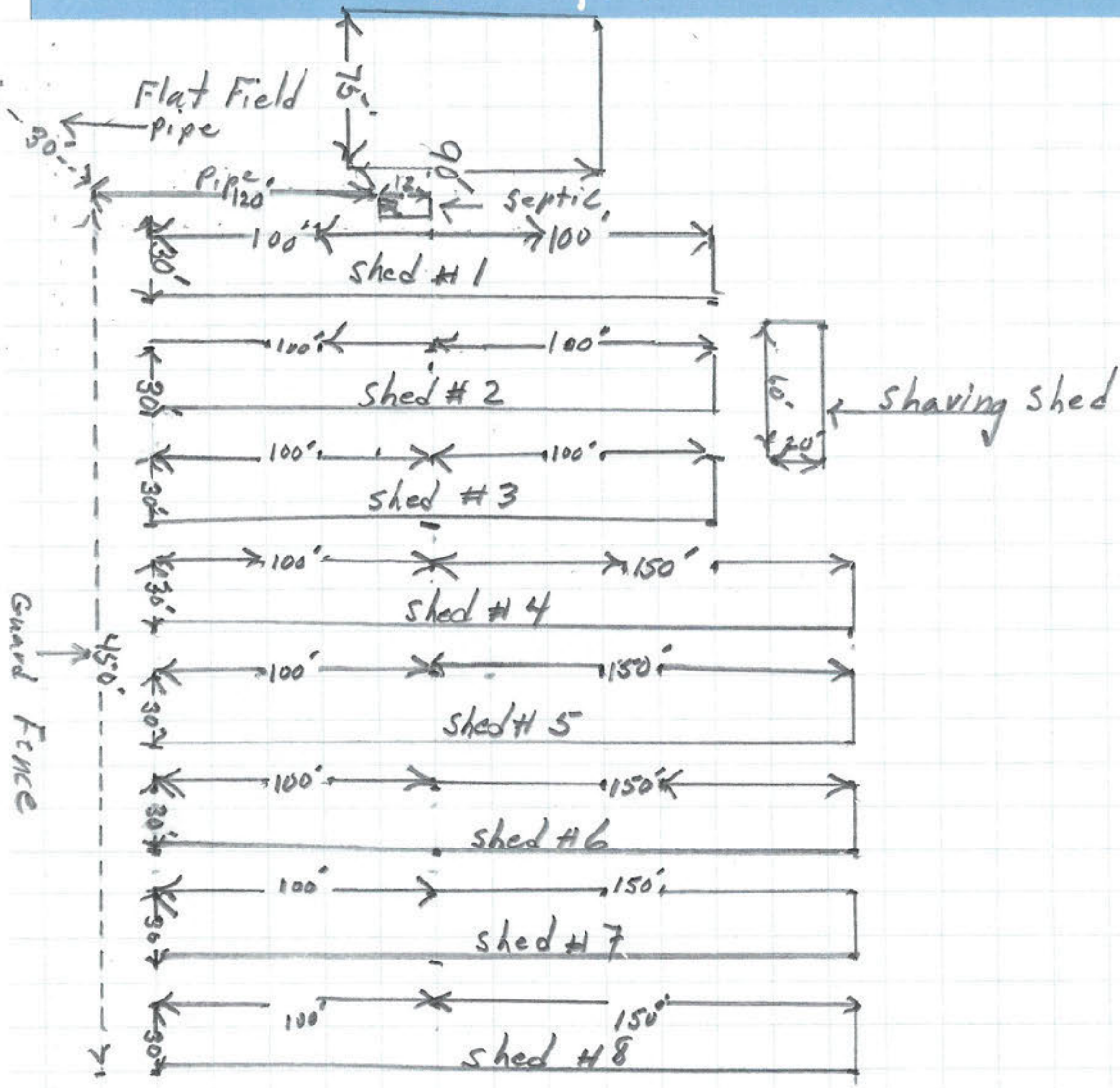
____
Inspector's Signature

Official Use:

MA# __________ Effective date: __________

Date copy sent to Operator: __________


Flat Field
75'
90'
30'
Pipe
Pipe 120'
12'
Septic
100'
100'
30'
Shed #1
100'
100'
30'
Shed #2
60'
20'
Shaving Shed
100'
100'
30'
Shed #3
100'
150'
30'
Shed #4
Guard Fence
450'
100'
150'
30'
Shed #5
100'
150'
30'
Shed #6
100'
150'
30'
Shed #7
100'
150'
30'
Shed #8

[redacted]

[redacted]

[redacted]

[redacted]

OREGON ANIMAL WASTE MANAGEMENT DESIGN AID (ORAWM)

Version 4.7

CLIENT: Masog Ranch LLC [redacted] road facillity

ASSISTED BY: Technical Service Provider ODA anderson

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	(lbs./day) N	P	K	Manure CF/D/AU	Annual Days Confined	Days Grazed	Days Off Farm
MINK(FEMALE)	3,000	5	15.0	0.94	0.83	0.12	14.10	12.45	1.80	1.38	365	0	0
MINK(MALE)	1,000	4	4.0	0.94	0.83	0.12	3.76	3.32	0.48	1.38	365	0	0
KIT	10,000	2	20.0	0.94	0.83	0.12	18.80	16.60	2.40	1.38	244	0	121
SHEEP	0	100	0.0	0.45	0.07	0.30	0.00	0.00	0.00	0.63	0	0	365
BEEF COW	0	1,200	0.0	0.35	0.08	0.25	0	0.00	0.00	1.67	0	0	365
CALF	0	600	0.0	0.45	0.08	0.29	0.00	0.00	0.00	1.23	0	0	365
Totals/Averages-	14,000	319	39.0	0.94	0.83	0.12	36.7	32.4	4.7	1.4			

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.
MINK(FEMALE)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	0
MINK(MALE)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	0
KIT	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
	10000	7500	0	0	0	0	2500	10000	10000	10000	10000	10000	0
SHEEP	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	
	0	0	0	0	0	0	0	0	0	0	0	0	0
BEEF COW	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	
	0	0	0	0	0	0	0	0	0	0	0	0	0
CALF	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	
	0	0	0	0	0	0	0	0	0	0	0	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>>>	0	0	0	0	0	0	0	0	0	0	0	0	0
Total AUM's>>>>>>>>>>	0	0	0	0	0	0	0	0	0	0	0	0	0

WEATHER STATION

CORVALLIS STATE UNIV

	25Yr-24Hr	4.50	Lot Runoff Factors as a Percent of Monthly Precipitation
	RCN=	95.00	
	Average Monthly Inches		

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	0

OREGON ANIMAL WASTE MANAGEMENT DESIGN AID (ORAWM)

Version 4.7

CLIENT: Masog Ranch LLC [redacted] road facillity

ASSISTED BY: Technical Service Provider ODA anderson

ANIMAL WASTE MANAGEMENT SYSTEM INVENTORY

Month	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		

Unpaved Lot Area >>	0
Roof Area >>	0
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>>>>>>>>>>>>>>>>	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	3000.0	2	0.00	0	0.0
Equipment Wash		2	0.00	0	0.0
Flushwater		2	0.00	0	0.0
Miscellaneous		1	10.00	10	1.3
Total>>>				10	1.3

CROP DATA

Field Number	Acres	Crop	Percent Dry Matter (DM)	Yield Units	Target Yield	Nutrients Removed in Pounds per Acre: Nitrogen N	Phosphorous P2O5	Potassium K2O
Main 1	37.8	Perennial Hay/Pasture(Med Intensity)	85%	Ton	4.00	163	55	156
Main 2	5.5	Perennial Hay/Pasture(Med Intensity)	85%	Ton	4.00	163	55	156
[redacted]	14.0	Perennial Hay/Pasture(Med Intensity)	85%	Ton	4.00	163	55	156
[redacted]	18.3	Grass/Legume Hay/Pasture	85%	Ton	4.00	136	49	36
[redacted]	2.1	Grass/Legume Hay/Pasture	85%	Ton	4.00	136	49	36
[redacted]	23.7	Grass/Legume Hay/Pasture	85%	Ton	4.00	136	49	36
[redacted]	9.4	Grass/Legume Hay/Pasture	85%	Ton	4.00	136	49	36
Off Farm								
Total Acres-	110.9							

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
MINK(FEMALE)	Confined	Sawdust	12.00	0.25	0.02	0	4
MINK(MALE)	Confined	Sawdust	12.00	0.25	0.02	0	1
KIT	Confined	Sawdust	12.00	0.25	0.02	0	5
SHEEP	Loose Housing	Loose Straw	2.50	5.40	2.16	0	0
BEEF COW	Loose Housing	Loose Straw	2.50	0.75	0.30	0	0
CALF	Loose Housing	Loose Straw	2.50	0.75	0.30	0	0

CLIENT: Masog Ranch LLC [redacted] road facillity
ASSISTED BY: Technical Service Provider ODA anderson

ANIMAL WASTE MANAGEMENT SYSTEM INVENTORY

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
MINK(FEMALE)	Dry Scrape System	100%	21	0	0	21	0	36	756
MINK(MALE)	Dry Scrape System	100%	6	0	0	6	0	36	202
KIT	Dry Scrape System	100%	28	0	0	28	0	36	1,009
SHEEP	Dry Scrape System	100%	0	0	0	0	0	36	0
BEEF COW	Dry Scrape System	100%	0	0	0	0	0	36	0
CALF	Dry Scrape System	100%	0	0	0	0	0	36	0
Total Solids>>>			55	0	0	54	0		1,967

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CLIENT: **Masog Ranch LLC [redacted] road facillity**
ASSISTED BY: **Technical Service Provider ODA anderson**

ANIMAL WASTE MANAGEMENT SYSTEM PRODUCTION

MONTHLY VOLUMES

Month	Runoff in Cubic Feet: Roof Area Square Feet 0	Paved Slab Area Square Feet 0	Unpaved Lot Area Square Feet 0	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
October	0	0	0	0	41	342	1,326	25	302	1,694	60,970	0	0	1,694
November	0	0	0	0	40	289	1,119	21	255	1,429	51,439	0	0	1,429
December	0	0	0	0	41	167	646	12	147	825	29,703	0	0	825
January	0	0	0	0	41	167	646	12	147	825	29,703	0	0	825
February	0	0	0	0	37	151	584	11	133	745	26,829	0	0	745
March	0	0	0	0	41	167	646	12	147	825	29,703	0	0	825
April	0	0	0	0	40	204	790	15	180	1,009	36,310	0	0	1,009
May	0	0	0	0	41	342	1,326	25	302	1,694	60,970	0	0	1,694
June	0	0	0	0	40	331	1,284	24	293	1,639	59,003	0	0	1,639
July	0	0	0	0	41	342	1,326	25	302	1,694	60,970	0	0	1,694
August	0	0	0	0	41	342	1,326	25	302	1,694	60,970	0	0	1,694
September	0	0	0	0	40	331	1,284	24	293	1,639	59,003	0	0	1,639
Annual	**0**	**0**	**0**	**0**	**488**	**3,173**	**12,304**	**234**	**2,804**	**15,710**	**565,572**	**0**	**0**	**15,710**
Annual Gallons	**0**	**0**	**0**	**0**	**3,650**	**23,732**	**92,034**	**1,748**		**117,513**		**0**		**117,513**

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	Grazing Manure Gallons/Yr	Confined Manure Cubic Feet/Yr
MINK(FEMALE)	0.00	0.00	0.00	14.10	28.52	2.17	0.00	0.00	0.00	0	7,556
MINK(MALE)	0.00	0.00	0.00	3.76	7.61	0.58	0.00	0.00	0.00	0	2,015
KIT	0.00	0.00	0.00	18.80	38.03	2.89	0.00	0.00	0.00	0	5,906
SHEEP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
BEEF COW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
CALF	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
									Total-	**0**	**15,477**

CLIENT: **Masog Ranch LLC** [redacted] **road facillity**
ASSISTED BY: **Technical Service Provider ODA anderson**

ANIMAL WASTE MANAGEMENT SYSTEM PRODUCTION

MONTHLY NUTRIENT PRODUCTION

	Pounds of Nutrients from **LIQUIDS**			Pounds of Nutrients from **SOLIDS**			Pounds of Nutrients from **GRAZING**			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
October	0	0	0	1,136	2,299	175	0	0	0	1,136	2,299	175
November	0	0	0	959	1,940	147	0	0	0	959	1,940	147
December	0	0	0	554	1,120	85	0	0	0	554	1,120	85
January	0	0	0	554	1,120	85	0	0	0	554	1,120	85
February	0	0	0	500	1,012	77	0	0	0	500	1,012	77
March	0	0	0	554	1,120	85	0	0	0	554	1,120	85
April	0	0	0	677	1,369	104	0	0	0	677	1,369	104
May	0	0	0	1,136	2,299	175	0	0	0	1,136	2,299	175
June	0	0	0	1,100	2,225	169	0	0	0	1,100	2,225	169
July	0	0	0	1,136	2,299	175	0	0	0	1,136	2,299	175
August	0	0	0	1,136	2,299	175	0	0	0	1,136	2,299	175
September	0	0	0	1,100	2,225	169	0	0	0	1,100	2,225	169
Annual	**0**	**0**	**0**	**10,542**	**21,326**	**1,622**	**0**	**0**	**0**	**10,542**	**21,326**	**1,622**

Total Liquids
Cubic Feet
41
40
41
41
37
41
40
41
40
41
41
40
488
3,650

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ASSISTED BY: **Technical Service Provider ODA anderson**

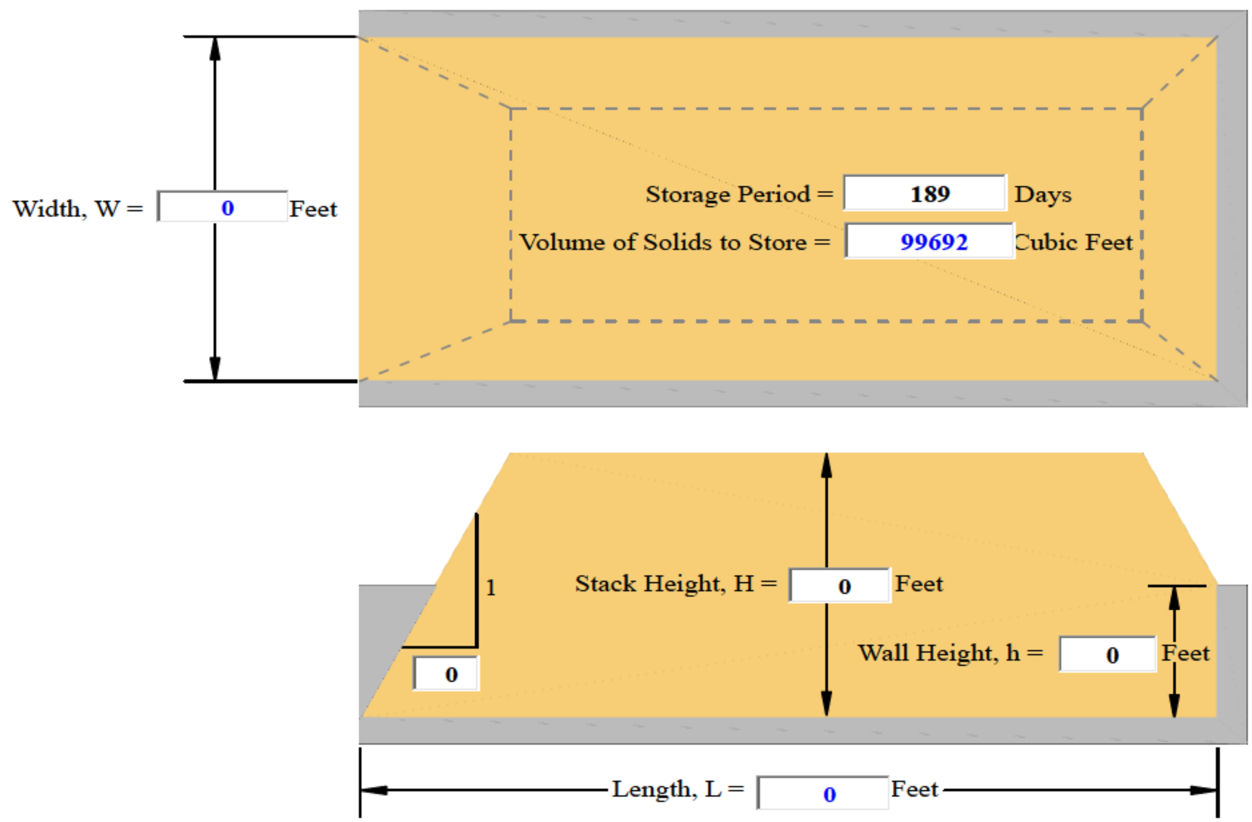
ANIMAL WASTE MANAGEMENT SYSTEM STORAGE

SOLIDS STACKING FACILITY

Solids Storage Facility Parameters	Value
Storage Period, Days=	240
Stacking Width, W in Feet=	0
Stacking Height, H in Feet=	0.00
Wall Height, h in Feet=	0.00
Stack Side Slope (X:1)=	0.00
Existing Storage, Cubic Feet=	6,167
Surface Area of Existing Storage, SF=	0
25 Year-24 Hour Storm Runoff, CF=	0
Volume Needed, Cubic Feet=	6,166
Design Volume, Cubic Feet=	0
Is Facility Covered?	YES

MONTHLY SOLIDS VOLUME STACKED IN FACILITY

Month	Number of Days	Manure CF	Bedding CF	Solids to Store CF	Solids to Store Tons	Normal Runoff CF
October	31	1668	25	847	30	0
November	30	1408	21	714	26	0
December	31	813	12	413	15	0
January	31	813	12	413	15	0
February	28	734	11	373	13	0
March	31	813	12	413	15	0
April	30	994	15	504	18	0
May	31	1668	25	847	30	0
June	30	1615	24	819	30	0
July	31	1668	25	847	30	0
August	31	1668	25	847	30	0
September	30	1615	24	819	30	0
Annual	365	15,477	234	7,855	283	0



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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	Solids CF	Waste to Store CF	Waste to Store Gallons
Storage Period, Days=	143	October	31	0	0	0	41	0	41	310
Tank Diameter, Feet=	0	November	30	0	0	0	40	0	40	300
		December	31	0	0	0	41	0	41	310
Existing Storage, Cubic Feet=	192	January	31	0	0	0	41	0	41	310
Surface Area of Existing Storage, SF=	0	February	28	0	0	0	37	0	37	280
25 Year-24 Hour Storm Runoff, CF=	0	March	31	0	0	0	41	0	41	310
Volume Needed, Cubic Feet=	192	April	30	0	0	0	40	0	40	300
Design Volume, Cubic Feet=	0	May	31	0	0	0	41	0	41	310
Is Tank Covered?	YES	June	30	0	0	0	40	0	40	300
Tank Dimensions?	Circular	July	31	0	0	0	41	0	41	310
		August	31	0	0	0	41	0	41	310
		September	30	0	0	0	40	0	40	300
		Annual	365	0	0	0	488	0	488	3,650

1.0 Feet

Minimum Freeboard = 1.0 Feet

25Yr-24Hr Storm Precipitation = 5 Inches

25Yr-24Hr Storm Runoff = 50084 Cubic Feet

90 Day Precip - Evap = 23.31 Inches

Runoff from Normal Precipitation = 111247 Cubic Feet

Depth = 123.2 Feet

Washwater = 13221 Cubic Feet

Manure = 68862 Cubic Feet

Diameter = 80 Feet

OREGON ANIMAL WASTE MANAGEMENT DESIGN AID (ORAWM)

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CLIENT: **Masog Ranch LLC [redacted] road facillity**
ASSISTED BY: **Technical Service Provider ODA anderson**

ANIMAL WASTE MANAGEMENT SYSTEM APPLICATION

MANAGEMENT CRITERIA FOR TRACTOR SPREADER APPLICATION OF SOLIDS

To apply 15,710 cubic feet of solids generated from the operation it will take approximately 79 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		Spread Width Feet	NITROGEN, N Concentration in Storage Facility		Pounds of Nutrients to be Applied	Number of Applications Needed to meet Crop Demand	Tons per Acre of Solids to Apply	Travel Length per Load Needed in Feet	Loads per Acre
			Bushels	CF		PPM	Lbs/Ton					
Main 1	37.8	Perennial Hay/Pasture(Med Intensity)	160	199	15	13,048	26.10	163	1.00	10.3	1013	3
Main 2	5.5	Perennial Hay/Pasture(Med Intensity)	160	199	15	13,048	26.10	163	1.00	10.3	1013	3
[redacted]	14	Perennial Hay/Pasture(Med Intensity)	160	199	15	13,048	26.10	163	1.00	10.3	1013	3
[redacted]	18.3	Grass/Legume Hay/Pasture	160	199	15	13,048	26.10	136	1.00	8.5	1219	2
[redacted]	2.1	Grass/Legume Hay/Pasture	160	199	15	13,048	26.10	136	1.00	8.5	1219	2
[redacted]	23.73	Grass/Legume Hay/Pasture	160	199	15	13,048	26.10	136	1.00	8.5	1219	2
[redacted]	9.42	Grass/Legume Hay/Pasture	160	199	15	13,048	26.10	136	1.00	8.5	1219	2

MANAGEMENT CRITERIA FOR BIG GUN SPRINKLER APPLICATION OF LIQUIDS

To apply 3,650 gallons of liquids generated from the operation it will take approximately 0 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		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
						PPM	Lbs/1000Gal					
Main 1	37.8	Perennial Hay/Pasture(Med Intensity)	300	250	1/2 Ci	0	0.00	163	1.00		1.45	#VALUE!
Main 2	5.5	Perennial Hay/Pasture(Med Intensity)	300	250	1/2 Ci	0	0.00	163	1.00		1.45	#VALUE!
	14	Perennial Hay/Pasture(Med Intensity)	300	250	1/2 Ci	0	0.00	163	1.00		1.45	#VALUE!
[redacted]	18.3	Grass/Legume Hay/Pasture	300	250	1/2 Ci	0	0.00	136	1.00		1.45	#VALUE!
[redacted]	2.1	Grass/Legume Hay/Pasture	300	250	1/2 Ci	0	0.00	136	1.00		1.45	#VALUE!
[redacted]	23.73	Grass/Legume Hay/Pasture	300	250	1/2 Ci	0	0.00	136	1.00		1.45	#VALUE!
[redacted]	9.42	Grass/Legume Hay/Pasture	300	250	1/2 Ci	0	0.00	136	1.00		1.45	#VALUE!

OREGON ANIMAL WASTE MANAGEMENT DESIGN AID (ORAWM)

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ASSISTED BY: **Technical Service Provider ODA anderson**

ANIMAL WASTE MANAGEMENT SYSTEM APPLICATION

MANAGEMENT CRITERIA FOR TANK WAGON APPLICATION OF LIQUIDS

To apply 3,650 gallons of liquids generated from the operation it will take approximately 1 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
Main 1	37.8	Perennial Hay/Pasture(Med Intensity)	4,000	15	0	0.00	163	1.00		#VALUE!	#VALUE!
Main 2	5.5	Perennial Hay/Pasture(Med Intensity)	4,000	15	0	0.00	163	1.00		#VALUE!	#VALUE!
[redacted]	14	Perennial Hay/Pasture(Med Intensity)	4,000	15	0	0.00	163	1.00		#VALUE!	#VALUE!
[redacted] 1	18.3	Grass/Legume Hay/Pasture	4,000	15	0	0.00	136	1.00		#VALUE!	#VALUE!
[redacted]	2.1	Grass/Legume Hay/Pasture	4,000	15	0	0.00	136	1.00		#VALUE!	#VALUE!
[redacted]	23.73	Grass/Legume Hay/Pasture	4,000	15	0	0.00	136	1.00		#VALUE!	#VALUE!
[redacted]	9.42	Grass/Legume Hay/Pasture	4,000	15	0	0.00	136	1.00		#VALUE!	#VALUE!

COMPUTED NUTRIENT CONCENTRATIONS IN STORAGE

Storage Facility	Annual Volume Production	Units	Concentration of Nutrients in Storage N	P_2O_5	K_2O	Units
Tank (Covered)	3,650	Gallons	0.00	0.00	0.00	lbs/1,000 Gal
Solids Storage Facility (Roofed)	141	Tons	26.10	67.87	5.16	lbs/Ton

Assumed Solids Density lbs/CF
36
36
36
36
36
36
36

Travel Rate Needed in Feet/Minute
#VALUE!
#VALUE!
#VALUE!
#VALUE!
#VALUE!
#VALUE!
#VALUE!

OREGON ANIMAL WASTE MANAGEMENT DESIGN AID (ORAWM)

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ASSISTED BY: **Technical Service Provider ODA anderson**

ANIMAL WASTE MANAGEMENT SYSTEM UTILIZATION

NUTRIENTS AVAILABLE AFTER STORAGE

Nutrient Source	Type of Operation: Mink / Type of Storage Facility	Pounds of Nutrients Available N	P_2O_5	K_2O	Percent Nutrients Retained After Storage N	P_2O_5	K_2O	Pounds of Nutrients Retained After Storage N	P_2O_5	K_2O
Liquids	Tank (Covered)	0	0	0	85%	90%	90%	0	0	0
Solids	Solids Storage Facility (Roofed)	10,542	21,326	1,622	70%	90%	90%	7,379	19,193	1,460
Grazing	NONE	0	0	0	100%	100%	100%	0	0	0

NUTRIENTS AVAILABLE AFTER APPLICATION

Nutrient Source	Type of Application System	Pounds of Nutrients Available N	P_2O_5	K_2O	Percent Nutrients Retained After Application N	P_2O_5	K_2O	Pounds of Nutrients Retained After Application N	P_2O_5	K_2O
Liquids	Sprinkling	0	0	0	75%	100%	100%	0	0	0
Solids	Broadcast (Incorporated 7 or more days after appli	7,379	19,193	1,460	70%	100%	100%	5,166	19,193	1,460
Grazing	Grazing	0	0	0	85%	100%	100%	0	0	0

NUTRIENTS AVAILABLE AFTER DENITRIFICATION

Nutrient Source	Location: Between Coastal and Cascade Mountains / Soil Drainage Class	Pounds of Nutrients Available N	P_2O_5	K_2O	Percent Nutrients Retained After Denitrification N	P_2O_5	K_2O	Pounds of Nutrients Retained After Denitrification N	P_2O_5	K_2O
Liquids	Moderately Well Drained	0	0	0	87%	100%	100%	0	0	0
Solids	Moderately Well Drained	5,166	19,193	1,460	87%	100%	100%	4,494	19,193	1,460
Grazing	Moderately Well Drained	0	0	0	87%	100%	100%	0	0	0
							TOTAL-	***4,494***	***19,193***	***1,460***

CLIENT: **Masog Ranch LLC [redacted] road facillity**
ASSISTED BY: **Technical Service Provider ODA anderson**

ANIMAL WASTE MANAGEMENT SYSTEM UTILIZATION

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

			LIQUIDS			SOLIDS			GRAZING		
Field Number	Acres	Crop	Percent to be Applied	Pounds of Nutrients to be Applied	Acres Needed for Utilization of Nutrients	Percent to be Applied	Pounds of Nutrients to be Applied	Acres Needed for Utilization of Nutrients	Percent to be Applied	Pounds of Nutrients to be Applied	Acres Needed for Utilization of Nutrients
Main 1	37.8	Perennial Hay/Pasture(Med Intensity)	0%	0	0	0%	0	0	0%	0	0
Main 2	5.5	Perennial Hay/Pasture(Med Intensity)	0%	0	0	0%	0	0	0%	0	0
[redacted]	14.0	Perennial Hay/Pasture(Med Intensity)	0%	0	0	0%	0	0	0%	0	0
[redacted]	18.3	Grass/Legume Hay/Pasture	100%	0	0	0%	0	0	0%	0	0
[redacted]	2.1	Grass/Legume Hay/Pasture	0%	0	0	5%	225	2	0%	0	0
[redacted]	23.7	Grass/Legume Hay/Pasture	0%	0	0	67%	3,011	22	0%	0	0
[redacted]	9.4	Grass/Legume Hay/Pasture	0%	0	0	28%	1,258	9	0%	0	0
Off Farm			0%	0		0%	0		100%	0	
TOTALS-	110.85		100%	0	0	100%	4,494	33	100%	0	0

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
Main 1	37.8	Perennial Hay/Pasture(Med Intensity)	0	0	0	163	55	156	-163	-55	-156
Main 2	5.5	Perennial Hay/Pasture(Med Intensity)	0	0	0	163	55	156	-163	-55	-156
[redacted]	14.0	Perennial Hay/Pasture(Med Intensity)	0	0	0	163	55	156	-163	-55	-156
[redacted]	18.3	Grass/Legume Hay/Pasture	0	0	0	136	49	36	-136	-49	-36
[redacted]	2.1	Grass/Legume Hay/Pasture	107	457	35	136	49	36	-29	408	-2
[redacted]	23.7	Grass/Legume Hay/Pasture	127	542	41	136	49	36	-9	493	5
[redacted]	9.4	Grass/Legume Hay/Pasture	134	570	43	136	49	36	-2	522	7
Off Farm											

AgSource Laboratories
A Subsidiary of Cooperative Resources International

323 Sixth Street
Umatilla, OR 97882
Tel:541-922-4894
umatilla@agsource.com

Soil Analysis

Submitted by: UMW16726
WILCO AGRILIANCE, LLC - Harrisburg

RANDY JAUNTZI

AQ20479 - AQ20482

Date Received
16-Sep-2015

17-Sep-2015

S8286

Field:

16-Sep-2015

Soil Analysis Report

Lab No.	Sample Id	pH	BpH	SS mmhos	OM %	Ex Carb	Bray P ppm	Olsen P ppm	Ammonium Acetate K ppm	Ammonium Acetate Mg meq	Ammonium Acetate Ca meq	Ammonium Acetate Na meq	NO3 N lb/a	NH4 N lb/a	S ppm	B ppm	Zn ppm	Mn ppm	Cu ppm	Fe ppm	Al ppm	Cl ppm	Est. CEC	Base Saturation H %	Base Saturation K %	Base Saturation Mg %	Base Saturation Ca %	Base Saturation Na %
AQ20479	[redacted]	4.9	5.4	0.2		NONE	26		259	2.0	9.7	0.11											29.5	57.6	2.2	6.9	32.9	0.4
AQ20481		5.4	5.7	0.1		NONE	99		307	5.0	18.7	0.18											38.6	36.2	2.0	12.8	48.5	0.5
AQ20480		5.3	5.6	0.1		NONE	134		198	3.1	17.3	0.15											36.0	41.7	1.4	8.5	47.9	0.4
AQ20482		5.2	5.7	0.1		NONE	289		355	3.8	17.9	0.14											36.7	38.1	2.5	10.4	48.6	0.4

OREGON ANIMAL WASTE MANAGEMENT DESIGN AID (ORAWM)

Version 4.7

CLIENT: Masog Ranch LLC [redacted] facillity

ASSISTED BY: Technical Service Provider ODA anderson

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	Days Confined
MINK(FEMALE)	7,200	5	36.0	0.94	0.83	0.12	33.84	29.88	4.32	1.38	365
MINK(MALE)	2,300	4	9.2	0.94	0.83	0.12	8.65	7.64	1.10	1.38	365
KIT	29,500	2	59.0	0.94	0.83	0.12	55.46	48.97	7.08	1.38	244
SHEEP	40	100	4.0	0.45	0.07	0.30	1.80	0.28	1.20	0.63	37
BEEF COW	15	1,200	18.0	0.35	0.08	0.25	6.3	1.44	4.50	1.67	37
CALF	10	600	6.0	0.45	0.08	0.29	2.70	0.48	1.74	1.23	37
Totals/Averages-	39,065	319	132.2	0.82	0.67	0.15	108.7	88.7	19.9	1.4	

GRAZING PERIOD

Percent of Month and Number of Animals Grazing

Type of Animal	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG
MINK(FEMALE)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	7200	7200	7200	7200	7200	7200	7200	7200	7200	7200	7200
MINK(MALE)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	2300	2300	2300	2300	2300	2300	2300	2300	2300	2300	2300
KIT	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	29500	15000	0	0	0	0	7500	29500	29500	29500	29500
SHEEP	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%
	40	40	40	40	40	40	40	40	40	40	40
BEEF COW	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%
	15	15	15	15	15	15	15	15	15	15	15
CALF	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%
	10	10	10	10	10	10	10	10	10	10	10
Total AUM's Available>	0	0	0	0	0	0	0	0	0	0	0
Total AUM's Needed>>>	25	25	25	25	25	25	25	25	25	25	25
Total AUM's>>>>>>>>>>>	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25

Annual	
Days Grazed	Days Off Farm
0	0
0	0
0	121
329	0
329	0
329	0

SEP	AU-YR.
0%	
7200	0
0%	
2300	0
0%	
29500	0
90%	
40	43
90%	
15	194
90%	
10	65
	0
	0
	0
	0
0	0
25	302
-25	-302

OREGON ANIMAL WASTE MANAGEMENT DESIGN AID (ORAWM)

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ANIMAL WASTE MANAGEMENT SYSTEM INVENTORY

WEATHER STATION

CORVALLIS STATE UNIV

Month	Precipitation	Evaporation	Paved	Unpaved
	25Yr-24Hr	4.50	Lot Runoff Factors as a Percent of Monthly Precipitation	
	RCN=	95.00		
	Average Monthly Inches			
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	0
Unpaved Lot Area >>>	0
Roof Area >>	0
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>>>>>>>>>>>>>>>>>	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	7200.0	2	0.00	0	0.0
Equipment Wash		2	0.00	0	0.0
Flushwater		2	0.00	0	0.0
Miscellaneous		1	20.00	20	2.7
Total>>				20	2.7

CROP DATA

Field Number	Acres	Crop	Percent Dry Matter (DM)	Yield Units	Target Yield	Nutrients Removed in Pounds per Acre: Nitrogen N	Phosphorous P_2O_5	Potassium K_2O
Main 1	37.8	Grass/Legume Hay/Pasture	85%	Ton	4.00	136	49	36
Main 2	5.5	Grass/Legume Hay/Pasture	85%	Ton	4.00	136	49	36
[redacted]	14.0	Grass/Legume Hay/Pasture	85%	Ton	4.00	136	49	36
[redacted]	18.3	Grass/Legume Hay/Pasture	85%	Ton	4.00	136	49	36
[redacted]	2.1	Grass/Legume Hay/Pasture	85%	Ton	4.00	136	49	36
[redacted]	23.7	Grass/Legume Hay/Pasture	85%	Ton	4.00	136	49	36
[redacted]	9.4	Grass/Legume Hay/Pasture	85%	Ton	4.00	136	49	36
Off Farm								
Total Acres-	110.9							

OREGON ANIMAL WASTE MANAGEMENT DESIGN AID (ORAWM)

Version 4.7

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ASSISTED BY: Technical Service Provider ODA anderson

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
MINK(FEMALE)	Confined	Sawdust	12.00	0.25	0.02	1	9
MINK(MALE)	Confined	Sawdust	12.00	0.25	0.02	0	2
KIT	Confined	Sawdust	12.00	0.25	0.02	1	15
SHEEP	Loose Housing	Loose Straw	2.50	5.40	2.16	9	22
BEEF COW	Loose Housing	Loose Straw	2.50	0.75	0.30	5	14
CALF	Loose Housing	Loose Straw	2.50	0.75	0.30	2	5

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
MINK(FEMALE)	Dry Scrape System	100%	50	0	0	50	0	36
MINK(MALE)	Dry Scrape System	100%	13	0	0	13	0	36
KIT	Dry Scrape System	100%	83	0	0	81	0	36
SHEEP	Dry Scrape System	100%	11	0	0	3	0	36
BEEF COW	Dry Scrape System	100%	35	0	0	30	0	36
CALF	Dry Scrape System	100%	9	0	0	7	0	36
Total Solids>>>			202	0	0	184	0	

Weight of Separated Solids Lbs/Day
1,815
464
2,975
402
1,277
330
7,264

OREGON ANIMAL WASTE MANAGEMENT DESIGN AID (ORAWM)

Version 4.7

CLIENT: **Masog Ranch LLC** [redacted] **facillity**

ASSISTED BY: **Technical Service Provider ODA anderson**

ANIMAL WASTE MANAGEMENT SYSTEM PRODUCTION

MONTHLY VOLUMES

	Runoff in Cubic Feet													
	Roof Area Square Feet	Paved Slab Area Square Feet	Unpaved Lot Area Square Feet	Silage Pit Surface Area, SF	Facility Water Use	Manure		Bedding		Solids Separated		Solids in Liquids		Total Solids
						Solids	Liquids							
Month	0	0	0	0	Cubic Feet	Cubic Feet	Cubic Feet	Cubic Feet	Pounds	Cubic Feet	Pounds	Cubic Feet	Pounds	Cubic Feet
October	0	0	0	0	83	930	3,652	116	930	4,698	169,126	0	0	4,698
November	0	0	0	0	80	654	2,580	95	683	3,328	119,796	0	0	3,328
December	0	0	0	0	83	412	1,645	78	473	2,136	76,890	0	0	2,136
January	0	0	0	0	83	412	1,645	78	473	2,136	76,890	0	0	2,136
February	0	0	0	0	75	372	1,486	71	427	1,929	69,449	0	0	1,929
March	0	0	0	0	83	412	1,645	78	473	2,136	76,890	0	0	2,136
April	0	0	0	0	80	526	2,086	85	570	2,697	97,103	0	0	2,697
May	0	0	0	0	83	930	3,652	116	930	4,698	169,126	0	0	4,698
June	0	0	0	0	80	900	3,534	113	900	4,546	163,671	0	0	4,546
July	0	0	0	0	83	930	3,652	116	930	4,698	169,126	0	0	4,698
August	0	0	0	0	83	930	3,652	116	930	4,698	169,126	0	0	4,698
September	0	0	0	0	80	900	3,534	113	900	4,546	163,671	0	0	4,546
Annual	0	0	0	0	976	8,307	32,763	1,176	8,621	42,246	1,520,864	0	0	42,246
Annual Gallons	0	0	0	0	7,300	62,139	245,065	8,798		316,002		0		316,002

DAILY NUTRIENT PRODUCTION

	Pounds/Day of Nutrients from **LIQUIDS**			Pounds/Day of Nutrients from **SOLIDS**			Pounds/Day of Nutrients from **GRAZING**			Grazing Manure	Confined Manure
Type of Animal	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O	Gallons/Yr	Cubic Feet/Yr
MINK(FEMALE)	0.00	0.00	0.00	33.84	68.46	5.21	0.00	0.00	0.00	0	18,133
MINK(MALE)	0.00	0.00	0.00	8.65	17.49	1.33	0.00	0.00	0.00	0	4,634
KIT	0.00	0.00	0.00	55.46	112.19	8.53	0.00	0.00	0.00	0	16,844
SHEEP	0.00	0.00	0.00	1.80	0.64	1.45	1.80	0.64	1.45	6,192	92
BEEF COW	0.00	0.00	0.00	6.30	3.30	5.42	6.30	3.30	5.42	73,863	1,097
CALF	0.00	0.00	0.00	2.70	1.10	2.10	2.70	1.10	2.10	18,134	269
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
									Total-	98,189	41,070

CLIENT: **Masog Ranch LLC** [redacted] **facillity**
ASSISTED BY: **Technical Service Provider ODA anderson**

ANIMAL WASTE MANAGEMENT SYSTEM PRODUCTION

MONTHLY NUTRIENT PRODUCTION

	Pounds of Nutrients from **LIQUIDS**			Pounds of Nutrients from **SOLIDS**			Pounds of Nutrients from **GRAZING**			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
October	0	0	0	3,070	6,158	495	301	141	250	3,371	6,299	745
November	0	0	0	2,153	4,305	353	292	136	242	2,445	4,441	595
December	0	0	0	1,351	2,680	230	301	141	250	1,652	2,821	481
January	0	0	0	1,351	2,680	230	301	141	250	1,652	2,821	481
February	0	0	0	1,220	2,421	208	272	127	226	1,492	2,548	434
March	0	0	0	1,351	2,680	230	301	141	250	1,652	2,821	481
April	0	0	0	1,730	3,449	288	292	136	242	2,022	3,585	530
May	0	0	0	3,070	6,158	495	301	141	250	3,371	6,299	745
June	0	0	0	2,971	5,959	479	292	136	242	3,262	6,095	721
July	0	0	0	3,070	6,158	495	301	141	250	3,371	6,299	745
August	0	0	0	3,070	6,158	495	301	141	250	3,371	6,299	745
September	0	0	0	2,971	5,959	479	292	136	242	3,262	6,095	721
Annual	**0**	**0**	**0**	**27,376**	**54,765**	**4,478**	**3,548**	**1,656**	**2,945**	**30,924**	**56,421**	**7,423**

Total Liquids
Cubic Feet
83
80
83
83
75
83
80
83
80
83
83
80
976
7,300

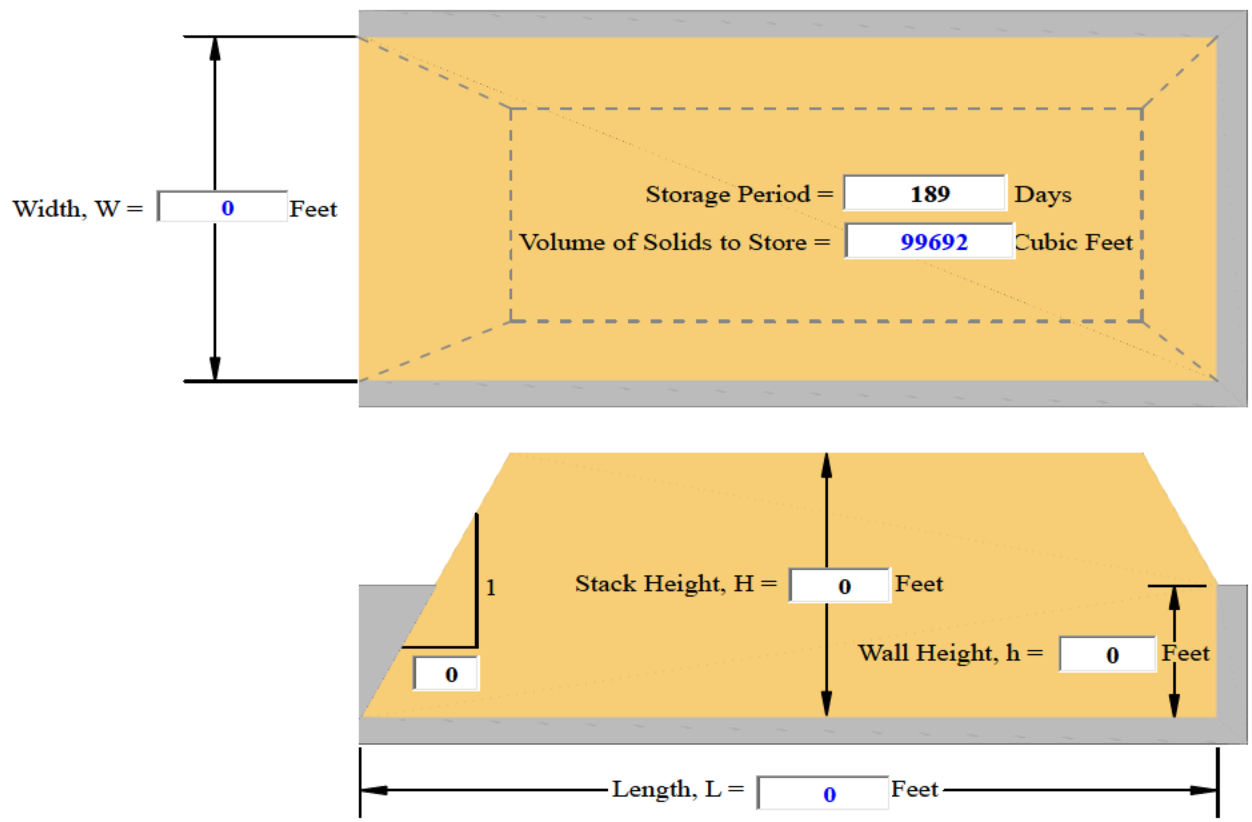
OREGON ANIMAL WASTE MANAGEMENT DESIGN AID (ORAWM)
Version 4.7

CLIENT: **Masog Ranch LLC [redacted] facillity**
ASSISTED BY: **Technical Service Provider ODA anderson**

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	Solids to Store Tons	Normal Runoff CF
Storage Period, Days=	365	October	31	4582	116	2,349	85	0
Stacking Width, W in Feet=	0	November	30	3233	95	1,664	60	0
Stacking Height, H in Feet=	0.00	December	31	2058	78	1,068	38	0
Wall Height, h in Feet=	0.00	January	31	2058	78	1,068	38	0
Stack Side Slope (X:1)=	0.00	February	28	1858	71	965	35	0
Existing Storage, Cubic Feet=	27,006	March	31	2058	78	1,068	38	0
Surface Area of Existing Storage, SF=	0	April	30	2612	85	1,349	49	0
25 Year-24 Hour Storm Runoff, CF=	0	May	31	4582	116	2,349	85	0
Volume Needed, Cubic Feet=	21,123	June	30	4434	113	2,273	82	0
Design Volume, Cubic Feet=	0	July	31	4582	116	2,349	85	0
Is Facility Covered?	YES	August	31	4582	116	2,349	85	0
		September	30	4434	113	2,273	82	0
		Annual	365	41,070	1,176	21,123	760	0



OREGON ANIMAL WASTE MANAGEMENT DESIGN AID (ORAWM)

Version 4.7

CLIENT: **Masog Ranch LLC [redacted] facillity**
ASSISTED BY: **Technical Service Provider ODA anderson**

ANIMAL WASTE MANAGEMENT SYSTEM STORAGE

TANK

Tank Parameters	Value
Storage Period, Days=	365
Tank Diameter, Feet=	0
Existing Storage, Cubic Feet=	1,021
Surface Area of Existing Storage, SF=	0
25 Year-24 Hour Storm Runoff, CF=	0
Volume Needed, Cubic Feet=	989
Design Volume, Cubic Feet=	0
Is Tank Covered?	YES
Tank Dimensions?	Circular

MONTHLY INFLOWS INTO TANK

Month	Number of days	Rain-Evap on Tank CF	Rain-Evap on Existing Storage, CF	Normal Runoff CF	Washwater CF	Solids CF	Waste to Store CF	Waste to Store Gallons
October	31	0	0	0	83	0	83	620
November	30	0	0	0	80	0	80	600
December	31	0	0	0	83	0	83	620
January	31	0	0	0	83	0	83	620
February	28	0	0	0	75	0	75	560
March	31	0	0	0	83	0	83	620
April	30	0	0	0	80	0	80	600
May	31	0	0	0	83	0	83	620
June	30	0	0	0	80	0	80	600
July	31	0	0	0	83	0	83	620
August	31	0	0	0	83	0	83	620
September	30	0	0	0	80	0	80	600
Annual	365	0	0	0	976	0	976	7,301

1.0 Feet

Minimum Freeboard = 1.0 Feet

25Yr-24Hr Storm Precipitation = 5 Inches

25Yr-24Hr Storm Runoff = 50084 Cubic Feet

90 Day Precip - Evap = 23.31 Inches

Runoff from Normal Precipitation = 111247 Cubic Feet

Washwater = 13221 Cubic Feet

Manure = 68862 Cubic Feet

Depth = 123.2 Feet

Diameter = 80 Feet

OREGON ANIMAL WASTE MANAGEMENT DESIGN AID (ORAWM)

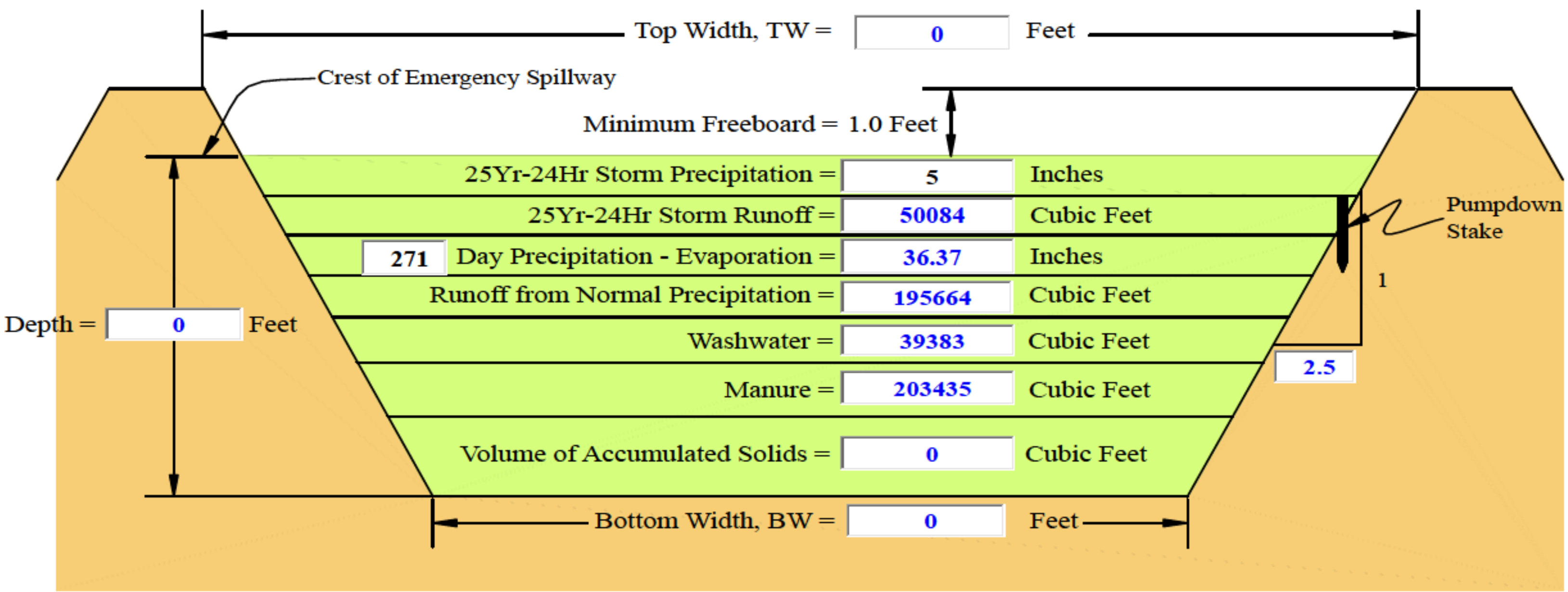
Version 4.7

CLIENT: **Masog Ranch LLC [redacted] facillity**
ASSISTED BY: **Technical Service Provider ODA anderson**

ANIMAL WASTE MANAGEMENT SYSTEM STORAGE

WASTE STORAGE POND — **MONTHLY INFLOWS INTO WASTE STORAGE POND**

Pond Parameters	Value	Month	Number of Days	Rain-Evap on Pond CF	Rain-Evap on Existing Storage, CF	Normal Runoff CF	Washwater CF	Solids CF	Waste to Store CF	Waste to Store Gallons
Storage Period, Days=	110	October	31	0	1,035	0	83	0	1,118	8,362
Side Slope (X:1)=	3.00	November	30	0	4,673	0	80	0	4,753	35,553
Bottom Width, BW, Feet=	0	December	31	0	5,115	0	83	0	5,198	38,883
Bottom Length, BL, Feet=	0	January	31	0	4,298	0	83	0	4,380	32,768
Accumulated Solids Duration, Years=	0	February	28	0	3,555	0	75	0	3,630	27,153
Existing Storage, Acre Feet=	2.80	March	31	0	2,453	0	83	0	2,535	18,966
Surface Area of Existing Storage, SF=	9,000	April	30	0	615	0	80	0	695	5,201
Minimum Soil Liner Depth, Feet=	1.00	May	31	0	-780	0	83	0	-697	-5,215
25 Year-24 Hour Storm Runoff, CF=	0	June	30	0	-2,138	0	80	0	-2,057	-15,390
Top Width, TW, Feet=	0	July	31	0	-3,765	0	83	0	-3,682	-27,544
Top Length, TL, Feet=	0	August	31	0	-3,293	0	83	0	-3,210	-24,010
Volume Needed, Acre Feet=	0.5	September	30	0	-1,493	0	80	0	-1,412	-10,565
Design Volume, Acre Feet=	0.0	Annual	365	0	10,275	0	976	0	11,251	84,163



OREGON ANIMAL WASTE MANAGEMENT DESIGN AID (ORAWM)

Version 4.7

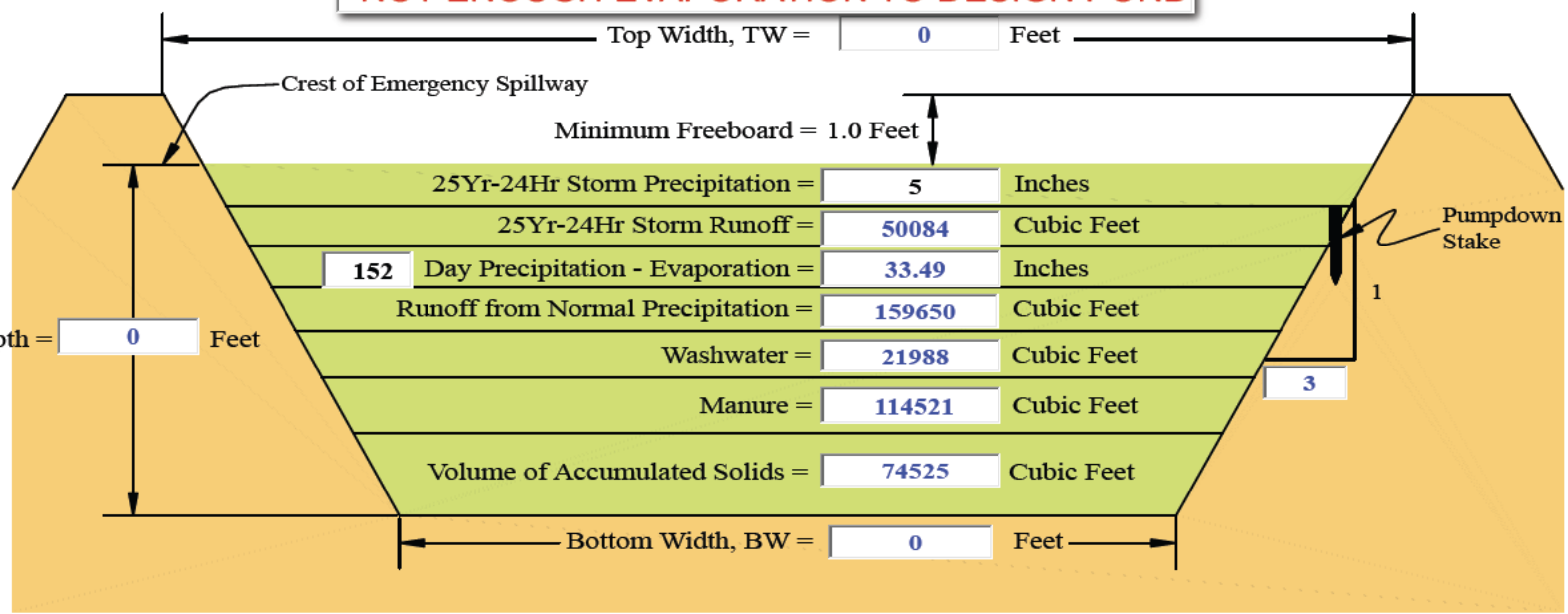
CLIENT: **Masog Ranch LLC [redacted] facillity**
ASSISTED BY: **Technical Service Provider ODA anderson**

ANIMAL WASTE MANAGEMENT SYSTEM STORAGE

EVAPORATION POND — **MONTHLY INFLOWS INTO EVAPORATION POND**

Evaporation Pond Parameters	Value	Month	Number of Days	Rain-Evap on Pond CF	Rain-Evap on Existing Storage, CF	Normal Runoff CF	Washwater CF	Solids CF	Waste to Store CF	Waste to Store Gallons
Storage Period, Days=	152	October	31	0	0	0	83	0	83	620
Side Slope (X:1)=	3.00	November	30	0	0	0	80	0	80	600
Bottom Width, BW, Feet=	0	December	31	0	0	0	83	0	83	620
Bottom Length, BL, Feet=	0	January	31	0	0	0	83	0	83	620
Accumulated Solids Duration, Years=	1	February	28	0	0	0	75	0	75	560
Existing Storage, Acre Feet=	0.00	March	31	0	0	0	83	0	83	620
Surface Area of Existing Storage, SF=	0	April	30	0	0	0	80	0	80	600
Minimum Soil Liner Depth, Feet=	1.00	May	31	0	0	0	83	0	83	620
25 Year-24 Hour Storm Runoff, CF=	0	June	30	0	0	0	80	0	80	600
Top Width, TW, Feet=	0	July	31	0	0	0	83	0	83	620
Top Length, TL, Feet=	0	August	31	0	0	0	83	0	83	620
Volume Needed, Acre Feet=	0.5	September	30	0	0	0	80	0	80	600
Design Volume, Acre Feet=	0.0	Annual	365	0	0	0	976	0	976	7,301

NOT ENOUGH EVAPORATION TO DESIGN POND



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ANIMAL WASTE MANAGEMENT SYSTEM APPLICATION

MANAGEMENT CRITERIA FOR TRACTOR SPREADER APPLICATION OF SOLIDS

To apply 42,246 cubic feet of solids generated from the operation it will take approximately 212 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/Ton	Pounds of Nutrients to be Applied	Number of Applications Needed to meet Crop Demand	Tons per Acre of Solids to Apply	Travel Length per Load Needed in Feet	Loads per Acre
Main 1	37.8	Grass/Legume Hay/Pasture	160	199	15	12,600	25.20	136	1.00	9.6	1082	3
Main 2	5.5	Grass/Legume Hay/Pasture	160	199	15	12,600	25.20	136	1.00	9.6	1082	3
Johnson	14	Grass/Legume Hay/Pasture	160	199	15	12,600	25.20	136	1.00	9.6	1082	3
Mcdowell 1	18.3	Grass/Legume Hay/Pasture	160	199	15	12,600	25.20	136	1.00	9.6	1082	3
McDowell 2	2.1	Grass/Legume Hay/Pasture	160	199	15	12,600	25.20	136	1.00	9.6	1082	3
Lebra	23.73	Grass/Legume Hay/Pasture	160	199	15	12,600	25.20	136	1.00	9.6	1082	3
Craig Lane	9.42	Grass/Legume Hay/Pasture	160	199	15	12,600	25.20	136	1.00	9.6	1082	3

MANAGEMENT CRITERIA FOR BIG GUN SPRINKLER APPLICATION OF LIQUIDS

To apply 7,300 gallons of liquids generated from the operation it will take approximately 0 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
Main 1	37.8	Grass/Legume Hay/Pasture	300	250	1/2 Ci	0	0.00	136	1.00		1.45	#VALUE!
Main 2	5.5	Grass/Legume Hay/Pasture	300	250	1/2 Ci	0	0.00	136	1.00		1.45	#VALUE!
	14	Grass/Legume Hay/Pasture	300	250	1/2 Ci	0	0.00	136	1.00		1.45	#VALUE!
Mcdowell 1	18.3	Grass/Legume Hay/Pasture	300	250	1/2 Ci	0	0.00	136	1.00		1.45	#VALUE!
McDowell 2	2.1	Grass/Legume Hay/Pasture	300	250	1/2 Ci	0	0.00	136	1.00		1.45	#VALUE!
Lebra	23.73	Grass/Legume Hay/Pasture	300	250	1/2 Ci	0	0.00	136	1.00		1.45	#VALUE!
Craig Lane	9.42	Grass/Legume Hay/Pasture	300	250	1/2 Ci	0	0.00	136	1.00		1.45	#VALUE!

OREGON ANIMAL WASTE MANAGEMENT DESIGN AID (ORAWM)

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ANIMAL WASTE MANAGEMENT SYSTEM APPLICATION

MANAGEMENT CRITERIA FOR TANK WAGON APPLICATION OF LIQUIDS

To apply 7,300 gallons of liquids generated from the operation it will take approximately 2 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
Main 1	37.8	Grass/Legume Hay/Pasture	4,000	15	0	0.00	136	1.00		#VALUE!	#VALUE!
Main 2	5.5	Grass/Legume Hay/Pasture	4,000	15	0	0.00	136	1.00		#VALUE!	#VALUE!
Johnson	14	Grass/Legume Hay/Pasture	4,000	15	0	0.00	136	1.00		#VALUE!	#VALUE!
Mcdowell 1	18.3	Grass/Legume Hay/Pasture	4,000	15	0	0.00	136	1.00		#VALUE!	#VALUE!
McDowell 2	2.1	Grass/Legume Hay/Pasture	4,000	15	0	0.00	136	1.00		#VALUE!	#VALUE!
Lebra	23.73	Grass/Legume Hay/Pasture	4,000	15	0	0.00	136	1.00		#VALUE!	#VALUE!
Craig Lane	9.42	Grass/Legume Hay/Pasture	4,000	15	0	0.00	136	1.00		#VALUE!	#VALUE!

COMPUTED NUTRIENT CONCENTRATIONS IN STORAGE

Storage Facility	Annual Volume Production	Units	Concentration of Nutrients in Storage N	P_2O_5	K_2O	Units
Tank (Covered)	7,300	Gallons	0.00	0.00	0.00	lbs/1,000 Gal
Solids Storage Facility (Roofed)	380	Tons	25.20	64.82	5.30	lbs/Ton

Assumed Solids Density lbs/CF
36
36
36
36
36
36
36

Travel Rate Needed in Feet/Minute
#VALUE!
#VALUE!
#VALUE!
#VALUE!
#VALUE!
#VALUE!
#VALUE!

CLIENT: **Masog Ranch LLC** [redacted] **facillity**
ASSISTED BY: **Technical Service Provider ODA anderson**

ANIMAL WASTE MANAGEMENT SYSTEM UTILIZATION

NUTRIENTS AVAILABLE AFTER STORAGE

Nutrient Source	Type of Operation: Mink / Type of Storage Facility	Pounds of Nutrients Available			Percent Nutrients Retained After Storage			Pounds of Nutrients Retained After Storage		
		N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Liquids	Tank (Covered)	0	0	0	85%	90%	90%	0	0	0
Solids	Solids Storage Facility (Roofed)	27,376	54,765	4,478	70%	90%	90%	19,163	49,289	4,030
Grazing	NONE	3,548	1,656	2,945	100%	100%	100%	3,548	1,656	2,945

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	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Liquids	Sprinkling	0	0	0	75%	100%	100%	0	0	0
Solids	Broadcast (Incorporated 7 or more days after appli	19,163	49,289	4,030	70%	100%	100%	13,414	49,289	4,030
Grazing	Grazing	3,548	1,656	2,945	85%	100%	100%	3,016	1,656	2,945

NUTRIENTS AVAILABLE AFTER DENITRIFICATION

Nutrient Source	Location: Between Coastal and Cascade Mountains / Soil Drainage Class	Pounds of Nutrients Available			Percent Nutrients Retained After Denitrification			Pounds of Nutrients Retained After Denitrification		
		N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Liquids	Somewhat Poorly Drained	0	0	0	80%	100%	100%	0	0	0
Solids	Somewhat Poorly Drained	13,414	49,289	4,030	80%	100%	100%	10,731	49,289	4,030
Grazing	Somewhat Poorly Drained	3,016	1,656	2,945	80%	100%	100%	2,413	1,656	2,945
							TOTAL-	***13,144***	***50,945***	***6,975***

OREGON ANIMAL WASTE MANAGEMENT DESIGN AID (ORAWM)
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ANIMAL WASTE MANAGEMENT SYSTEM UTILIZATION

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
Main 1	37.8	Grass/Legume Hay/Pasture	34%	0	0	34%	3,659	27	50%	1,206	9
Main 2	5.5	Grass/Legume Hay/Pasture	5%	0	0	5%	532	4	7%	169	1
Johnson	14.0	Grass/Legume Hay/Pasture	13%	0	0	8%	859	6	43%	1,037	8
Mcdowell 1	18.3	Grass/Legume Hay/Pasture	35%	0	0	17%	1,772	13	0%	0	0
McDowell 2	2.1	Grass/Legume Hay/Pasture	13%	0	0	2%	203	1	0%	0	0
Lebra	23.7	Grass/Legume Hay/Pasture	0%	0	0	26%	2,790	21	0%	0	0
Craig Lane	9.4	Grass/Legume Hay/Pasture	0%	0	0	8%	912	7	0%	0	0
Off Farm			0%	0		0%	4		0%	0	
TOTALS-	**110.85**		**100%**	**0**	**0**	**100%**	**10,731**	**79**	**100%**	**2,413**	**18**

NUTRIENT BALANCE BASED ON AVAILABLE ACRES

Field Number	Acres	Crop	NUTRIENTS APPLIED Nitrogen, N Lbs/Acre	NUTRIENTS APPLIED Phosphorous, P2O5 Lbs/Acre	NUTRIENTS APPLIED Potassium, K2O Lbs/Acre	- NUTRIENTS REMOVED Nitrogen, N Lbs/Acre	NUTRIENTS REMOVED Phosphorous, P2O5 Lbs/Acre	NUTRIENTS REMOVED Potassium, K2O Lbs/Acre	= NUTRIENT BALANCE Nitrogen, N Lbs/Acre	NUTRIENT BALANCE Phosphorous, P2O5 Lbs/Acre	NUTRIENT BALANCE Potassium, K2O Lbs/Acre
Main 1	37.8	Grass/Legume Hay/Pasture	129	467	75	136	49	36	-7	418	39
Main 2	5.5	Grass/Legume Hay/Pasture	128	466	74	136	49	36	-8	417	37
Johnson	14.0	Grass/Legume Hay/Pasture	135	333	113	136	49	36	0	284	77
Mcdowell 1	18.3	Grass/Legume Hay/Pasture	97	445	36	136	49	36	-39	396	0
McDowell 2	2.1	Grass/Legume Hay/Pasture	97	445	36	136	49	36	-39	396	0
Lebra	23.7	Grass/Legume Hay/Pasture	118	540	44	136	49	36	-18	491	8
Craig Lane	9.4	Grass/Legume Hay/Pasture	97	445	36	136	49	36	-39	396	0
Off Farm											

FIELD SUMMARY & WESTERN OREGON P INDEX

Enter data in gray cells and select best choice from drop down menus.
Cells with blue font are completed automatically.

Grower: Masog
Application Plan by:
Date: July 1, 2016

Field	Main 1	Main 2	[redacted]	Liquid application area	[redacted]	[redacted]	[redacted]	Craig lane
Acres			18.28		18.28	2.1	23.73	9.42
Soil	LINN COUNTY	LINN COUNTY	19, Chapman	19, Chapman	19, Chapman	19, Chapman	19, Chapman	19, Chapman
Soil test date	December 3, 2014	December 3, 2014	September 16, 2015	December 3, 2014	August 5, 2016	August 5,2016	September 16, 2015	September 16, 2015
Bray 1 P (ppm)	32	35	35	11	64	64	48	52
Acetate K (ppm)					135	135	113	210
pH								
SMP								
TRANSPORT FACTORS								
Sheet & rill erosion (tons/ac-yr)	<1	<1	<1	<1	<1	<1	<1	<1
Irrigation erosion (tons/ac-yr)	not irrigated	not irrigated	not irrigated	not irrigated	not irrigated	not irrigated	not irrigated	not irrigated
Runoff Class	none	none	low	low	low	low	low	low
Flooding Frequency	none	none	rare	rare	rare	rare	rare	rare
Distance to stream (ft)	>500 ft	<100 ft	>500 ft	>500 ft	>500 ft	>500 ft	>500 ft	<100 ft
Buffers	> 30 ft or NR	> 30 ft or NR	> 30 ft or NR	> 30 ft or NR	> 30 ft or NR	> 30 ft or NR	> 30 ft or NR	> 30 ft or NR
Drainage	no tiles	no tiles	no tiles	no tiles	no tiles	no tiles	no tiles	no tiles
SOURCE FACTORS								
Commercial P2O5 rate (lbs/ac)	0	0	0	0	0	0	0	0
Commercial P2O5 method	None applied	None applied	None applied	None applied	None applied	None applied	None applied	None applied
Commercial P2O5 timing	None applied	None applied	None applied	None applied	None applied	None applied	None applied	None applied
Organic P2O5 rate (lbs/ac)	607	593	470	607	322	457	485	509
Organic P2O5 method	Not incorp. in	Not incorp. in	Not incorp. in	Incorp. in 5 da	Not incorp. in	Not incorp. in	Not incorp. in	Not incorp. in
Organic P2O5 timing	No app. Nov.	No app. Nov.	No app. Nov.	All months po	All months po	All months po	No app. Nov.	No app. Nov.
SCORE	16.1	15.9	15.2	17.9	18.6	21.3	16.3	17.1
P RUNOFF RISK RATING	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium

COMMENTS

OREGON ANIMAL WASTE MANAGEMENT DESIGN AID (ORAWM)

Version 4.7

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ASSISTED BY: Technical Service Provider ODA anderson

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	(lbs./day) N	P	K	Manure CF/D/AU	Annual Days Confined	Days Grazed	Days Off Farm
MINK(FEMALE)	4,200	5	21.0	0.94	0.83	0.12	19.74	17.43	2.52	1.38	365	0	0
MINK(MALE)	1,300	4	5.2	0.94	0.83	0.12	4.89	4.32	0.62	1.38	365	0	0
KIT	19,500	2	39.0	0.94	0.83	0.12	36.66	32.37	4.68	1.38	244	0	121
SHEEP	40	100	4.0	0.45	0.07	0.30	1.80	0.28	1.20	0.63	37	329	0
BEEF COW	15	1,200	18.0	0.35	0.08	0.25	6.3	1.44	4.50	1.67	37	329	0
CALF	10	600	6.0	0.45	0.08	0.29	2.70	0.48	1.74	1.23	37	329	0
Totals/Averages-	25,065	319	93.2	0.77	0.60	0.16	72.1	56.3	15.3	1.4			

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.
MINK(FEMALE)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	0
MINK(MALE)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300	1300	0
KIT	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
	19500	15000	0	0	0	0	7500	19500	19500	19500	19500	19500	0
SHEEP	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	
	40	40	40	40	40	40	40	40	40	40	40	40	43
BEEF COW	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	
	15	15	15	15	15	15	15	15	15	15	15	15	194
CALF	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	
	10	10	10	10	10	10	10	10	10	10	10	10	65
													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>>>	25	25	25	25	25	25	25	25	25	25	25	25	302
Total AUM's>>>>>>>>>>	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-302

WEATHER STATION

CORVALLIS STATE UNIV

			Lot Runoff Factors as a Percent of Monthly Precipitation
	25Yr-24Hr	4.50	
	RCN=	95.00	
	Average Monthly Inches		

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	0

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ANIMAL WASTE MANAGEMENT SYSTEM INVENTORY

Month	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		

Unpaved Lot Area >>	0
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	4200.0	2	0.00	0	0.0
Equipment Wash		2	0.00	0	0.0
Flushwater		2	0.00	0	0.0
Miscellaneous		1	10.00	10	1.3
Total>>>				10	1.3

CROP DATA

Field Number	Acres	Crop	Percent Dry Matter (DM)	Yield Units	Target Yield	Nutrients Removed in Pounds per Acre: Nitrogen N	Phosphorous P2O5	Potassium K2O
Main 1	37.8	Perennial Hay/Pasture(Med Intensity)	85%	Ton	4.00	163	55	156
Main 2	5.5	Perennial Hay/Pasture(Med Intensity)	85%	Ton	4.00	163	55	156
[redacted]	14.0	Perennial Hay/Pasture(Med Intensity)	85%	Ton	4.00	163	55	156
[redacted]	18.3	Grass/Legume Hay/Pasture	85%	Ton	4.00	136	49	36
[redacted]	2.1	Grass/Legume Hay/Pasture	85%	Ton	4.00	136	49	36
[redacted]	23.7	Grass/Legume Hay/Pasture	85%	Ton	4.00	136	49	36
[redacted]	9.4	Grass/Legume Hay/Pasture	85%	Ton	4.00	136	49	36
Off Farm								
Total Acres-	110.9							

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
MINK(FEMALE)	Confined	Sawdust	12.00	0.25	0.02	0	5
MINK(MALE)	Confined	Sawdust	12.00	0.25	0.02	0	1
KIT	Confined	Sawdust	12.00	0.25	0.02	1	10
SHEEP	Loose Housing	Loose Straw	2.50	5.40	2.16	9	22
BEEF COW	Loose Housing	Loose Straw	2.50	0.75	0.30	5	14
CALF	Loose Housing	Loose Straw	2.50	0.75	0.30	2	5

OREGON ANIMAL WASTE MANAGEMENT DESIGN AID (ORAWM)

Version 4.7

CLIENT: Masog Ranch LLC
ASSISTED BY: Technical Service Provider ODA anderson

ANIMAL WASTE MANAGEMENT SYSTEM INVENTORY

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
MINK(FEMALE)	Dry Scrape System	100%	29	0	0	29	0	36	1,059
MINK(MALE)	Dry Scrape System	100%	7	0	0	7	0	36	262
KIT	Dry Scrape System	100%	55	0	0	54	0	36	1,967
SHEEP	Dry Scrape System	100%	11	0	0	3	0	36	402
BEEF COW	Dry Scrape System	100%	35	0	0	30	0	36	1,277
CALF	Dry Scrape System	100%	9	0	0	7	0	36	330
Total Solids>>>			147	0	0	130	0		5,297

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ANIMAL WASTE MANAGEMENT SYSTEM PRODUCTION

MONTHLY VOLUMES

Month	Runoff in Cubic Feet: Roof Area Square Feet 0	Paved Slab Area Square Feet 0	Unpaved Lot Area Square Feet 0	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
October	0	0	0	0	41	588	2,325	91	628	3,004	108,156	0	0	3,004
November	0	0	0	0	40	492	1,954	83	540	2,529	91,051	0	0	2,529
December	0	0	0	0	41	246	999	66	326	1,311	47,187	0	0	1,311
January	0	0	0	0	41	246	999	66	326	1,311	47,187	0	0	1,311
February	0	0	0	0	37	222	902	60	294	1,184	42,620	0	0	1,184
March	0	0	0	0	41	246	999	66	326	1,311	47,187	0	0	1,311
April	0	0	0	0	40	365	1,461	73	428	1,899	68,358	0	0	1,899
May	0	0	0	0	41	588	2,325	91	628	3,004	108,156	0	0	3,004
June	0	0	0	0	40	569	2,250	88	608	2,907	104,667	0	0	2,907
July	0	0	0	0	41	588	2,325	91	628	3,004	108,156	0	0	3,004
August	0	0	0	0	41	588	2,325	91	628	3,004	108,156	0	0	3,004
September	0	0	0	0	40	569	2,250	88	608	2,907	104,667	0	0	2,907
Annual	**0**	**0**	**0**	**0**	**488**	**5,304**	**21,117**	**955**	**5,968**	**27,376**	**985,549**	**0**	**0**	**27,376**
Annual Gallons	**0**	**0**	**0**	**0**	**3,650**	**39,677**	**157,955**	**7,144**		**204,775**		**0**		**204,775**

DAILY NUTRIENT PRODUCTION

Type of Animal	Pounds/Day of Nutrients from **LIQUIDS**: N	P2O5	K2O	Pounds/Day of Nutrients from **SOLIDS**: N	P2O5	K2O	Pounds/Day of Nutrients from **GRAZING**: N	P2O5	K2O	Grazing Manure Gallons/Yr	Confined Manure Cubic Feet/Yr
MINK(FEMALE)	0.00	0.00	0.00	19.74	39.93	3.04	0.00	0.00	0.00	0	10,578
MINK(MALE)	0.00	0.00	0.00	4.89	9.89	0.75	0.00	0.00	0.00	0	2,619
KIT	0.00	0.00	0.00	36.66	74.16	5.64	0.00	0.00	0.00	0	11,766
SHEEP	0.00	0.00	0.00	1.80	0.64	1.45	1.80	0.64	1.45	6,192	92
BEEF COW	0.00	0.00	0.00	6.30	3.30	5.42	6.30	3.30	5.42	73,863	1,097
CALF	0.00	0.00	0.00	2.70	1.10	2.10	2.70	1.10	2.10	18,134	269
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
									Total-	**98,189**	**26,421**

CLIENT: **Masog Ranch LLC**
ASSISTED BY: **Technical Service Provider ODA anderson**

ANIMAL WASTE MANAGEMENT SYSTEM PRODUCTION

MONTHLY NUTRIENT PRODUCTION

	Pounds of Nutrients from **LIQUIDS**			Pounds of Nutrients from **SOLIDS**			Pounds of Nutrients from **GRAZING**			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
October	0	0	0	1,933	3,859	320	301	141	250	2,235	4,000	570
November	0	0	0	1,617	3,221	271	292	136	242	1,909	3,357	513
December	0	0	0	797	1,560	145	301	141	250	1,098	1,701	395
January	0	0	0	797	1,560	145	301	141	250	1,098	1,701	395
February	0	0	0	720	1,409	131	272	127	226	992	1,536	357
March	0	0	0	797	1,560	145	301	141	250	1,098	1,701	395
April	0	0	0	1,194	2,365	206	292	136	242	1,486	2,501	448
May	0	0	0	1,933	3,859	320	301	141	250	2,235	4,000	570
June	0	0	0	1,871	3,735	310	292	136	242	2,163	3,871	552
July	0	0	0	1,933	3,859	320	301	141	250	2,235	4,000	570
August	0	0	0	1,933	3,859	320	301	141	250	2,235	4,000	570
September	0	0	0	1,871	3,735	310	292	136	242	2,163	3,871	552
Annual	**0**	**0**	**0**	**17,398**	**34,581**	**2,943**	**3,548**	**1,656**	**2,945**	**20,946**	**36,236**	**5,888**

Total Liquids
Cubic Feet
41
40
41
41
37
41
40
41
40
41
41
40
488
3,650

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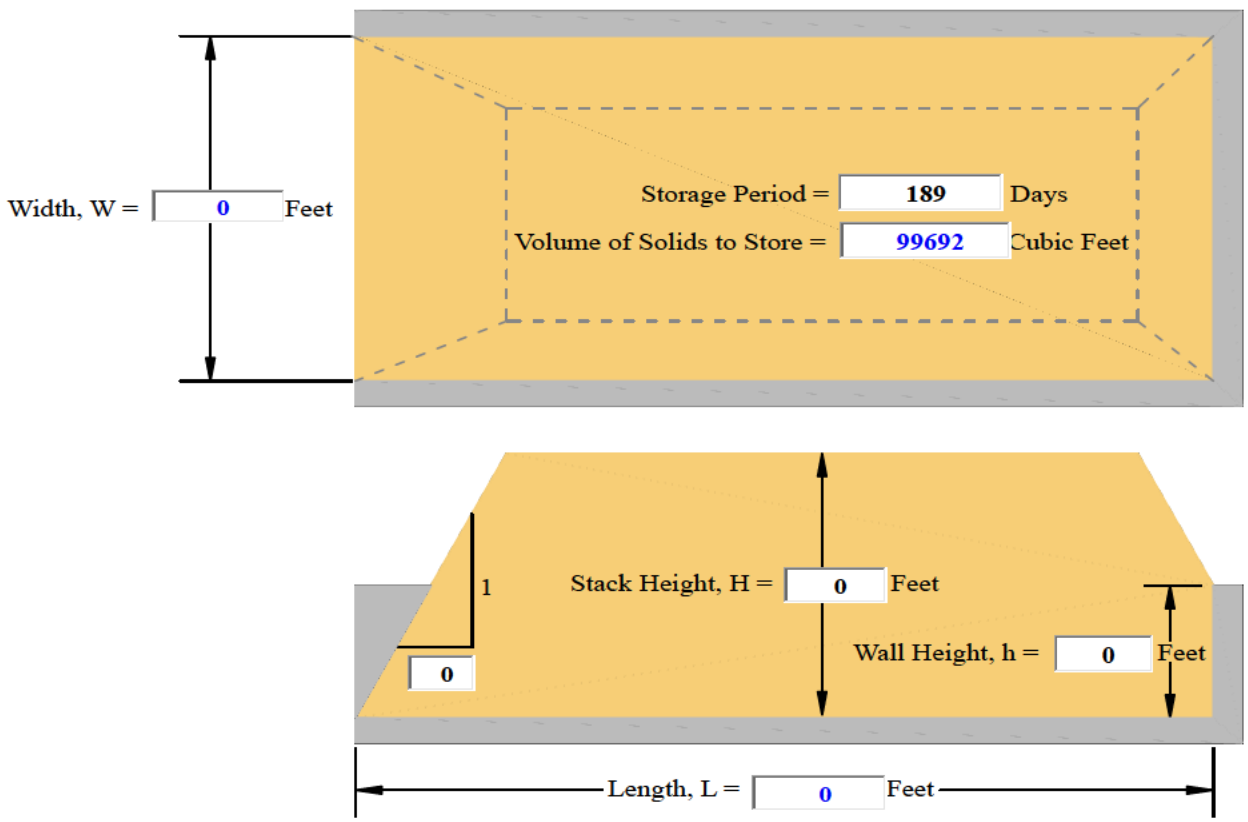
ANIMAL WASTE MANAGEMENT SYSTEM STORAGE

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	Solids to Store Tons	Normal Runoff CF
Storage Period, Days=	365	October	31	2913	91	1,502	54	0
Stacking Width, W in Feet=	0	November	30	2447	83	1,265	46	0
Stacking Height, H in Feet=	0.00	December	31	1245	66	655	24	0
Wall Height, h in Feet=	0.00	January	31	1245	66	655	24	0
Stack Side Slope (X:1)=	0.00	February	28	1124	60	592	21	0
Existing Storage, Cubic Feet=	14,272	March	31	1245	66	655	24	0
Surface Area of Existing Storage, SF=	0	April	30	1826	73	949	34	0
25 Year-24 Hour Storm Runoff, CF=	0	May	31	2913	91	1,502	54	0
Volume Needed, Cubic Feet=	13,688	June	30	2819	88	1,454	52	0
Design Volume, Cubic Feet=	0	July	31	2913	91	1,502	54	0
Is Facility Covered?	YES	August	31	2913	91	1,502	54	0
		September	30	2819	88	1,454	52	0
		Annual	365	26,421	955	13,688	493	0



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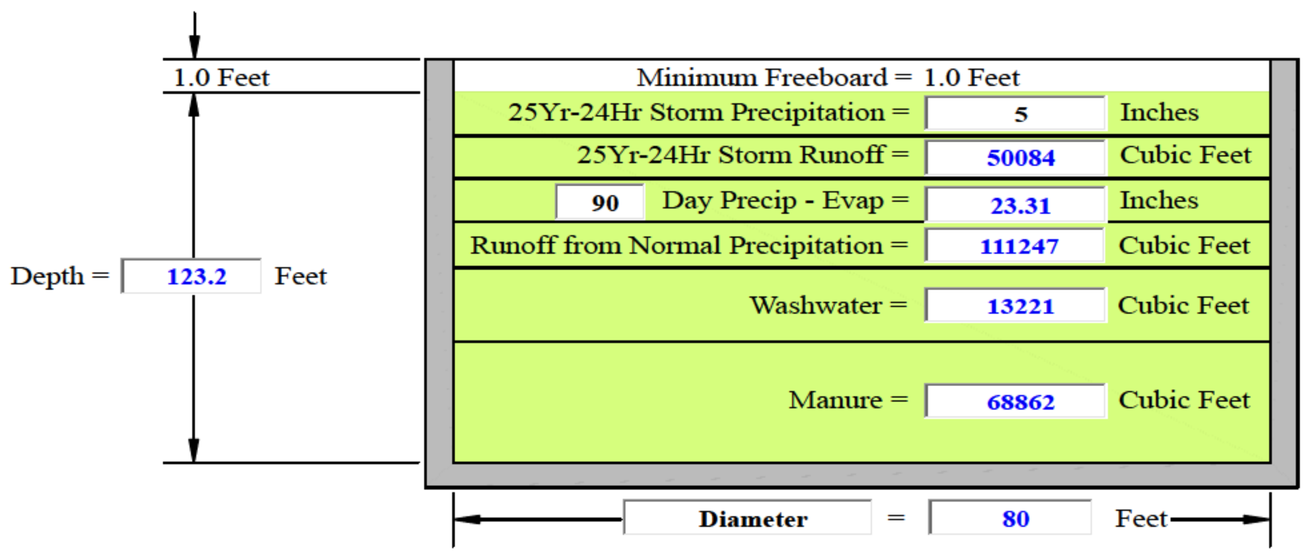
ANIMAL WASTE MANAGEMENT SYSTEM STORAGE

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	Solids CF	Waste to Store CF	Waste to Store Gallons
Storage Period, Days=	195	October	31	0	0	0	41	0	41	310
Tank Diameter, Feet=	0	November	30	0	0	0	40	0	40	300
		December	31	0	0	0	41	0	41	310
Existing Storage, Cubic Feet=	267	January	31	0	0	0	41	0	41	310
Surface Area of Existing Storage, SF=	0	February	28	0	0	0	37	0	37	280
25 Year-24 Hour Storm Runoff, CF=	0	March	31	0	0	0	41	0	41	310
Volume Needed, Cubic Feet=	263	April	30	0	0	0	40	0	40	300
Design Volume, Cubic Feet=	0	May	31	0	0	0	41	0	41	310
Is Tank Covered?	YES	June	30	0	0	0	40	0	40	300
Tank Dimensions?	Circular	July	31	0	0	0	41	0	41	310
		August	31	0	0	0	41	0	41	310
		September	30	0	0	0	40	0	40	300
		Annual	365	0	0	0	488	0	488	3,650



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ANIMAL WASTE MANAGEMENT SYSTEM APPLICATION

MANAGEMENT CRITERIA FOR TRACTOR SPREADER APPLICATION OF SOLIDS

To apply 27,376 cubic feet of solids generated from the operation it will take approximately 138 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/Ton	Pounds of Nutrients to be Applied	Number of Applications Needed to meet Crop Demand	Tons per Acre of Solids to Apply	Travel Length per Load Needed in Feet	Loads per Acre
Main 1	37.8	Perennial Hay/Pasture(Med Intensity)	160	199	15	12,357	24.71	163	1.00	11.8	882	3
Main 2	5.5	Perennial Hay/Pasture(Med Intensity)	160	199	15	12,357	24.71	163	1.00	11.8	882	3
Johnson	14	Perennial Hay/Pasture(Med Intensity)	160	199	15	12,357	24.71	163	1.00	11.8	882	3
Mcdowell 1	18.3	Grass/Legume Hay/Pasture	160	199	15	12,357	24.71	136	1.00	9.8	1061	3
McDowell 2	2.1	Grass/Legume Hay/Pasture	160	199	15	12,357	24.71	136	1.00	9.8	1061	3
Lebra	23.73	Grass/Legume Hay/Pasture	160	199	15	12,357	24.71	136	1.00	9.8	1061	3
Craig Lane	9.42	Grass/Legume Hay/Pasture	160	199	15	12,357	24.71	136	1.00	9.8	1061	3

MANAGEMENT CRITERIA FOR BIG GUN SPRINKLER APPLICATION OF LIQUIDS

To apply 3,650 gallons of liquids generated from the operation it will take approximately 0 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
Main 1	37.8	Perennial Hay/Pasture(Med Intensity)	300	250	1/2 Ci	0	0.00	163	1.00		1.45	#VALUE!
Main 2	5.5	Perennial Hay/Pasture(Med Intensity)	300	250	1/2 Ci	0	0.00	163	1.00		1.45	#VALUE!
	14	Perennial Hay/Pasture(Med Intensity)	300	250	1/2 Ci	0	0.00	163	1.00		1.45	#VALUE!
Mcdowell 1	18.3	Grass/Legume Hay/Pasture	300	250	1/2 Ci	0	0.00	136	1.00		1.45	#VALUE!
McDowell 2	2.1	Grass/Legume Hay/Pasture	300	250	1/2 Ci	0	0.00	136	1.00		1.45	#VALUE!
Lebra	23.73	Grass/Legume Hay/Pasture	300	250	1/2 Ci	0	0.00	136	1.00		1.45	#VALUE!
Craig Lane	9.42	Grass/Legume Hay/Pasture	300	250	1/2 Ci	0	0.00	136	1.00		1.45	#VALUE!

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ASSISTED BY: **Technical Service Provider ODA anderson**

ANIMAL WASTE MANAGEMENT SYSTEM APPLICATION

MANAGEMENT CRITERIA FOR TANK WAGON APPLICATION OF LIQUIDS

To apply 3,650 gallons of liquids generated from the operation it will take approximately 1 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	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
Main 1	37.8	Perennial Hay/Pasture(Med Intensity)	4,000	15	0	0.00	163	1.00		#VALUE!	#VALUE!
Main 2	5.5	Perennial Hay/Pasture(Med Intensity)	4,000	15	0	0.00	163	1.00		#VALUE!	#VALUE!
Johnson	14	Perennial Hay/Pasture(Med Intensity)	4,000	15	0	0.00	163	1.00		#VALUE!	#VALUE!
Mcdowell 1	18.3	Grass/Legume Hay/Pasture	4,000	15	0	0.00	136	1.00		#VALUE!	#VALUE!
McDowell 2	2.1	Grass/Legume Hay/Pasture	4,000	15	0	0.00	136	1.00		#VALUE!	#VALUE!
Lebra	23.73	Grass/Legume Hay/Pasture	4,000	15	0	0.00	136	1.00		#VALUE!	#VALUE!
Craig Lane	9.42	Grass/Legume Hay/Pasture	4,000	15	0	0.00	136	1.00		#VALUE!	#VALUE!

COMPUTED NUTRIENT CONCENTRATIONS IN STORAGE

Storage Facility	Annual Volume Production	Units	Concentration of Nutrients in Storage N	P_2O_5	K_2O	Units
Tank (Covered)	3,650	Gallons	0.00	0.00	0.00	lbs/1,000 Gal
Solids Storage Facility (Roofed)	246	Tons	24.71	63.16	5.37	lbs/Ton

Assumed Solids Density lbs/CF
36
36
36
36
36
36
36

Travel Rate Needed in Feet/Minute
#VALUE!
#VALUE!
#VALUE!
#VALUE!
#VALUE!
#VALUE!
#VALUE!

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ANIMAL WASTE MANAGEMENT SYSTEM UTILIZATION

NUTRIENTS AVAILABLE AFTER STORAGE

Nutrient Source	Type of Operation: Mink / Type of Storage Facility	Pounds of Nutrients Available N	P2O5	K2O	Percent Nutrients Retained After Storage N	P2O5	K2O	Pounds of Nutrients Retained After Storage N	P2O5	K2O
Liquids	Tank (Covered)	0	0	0	85%	90%	90%	0	0	0
Solids	Solids Storage Facility (Roofed)	17,398	34,581	2,943	70%	90%	90%	12,179	31,123	2,649
Grazing	NONE	3,548	1,656	2,945	100%	100%	100%	3,548	1,656	2,945

NUTRIENTS AVAILABLE AFTER APPLICATION

Nutrient Source	Type of Application System	Pounds of Nutrients Available N	P2O5	K2O	Percent Nutrients Retained After Application N	P2O5	K2O	Pounds of Nutrients Retained After Application N	P2O5	K2O
Liquids	Sprinkling	0	0	0	75%	100%	100%	0	0	0
Solids	Broadcast (Incorporated 7 or more days after appli	12,179	31,123	2,649	70%	100%	100%	8,525	31,123	2,649
Grazing	Grazing	3,548	1,656	2,945	85%	100%	100%	3,016	1,656	2,945

NUTRIENTS AVAILABLE AFTER DENITRIFICATION

Nutrient Source	Location: Between Coastal and Cascade Mountains / Soil Drainage Class	Pounds of Nutrients Available N	P2O5	K2O	Percent Nutrients Retained After Denitrification N	P2O5	K2O	Pounds of Nutrients Retained After Denitrification N	P2O5	K2O
Liquids	Somewhat Poorly Drained	0	0	0	80%	100%	100%	0	0	0
Solids	Somewhat Poorly Drained	8,525	31,123	2,649	80%	100%	100%	6,820	31,123	2,649
Grazing	Somewhat Poorly Drained	3,016	1,656	2,945	80%	100%	100%	2,413	1,656	2,945
							TOTAL-	***9,232***	***32,778***	***5,594***

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ANIMAL WASTE MANAGEMENT SYSTEM UTILIZATION

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

			LIQUIDS			SOLIDS			GRAZING		
Field Number	Acres	Crop	Percent to be Applied	Pounds of Nutrients to be Applied	Acres Needed for Utilization of Nutrients	Percent to be Applied	Pounds of Nutrients to be Applied	Acres Needed for Utilization of Nutrients	Percent to be Applied	Pounds of Nutrients to be Applied	Acres Needed for Utilization of Nutrients
Main 1	37.8	Perennial Hay/Pasture(Med Intensity)	100%	0	0	71%	4,842	30	51%	1,230	8
Main 2	5.5	Perennial Hay/Pasture(Med Intensity)	0%	0	0	10%	682	4	9%	217	1
Johnson	14.0	Perennial Hay/Pasture(Med Intensity)	0%	0	0	19%	1,296	8	40%	965	6
Mcdowell 1	18.3	Grass/Legume Hay/Pasture	0%	0	0	0%	0	0	0%	0	0
McDowell 2	2.1	Grass/Legume Hay/Pasture	0%	0	0	0%	0	0	0%	0	0
Lebra	23.7	Grass/Legume Hay/Pasture	0%	0	0	0%	0	0	0%	0	0
Craig Lane	9.4	Grass/Legume Hay/Pasture	0%	0	0		0	0	0%	0	0
Off Farm			0%	0		0%	0		0%	0	
TOTALS-	**110.85**		**100%**	**0**	**0**	**100%**	**6,820**	**42**	**100%**	**2,413**	**15**

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
Main 1	37.8	Perennial Hay/Pasture(Med Intensity)	161	607	89	163	55	156	-3	552	-66
Main 2	5.5	Perennial Hay/Pasture(Med Intensity)	163	593	96	163	55	156	0	538	-59
Johnson	14.0	Perennial Hay/Pasture(Med Intensity)	161	470	120	163	55	156	-2	415	-36
Mcdowell 1	18.3	Grass/Legume Hay/Pasture	0	0	0	136	49	36	-136	-49	-36
McDowell 2	2.1	Grass/Legume Hay/Pasture	0	0	0	136	49	36	-136	-49	-36
Lebra	23.7	Grass/Legume Hay/Pasture	0	0	0	136	49	36	-136	-49	-36
Craig Lane	9.4	Grass/Legume Hay/Pasture	0	0	0	136	49	36	-136	-49	-36
Off Farm											

United States
Department of
Agriculture

NRCS

Natural
Resources
Conservation
Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for

Linn County Area, Oregon

Masog [redacted] Facillity

[redacted]

June 30, 2016

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (http://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Linn County Area, Oregon
Survey Area Data: Version 10, Sep 18, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jul 5, 2011—Jul 6, 2011

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Linn County Area, Oregon (OR639)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
19	Chapman loam	58.6	91.9%
67	McBee silty clay loam	5.1	8.1%
Totals for Area of Interest		**63.7**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Linn County Area, Oregon

19—Chapman loam

Map Unit Setting

National map unit symbol: 24wb
Elevation: 170 to 700 feet
Mean annual precipitation: 40 to 50 inches
Mean annual air temperature: 52 to 54 degrees F
Frost-free period: 165 to 210 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Chapman and similar soils: 85 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Chapman

Setting

Landform: Flood plains, terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Mixed silty, clayey, and sandy alluvium derived from mixed sources

Typical profile

H1 - 0 to 13 inches: loam
H2 - 13 to 52 inches: clay loam
H3 - 52 to 60 inches: gravelly sandy loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: Rare
Frequency of ponding: None
Available water storage in profile: High (about 9.2 inches)

Interpretive groups

Land capability classification (irrigated): 1
Land capability classification (nonirrigated): 1
Hydrologic Soil Group: B
Other vegetative classification: Well drained < 15% Slopes (G002XY002OR)

67—McBee silty clay loam

Map Unit Setting

National map unit symbol: 24yz

Elevation: 150 to 600 feet
Mean annual precipitation: 40 to 50 inches
Mean annual air temperature: 52 to 54 degrees F
Frost-free period: 165 to 210 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Mcbee and similar soils: 85 percent
Minor components: 3 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Mcbee

Setting

Landform: Flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Moderately fine textured alluvium derived from mixed sources

Typical profile

H1 - 0 to 19 inches: silty clay loam
H2 - 19 to 60 inches: silty clay loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: About 24 to 36 inches
Frequency of flooding: Occasional
Frequency of ponding: None
Available water storage in profile: High (about 10.7 inches)

Interpretive groups

Land capability classification (irrigated): 2w
Land capability classification (nonirrigated): 2w
Hydrologic Soil Group: C
Other vegetative classification: Moderately Well Drained < 15% Slopes (G002XY004OR)

Minor Components

Wapato

Percent of map unit: 3 percent
Landform: Flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Other vegetative classification: Poorly Drained (G002XY006OR)

Soil Information for All Uses

Suitabilities and Limitations for Use

The Suitabilities and Limitations for Use section includes various soil interpretations displayed as thematic maps with a summary table for the soil map units in the selected area of interest. A single value or rating for each map unit is generated by aggregating the interpretive ratings of individual map unit components. This aggregation process is defined for each interpretation.

Waste Management

Waste Management interpretations are tools designed to guide the user in evaluating soils for use of organic wastes and wastewater as productive resources. Example interpretations include land application of manure, food processing waste, and municipal sewage sludge, and disposal of wastewater by irrigation or overland flow process.

Manure and Food-Processing Waste

The application of manure and food-processing waste not only disposes of waste material but also can improve crop production by increasing the supply of nutrients in the soils where the material is applied. Manure is the excrement of livestock and poultry, and food-processing waste is damaged fruit and vegetables and the peelings, stems, leaves, pits, and soil particles removed in food preparation. The manure and food-processing waste are solid, slurry, or liquid. Their nitrogen content varies. A high content of nitrogen limits the application rate. Toxic or otherwise dangerous wastes, such as those mixed with the lye used in food processing, are not considered in the ratings.

The ratings are based on the soil properties that affect absorption, plant growth, microbial activity, erodibility, the rate at which the waste is applied, and the method by which the waste is applied. The properties that affect absorption include saturated hydraulic conductivity (Ksat), depth to a water table, ponding, the sodium adsorption ratio, depth to bedrock or a cemented pan, and available water capacity. The properties that affect plant growth and microbial activity include reaction, the sodium adsorption ratio, salinity, and bulk density. The wind erodibility group, soil erosion factor K, and slope are considered in estimating the likelihood that wind erosion or water erosion will transport the waste material from the application site. Stones, cobbles, a water table, ponding, and flooding can hinder the application of waste. Permanently frozen soils are unsuitable for waste treatment.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect agricultural waste management. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

Soil Rating Polygons

- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines

- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points

- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Linn County Area, Oregon
Survey Area Data: Version 10, Sep 18, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jul 5, 2011—Jul 6, 2011

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Tables—Manure and Food-Processing Waste

Manure and Food-Processing Waste— Summary by Map Unit — Linn County Area, Oregon (OR639)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
19	Chapman loam	Somewhat limited	Chapman (85%)	Too acid (0.03)	58.6	91.9%
67	McBee silty clay loam	Somewhat limited	McBee (85%)	Depth to saturated zone (0.86)	5.1	8.1%
				Flooding (0.60)		
				Too acid (0.03)		
Totals for Area of Interest					**63.7**	**100.0%**

Manure and Food-Processing Waste— Summary by Rating Value		
Rating	**Acres in AOI**	**Percent of AOI**
Somewhat limited	63.7	100.0%
Totals for Area of Interest	**63.7**	**100.0%**

Rating Options—Manure and Food-Processing Waste

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

Soil Reports

The Soil Reports section includes various formatted tabular and narrative reports (tables) containing data for each selected soil map unit and each component of each unit. No aggregation of data has occurred as is done in reports in the Soil Properties and Qualities and Suitabilities and Limitations sections.

The reports contain soil interpretive information as well as basic soil properties and qualities. A description of each report (table) is included.

Soil Physical Properties

This folder contains a collection of tabular reports that present soil physical properties. The reports (tables) include all selected map units and components for each map unit. Soil physical properties are measured or inferred from direct observations in the field or laboratory. Examples of soil physical properties include percent clay, organic matter, saturated hydraulic conductivity, available water capacity, and bulk density.

Physical Soil Properties

This table shows estimates of some physical characteristics and features that affect soil behavior. These estimates are given for the layers of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

Depth to the upper and lower boundaries of each layer is indicated.

Particle size is the effective diameter of a soil particle as measured by sedimentation, sieving, or micrometric methods. Particle sizes are expressed as classes with specific effective diameter class limits. The broad classes are sand, silt, and clay, ranging from the larger to the smaller.

Sand as a soil separate consists of mineral soil particles that are 0.05 millimeter to 2 millimeters in diameter. In this table, the estimated sand content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Silt as a soil separate consists of mineral soil particles that are 0.002 to 0.05 millimeter in diameter. In this table, the estimated silt content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Clay as a soil separate consists of mineral soil particles that are less than 0.002 millimeter in diameter. In this table, the estimated clay content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The content of sand, silt, and clay affects the physical behavior of a soil. Particle size is important for engineering and agronomic interpretations, for determination of soil hydrologic qualities, and for soil classification.

The amount and kind of clay affect the fertility and physical condition of the soil and the ability of the soil to adsorb cations and to retain moisture. They influence shrink-swell potential, saturated hydraulic conductivity (Ksat), plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and earthmoving operations.

Moist bulk density is the weight of soil (ovendry) per unit volume. Volume is measured when the soil is at field moisture capacity, that is, the moisture content at 1/3- or 1/10-bar (33kPa or 10kPa) moisture tension. Weight is determined after the soil is dried at 105 degrees C. In the table, the estimated moist bulk density of each soil horizon is expressed in grams per cubic centimeter of soil material that is less than 2 millimeters in diameter. Bulk density data are used to compute linear extensibility, shrink-swell potential, available water capacity, total pore space, and other soil properties. The moist bulk density of a soil indicates the pore space available for water and roots. Depending on soil texture, a bulk density of more than 1.4 can restrict water storage and root penetration. Moist bulk density is influenced by texture, kind of clay, content of organic matter, and soil structure.

Saturated hydraulic conductivity (Ksat) refers to the ease with which pores in a saturated soil transmit water. The estimates in the table are expressed in terms of micrometers per second. They are based on soil characteristics observed in the field, particularly structure, porosity, and texture. Saturated hydraulic conductivity (Ksat) is considered in the design of soil drainage systems and septic tank absorption fields.

Available water capacity refers to the quantity of water that the soil is capable of storing for use by plants. The capacity for water storage is given in inches of water per inch of soil for each soil layer. The capacity varies, depending on soil properties that affect retention of water. The most important properties are the content of organic matter, soil texture, bulk density, and soil structure. Available water capacity is an important factor in the choice of plants or crops to be grown and in the design and management of irrigation systems. Available water capacity is not an estimate of the quantity of water actually available to plants at any given time.

Linear extensibility refers to the change in length of an unconfined clod as moisture content is decreased from a moist to a dry state. It is an expression of the volume change between the water content of the clod at 1/3- or 1/10-bar tension (33kPa or 10kPa tension) and oven dryness. The volume change is reported in the table as percent change for the whole soil. The amount and type of clay minerals in the soil influence volume change.

Linear extensibility is used to determine the shrink-swell potential of soils. The shrink-swell potential is low if the soil has a linear extensibility of less than 3 percent; moderate if 3 to 6 percent; high if 6 to 9 percent; and very high if more than 9 percent. If the linear extensibility is more than 3, shrinking and swelling can cause damage to buildings, roads, and other structures and to plant roots. Special design commonly is needed.

Organic matter is the plant and animal residue in the soil at various stages of decomposition. In this table, the estimated content of organic matter is expressed as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter. The content of organic matter in a soil can be maintained by returning crop residue to the soil.

Organic matter has a positive effect on available water capacity, water infiltration, soil organism activity, and tilth. It is a source of nitrogen and other nutrients for crops and soil organisms.

Erosion factors are shown in the table as the K factor (Kw and Kf) and the T factor. Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) and the

Revised Universal Soil Loss Equation (RUSLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter and on soil structure and Ksat. Values of K range from 0.02 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water.

Erosion factor Kw indicates the erodibility of the whole soil. The estimates are modified by the presence of rock fragments.

Erosion factor Kf indicates the erodibility of the fine-earth fraction, or the material less than 2 millimeters in size.

Erosion factor T is an estimate of the maximum average annual rate of soil erosion by wind and/or water that can occur without affecting crop productivity over a sustained period. The rate is in tons per acre per year.

Wind erodibility groups are made up of soils that have similar properties affecting their susceptibility to wind erosion in cultivated areas. The soils assigned to group 1 are the most susceptible to wind erosion, and those assigned to group 8 are the least susceptible. The groups are described in the "National Soil Survey Handbook."

Wind erodibility index is a numerical value indicating the susceptibility of soil to wind erosion, or the tons per acre per year that can be expected to be lost to wind erosion. There is a close correlation between wind erosion and the texture of the surface layer, the size and durability of surface clods, rock fragments, organic matter, and a calcareous reaction. Soil moisture and frozen soil layers also influence wind erosion.

Reference:

United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. (http://soils.usda.gov)

Physical Soil Properties–Linn County Area, Oregon														
Map symbol and soil name	Depth	Sand	Silt	Clay	Moist bulk density	Saturated hydraulic conductivity	Available water capacity	Linear extensibility	Organic matter	Erosion factors			Wind erodibility group	Wind erodibility index
										Kw	Kf	T		
	In	*Pct*	*Pct*	*Pct*	*g/cc*	*micro m/sec*	*In/In*	*Pct*	*Pct*					
19—Chapman loam														
Chapman	0-13	-40-	-38-	18-23- 27	1.20-1.30-1.40	4.00-9.00-14.00	0.19-0.20-0.21	0.0- 1.5- 2.9	2.0- 3.5-5.0	.28	.28	5	6	48
	13-52	-35-	-38-	20-28- 35	1.20-1.30-1.40	4.00-9.00-14.00	0.13-0.15-0.16	3.0- 4.5- 5.9	1.0- 2.0-3.0	.28	.28			
	52-60	-68-	-20-	5-13- 20	1.30-1.40-1.50	14.00-28.00-42.00	0.07-0.09-0.10	0.0- 1.5- 2.9	0.3- 0.6-1.0	.15	.24			
67—McBee silty clay loam														
Mcbee	0-19	- 7-	-62-	27-31- 35	1.20-1.30-1.40	4.00-9.00-14.00	0.19-0.20-0.21	3.0- 4.5- 5.9	3.0- 4.5-6.0	.32	.32	5	6	48
	19-60	- 7-	-63-	25-30- 45	1.20-1.30-1.40	4.00-9.00-14.00	0.13-0.17-0.21	3.0- 4.5- 5.9	0.5- 2.3-4.0	.37	.37			

Vegetative Productivity

This folder contains a collection of tabular reports that present vegetative productivity data. The reports (tables) include all selected map units and components for each map unit. Vegetative productivity includes estimates of potential vegetative production for a variety of land uses, including cropland, forestland, hayland, pastureland, horticulture and rangeland. In the underlying database, some states maintain crop yield data by individual map unit component. Other states maintain the data at the map unit level. Attributes are included for both, although only one or the other is likely to contain data for any given geographic area. For other land uses, productivity data is shown only at the map unit component level. Examples include potential crop yields under irrigated and nonirrigated conditions, forest productivity, forest site index, and total rangeland production under of normal, favorable and unfavorable conditions.

Irrigated Yields by Map Unit Component

The average yields per acre that can be expected of the principal crops under a high level of management are shown in this table. In any given year, yields may be higher or lower than those indicated in the table because of variations in rainfall and other climatic factors.

The yields are based mainly on the experience and records of farmers, conservationists, and extension agents. Available yield data from nearby counties and results of field trials and demonstrations also are considered.

The management needed to obtain the indicated yields of the various crops depends on the kind of soil and the crop. Management can include drainage, erosion control, and protection from flooding; the proper planting and seeding rates; suitable high-yielding crop varieties; appropriate and timely tillage; control of weeds, plant diseases, and harmful insects; favorable soil reaction and optimum levels of nitrogen, phosphorus, potassium, and trace elements for each crop; effective use of crop residue, barnyard manure, and green manure crops; and harvesting that ensures the smallest possible loss.

If yields of irrigated crops are given, it is assumed that the irrigation system is adapted to the soils and to the crops grown, that good-quality irrigation water is uniformly applied as needed, and that tillage is kept to a minimum.

Pasture yields are expressed in terms of animal unit months. An animal unit month (AUM) is the amount of forage required by one mature cow of approximately 1,000 pounds weight, with or without a calf, for 1 month.

The estimated yields reflect the productive capacity of each soil for each of the principal crops. Yields are likely to increase as new production technology is developed. The productivity of a given soil compared with that of other soils, however, is not likely to change.

Crops other than those shown in the table are grown in the survey area, but estimated yields are not listed because the acreage of such crops is small. The local office of the Natural Resources Conservation Service or of the Cooperative Extension Service can provide information about the management and productivity of the soils for those crops.

The land capability classification of map units in the survey area is shown in this table. This classification shows, in a general way, the suitability of soils for most kinds of field crops (United States Department of Agriculture, Soil Conservation Service, 1961). Crops that require special management are excluded. The soils are grouped according to their limitations for field crops, the risk of damage if they are used for crops, and the way they respond to management. The criteria used in grouping the soils do not include major and generally expensive landforming that would change slope, depth, or other characteristics of the soils, nor do they include possible but unlikely major reclamation projects. Capability classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for rangeland, for forestland, or for engineering purposes.

In the capability system, soils are generally grouped at three levels: capability class, subclass, and unit.

Capability classes, the broadest groups, are designated by the numbers 1 through 8. The numbers indicate progressively greater limitations and narrower choices for practical use. The classes are defined as follows:

- Class 1 soils have slight limitations that restrict their use.
- Class 2 soils have moderate limitations that restrict the choice of plants or that require moderate conservation practices.
- Class 3 soils have severe limitations that restrict the choice of plants or that require special conservation practices, or both.
- Class 4 soils have very severe limitations that restrict the choice of plants or that require very careful management, or both.
- Class 5 soils are subject to little or no erosion but have other limitations, impractical to remove, that restrict their use mainly to pasture, rangeland, forestland, or wildlife habitat.
- Class 6 soils have severe limitations that make them generally unsuitable for cultivation and that restrict their use mainly to pasture, rangeland, forestland, or wildlife habitat.
- Class 7 soils have very severe limitations that make them unsuitable for cultivation and that restrict their use mainly to grazing, forestland, or wildlife habitat.
- Class 8 soils and miscellaneous areas have limitations that preclude commercial plant production and that restrict their use to recreational purposes, wildlife habitat, watershed, or esthetic purposes.

Capability subclasses are soil groups within one class. They are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, 2e. The letter *e* shows that the main hazard is the risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the United States, shows that the chief limitation is climate that is very cold or very dry.

In class 1 there are no subclasses because the soils of this class have few limitations. Class 5 contains only the subclasses indicated by *w*, *s*, or *c* because the soils in class 5 are subject to little or no erosion.

Capability units are soil groups within a subclass. The soils in a capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, 2e-4 and 3e-6. These units are not given in all soil surveys.

Reference:
United States Department of Agriculture, Soil Conservation Service. 1961. Land capability classification. U.S. Department of Agriculture Handbook 210.

Report—Irrigated Yields by Map Unit Component

Irrigated Yields by Map Unit Component–Linn County Area, Oregon				
Map symbol and soil name	**Land capability**	**Grass hay**	**Pasture**	**Perennial ryegrass seed**
			AUM	
19—Chapman loam				
Chapman	1	—	18.0	—
67—McBee silty clay loam				
Mcbee	2w	—	16.0	—

Water Features

This folder contains tabular reports that present soil hydrology information. The reports (tables) include all selected map units and components for each map unit. Water Features include ponding frequency, flooding frequency, and depth to water table.

Water Features

This table gives estimates of various soil water features. The estimates are used in land use planning that involves engineering considerations.

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The four hydrologic soil groups are:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas.

Surface runoff refers to the loss of water from an area by flow over the land surface. Surface runoff classes are based on slope, climate, and vegetative cover. The concept indicates relative runoff for very specific conditions. It is assumed that the surface of the soil is bare and that the retention of surface water resulting from irregularities in the ground surface is minimal. The classes are negligible, very low, low, medium, high, and very high.

The *months* in the table indicate the portion of the year in which a water table, ponding, and/or flooding is most likely to be a concern.

Water table refers to a saturated zone in the soil. The water features table indicates, by month, depth to the top (*upper limit*) and base (*lower limit*) of the saturated zone in most years. Estimates of the upper and lower limits are based mainly on observations of the water table at selected sites and on evidence of a saturated zone, namely grayish colors or mottles (redoximorphic features) in the soil. A saturated zone that lasts for less than a month is not considered a water table.

Ponding is standing water in a closed depression. Unless a drainage system is installed, the water is removed only by percolation, transpiration, or evaporation. The table indicates *surface water depth* and the *duration* and *frequency* of ponding. Duration is expressed as *very brief* if less than 2 days, *brief* if 2 to 7 days, *long* if 7 to 30 days, and *very long* if more than 30 days. Frequency is expressed as none, rare, occasional, and frequent. *None* means that ponding is not probable; *rare* that it is unlikely but possible under unusual weather conditions (the chance of ponding is nearly 0 percent to 5 percent in any year); *occasional* that it occurs, on the average, once or less in 2 years (the chance of ponding is 5 to 50 percent in any year); and *frequent* that it occurs, on the average, more than once in 2 years (the chance of ponding is more than 50 percent in any year).

Flooding is the temporary inundation of an area caused by overflowing streams, by runoff from adjacent slopes, or by tides. Water standing for short periods after rainfall or snowmelt is not considered flooding, and water standing in swamps and marshes is considered ponding rather than flooding.

Duration and *frequency* are estimated. Duration is expressed as *extremely brief* if 0.1 hour to 4 hours, *very brief* if 4 hours to 2 days, *brief* if 2 to 7 days, *long* if 7 to 30 days, and *very long* if more than 30 days. Frequency is expressed as none, very rare, rare, occasional, frequent, and very frequent. *None* means that flooding is not probable; *very rare* that it is very unlikely but possible under extremely unusual weather conditions (the chance of flooding is less than 1 percent in any year); *rare* that it is unlikely but possible under unusual weather conditions (the chance of flooding is 1 to 5 percent in any year); *occasional* that it occurs infrequently under normal weather conditions (the chance of flooding is 5 to 50 percent in any year); *frequent* that it is likely to occur often under normal weather conditions (the chance of flooding is more than 50 percent in any year but is less than 50 percent in all months in any year); and *very frequent* that it is likely to occur very often under normal weather conditions (the chance of flooding is more than 50 percent in all months of any year).

The information is based on evidence in the soil profile, namely thin strata of gravel, sand, silt, or clay deposited by floodwater; irregular decrease in organic matter content with increasing depth; and little or no horizon development.

Also considered are local information about the extent and levels of flooding and the relation of each soil on the landscape to historic floods. Information on the extent of flooding based on soil data is less specific than that provided by detailed engineering surveys that delineate flood-prone areas at specific flood frequency levels.

Absence of an entry indicates that the data were not estimated. The dash indicates no documented presence.

Water Features–Linn County Area, Oregon										
Map unit symbol and soil name	**Hydrologic group**	**Surface runoff**	**Month**	**Water table**		**Ponding**			**Flooding**	
				Upper limit	**Lower limit**	**Surface depth**	**Duration**	**Frequency**	**Duration**	**Frequency**
				Ft	*Ft*	*Ft*				
19—Chapman loam										
Chapman	B	—	January	—	—	—	—	None	—	Rare
			February	—	—	—	—	None	—	Rare
			March	—	—	—	—	None	—	Rare
			April	—	—	—	—	None	—	Rare
			May	—	—	—	—	None	—	Rare
			June	—	—	—	—	None	—	None
			July	—	—	—	—	None	—	None
			August	—	—	—	—	None	—	None
			September	—	—	—	—	None	—	None
			October	—	—	—	—	None	—	Rare
			November	—	—	—	—	None	—	Rare
			December	—	—	—	—	None	—	Rare

Water Features–Linn County Area, Oregon										
Map unit symbol and soil name	**Hydrologic group**	**Surface runoff**	**Month**	**Water table**		**Ponding**			**Flooding**	
				Upper limit	**Lower limit**	**Surface depth**	**Duration**	**Frequency**	**Duration**	**Frequency**
				Ft	*Ft*	*Ft*				
67—McBee silty clay loam										
Mcbee	C	—	January	2.0-3.0	>6.0	—	—	None	Brief (2 to 7 days)	Occasional
			February	2.0-3.0	>6.0	—	—	None	Brief (2 to 7 days)	Occasional
			March	2.0-3.0	>6.0	—	—	None	Brief (2 to 7 days)	Occasional
			April	2.0-3.0	>6.0	—	—	None	—	None
			May	—	—	—	—	None	—	None
			June	—	—	—	—	None	—	None
			July	—	—	—	—	None	—	None
			August	—	—	—	—	None	—	None
			September	—	—	—	—	None	—	None
			October	—	—	—	—	None	—	None
			November	2.0-3.0	>6.0	—	—	None	Brief (2 to 7 days)	Occasional
			December	2.0-3.0	>6.0	—	—	None	Brief (2 to 7 days)	Occasional

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United States Department of Agriculture

NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for

Linn County Area, Oregon

Masog Mink Ranch Main facillity

[redacted]

July 21, 2016

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (http://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

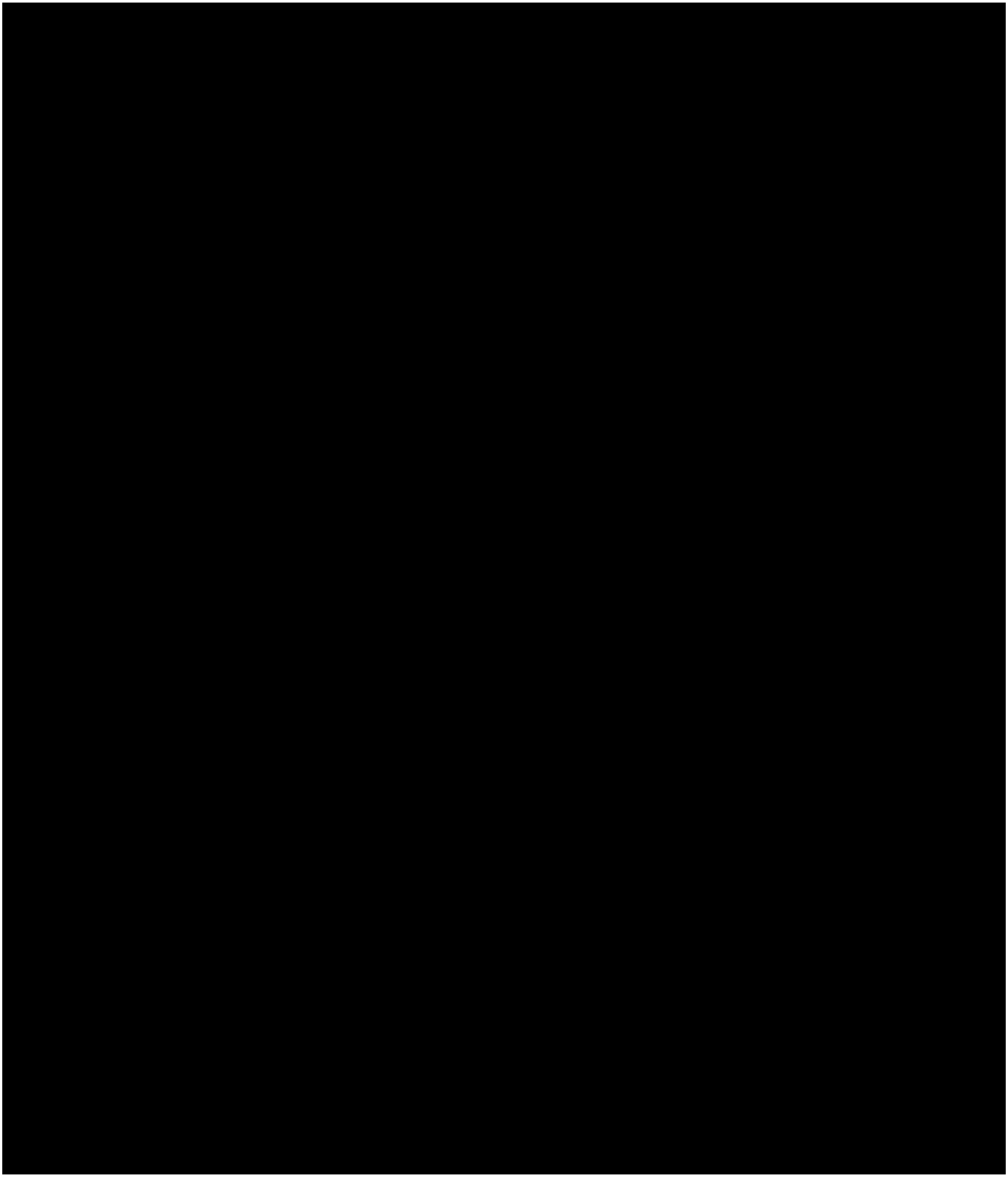
Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Soil Map



MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Linn County Area, Oregon
Survey Area Data: Version 10, Sep 18, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jul 5, 2011—Jul 6, 2011

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Linn County Area, Oregon (OR639)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
24	Clackamas variant silt loam	36.1	52.6%
29	Courtney gravelly silty clay loam	8.1	11.7%
33	Dayton silt loam	13.8	20.1%
46	Holcomb silt loam	10.7	15.6%
Totals for Area of Interest		**68.6**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Linn County Area, Oregon

24—Clackamas variant silt loam

Map Unit Setting

National map unit symbol: 24wl
Elevation: 170 to 800 feet
Mean annual precipitation: 40 to 60 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 165 to 210 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Clackamas variant and similar soils: 85 percent
Courtney and similar soils: 2 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Clackamas Variant

Setting

Landform: Stream terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear, concave
Across-slope shape: Linear, concave
Parent material: Silty alluvium over gravelly alluvium derived from mixed sources

Typical profile

H1 - 0 to 13 inches: silt loam
H2 - 13 to 27 inches: gravelly silty clay loam
H3 - 27 to 60 inches: very gravelly clay

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 24 to 36 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 7.6 inches)

Interpretive groups

Land capability classification (irrigated): 2w
Land capability classification (nonirrigated): 2w
Hydrologic Soil Group: C
Other vegetative classification: Moderately Well Drained < 15% Slopes (G002XY004OR)

Description of Courtney

Setting

Landform: Stream terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear, concave

Across-slope shape: Linear, concave
Parent material: Gravelly and clayey alluvium derived from mixed sources

Typical profile

H1 - 0 to 17 inches: gravelly silty clay loam
H2 - 17 to 33 inches: gravelly clay
H3 - 33 to 48 inches: very gravelly clay loam
H4 - 48 to 60 inches: extremely gravelly sand

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: About 0 to 18 inches
Frequency of flooding: Rare
Frequency of ponding: Frequent
Available water storage in profile: Moderate (about 7.1 inches)

Interpretive groups

Land capability classification (irrigated): 4w
Land capability classification (nonirrigated): 4w
Hydrologic Soil Group: D
Other vegetative classification: Poorly Drained (G002XY006OR)

Minor Components

Awbrig

Percent of map unit: 3 percent
Landform: Stream terraces
Landform position (three-dimensional): Tread
Down-slope shape: Concave, linear
Across-slope shape: Concave, linear
Other vegetative classification: Poorly Drained (G002XY006OR)

Conser

Percent of map unit: 2 percent
Landform: Stream terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear, concave
Across-slope shape: Linear, concave
Other vegetative classification: Poorly Drained (G002XY006OR)

29—Courtney gravelly silty clay loam

Map Unit Setting

National map unit symbol: 24wr
Elevation: 90 to 1,000 feet
Mean annual precipitation: 30 to 60 inches

Mean annual air temperature: 50 to 55 degrees F
Frost-free period: 160 to 235 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Courtney and similar soils: 85 percent
Conser and similar soils: 3 percent
Minor components: 8 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Courtney

Setting

Landform: Stream terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear, concave
Across-slope shape: Linear, concave
Parent material: Gravelly and clayey alluvium derived from mixed sources

Typical profile

H1 - 0 to 17 inches: gravelly silty clay loam
H2 - 17 to 33 inches: gravelly clay
H3 - 33 to 48 inches: very gravelly clay loam
H4 - 48 to 60 inches: extremely gravelly sand

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: 10 to 19 inches to abrupt textural change
Natural drainage class: Poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: About 0 to 18 inches
Frequency of flooding: Rare
Frequency of ponding: Frequent
Available water storage in profile: Low (about 3.0 inches)

Interpretive groups

Land capability classification (irrigated): 4w
Land capability classification (nonirrigated): 4w
Hydrologic Soil Group: D
Other vegetative classification: Poorly Drained (G002XY006OR)

Description of Conser

Setting

Landform: Stream terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear, concave
Across-slope shape: Linear, concave
Parent material: Silty and clayey alluvium derived from mixed sources

Typical profile

H1 - 0 to 17 inches: silty clay loam
H2 - 17 to 64 inches: silty clay

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches

Natural drainage class: Poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 0 to 18 inches
Frequency of flooding: Rare
Frequency of ponding: Frequent
Available water storage in profile: High (about 9.8 inches)

Interpretive groups

Land capability classification (irrigated): 3w
Land capability classification (nonirrigated): 3w
Hydrologic Soil Group: C/D
Other vegetative classification: Poorly Drained (G002XY006OR)

Minor Components

Bashaw

Percent of map unit: 4 percent
Landform: Flood plains

Awbrig

Percent of map unit: 4 percent
Landform: Stream terraces
Landform position (three-dimensional): Tread
Down-slope shape: Concave, linear
Across-slope shape: Concave, linear
Other vegetative classification: Poorly Drained (G002XY006OR)

33—Dayton silt loam

Map Unit Setting

National map unit symbol: 24x2
Elevation: 200 to 400 feet
Mean annual precipitation: 40 to 50 inches
Mean annual air temperature: 52 to 54 degrees F
Frost-free period: 165 to 210 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Dayton and similar soils: 85 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Dayton

Setting

Landform: Terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear, concave
Across-slope shape: Linear, concave

Parent material: Silty and clayey alluvium and lacustrine deposits

Typical profile

H1 - 0 to 9 inches: silt loam
H2 - 9 to 15 inches: silt loam
H3 - 15 to 40 inches: silty clay
H4 - 40 to 76 inches: silt loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: 12 to 24 inches to abrupt textural change
Natural drainage class: Poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: About 0 to 18 inches
Frequency of flooding: None
Frequency of ponding: Frequent
Available water storage in profile: Low (about 3.2 inches)

Interpretive groups

Land capability classification (irrigated): 4w
Land capability classification (nonirrigated): 4w
Hydrologic Soil Group: D
Other vegetative classification: Poorly Drained (G002XY006OR)

Minor Components

Concord

Percent of map unit: 3 percent
Landform: Terraces
Landform position (three-dimensional): Tread
Down-slope shape: Concave, linear
Across-slope shape: Concave, linear
Other vegetative classification: Poorly Drained (G002XY006OR)

Dayton, gravelly clay substratum

Percent of map unit: 2 percent
Landform: Terraces

46—Holcomb silt loam

Map Unit Setting

National map unit symbol: 24xt
Elevation: 200 to 400 feet
Mean annual precipitation: 40 to 50 inches
Mean annual air temperature: 52 to 54 degrees F
Frost-free period: 165 to 210 days
Farmland classification: Prime farmland if drained

Map Unit Composition

Holcomb and similar soils: 85 percent

Minor components: 6 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Holcomb

Setting

Landform: Terraces
Landform position (three-dimensional): Tread
Down-slope shape: Convex, linear
Across-slope shape: Convex, linear
Parent material: Silty and clayey alluvium derived from mixed sources

Typical profile

H1 - 0 to 7 inches: silt loam
H2 - 7 to 27 inches: silty clay loam
H3 - 27 to 47 inches: clay
H4 - 47 to 60 inches: silty clay loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: 15 to 30 inches to abrupt textural change
Natural drainage class: Somewhat poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: About 12 to 18 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 5.2 inches)

Interpretive groups

Land capability classification (irrigated): 3w
Land capability classification (nonirrigated): 3w
Hydrologic Soil Group: D
Other vegetative classification: Poorly Drained (G002XY006OR)

Minor Components

Concord

Percent of map unit: 3 percent
Landform: Terraces
Landform position (three-dimensional): Tread
Down-slope shape: Concave, linear
Across-slope shape: Concave, linear
Other vegetative classification: Poorly Drained (G002XY006OR)

Dayton

Percent of map unit: 3 percent
Landform: Terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear, concave
Across-slope shape: Linear, concave
Other vegetative classification: Poorly Drained (G002XY006OR)

Soil Information for All Uses

Suitabilities and Limitations for Use

The Suitabilities and Limitations for Use section includes various soil interpretations displayed as thematic maps with a summary table for the soil map units in the selected area of interest. A single value or rating for each map unit is generated by aggregating the interpretive ratings of individual map unit components. This aggregation process is defined for each interpretation.

Vegetative Productivity

Vegetative productivity includes estimates of potential vegetative production for a variety of land uses, including cropland, forestland, hayland, pastureland, horticulture and rangeland. In the underlying database, some states maintain crop yield data by individual map unit component. Other states maintain the data at the map unit level. Attributes are included for both, although only one or the other is likely to contain data for any given geographic area. For other land uses, productivity data is shown only at the map unit component level. Examples include potential crop yields under irrigated and nonirrigated conditions, forest productivity, forest site index, and total rangeland production under of normal, favorable and unfavorable conditions.

Yields of Non-Irrigated Crops (Component): Grass-legume hay (Tons)

These are the estimated average yields per acre that can be expected of selected nonirrigated crops under a high level of management. In any given year, yields may be higher or lower than those indicated because of variations in rainfall and other climatic factors.

In the database, some states maintain crop yield data by individual map unit component and others maintain the data at the map unit level. Attributes are included in this application for both, although only one or the other is likely to contain data for any given geographic area. This attribute uses data maintained at the map unit component level.

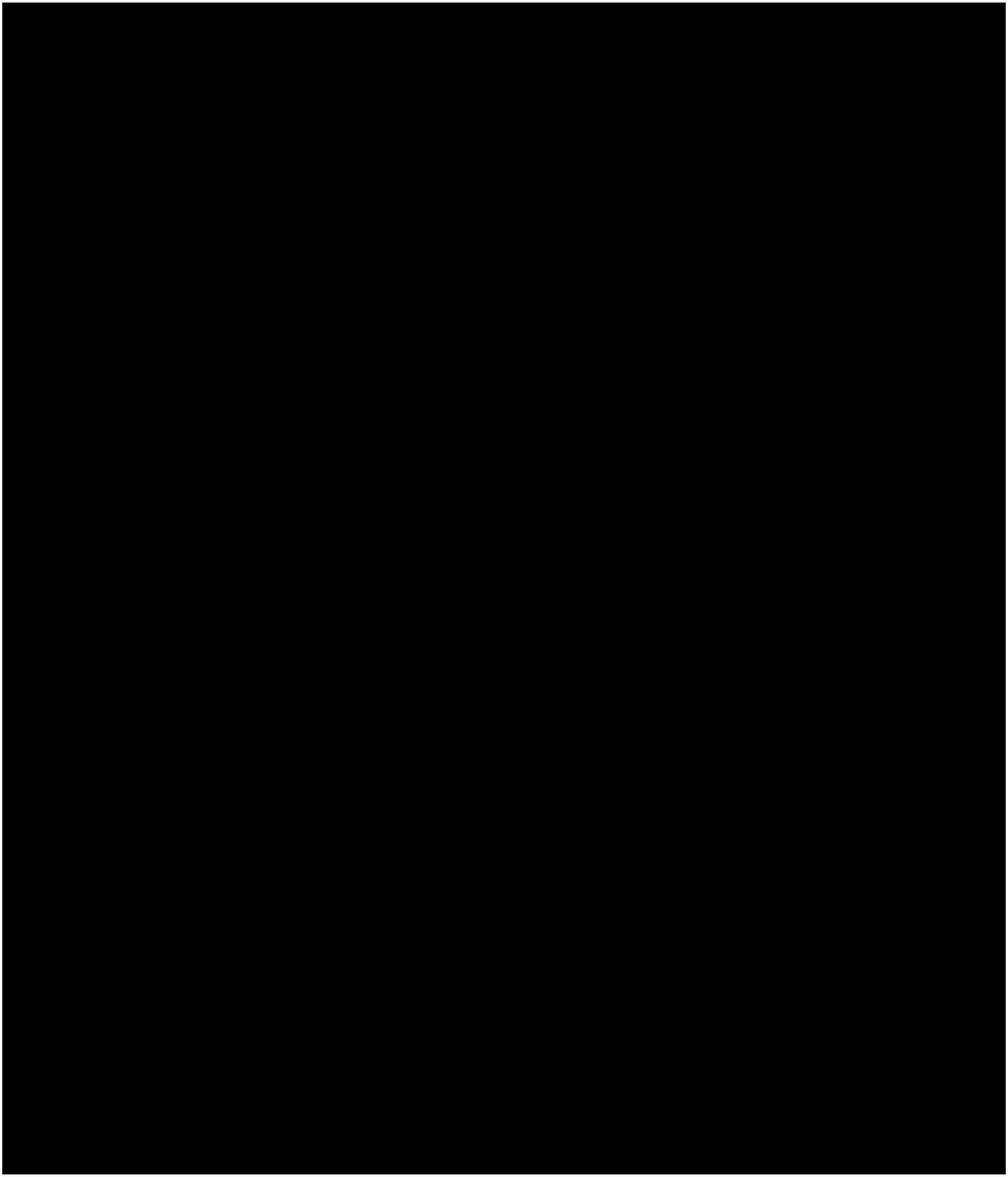
The yields are actually recorded as three separate values in the database. A low value and a high value indicate the range for the soil component. A "representative" value indicates the expected value for the component. For these yields, only the representative value is used.

The yields are based mainly on the experience and records of farmers, conservationists, and extension agents. Available yield data from nearby areas and results of field trials and demonstrations also are considered.

The management needed to obtain the indicated yields of the various crops depends on the kind of soil and the crop. Management can include drainage, erosion control, and protection from flooding; the proper planting and seeding rates; suitable high-yielding crop varieties; appropriate and timely tillage; control of weeds, plant diseases, and harmful insects; favorable soil reaction and optimum levels of nitrogen, phosphorus, potassium, and trace elements for each crop; effective use of crop residue, barnyard manure, and green manure crops; and harvesting that ensures the smallest possible loss.

The estimated yields reflect the productive capacity of each soil for the selected crop. Yields are likely to increase as new production technology is developed. The productivity of a given soil compared with that of other soils, however, is not likely to change.

Map—Yields of Non-Irrigated Crops (Component): Grass-legume hay (Tons)



MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

Soil Rating Polygons

- <= 0.10
- > 0.10 and <= 2.90
- Not rated or not available

Soil Rating Lines

- <= 0.10
- > 0.10 and <= 2.90
- Not rated or not available

Soil Rating Points

- <= 0.10
- > 0.10 and <= 2.90
- Not rated or not available

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Linn County Area, Oregon
Survey Area Data: Version 10, Sep 18, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jul 5, 2011—Jul 6, 2011

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Table—Yields of Non-Irrigated Crops (Component): Grass-legume hay (Tons)

Yields of Non-Irrigated Crops (Component): Grass-legume hay (Tons)— Summary by Map Unit — Linn County Area, Oregon (OR639)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
24	Clackamas variant silt loam		36.1	52.6%
29	Courtney gravelly silty clay loam		8.1	11.7%
33	Dayton silt loam	2.90	13.8	20.1%
46	Holcomb silt loam	0.10	10.7	15.6%
Totals for Area of Interest			**68.6**	**100.0%**

Rating Options—Yields of Non-Irrigated Crops (Component): Grass-legume hay (Tons)

Crop: Grass-legume hay

Yield Units: Tons

Aggregation Method: Weighted Average

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Interpret Nulls as Zero: Yes

Soil Reports

The Soil Reports section includes various formatted tabular and narrative reports (tables) containing data for each selected soil map unit and each component of each unit. No aggregation of data has occurred as is done in reports in the Soil Properties and Qualities and Suitabilities and Limitations sections.

The reports contain soil interpretive information as well as basic soil properties and qualities. A description of each report (table) is included.

Soil Physical Properties

This folder contains a collection of tabular reports that present soil physical properties. The reports (tables) include all selected map units and components for each map unit. Soil physical properties are measured or inferred from direct observations in the field or laboratory. Examples of soil physical properties include percent clay, organic matter, saturated hydraulic conductivity, available water capacity, and bulk density.

Engineering Properties

This table gives the engineering classifications and the range of engineering properties for the layers of each soil in the survey area.

Hydrologic soil group is a group of soils having similar runoff potential under similar storm and cover conditions. The criteria for determining Hydrologic soil group is found in the National Engineering Handbook, Chapter 7 issued May 2007(http://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=17757.wba). Listing HSGs by soil map unit component and not by soil series is a new concept for the engineers. Past engineering references contained lists of HSGs by soil series. Soil series are continually being defined and redefined, and the list of soil series names changes so frequently as to make the task of maintaining a single national list virtually impossible. Therefore, the criteria is now used to calculate the HSG using the component soil properties and no such national series lists will be maintained. All such references are obsolete and their use should be discontinued. Soil properties that influence runoff potential are those that influence the minimum rate of infiltration for a bare soil after prolonged wetting and when not frozen. These properties are depth to a seasonal high water table, saturated hydraulic conductivity after prolonged wetting, and depth to a layer with a very slow water transmission rate. Changes in soil properties caused by land management or climate changes also cause the hydrologic soil group to change. The influence of ground cover is treated independently. There are four hydrologic soil groups, A, B, C, and D, and three dual groups, A/D, B/D, and C/D. In the dual groups, the first letter is for drained areas and the second letter is for undrained areas.

The four hydrologic soil groups are described in the following paragraphs:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

Depth to the upper and lower boundaries of each layer is indicated.

Texture is given in the standard terms used by the U.S. Department of Agriculture. These terms are defined according to percentages of sand, silt, and clay in the fraction of the soil that is less than 2 millimeters in diameter. "Loam," for example, is soil that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the content of particles coarser than sand is 15 percent or more, an appropriate modifier is added, for example, "gravelly."

Classification of the soils is determined according to the Unified soil classification system (ASTM, 2005) and the system adopted by the American Association of State Highway and Transportation Officials (AASHTO, 2004).

The Unified system classifies soils according to properties that affect their use as construction material. Soils are classified according to particle-size distribution of the fraction less than 3 inches in diameter and according to plasticity index, liquid limit, and organic matter content. Sandy and gravelly soils are identified as GW, GP, GM, GC, SW, SP, SM, and SC; silty and clayey soils as ML, CL, OL, MH, CH, and OH; and highly organic soils as PT. Soils exhibiting engineering properties of two groups can have a dual classification, for example, CL-ML.

The AASHTO system classifies soils according to those properties that affect roadway construction and maintenance. In this system, the fraction of a mineral soil that is less than 3 inches in diameter is classified in one of seven groups from A-1 through A-7 on the basis of particle-size distribution, liquid limit, and plasticity index. Soils in group A-1 are coarse grained and low in content of fines (silt and clay). At the other extreme, soils in group A-7 are fine grained. Highly organic soils are classified in group A-8 on the basis of visual inspection.

If laboratory data are available, the A-1, A-2, and A-7 groups are further classified as A-1-a, A-1-b, A-2-4, A-2-5, A-2-6, A-2-7, A-7-5, or A-7-6. As an additional refinement, the suitability of a soil as subgrade material can be indicated by a group index number. Group index numbers range from 0 for the best subgrade material to 20 or higher for the poorest.

Rock fragments larger than 10 inches in diameter and 3 to 10 inches in diameter are indicated as a percentage of the total soil on a dry-weight basis. The percentages are estimates determined mainly by converting volume percentage in the field to weight percentage.

Percentage (of soil particles) passing designated sieves is the percentage of the soil fraction less than 3 inches in diameter based on an ovendry weight. The sieves, numbers 4, 10, 40, and 200 (USA Standard Series), have openings of 4.76, 2.00, 0.420, and 0.074 millimeters, respectively. Estimates are based on laboratory tests of soils sampled in the survey area and in nearby areas and on estimates made in the field.

Liquid limit and *plasticity index* (Atterberg limits) indicate the plasticity characteristics of a soil. The estimates are based on test data from the survey area or from nearby areas and on field examination.

References:

American Association of State Highway and Transportation Officials (AASHTO). 2004. Standard specifications for transportation materials and methods of sampling and testing. 24th edition.

American Society for Testing and Materials (ASTM). 2005. Standard classification of soils for engineering purposes. ASTM Standard D2487-00.

Absence of an entry indicates that the data were not estimated. The asterisk '*' denotes the representative texture; other possible textures follow the dash. The criteria for determining the hydrologic soil group for individual soil components is found in the National Engineering Handbook, Chapter 7 issued May 2007(http://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=17757.wba).

Engineering Properties–Linn County Area, Oregon														
Map unit symbol and soil name	**Pct. of map unit**	**Hydrologic group**	**Depth**	**USDA texture**	**Classification**		**Fragments**		**Percentage passing sieve number—**				**Liquid limit**	**Plasticity index**
					Unified	**AASHTO**	**>10 inches**	**3-10 inches**	**4**	**10**	**40**	**200**		
			In				*Pct*	*Pct*					*Pct*	
24—Clackamas variant silt loam														
Clackamas variant	85	C	0-13	Silt loam	ML	A-4	0- 0- 0	0- 0- 0	80-90-100	75-88-100	70-85-100	65-78-90	25-30-35	NP-3 -5
			13-27	Silty clay loam, gravelly silty clay loam	CL	A-6	0- 0- 0	0- 3- 5	75-88-100	70-85-100	65-83-100	60-75-90	35-38-40	15-18-20
			27-60	Very gravelly clay	GC	A-2, A-7	0- 0- 0	5- 8- 10	35-43-50	30-38-45	25-35-45	25-35-45	45-50-55	20-25-30
Courtney	2	D	0-17	Gravelly silty clay loam	CL, ML	A-6	0- 0- 0	0- 5- 10	65-73-80	60-68-75	55-63-70	50-55-60	35-38-40	10-13-15
			17-33	Gravelly clay, gravelly silty clay	CH	A-7	0- 0- 0	0- 3- 5	60-70-80	55-65-75	50-60-70	50-58-65	60-70-80	35-43-50
			33-48	Very gravelly clay loam, extremely gravelly clay loam	GC, GM	A-2	0- 0- 0	5- 8- 10	20-30-40	15-25-35	15-25-35	10-18-25	35-38-40	10-13-15
			48-60	Very gravelly sand, extremely gravelly sand	GP, GW	A-1	0- 0- 0	5-10- 15	20-30-40	15-25-35	10-20-30	0- 3- 5	0-7 -14	NP

Engineering Properties–Linn County Area, Oregon															
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			In				*Pct*	*Pct*					*Pct*	
29—Courtney gravelly silty clay loam														
Courtney	85	D	0-17	Gravelly silty clay loam	CL, ML	A-6	0- 0- 0	0- 5- 10	65-73-80	60-68-75	55-63-70	50-55-60	35-38-40	10-13-15
			17-33	Gravelly clay, gravelly silty clay	CH	A-7	0- 0- 0	0- 3- 5	60-70-80	55-65-75	50-60-70	50-58-65	60-70-80	35-43-50
			33-48	Very gravelly clay loam, extremely gravelly clay loam	GC, GM	A-2	0- 0- 0	5- 8- 10	20-30-40	15-25-35	15-25-35	10-18-25	35-38-40	10-13-15
			48-60	Very gravelly sand, extremely gravelly sand	GP, GW	A-1	0- 0- 0	5-10- 15	20-30-40	15-25-35	10-20-30	0- 3- 5	0-7 -14	NP
Conser	3	C/D	0-17	Silty clay loam	CL	A-6	0- 0- 0	0- 0- 0	100-100-100	95-98-100	95-98-100	85-90-95	35-38-40	15-18-20
			17-64	Clay, silty clay, silty clay loam	CH, CL	A-7	0- 0- 0	0- 0- 0	100-100-100	95-98-100	95-98-100	90-93-95	45-50-55	20-25-30
33—Dayton silt loam														
Dayton	85	D	0-9	Silt loam	ML	A-4	0- 0- 0	0- 0- 0	100-100-100	95-98-100	90-95-100	85-93-100	30-33-35	5-8 -10
			9-15	Silt loam, silty clay loam	ML	A-4, A-6	0- 0- 0	0- 0- 0	100-100-100	95-98-100	90-95-100	90-95-100	30-35-40	5-10-15
			15-40	Silty clay, clay	CH	A-7	0- 0- 0	0- 0- 0	100-100-100	95-98-100	90-95-100	90-95-100	55-63-70	35-40-45
			40-76	Silt loam, silty clay loam	ML	A-4, A-6	0- 0- 0	0- 0- 0	100-100-100	95-98-100	90-95-100	85-90-95	30-35-40	5-10-15

Engineering Properties–Linn County Area, Oregon

Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Fragments		Percentage passing sieve number—				Liquid limit	Plasticity index
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200		
			In				*Pct*	*Pct*					*Pct*	
46—Holcomb silt loam														
Holcomb	85	D	0-7	Silt loam	ML	A-4	0- 0- 0	0- 0- 0	100-100-100	95-98-100	90-93-95	90-93-95	30-33-35	5-8 -10
			7-27	Silty clay loam, silt loam	CL, ML	A-4, A-6	0- 0- 0	0- 0- 0	100-100-100	100-100-100	95-98-100	90-93-95	30-35-40	5-10-15
			27-47	Clay, silty clay	CH	A-7	0- 0- 0	0- 0- 0	80-90-100	75-88-100	70-85-100	65-83-100	60-70-80	40-45-50
			47-60	Silt loam, silty clay loam, clay loam	ML	A-7, A-4, A-6	0- 0- 0	0- 0- 0	85-93-100	80-90-100	75-85-95	70-83-95	30-40-50	5-13-20

Physical Soil Properties

This table shows estimates of some physical characteristics and features that affect soil behavior. These estimates are given for the layers of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

Depth to the upper and lower boundaries of each layer is indicated.

Particle size is the effective diameter of a soil particle as measured by sedimentation, sieving, or micrometric methods. Particle sizes are expressed as classes with specific effective diameter class limits. The broad classes are sand, silt, and clay, ranging from the larger to the smaller.

Sand as a soil separate consists of mineral soil particles that are 0.05 millimeter to 2 millimeters in diameter. In this table, the estimated sand content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Silt as a soil separate consists of mineral soil particles that are 0.002 to 0.05 millimeter in diameter. In this table, the estimated silt content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

Clay as a soil separate consists of mineral soil particles that are less than 0.002 millimeter in diameter. In this table, the estimated clay content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The content of sand, silt, and clay affects the physical behavior of a soil. Particle size is important for engineering and agronomic interpretations, for determination of soil hydrologic qualities, and for soil classification.

The amount and kind of clay affect the fertility and physical condition of the soil and the ability of the soil to adsorb cations and to retain moisture. They influence shrink-swell potential, saturated hydraulic conductivity (Ksat), plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and earthmoving operations.

Moist bulk density is the weight of soil (ovendry) per unit volume. Volume is measured when the soil is at field moisture capacity, that is, the moisture content at 1/3- or 1/10-bar (33kPa or 10kPa) moisture tension. Weight is determined after the soil is dried at 105 degrees C. In the table, the estimated moist bulk density of each soil horizon is expressed in grams per cubic centimeter of soil material that is less than 2 millimeters in diameter. Bulk density data are used to compute linear extensibility, shrink-swell potential, available water capacity, total pore space, and other soil properties. The moist bulk density of a soil indicates the pore space available for water and roots. Depending on soil texture, a bulk density of more than 1.4 can restrict water storage and root penetration. Moist bulk density is influenced by texture, kind of clay, content of organic matter, and soil structure.

Saturated hydraulic conductivity (Ksat) refers to the ease with which pores in a saturated soil transmit water. The estimates in the table are expressed in terms of micrometers per second. They are based on soil characteristics observed in the field, particularly structure, porosity, and texture. Saturated hydraulic conductivity (Ksat) is considered in the design of soil drainage systems and septic tank absorption fields.

Available water capacity refers to the quantity of water that the soil is capable of storing for use by plants. The capacity for water storage is given in inches of water per inch of soil for each soil layer. The capacity varies, depending on soil properties that affect retention of water. The most important properties are the content of organic matter, soil texture, bulk density, and soil structure. Available water capacity is an important factor in the choice of plants or crops to be grown and in the design and management of irrigation systems. Available water capacity is not an estimate of the quantity of water actually available to plants at any given time.

Linear extensibility refers to the change in length of an unconfined clod as moisture content is decreased from a moist to a dry state. It is an expression of the volume change between the water content of the clod at 1/3- or 1/10-bar tension (33kPa or 10kPa tension) and oven dryness. The volume change is reported in the table as percent change for the whole soil. The amount and type of clay minerals in the soil influence volume change.

Linear extensibility is used to determine the shrink-swell potential of soils. The shrink-swell potential is low if the soil has a linear extensibility of less than 3 percent; moderate if 3 to 6 percent; high if 6 to 9 percent; and very high if more than 9 percent. If the linear extensibility is more than 3, shrinking and swelling can cause damage to buildings, roads, and other structures and to plant roots. Special design commonly is needed.

Organic matter is the plant and animal residue in the soil at various stages of decomposition. In this table, the estimated content of organic matter is expressed as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter. The content of organic matter in a soil can be maintained by returning crop residue to the soil.

Organic matter has a positive effect on available water capacity, water infiltration, soil organism activity, and tilth. It is a source of nitrogen and other nutrients for crops and soil organisms.

Erosion factors are shown in the table as the K factor (Kw and Kf) and the T factor. Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation (RUSLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter and on soil structure and Ksat. Values of K range from 0.02 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water.

Erosion factor Kw indicates the erodibility of the whole soil. The estimates are modified by the presence of rock fragments.

Erosion factor Kf indicates the erodibility of the fine-earth fraction, or the material less than 2 millimeters in size.

Erosion factor T is an estimate of the maximum average annual rate of soil erosion by wind and/or water that can occur without affecting crop productivity over a sustained period. The rate is in tons per acre per year.

Wind erodibility groups are made up of soils that have similar properties affecting their susceptibility to wind erosion in cultivated areas. The soils assigned to group 1 are the most susceptible to wind erosion, and those assigned to group 8 are the least susceptible. The groups are described in the "National Soil Survey Handbook."

Wind erodibility index is a numerical value indicating the susceptibility of soil to wind erosion, or the tons per acre per year that can be expected to be lost to wind erosion.

There is a close correlation between wind erosion and the texture of the surface layer, the size and durability of surface clods, rock fragments, organic matter, and a calcareous reaction. Soil moisture and frozen soil layers also influence wind erosion.

Reference:

United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. (http://soils.usda.gov)

Physical Soil Properties–Linn County Area, Oregon														
Map symbol and soil name	**Depth**	**Sand**	**Silt**	**Clay**	**Moist bulk density**	**Saturated hydraulic conductivity**	**Available water capacity**	**Linear extensibility**	**Organic matter**	**Erosion factors**			**Wind erodibility group**	**Wind erodibility index**
										Kw	**Kf**	**T**		
	In	*Pct*	*Pct*	*Pct*	*g/cc*	*micro m/sec*	*In/In*	*Pct*	*Pct*					
24—Clackamas variant silt loam														
Clackamas variant	0-13	-26-	-52-	18-22- 25	1.20-1.30-1.40	4.00-9.00-14.00	0.16-0.19-0.21	0.0- 1.5- 2.9	3.0- 4.0-5.0	.24	.24	4	6	48
	13-27	-20-	-49-	27-31- 35	1.30-1.35-1.40	1.40-3.00-4.00	0.14-0.18-0.21	3.0- 4.5- 5.9	0.5- 1.8-3.0	.24	.43			
	27-60	-23-	-29-	40-48- 55	1.30-1.35-1.40	0.42-0.91-1.40	0.04-0.08-0.11	6.0- 7.5- 8.9	0.0- 0.3-0.5	.10	.24			
Courtney	0-17	-20-	-49-	27-31- 35	1.30-1.35-1.40	1.40-3.00-4.00	0.16-0.18-0.19	3.0- 4.5- 5.9	2.0- 3.5-5.0	.20	.37	3	7	38
	17-33	-17-	-28-	50-55- 60	1.30-1.35-1.40	0.01-0.20-0.42	0.11-0.13-0.14	6.0- 7.5- 8.9	0.5- 1.3-2.0	.10	.24			
	33-48	-35-	-34-	27-31- 35	1.30-1.35-1.40	1.40-3.00-4.00	0.07-0.10-0.13	3.0- 4.5- 5.9	0.2- 0.6-1.0	.10	.32			
	48-60	-96-	- 2-	0- 3- 5	1.30-1.35-1.40	42.00-92.00-141.00	0.03-0.04-0.05	0.0- 1.5- 2.9	0.2- 0.3-0.5	.02	.05			

Physical Soil Properties–Linn County Area, Oregon														
Map symbol and soil name	Depth	Sand	Silt	Clay	Moist bulk density	Saturated hydraulic conductivity	Available water capacity	Linear extensibility	Organic matter	Erosion factors			Wind erodibility group	Wind erodibility index
										Kw	Kf	T		
	In	*Pct*	*Pct*	*Pct*	*g/cc*	*micro m/sec*	*In/In*	*Pct*	*Pct*					
29—Courtney gravelly silty clay loam														
Courtney	0-17	-20-	-49-	27-31- 35	1.30-1.35-1.40	1.40-3.00-4.00	0.16-0.18-0.19	3.0- 4.5- 5.9	2.0- 3.5-5.0	.20	.37	3	7	38
	17-33	-17-	-28-	50-55- 60	1.30-1.35-1.40	0.01-0.20-0.42	0.11-0.13-0.14	6.0- 7.5- 8.9	0.5- 1.3-2.0	.10	.24			
	33-48	-35-	-34-	27-31- 35	1.30-1.35-1.40	1.40-3.00-4.00	0.07-0.10-0.13	3.0- 4.5- 5.9	0.2- 0.6-1.0	.10	.32			
	48-60	-96-	- 2-	0- 3- 5	1.30-1.35-1.40	42.00-92.00-141.00	0.03-0.04-0.05	0.0- 1.5- 2.9	0.2- 0.3-0.5	.02	.05			
Conser	0-17	-20-	-49-	27-31- 35	1.20-1.30-1.40	4.00-9.00-14.00	0.19-0.20-0.21	3.0- 4.5- 5.9	4.0- 6.0-8.0	.32	.32	5	6	48
	17-64	- 6-	-47-	35-48- 60	1.20-1.30-1.40	0.42-0.91-1.40	0.14-0.15-0.16	6.0- 7.5- 8.9	0.5- 2.3-4.0	.28	.28			
33—Dayton silt loam														
Dayton	0-9	-29-	-53-	15-18- 20	1.30-1.35-1.40	4.00-9.00-14.00	0.18-0.22-0.25	0.0- 1.5- 2.9	1.0- 2.5-4.0	.43	.43	3	5	56
	9-15	-25-	-53-	15-23- 30	1.25-1.33-1.40	4.00-9.00-14.00	0.18-0.21-0.24	0.0- 1.5- 2.9	0.5- 0.8-1.0	.49	.49			
	15-40	- 7-	-48-	40-45- 50	1.25-1.33-1.40	0.01-0.20-0.42	0.03-0.04-0.05	6.0- 7.5- 8.9	0.5- 0.8-1.0	.32	.32			
	40-76	-25-	-53-	15-23- 30	1.30-1.35-1.40	1.40-8.00-14.00	0.15-0.18-0.20	0.0- 1.5- 2.9	0.0- 0.3-0.5	.43	.43			

Physical Soil Properties–Linn County Area, Oregon														
Map symbol and soil name	**Depth**	**Sand**	**Silt**	**Clay**	**Moist bulk density**	**Saturated hydraulic conductivity**	**Available water capacity**	**Linear extensibility**	**Organic matter**	**Erosion factors**			**Wind erodibility group**	**Wind erodibility index**
										Kw	**Kf**	**T**		
	In	*Pct*	*Pct*	*Pct*	*g/cc*	*micro m/sec*	*In/In*	*Pct*	*Pct*					
46—Holcomb silt loam														
Holcomb	0-7	-25-	-53-	20-23- 25	1.30-1.35-1.40	4.00-9.00-14.00	0.19-0.20-0.21	0.0- 1.5- 2.9	3.0- 4.0-5.0	.32	.32	4	6	48
	7-27	-20-	-53-	25-28- 30	1.30-1.35-1.40	4.00-9.00-14.00	0.18-0.19-0.20	3.0- 4.5- 5.9	1.0- 2.0-3.0	.37	.37			
	27-47	-26-	-29-	40-45- 50	1.30-1.35-1.40	0.01-0.20-0.42	0.03-0.04-0.05	6.0- 7.5- 8.9	0.5- 0.8-1.0	.28	.28			
	47-60	-20-	-48-	25-33- 40	1.30-1.35-1.40	0.42-0.91-1.40	0.05-0.10-0.15	3.0- 4.5- 5.9	0.0- 0.3-0.5	.43	.43			

Vegetative Productivity

This folder contains a collection of tabular reports that present vegetative productivity data. The reports (tables) include all selected map units and components for each map unit. Vegetative productivity includes estimates of potential vegetative production for a variety of land uses, including cropland, forestland, hayland, pastureland, horticulture and rangeland. In the underlying database, some states maintain crop yield data by individual map unit component. Other states maintain the data at the map unit level. Attributes are included for both, although only one or the other is likely to contain data for any given geographic area. For other land uses, productivity data is shown only at the map unit component level. Examples include potential crop yields under irrigated and nonirrigated conditions, forest productivity, forest site index, and total rangeland production under of normal, favorable and unfavorable conditions.

Nonirrigated Yields by Map Unit Component

The average yields per acre that can be expected of the principal crops under a high level of management are shown in this table. In any given year, yields may be higher or lower than those indicated in the table because of variations in rainfall and other climatic factors.

The yields are based mainly on the experience and records of farmers, conservationists, and extension agents. Available yield data from nearby counties and results of field trials and demonstrations also are considered.

The management needed to obtain the indicated yields of the various crops depends on the kind of soil and the crop. Management can include drainage, erosion control, and protection from flooding; the proper planting and seeding rates; suitable high-yielding crop varieties; appropriate and timely tillage; control of weeds, plant diseases, and harmful insects; favorable soil reaction and optimum levels of nitrogen, phosphorus, potassium, and trace elements for each crop; effective use of crop residue, barnyard manure, and green manure crops; and harvesting that ensures the smallest possible loss.

If yields of irrigated crops are given, it is assumed that the irrigation system is adapted to the soils and to the crops grown, that good-quality irrigation water is uniformly applied as needed, and that tillage is kept to a minimum.

Pasture yields are expressed in terms of animal unit months. An animal unit month (AUM) is the amount of forage required by one mature cow of approximately 1,000 pounds weight, with or without a calf, for 1 month.

The estimated yields reflect the productive capacity of each soil for each of the principal crops. Yields are likely to increase as new production technology is developed. The productivity of a given soil compared with that of other soils, however, is not likely to change.

Crops other than those shown in the table are grown in the survey area, but estimated yields are not listed because the acreage of such crops is small. The local office of the Natural Resources Conservation Service or of the Cooperative Extension Service can provide information about the management and productivity of the soils for those crops.

The land capability classification of map units in the survey area is shown in this table. This classification shows, in a general way, the suitability of soils for most kinds of field crops (United States Department of Agriculture, Soil Conservation Service, 1961). Crops that require special management are excluded. The soils are grouped according to their limitations for field crops, the risk of damage if they are used for crops, and the way they respond to management. The criteria used in grouping the soils do not include major and generally expensive landforming that would change slope, depth, or other characteristics of the soils, nor do they include possible but unlikely major reclamation projects. Capability classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for rangeland, for forestland, or for engineering purposes.

In the capability system, soils are generally grouped at three levels: capability class, subclass, and unit.

Capability classes, the broadest groups, are designated by the numbers 1 through 8. The numbers indicate progressively greater limitations and narrower choices for practical use. The classes are defined as follows:

- Class 1 soils have slight limitations that restrict their use.
- Class 2 soils have moderate limitations that restrict the choice of plants or that require moderate conservation practices.
- Class 3 soils have severe limitations that restrict the choice of plants or that require special conservation practices, or both.
- Class 4 soils have very severe limitations that restrict the choice of plants or that require very careful management, or both.
- Class 5 soils are subject to little or no erosion but have other limitations, impractical to remove, that restrict their use mainly to pasture, rangeland, forestland, or wildlife habitat.
- Class 6 soils have severe limitations that make them generally unsuitable for cultivation and that restrict their use mainly to pasture, rangeland, forestland, or wildlife habitat.
- Class 7 soils have very severe limitations that make them unsuitable for cultivation and that restrict their use mainly to grazing, forestland, or wildlife habitat.
- Class 8 soils and miscellaneous areas have limitations that preclude commercial plant production and that restrict their use to recreational purposes, wildlife habitat, watershed, or esthetic purposes.

Capability subclasses are soil groups within one class. They are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, 2e. The letter *e* shows that the main hazard is the risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the United States, shows that the chief limitation is climate that is very cold or very dry.

In class 1 there are no subclasses because the soils of this class have few limitations. Class 5 contains only the subclasses indicated by *w*, *s*, or *c* because the soils in class 5 are subject to little or no erosion.

Capability units are soil groups within a subclass. The soils in a capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, 2e-4 and 3e-6. These units are not given in all soil surveys.

Reference:
United States Department of Agriculture, Soil Conservation Service. 1961. Land capability classification. U.S. Department of Agriculture Handbook 210.

Report—Nonirrigated Yields by Map Unit Component

Nonirrigated Yields by Map Unit Component–Linn County Area, Oregon				
Map symbol and soil name	**Land capability**	**Grass hay**	**Grass-legume hay**	**Pasture**
			Tons	*AUM*
24—Clackamas variant silt loam				
Clackamas variant	2w	—	—	8.0
Courtney	4w	—	—	8.0
29—Courtney gravelly silty clay loam				
Courtney	4w	—	—	8.0
Conser	3w	—	—	10.0
33—Dayton silt loam				
Dayton	4w	—	3.00	8.0
46—Holcomb silt loam				
Holcomb	3w	—	—	10.0

Waste Management

This folder contains a collection of tabular reports that present soil interpretations related to waste management. The reports (tables) include all selected map units and components for each map unit, limiting features and interpretive ratings. Waste management interpretations are tools designed to guide the user in evaluating soils for use of organic wastes and wastewater as productive resources. Example interpretations include land application of manure, food processing waste, and municipal sewage sludge, and disposal of wastewater by irrigation or overland flow process.

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

Soil properties are important considerations in areas where soils are used as sites for the treatment and disposal of organic waste and wastewater. Selection of soils with properties that favor waste management can help to prevent environmental damage.

This table shows the degree and kind of soil limitations affecting the treatment of agricultural waste, including municipal and food-processing wastewater and effluent from lagoons or storage ponds. Municipal wastewater is the waste stream from a municipality. It contains domestic waste and may contain industrial waste. It may have received primary or secondary treatment. It is rarely untreated sewage. Food-processing wastewater results from the preparation of fruits, vegetables, milk, cheese, and meats for public consumption. In places it is high in content of sodium and chloride. In the context of this table, the effluent in lagoons and storage ponds is from facilities used to treat or store food-processing wastewater or domestic or animal waste. Domestic and food-processing wastewater is very dilute, and the effluent from the facilities that treat or store it commonly is very low in content of carbonaceous and nitrogenous material; the content of nitrogen commonly ranges from 10 to 30 milligrams per liter. The wastewater from animal waste treatment lagoons or storage ponds, however, has much higher concentrations of these materials, mainly because the manure has not been diluted as much as the domestic waste. The content of nitrogen in this wastewater generally ranges from 50 to 2,000 milligrams per liter. When wastewater is applied, checks should be made to ensure that nitrogen, heavy metals, and salts are not added in excessive amounts.

The ratings in the table are for waste management systems that not only dispose of and treat organic waste or wastewater but also are beneficial to crops. The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect agricultural waste management. *Not limited* indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. *Somewhat limited* indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. *Very limited* indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings in the tables indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

Application of manure and food-processing waste not only disposes of waste material but also can improve crop production by increasing the supply of nutrients in the soils where the material is applied. Manure is the excrement of livestock and poultry, and food-processing waste is damaged fruit and vegetables and the peelings, stems, leaves, pits, and soil particles removed in food preparation. The manure and food-processing waste are solid, slurry, or liquid. Their nitrogen content varies. A high content of nitrogen limits the application rate. Toxic or otherwise dangerous wastes, such as those mixed with the lye used in food processing, are not considered in the ratings.

The ratings are based on the soil properties that affect absorption, plant growth, microbial activity, erodibility, the rate at which the waste is applied, and the method by which the waste is applied. The properties that affect absorption include saturated hydraulic conductivity (Ksat), depth to a water table, ponding, the sodium adsorption ratio, depth to bedrock or a cemented pan, and available water capacity. The properties that affect plant growth and microbial activity include reaction, the sodium adsorption ratio, salinity, and bulk density. The wind erodibility group, the soil erosion factor K, and slope are considered in estimating the likelihood that wind erosion or water erosion will transport the waste material from the application site. Stones, cobbles, a water table, ponding, and flooding can hinder the application of waste. Permanently frozen soils are unsuitable for waste treatment.

Application of sewage sludge not only disposes of waste material but also can improve crop production by increasing the supply of nutrients in the soils where the material is applied. In the context of this table, sewage sludge is the residual product of the treatment of municipal sewage. The solid component consists mainly of cell mass, primarily bacteria cells that developed during secondary treatment and have incorporated soluble organics into their own bodies. The sludge has small amounts of sand, silt, and other solid debris. The content of nitrogen varies. Some sludge has constituents that are toxic to plants or hazardous to the food chain, such as heavy metals and exotic organic compounds, and should be analyzed chemically prior to use.

The content of water in the sludge ranges from about 98 percent to less than 40 percent. The sludge is considered liquid if it is more than about 90 percent water, slurry if it is about 50 to 90 percent water, and solid if it is less than about 50 percent water.

The ratings in the table are based on the soil properties that affect absorption, plant growth, microbial activity, erodibility, the rate at which the sludge is applied, and the method by which the sludge is applied. The properties that affect absorption, plant growth, and microbial activity include Ksat, depth to a water table, ponding, the sodium adsorption ratio, depth to bedrock or a cemented pan, available water capacity, reaction, salinity, and bulk density. The wind erodibility group, the soil erosion factor K, and slope are considered in estimating the likelihood that wind erosion or water erosion will transport the waste material from the application site. Stones, cobbles, a water table, ponding, and flooding can hinder the application of sludge. Permanently frozen soils are unsuitable for waste treatment.

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

[Onsite investigation may be needed to validate the interpretations in this table and to confirm the identity of the soil on a given site. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the potential limitation. The table shows only the top five limitations for any given soil. The soil may have additional limitations]

Agricultural Disposal of Manure, Food-Processing Waste, and Sewage Sludge–Linn County Area, Oregon					
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
24—Clackamas variant silt loam					
Clackamas variant	85	Very limited		Very limited	
		Slow water movement	1.00	Slow water movement	1.00
		Depth to saturated zone	0.86	Depth to saturated zone	0.86
		Too acid	0.11	Too acid	0.42
Courtney	2	Very limited		Very limited	
		Filtering capacity	1.00	Filtering capacity	1.00
		Slow water movement	1.00	Slow water movement	1.00
		Ponding	1.00	Ponding	1.00
		Depth to saturated zone	1.00	Depth to saturated zone	1.00
		Runoff	0.40	Too acid	0.67
29—Courtney gravelly silty clay loam					
Courtney	85	Very limited		Very limited	
		Filtering capacity	1.00	Filtering capacity	1.00
		Slow water movement	1.00	Slow water movement	1.00
		Ponding	1.00	Ponding	1.00
		Depth to saturated zone	1.00	Depth to saturated zone	1.00
		Strongly contrasting textural stratification	1.00	Strongly contrasting textural stratification	1.00
Conser	3	Very limited		Very limited	
		Slow water movement	1.00	Ponding	1.00
		Ponding	1.00	Depth to saturated zone	1.00
		Depth to saturated zone	1.00	Slow water movement	1.00
		Leaching	0.50	Flooding	0.40
		Too acid	0.03	Too acid	0.14
33—Dayton silt loam					
Dayton	85	Very limited		Very limited	
		Slow water movement	1.00	Slow water movement	1.00
		Ponding	1.00	Ponding	1.00
		Depth to saturated zone	1.00	Depth to saturated zone	1.00
		Strongly contrasting textural stratification	1.00	Strongly contrasting textural stratification	1.00
		Runoff	0.40	Too acid	0.67

Agricultural Disposal of Manure, Food-Processing Waste, and Sewage Sludge–Linn County Area, Oregon					
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
46—Holcomb silt loam					
Holcomb	85	Very limited		Very limited	
		Slow water movement	1.00	Slow water movement	1.00
		Depth to saturated zone	1.00	Depth to saturated zone	1.00
		Strongly contrasting textural stratification	0.71	Strongly contrasting textural stratification	0.71
		Runoff	0.40	Too acid	0.14
		Too acid	0.03		

Water Features

This folder contains tabular reports that present soil hydrology information. The reports (tables) include all selected map units and components for each map unit. Water Features include ponding frequency, flooding frequency, and depth to water table.

Water Features

This table gives estimates of various soil water features. The estimates are used in land use planning that involves engineering considerations.

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The four hydrologic soil groups are:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas.

Surface runoff refers to the loss of water from an area by flow over the land surface. Surface runoff classes are based on slope, climate, and vegetative cover. The concept indicates relative runoff for very specific conditions. It is assumed that the surface of the soil is bare and that the retention of surface water resulting from irregularities in the ground surface is minimal. The classes are negligible, very low, low, medium, high, and very high.

The *months* in the table indicate the portion of the year in which a water table, ponding, and/or flooding is most likely to be a concern.

Water table refers to a saturated zone in the soil. The water features table indicates, by month, depth to the top (*upper limit*) and base (*lower limit*) of the saturated zone in most years. Estimates of the upper and lower limits are based mainly on observations of the water table at selected sites and on evidence of a saturated zone, namely grayish colors or mottles (redoximorphic features) in the soil. A saturated zone that lasts for less than a month is not considered a water table.

Ponding is standing water in a closed depression. Unless a drainage system is installed, the water is removed only by percolation, transpiration, or evaporation. The table indicates *surface water depth* and the *duration* and *frequency* of ponding. Duration is expressed as *very brief* if less than 2 days, *brief* if 2 to 7 days, *long* if 7 to 30 days, and *very long* if more than 30 days. Frequency is expressed as none, rare, occasional, and frequent. *None* means that ponding is not probable; *rare* that it is unlikely but possible under unusual weather conditions (the chance of ponding is nearly 0 percent to 5 percent in any year); *occasional* that it occurs, on the average, once or less in 2 years (the chance of ponding is 5 to 50 percent in any year); and *frequent* that it occurs, on the average, more than once in 2 years (the chance of ponding is more than 50 percent in any year).

Flooding is the temporary inundation of an area caused by overflowing streams, by runoff from adjacent slopes, or by tides. Water standing for short periods after rainfall or snowmelt is not considered flooding, and water standing in swamps and marshes is considered ponding rather than flooding.

Duration and *frequency* are estimated. Duration is expressed as *extremely brief* if 0.1 hour to 4 hours, *very brief* if 4 hours to 2 days, *brief* if 2 to 7 days, *long* if 7 to 30 days, and *very long* if more than 30 days. Frequency is expressed as none, very rare, rare, occasional, frequent, and very frequent. *None* means that flooding is not probable; *very rare* that it is very unlikely but possible under extremely unusual weather conditions (the chance of flooding is less than 1 percent in any year); *rare* that it is unlikely but possible under unusual weather conditions (the chance of flooding is 1 to 5 percent in any year); *occasional* that it occurs infrequently under normal weather conditions (the chance of flooding is 5 to 50 percent in any year); *frequent* that it is likely to occur often under normal weather conditions (the chance of flooding is more than 50 percent in any year but is less than 50 percent in all months in any year); and *very frequent* that it is likely to occur very often under normal weather conditions (the chance of flooding is more than 50 percent in all months of any year).

The information is based on evidence in the soil profile, namely thin strata of gravel, sand, silt, or clay deposited by floodwater; irregular decrease in organic matter content with increasing depth; and little or no horizon development.

Also considered are local information about the extent and levels of flooding and the relation of each soil on the landscape to historic floods. Information on the extent of flooding based on soil data is less specific than that provided by detailed engineering surveys that delineate flood-prone areas at specific flood frequency levels.

Absence of an entry indicates that the data were not estimated. The dash indicates no documented presence.

Water Features–Linn County Area, Oregon										
Map unit symbol and soil name	Hydrologic group	Surface runoff	Month	Water table		Ponding			Flooding	
				Upper limit	Lower limit	Surface depth	Duration	Frequency	Duration	Frequency
				Ft	*Ft*	*Ft*				
24—Clackamas variant silt loam										
Clackamas variant	C	—	January	2.0-3.0	2.2-3.1	—	—	None	—	None
			February	2.0-3.0	2.2-3.1	—	—	None	—	None
			March	2.0-3.0	2.2-3.1	—	—	None	—	None
			April	2.0-3.0	2.2-3.1	—	—	None	—	None
			May	2.0-3.0	2.2-3.1	—	—	None	—	None
			June	—	—	—	—	None	—	None
			July	—	—	—	—	None	—	None
			August	—	—	—	—	None	—	None
			September	—	—	—	—	None	—	None
			October	—	—	—	—	None	—	None
			November	2.0-3.0	2.2-3.1	—	—	None	—	None

Water Features–Linn County Area, Oregon										
Map unit symbol and soil name	**Hydrologic group**	**Surface runoff**	**Month**	**Water table**		**Ponding**			**Flooding**	
				Upper limit	**Lower limit**	**Surface depth**	**Duration**	**Frequency**	**Duration**	**Frequency**
				Ft	*Ft*	*Ft*				
			December	2.0-3.0	2.2-3.1	—	—	None	—	None
Courtney	D	—	January	0.0-1.5	>6.0	0.0-0.5	Long (7 to 30 days)	Frequent	—	Rare
			February	0.0-1.5	>6.0	0.0-0.5	Long (7 to 30 days)	Frequent	—	Rare
			March	0.0-1.5	>6.0	0.0-0.5	Long (7 to 30 days)	Frequent	—	Rare
			April	0.0-1.5	>6.0	0.0-0.5	Long (7 to 30 days)	Frequent	—	Rare
			May	0.0-1.5	>6.0	0.0-0.5	Long (7 to 30 days)	Frequent	—	Rare
			June	—	—	—	—	None	—	None
			July	—	—	—	—	None	—	None
			August	—	—	—	—	None	—	None
			September	—	—	—	—	None	—	None
			October	—	—	—	—	None	—	None
			November	0.0-1.5	>6.0	0.0-0.5	Long (7 to 30 days)	Frequent	—	Rare
			December	0.0-1.5	>6.0	0.0-0.5	Long (7 to 30 days)	Frequent	—	Rare

Water Features–Linn County Area, Oregon										
Map unit symbol and soil name	Hydrologic group	Surface runoff	Month	Water table		Ponding			Flooding	
				Upper limit	Lower limit	Surface depth	Duration	Frequency	Duration	Frequency
				Ft	*Ft*	*Ft*				
29—Courtney gravelly silty clay loam										
Courtney	D	—	January	0.0-1.5	>6.0	0.0-0.5	Long (7 to 30 days)	Frequent	—	Rare
			February	0.0-1.5	>6.0	0.0-0.5	Long (7 to 30 days)	Frequent	—	Rare
			March	0.0-1.5	>6.0	0.0-0.5	Long (7 to 30 days)	Frequent	—	Rare
			April	0.0-1.5	>6.0	0.0-0.5	Long (7 to 30 days)	Frequent	—	Rare
			May	0.0-1.5	>6.0	0.0-0.5	Long (7 to 30 days)	Frequent	—	Rare
			June	—	—	—	—	None	—	None
			July	—	—	—	—	None	—	None
			August	—	—	—	—	None	—	None
			September	—	—	—	—	None	—	None
			October	—	—	—	—	None	—	None
			November	0.0-1.5	>6.0	0.0-0.5	Long (7 to 30 days)	Frequent	—	Rare

Water Features–Linn County Area, Oregon										
Map unit symbol and soil name	Hydrologic group	Surface runoff	Month	Water table		Ponding			Flooding	
				Upper limit	Lower limit	Surface depth	Duration	Frequency	Duration	Frequency
				Ft	*Ft*	*Ft*				
			December	0.0-1.5	>6.0	0.0-0.5	Long (7 to 30 days)	Frequent	—	Rare
Conser	C/D	—	January	0.0-1.5	>6.0	0.0-0.5	Long (7 to 30 days)	Frequent	—	Rare
			February	0.0-1.5	>6.0	0.0-0.5	Long (7 to 30 days)	Frequent	—	Rare
			March	0.0-1.5	>6.0	0.0-0.5	Long (7 to 30 days)	Frequent	—	Rare
			April	0.0-1.5	>6.0	0.0-0.5	Long (7 to 30 days)	Frequent	—	Rare
			May	0.0-1.5	>6.0	0.0-0.5	Long (7 to 30 days)	Frequent	—	Rare
			June	—	—	—	—	None	—	None
			July	—	—	—	—	None	—	None
			August	—	—	—	—	None	—	None
			September	—	—	—	—	None	—	None
			October	—	—	—	—	None	—	None
			November	0.0-1.5	>6.0	0.0-0.5	Long (7 to 30 days)	Frequent	—	Rare
			December	0.0-1.5	>6.0	0.0-0.5	Long (7 to 30 days)	Frequent	—	Rare

Water Features–Linn County Area, Oregon										
Map unit symbol and soil name	Hydrologic group	Surface runoff	Month	Water table		Ponding			Flooding	
				Upper limit	Lower limit	Surface depth	Duration	Frequency	Duration	Frequency
				Ft	*Ft*	*Ft*				
33—Dayton silt loam										
Dayton	D	—	January	0.0-1.5	>6.0	0.0-0.5	Long (7 to 30 days)	Frequent	—	None
			February	0.0-1.5	>6.0	0.0-0.5	Long (7 to 30 days)	Frequent	—	None
			March	0.0-1.5	>6.0	0.0-0.5	Long (7 to 30 days)	Frequent	—	None
			April	0.0-1.5	>6.0	0.0-0.5	Long (7 to 30 days)	Frequent	—	None
			May	0.0-1.5	>6.0	0.0-0.5	Long (7 to 30 days)	Frequent	—	None
			June	—	—	—	—	None	—	None
			July	—	—	—	—	None	—	None
			August	—	—	—	—	None	—	None
			September	—	—	—	—	None	—	None
			October	—	—	—	—	None	—	None
			November	0.0-1.5	>6.0	0.0-0.5	Long (7 to 30 days)	Frequent	—	None
			December	0.0-1.5	>6.0	0.0-0.5	Long (7 to 30 days)	Frequent	—	None

Water Features–Linn County Area, Oregon										
Map unit symbol and soil name	Hydrologic group	Surface runoff	Month	Water table		Ponding			Flooding	
				Upper limit	Lower limit	Surface depth	Duration	Frequency	Duration	Frequency
				Ft	*Ft*	*Ft*				
46—Holcomb silt loam										
Holcomb	D	—	January	1.0-1.5	>6.0	—	—	None	—	None
			February	1.0-1.5	>6.0	—	—	None	—	None
			March	1.0-1.5	>6.0	—	—	None	—	None
			April	1.0-1.5	>6.0	—	—	None	—	None
			May	1.0-1.5	>6.0	—	—	None	—	None
			June	—	—	—	—	None	—	None
			July	—	—	—	—	None	—	None
			August	—	—	—	—	None	—	None
			September	—	—	—	—	None	—	None
			October	—	—	—	—	None	—	None
			November	1.0-1.5	>6.0	—	—	None	—	None
			December	1.0-1.5	>6.0	—	—	None	—	None

Water Management

This folder contains a collection of tabular reports that present soil interpretations related to water management. The reports (tables) include all selected map units and components for each map unit, limiting features and interpretive ratings. Water management interpretations are tools for evaluating the potential of the soil in the application of various water management practices. Example interpretations include pond reservoir area, embankments, dikes, levees, and excavated ponds.

Irrigation - Surface

This table shows the degree and kind of soil limitations that affect irrigation systems on mineral soils. The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect these uses. *Not limited* indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. *Somewhat limited* indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. *Very limited* indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings in the table indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

Irrigation systems are used to provide supplemental water to crops, orchards, vineyards, and vegetables in area where natural precipitation will not support desired production of crops being grown.

Irrigation, surface (graded) evaluates a soil for graded flood or furrow irrigation systems. The ratings are for soils in their natural condition and do not consider present land use. .

Graded surface irrigation systems include graded border and graded furrow irrigation systems. Graded border irrigation systems allow irrigation water to flow across the soil surface while being confined by borders. Graded furrow irrigation systems are systems that allow irrigation water to flow down furrow valleys while the crop being irrigated is planted on the furrow ridge. Generally, graded border systems are suitable for small grains while graded furrow systems are suitable for row crops.

The soil properties and qualities important in the design and management of graded surface irrigation systems are depth, available water holding capacity, sodium adsorption ratio, surface rocks, permeability, salinity, slope, wetness, and flooding. Features that affect system performance and plant growth are salinity, sodium adsorption ratio, wetness, calcium carbonate content, and available water holding capacity. .

Irrigation, surface (level) evaluates a soil for basin, paddy, level furrow, or level border irrigation systems. The ratings are for soils in their natural condition and do not consider present land use.

Level surface irrigation systems are irrigation systems that use flood irrigation techniques to spread irrigation water at a specified depth across the application area. Basin, paddy, and borders generally use external ridges or borders to confine the irrigation application while level furrow systems use furrow valleys and end blocks or border ridges to confine the irrigation application during irrigation. With furrow irrigation the crop is usually planted on the furrow ridge. Generally, basin, paddy and level border irrigation systems are suitable for rice, small grain, pasture, and forage production. Level furrow systems are generally suited for row crops.

The soil properties and qualities important in the design and management of level surface irrigation systems are depth, available water holding capacity, sodium adsorption ratio, permeability, salinity, slope, and flooding. The soil properties and qualities that influence installation are depth, flooding, and ponding. The features that affect performance of the system and plant growth are salinity, sodium adsorption ratio, and available water holding capacity.

Information in this table is intended for land use planning, for evaluating land use alternatives, and for planning site investigations prior to design and construction. The information, however, has limitations. For example, estimates and other data generally apply only to that part of the soil between the surface and a depth of 5 to 7 feet. Because of the map scale, small areas of different soils may be included within the mapped areas of a specific soil.

The information is not site specific and does not eliminate the need for onsite investigation of the soils or for testing and analysis by personnel experienced in the design and construction of engineering works.

Government ordinances and regulations that restrict certain land uses or impose specific design criteria were not considered in preparing the information in this table. Local ordinances and regulations should be considered in planning, in site selection, and in design. The irrigation interpretations are not designed or intended to be used in a regulatory manner.

Report—Irrigation - Surface

[The information in this table provides irrigation interpretations for mineral soils. Onsite investigation may be needed to validate the interpretations and to confirm the identity of the soil on a given site. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the potential limitation. The table shows only the top five limitations for any given soil. The soil may have additional limitations]

Irrigation - Surface–Linn County Area, Oregon					
Map symbol and soil name	Pct. of map unit	Irrigation, Surface (graded)		Irrigation, Surface (level)	
		Rating class and limiting features	Value	Rating class and limiting features	Value
24—Clackamas variant silt loam					
Clackamas variant	85	Somewhat limited		Somewhat limited	
		Slope	0.50	Rapid water movement	0.03
		Rapid water movement	0.03		
Courtney	2	Very limited		Very limited	
		Seepage	1.00	Seepage	1.00
		Ponding	1.00	Ponding	1.00
		Slope	0.50		
29—Courtney gravelly silty clay loam					
Courtney	85	Very limited		Very limited	
		Seepage	1.00	Seepage	1.00
		Ponding	1.00	Ponding	1.00
		Slope	0.50		
Conser	3	Very limited		Very limited	
		Ponding	1.00	Ponding	1.00
33—Dayton silt loam					
Dayton	85	Very limited		Very limited	
		Ponding	1.00	Ponding	1.00
46—Holcomb silt loam					
Holcomb	85	Somewhat limited		Somewhat limited	
		Rapid water movement	0.69	Rapid water movement	0.69
		Slope	0.50		

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Monitoring Soil Nutrients Using a Management Unit Approach

M.L. Staben, J.W. Ellsworth, D.M. Sullivan, D. Horneck, B.D. Brown, and R.G. Stevens

What's in this publication?

This publication focuses on how to design a soil nutrient monitoring strategy that fits today's requirements for record keeping and increased accuracy in managing nitrogen (N), phosphorus (P), and other nutrients. We advocate the use of management units or zones for soil testing and nutrient application. To measure a real change in soil test values over time, you will need to use consistent management units over many growing seasons.

In this publication, a management unit is considered an area in a field that is soil-sampled and fertilized separately for one or more nutrients. Different management unit delineations may be more appropriate for insect, weed, and disease control; irrigation water management; and other cultural practices.

The management unit approach is designed to provide better information to make nutrient management decisions at a reasonable cost. This approach combines the ease of traditional whole-field sampling and the power of an intensive grid sampling method (see pages 2–3). With a management unit approach, a grower can vary the amount and type of nutrient applications within a field without the need for grid sampling.

A monitoring strategy will answer only the questions it was designed to answer. Each field will have a specific soil sampling strategy. Key questions to consider when developing a soil testing strategy for nutrient management are discussed in this publication, including time of sampling, depth of sampling, number of subsamples, and location for sampling in the management unit.

A soil sampling protocol designed to measure changes in soil nutrient status over time must minimize random variability in soil test results. This is especially important when soil sampling is part of a required nutrient management plan. This publication suggests strategies for minimizing random variability.

Two examples of nutrient monitoring are provided to illustrate the process of deciding when, where, and how to sample, as well as how to interpret the soil test results. One example uses reference sampling areas

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within management units, and the other uses random sampling throughout the management unit. These examples are intended to illustrate the process of using management units to make nutrient management decisions.

What are the advantages of the management unit approach?

The sidebars on this page and the following page describe two approaches to sampling: whole-field sampling and grid sampling. Each sampling strategy has limitations that can be overcome by adopting a management unit approach, as described in this publication.

The goal of using a management unit approach is to save money, and often time, compared to grid-based sampling methods, while obtaining more accurate data than that provided by whole-field sampling. The management unit approach is designed to provide many of the benefits of grid sampling while overcoming its high cost and other limitations. In many cases, this process allows growers to make fertilizer or amendment applications without the use of global positioning system (GPS) units and expensive variable-rate controllers.

Developing and using management units can allow a producer to apply amendments in varying amounts within a field. Higher levels of a particular nutrient can be applied in areas of the field that are likely to respond or have not reached a critical limit, while less or none can be applied in areas that have higher values and are less likely to respond. In most cases, this type of sampling plan satisfies many regulatory requirements while allowing the crop to be managed in a reasonable way.

Whole-field sampling

The whole-field soil sampling approach is a simple protocol used for many cropping systems. Soil cores are collected from the entire field, mixed together, and a single composite sample is sent to a laboratory for analysis.

The problem with whole-field sampling is that it treats the entire field the same regardless of differences in landscape position, soil characteristics, or cropping history. Thus, conclusions drawn from the soil test may not be appropriate for each part of the field. Often, average nutrient levels are found in only a small part of the field. The rest of the field is either higher or lower than the average. Basing fertilizer application on the field average means that some areas will be overfertilized and others will be underfertilized.

What criteria are used to divide a field into management units?

When deciding how to divide a field into management units, both soil features and the grower’s needs and priorities for managing each field should be considered. The goal is to divide fields into areas that are more uniform than the field as a whole.

The basis for consideration can include inherent variability (soil texture, topography, mineralogy, drainage, soil test values), variability associated with current management (tillage, irrigation water distribution), and historical variability (previous crop yields, manure application, field leveling, old fence lines) within a field. The minimum size of a management unit should be defined by equipment size, so that each management unit is large enough to be fertilized separately.

Grid sampling

The most accurate picture of the characteristics of a field would be produced by sampling every point within the field. Since it is impractical to do so, grid sampling can be used as an improvement over whole-field sampling. First, a field is systematically divided into areas of uniform size and shape (called cells) to form a grid. Cells often consist of 1 to 5 acres. Then, samples (consisting of a composite of 10 or more cores) are taken from each cell and analyzed. Thus, each cell has its own sample and analysis result.

The purpose of grid sampling is to create a detailed map of the field that allows the grower to identify areas that will receive a unique management practice. Using software that estimates soil test results between cells, patterns of estimated nutrient availability can be determined and a nutrient application map created.

The main challenge of grid sampling is its expense. A 125-acre field can have as many as 125 individual samples (if the field is divided into 1-acre cells). On a farm of several hundred acres, the cost of sampling (labor and equipment) and lab fees can become prohibitive. On the other hand, some labs give a substantial discount to growers who grid sample.

Grid sampling does not need to be done every year for most soil tests. The cost could be spread over a rotation by sampling intensively before one crop to create management units and then taking a few samples in subsequent years to verify the spatial patterns of soil nutrients.

Another limitation to grid sampling is that the grid spacing chosen may either obscure or exaggerate variability caused by a regular pattern such as wheel rows or movable sprinkler lines. However, modified versions of grid sampling patterns can overcome this potential weakness.

Dividing a field into management units is a combination of art and science. The management unit approach for soil sampling described in this publication enables growers to use their knowledge of the field to help define management units. Often, management units can be delineated on the basis of soil color or other landscape features that are easy to identify visually.

Certain field features, such as areas where soil was removed for field leveling, are not clearly delineated on most maps. However, you might be able to obtain cut-and-fill maps from the operator who did the leveling. Such maps can be quite useful in delineating nutrient management units.

Consider using other sources of information to delineate management units. Maps produced from remote sensing data (e.g., aerial photos or satellite imagery) and yield monitors are useful visual aids. Other tools include geographic information systems (GIS) software and GPS units.

Time and skill are required to manipulate the raw map data into a format that allows overlay of maps for the same field. After a multiple layer map is created, many factors can be considered simultaneously to delineate management units. These maps are also useful for recording soil sampling locations within the field.

Where should I collect soil samples from within a management unit?

Collect soil cores throughout each management unit (unit sampling) or from a smaller reference sampling area within a management unit (Figure 1). Select one of these approaches, and use it consistently.

In the center-pivot irrigated field shown in Figure 1, each of the three management units is delineated by one or more soil properties or management practices. For example, Management Unit 1 may be an eroded hilltop, Management Unit 2 may consist of side slopes with shallow topsoil, and Management Unit 3 may consist of bottomlands with poor drainage and high organic matter. The sampling plan for the field on the left (A) uses a zigzag pattern to collect subsamples, or cores, across the entire management unit. Soil cores collected within each management unit are composited into one sample for that management unit. In the field on the right (B), reference sampling areas are established away from the edges of the field but near access points such as the pivot road.

The sampling location for each core may or may not be recorded (georeferenced).

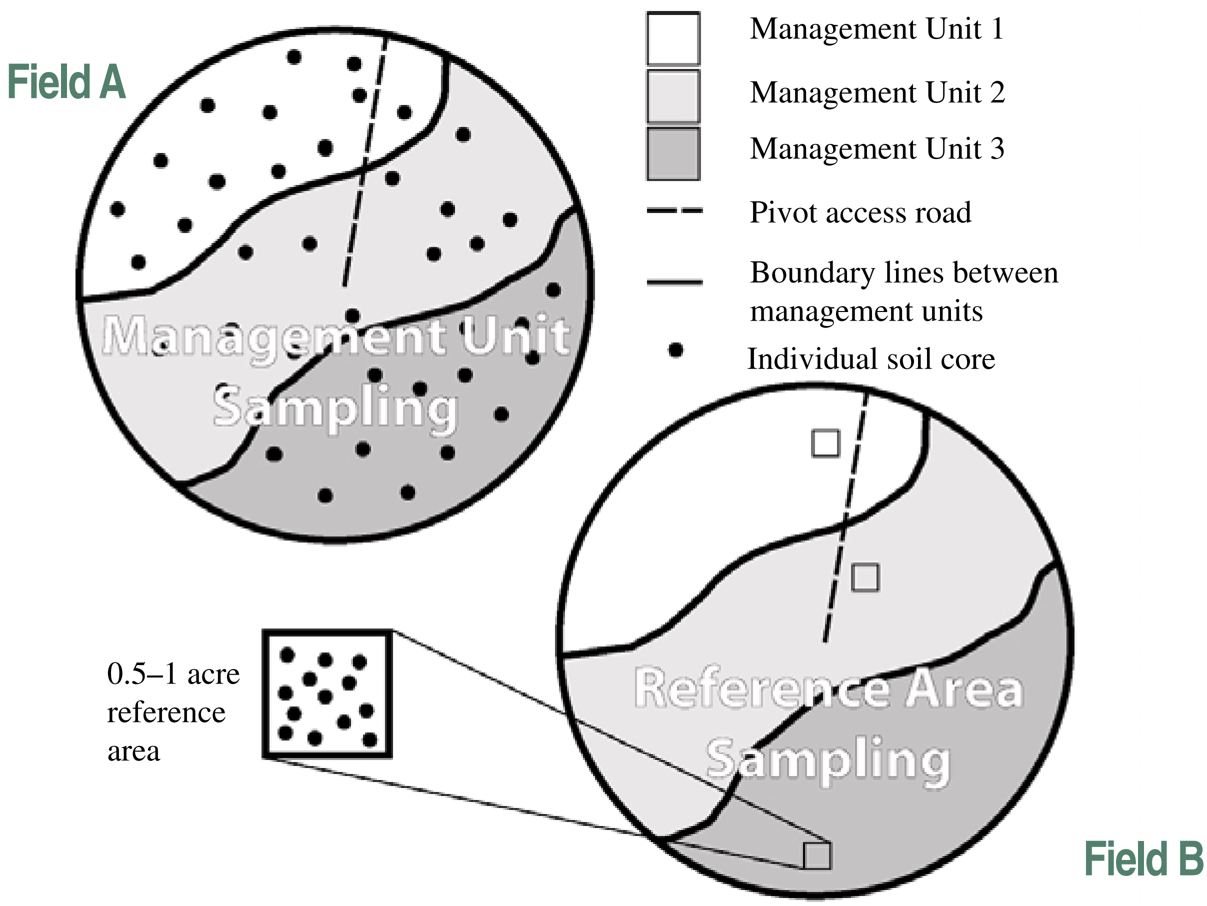

Figure 1.—Aerial view of two fields with a center-pivot overhead sprinkler irrigation system that have been divided into three management units. The top left field (A) illustrates a random sampling approach for sampling within each management unit. The lower right field (B) illustrates the reference sampling area approach for sampling within each management unit.

The benefit of georeferencing sampling locations is that in subsequent years you can return to the same areas with some degree of accuracy and minimize year-to-year variability. Georeferencing commonly is done with a GPS unit. Currently, the least expensive units can be accurate to ± 15 to 20 feet, under ideal conditions. Alternatively, it may be possible to install markers in the field that will withstand farming practices, allowing them to be found for future sampling.

For either the unit or reference sampling approach, avoid collecting samples from small, atypical areas such as animal feeding areas, gate and watering areas, corral and home sites, old roads, field edges, and eroded hilltops. It might be useful to analyze such samples separately for possible consideration as separate management units.

Management unit sampling approach

Take individual soil cores (10 or more) randomly over the entire management unit and mix them into a composite (Figure 1a).

Advantages of sampling randomly within management units include:

- One sample represents the entire management unit.
- Likely to provide better data than the reference sampling area approach when uniformity in soil or management practices (e.g., manure application) is uncertain.

Disadvantages of sampling randomly within management units include:

- Sample collection requires more time compared to sample collection by the reference sampling area approach (described at right).
- Heavy sampling equipment, if required, must be moved across the management unit.

Reference sampling area approach

Reference sampling areas are smaller sampling areas within a management unit. They can be used for representative soil sampling and other crop monitoring activities, such as plant tissue sampling, soil moisture measurement, or crop yield estimates. This method is most beneficial when heavy sampling equipment is used or when the management unit is very uniform.

The intensity of management and variability of the field should dictate how large an area can be represented by one reference sampling area. A local expert (university Extension personnel; private certified crop advisor, agronomist, or soil scientist; or Natural Resources Conservation Service personnel) can be consulted to assist you in determining what might be appropriate for your situation.

Reference sampling areas should be representative of the entire management unit and easy to access. To make sure a reference sampling area is representative, compare soil test values from proposed reference sampling area(s) with soil test values for a composite sample taken from the entire management unit (see "Management unit sampling approach").

Within each management unit, select an area of 0.5 to 1 acre for each reference sampling area (Figure 1b). Plan to georeference the four corners of the sampling area to minimize year-to-year variability. Ways to georeference reference sampling areas, besides using GPS, include using specific tree numbers in an orchard, measuring the distance from a fence or fixed equipment, or installing markers.

Advantages of reference sampling areas include the following.

- Fields can be sampled more quickly.
- It is easier to georeference sampling locations.

- You can use more than one reference sampling area within a management unit to allow for differences in known management variables (e.g., irrigation water distribution).
- There is more year-to-year consistency due to less spatial variability.

Disadvantages of reference sampling areas include the following.

- The reference sampling area may not represent the management unit as a whole.
- If georeference coordinates or field markers are lost, the exact location of the reference sampling area may be lost.
- Heavy traffic within the reference area may occur if care is not taken.
- The sampling area will be compromised if a nutrient or other amendment spill occurs within the reference sampling area.

The reference sampling area approach often is used for in-season testing for soil nitrate, because:

- More soil cores can be collected in a given amount of time.
- Fixed soil moisture monitoring sites (e.g., neutron probe) can be located within the same reference sampling area.
- Reduced sampling equipment traffic over the field reduces crop damage and soil compaction.

How to develop a plan for soil nutrient monitoring

Soil test data will answer only the questions the test was designed to answer. The following steps and questions can help you design a monitoring system tailored to your needs (Table 1). Two examples of how to develop a plan are included (see Examples 1 and 2, pages 10–13).

Table 1.—Considerations and questions for designing a soil nutrient monitoring plan.

Soil monitoring considerations	Specific questions
Objectives	• What is (are) your objective(s) for nutrient monitoring? • What nutrients or other soil chemical properties do you want to measure? • Are you required by any agreement to monitor specific nutrients or soil chemical properties?
Where to sample	• Should you collect samples throughout the management unit, or use a reference sampling area? • Do you plan to georeference locations where soil cores are collected? • What method will you use to georeference sampling locations?
How to sample	• When should samples be collected? • What soil sampling depth(s) are appropriate? • How many soil cores will be collected for each composite sample sent to a laboratory for analysis? • Should you sample using a zigzag approach or a systematic sampling method within the sampling area?

Table 2.—Typical frequency for assessment of changes in soil test values.

As needed for specific cropping system	Annually**	Periodic (once per crop rotation or every 3 to 5 years)	Once, if necessary, for initial site assessment
Nitrate-N (NO_3-N)*: preplant, in-season, or postharvest	extractable boron (B), total or sulfate-sulfur (S)***, electrical conductivity (EC)	pH, lime requirement, Bray or Olsen P, extractable bases (K, Ca, Mg, Na), extractable micronutrients (DTPA-Zn, Mn, Cu, Fe)	soil texture, cation exchange capacity (CEC), organic matter

* Soil testing frequency for nitrate-N varies widely for different cropping systems.

** For cropping systems with high-sodium (Na) irrigation water, an annual test for sodium absorption ratio (SAR) is recommended. The SAR test includes determination of exchangeable calcium (Ca), magnesium (Mg), and sodium (Na).

*** For sulfur (S), plant-tissue testing is preferred over soil testing. Soil test sulfur (sulfate-S or total S) is not a good predictor of crop yield response to S fertilizer in many situations.

Objectives

Think carefully about your objectives. Soil testing can be used just to monitor nutrient levels for record-keeping requirements, or it can be used to guide nutrient application decisions. Agricultural professionals (university Extension personnel; private certified crop advisors, agronomists, or soil scientists; and Natural Resources Conservation Service personnel) often can help in designing a customized sampling strategy.

What nutrients or other soil chemical properties do you want to measure?

Soil tests that provide useful information for nutrient management purposes are listed in Table 2.

One of the goals of a soil testing program may be to avoid excessive application of nutrients or salts. Repeated application of organic materials, such as compost, manure, or biosolids, typically results in buildup of one or more nutrients, and possibly soluble salts. As an example, if manure application rates are based on supplying enough N for the crop, other nutrients (e.g., phosphorus and potassium) usually are added at rates greater than crop utilization. Soil testing can be used to track nutrient accumulation over time.

Because each organic material (e.g., manure, biosolids, compost) contains a unique balance of nutrients, a nutrient analysis of the organic material often is helpful in deciding which soil tests are appropriate. General information about the nutrient concentrations present in various organic materials can be found in Extension publications (see “For more information”).

Several tests commonly offered by agricultural testing laboratories—organic matter, ammonium-N (NH_4-N), and sulfur (S)—are less useful in assessing management effects on soil fertility. Their shortcomings are discussed briefly here.

Soil sampling for ammonium-N (NH_4-N) is not recommended unless fertilizer or other organic amendments have been applied during the past 30 days, or if soil has remained dry or cold since N application. In most situations, ammonium-N is rapidly converted to nitrate-N (NO_3-N) in soil.

Soil organic matter testing often is part of a "routine" soil test, but it has limited value for nutrient management. Most fertilizer guides for irrigated crops do not use soil organic matter as a basis for nutrient management recommendations. (Some dryland fertilizer guides use soil organic matter values to adjust N recommendations.)

Soil organic matter content changes very slowly in response to management changes (tillage or organic amendment addition). Annual testing of soil organic matter is not recommended because random measurement error usually obscures small changes in organic matter content over time. Periodic soil organic matter testing (once per crop rotation or every 5 years) may be useful in measuring the impact of long-term management changes that are expected to build soil organic matter.

For sulfur (S), plant-tissue testing is preferred over soil testing. Soil test sulfur (sulfate-S or total S) is not a good predictor of crop yield response to S fertilizer in many situations.

Are you required by any agreement to monitor specific nutrients or soil chemical properties?

Nutrient management plans required by state or federal agencies often specify required soil analyses and sampling frequency. At a minimum, a sampling plan should meet agency requirements (if applicable). For example, landowners who participate in the Natural Resources Conservation Service (NRCS) Environmental Quality Incentives Program (EQIP) for nutrient management often are required to collect soil test data according to NRCS specifications.

Where to sample

Collect soil cores throughout each management unit (unit sampling) or from a reference sampling area within each management unit, as discussed previously in "Where should I collect soil samples from within a management unit?"

How to sample

When should samples be collected?

The recommended sampling frequency is based on the rate of change in soil test values over time (Table 2). Tests for soil characteristics that do not change greatly in response to fertilizer or organic amendment addition (e.g., soil texture and cation exchange capacity) often are not necessary.

Timing of soil sampling is most critical for nitrate-nitrogen, because this form of N is mobile in soil water. Generally, it is best to collect soil samples for nitrate-N analysis close to N fertilizer application time.

Soil tests for soil characteristics that change slowly in response to management (periodic soil tests in Table 2) are recommended once per crop rotation or every 3 to 5 years. For these tests, small variations occur seasonally due to soil biological processes, crop residue decomposition, soil water status, and tillage. In determining management effects on these soil test values, develop a consistent protocol for the timing of sample collection.

What soil sampling depth(s) are appropriate?

Consult university fertilizer guides or nutrient management guides for the crop. Determine the soil sampling depth and any other special considerations for soil sampling in a particular cropping system. For many agronomic crops, interpretive tables for soil test values are based on a sample taken to a 0- to 6-inch or a 0- to 12-inch depth. However, some N recommendations are based on sample depths up to 24 or 48 inches.

Using shallower sampling depths, in some cases, can allow for the detection of changes in soil nutrient status before they would be detected using a traditional sampling depth (6 or 12 inches). For pastures and some perennial crops where tillage is absent, nutrients with limited mobility (e.g., P and K) may accumulate near the soil surface. Sampling closer to the soil surface increases the probability of detecting changes in soil test values over time.

In some cases it is useful to split a sample by depth. For example, if the university guide is based on a 12-inch depth, it might be useful to collect two samples, 0 to 3 inches deep and 3 to 12 inches deep. Splitting the samples by depth allows you to compare soil test values for the 0- to 12-inch depth (weighted average of 0- to 3- and 4- to 12-inch depths) with the fertilizer guide, while also evaluating changes in surface soil test values (0 to 3 inches) over time. Table 3 shows how to calculate a weighted average.

How many soil cores should you collect for a composite sample?

Increasing the number of soil cores (subsamples) taken in a sampling area generally increases the accuracy of the data. Fewer soil cores are needed to represent a smaller sampling area (Table 4). Mix soil cores thoroughly and submit a

Table 3.—Calculating a weighted average.

How measured	Sample depth (inches)	Soil core length (inches)	Soil test value (ppm)
Sampled	0–3	3	40
Sampled	4–12	9	20
Calculated*	0–12	12	25

*Weighted average of 0- to 3- and 4- to 12-inch depths is derived by:
[(core length x soil test value) + (core length x soil test value)] ÷ total sample depth

Example: [(3 x 40) + (9 x 20)] ÷ 12 = 25

Table 4.—Minimum number of cores per sample and size of sampling areas.

	Whole field	Entire management unit	Reference sampling area within management unit
Minimum cores/sample	20	10	5–8
Minimum acres/site	100% of field	varies	1% or less of management unit

composite sample to the laboratory. Check with the laboratory to determine the amount of soil needed for the desired analyses.

Should you sample in a zigzag pattern or use a systematic sampling method within the sampling area?

For some crops, a zigzag pattern or other haphazard approach to collecting soil cores is appropriate. Systematic sampling perpendicular to a furrow-irrigated bed, fertilizer band, or perennial crop row sometimes is used to reduce variability in test results. If you choose a systematic sampling method, you must use it consistently in order to compare soil test values over time.

Sampling checklist

Consistent sampling techniques are essential. Make sure each of the following aspects (each was discussed above) will be handled before going to the field to take soil samples:

- Nutrients to be monitored
- Size and location of management units or reference sampling areas
- Sampling depth(s)
- Number of cores per composite sample
- Systematic sampling instructions (if applicable)

See "For more information" for publications describing routine soil sampling collection and handling techniques.

Example 1: Monitoring nitrogen in a silage corn field

Two years ago a grower purchased a 75-acre field. The new owner has no soil test data and little information on how the field was managed. He plans to conventionally till the field and plant it to silage corn and is concerned about how best to manage nitrogen fertilization. He uses best management practices to ensure timely and even distribution of irrigation water via overhead sprinklers.

The grower has a 20-year old aerial photo of the field and the soil survey report for the area. The photo shows that there was a corral in a part of the field. The grower decides that the former corral area will need to be a separate management unit (Management Unit 1), and the rest of the field will be the second management unit (Management Unit 2).

Developing a monitoring plan

Nutrient monitoring objectives

The grower wants to determine an appropriate nitrogen application rate for silage corn in this field. From a longer term perspective, by creating management units, he will be able to more closely meet the nutritional needs of the crops and, ideally, to reduce his fertilizer expenses and possible nitrate loss from the field.

Because part of the field has been a corral, the grower suspects this area may have a higher nutrient-supplying capacity than the rest of the field. The grower does not own livestock and will not be applying manure to the field.

Table 5.—PSNT and at-harvest stalk nitrate-nitrogen for Example 1.

	Nitrate-nitrogen (mg/kg or ppm) Management Unit 1 (old corral site)	Management Unit 2 (rest of field)
Soil test (PSNT) at six-leaf growth stage	30	10
Corn stalk at harvest	4,500	5,500

Sampling approach

The grower wants to keep his sampling plan fairly simple by using reference sampling areas in the two management units. The reference sampling areas are located on the same side of the field and are fairly close to the road for easy access. Should plant tissue testing become necessary, those samples also will be taken from the reference sampling areas.

The grower has a GPS unit and uses it to record the location of the four corners of the reference sampling areas in the two management units. He collects 10 cores (5 cores is the minimum per unit) in each reference sampling area to create a representative sample.

Both soil and plant tissue testing will be used to monitor crop N status. Soil samples (0- to 12-inch depth) will be collected at the six-leaf growth stage. Plant tissue (corn stalks) will be collected at harvest. A university nutrient management guide, *The Presidedress Soil Nitrate Test (PSNT) for Western Oregon and Western Washington*, will be used to determine methods used in soil and plant tissue sampling. The guide also will be used to interpret soil test and plant tissue test results.

Results

Table 5 shows the results of soil and tissue testing for both management units.

The presidedress soil nitrate test value for Management Unit 1 (previous corral site) was above the 25 ppm nitrate-N sufficiency level given in the nutrient management guide. Thus, fertilizer N was not applied to this unit. Nitrogen was applied at sidedress time to Management Unit 2 at a rate of 100 lb N per acre as recommended in the guide.

The at-harvest stalk nitrate-N concentration in corn from Management Unit 1 was in the range required for optimum yield (above 3,500 ppm) given in the nutrient management guide. This result confirmed the decision not to sidedress N fertilizer in that management unit. Corn in Management Unit 2 had an at-harvest stalk nitrate value of 5,500 ppm, indicating that sufficient N was present for maximum yield. By using the management unit approach, yields were maintained and N fertilizer use was reduced.

Example 2: Monitoring soil phosphorus over a 6-year period

A grower has a 105-acre field that is irrigated with overhead sprinklers mounted on a wheel line. He wants to utilize composted manure from a drylot dairy and commercial fertilizers to supply nutrients for potatoes, a spring small grain crop, and a winter small grain crop grown in a 3-year rotation.

The grower worked with a consulting soil scientist to define management units for this field. The field was leveled many

Table 6.—Nutrient management strategies for Example 2.

Management unit	Initial soil test P	Strategy
1	15	Apply compost every year.
2	21	Apply compost every third year.
3	29	No compost applied.

years ago when it was furrow irrigated. Bare-soil aerial photographs were used to delineate management units defined by the amount of exposed subsoil. Soil color was directly related to topsoil depth, soil organic matter content, and soil test values. The management unit with the lightest color on the aerial photo, Management Unit 1, had the lowest organic matter content and the lowest soil test P value (15 ppm bicarbonate extractable P). Management Unit 3 had the highest organic matter content and the highest soil test P (29 ppm). Management Unit 2 had intermediate organic matter and intermediate soil test P (21 ppm).

Developing a monitoring plan

Nutrient monitoring objectives

The goal of the soil testing program is to efficiently use a combination of composted manure and fertilizer P to satisfy crop needs. Composted manure will be applied each year to Management Unit 1 (lowest soil test P) and every third year to Management Unit 2 (intermediate soil test P). Management Unit 3 will not receive composted manure application because it has higher soil test P values. (See Table 6.)

The phosphorus fertilizer rate for each crop will be determined using university nutrient management guides in conjunction with P soil test values for Management Unit 2 (intermediate soil test P) (Table 6). Phosphorus fertilizer (if needed for a particular crop) will be placed near the row at a single rate across the entire field. The grower does not have equipment capable of delivering a variable rate fertilizer application.

Sampling approach

Annual sampling will be used to track changes in soil test P over time. Because composted manure distribution across the field is not always uniform, the grower chooses a random sampling scheme, collecting soil cores in a zigzag pattern through each management unit. He records each management unit boundary and soil core collection location with a GPS unit to minimize year-to-year variation.

Management units will be sampled every year in the late winter or early spring. Samples will be taken at the 0- to 12-inch depth, as this is the depth recommended in university fertilizer guides for this region. From each management unit, 10 cores will be taken and composited into a single sample.

Results

Figure 2 (page 13) shows that soil test P values remained relatively constant in each management unit in the field over a 6-year period. All crops received adequate P for maximum yield.

The management unit approach allowed the grower to continue composted manure application to the portion of the field where additional P has agronomic benefit (Management Unit 1), while avoiding excess P buildup in the portion of the field with higher soil test P values (Management Unit 3). Fertilizer costs were reduced because a portion of crop P needs was supplied by composted manure.

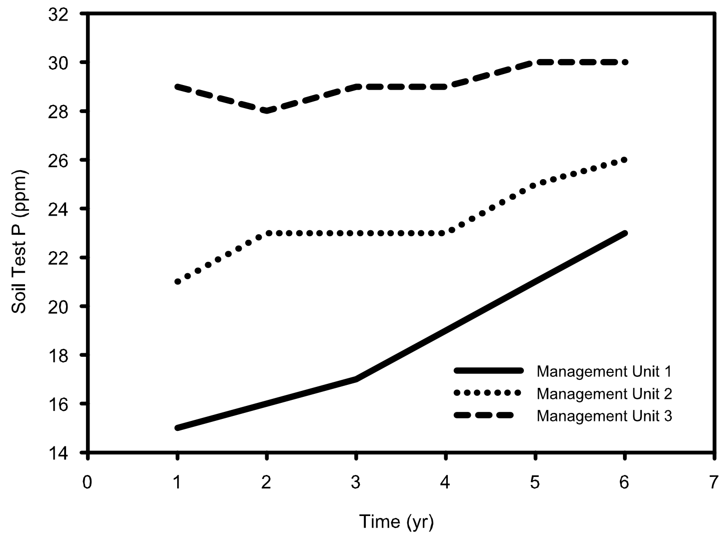

Figure 2.—Soil test P values for three management units in Example 2.

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Spring grains

Western Oregon—west of Cascades

E.H. Gardner, T.L. Jackson, and W.E. Kronstad

Good management practices are essential if optimum fertilizer responses are to be realized. These practices include 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 cultural practices, crop response to 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.

Follow recommended soil sampling procedures to estimate fertilizer needs. The Oregon State University Extension Service agent in your county can provide you with soil sampling instructions, soil sample bags, and information sheets.

Field experiments with spring grains in western Oregon have shown that early seeding (by April 1 or earlier) and the proper use of fertilizer give best results. Near normal yields can be obtained even if the crop is infected with yellow dwarf virus.

In recent years, yellow dwarf virus disease has reduced yields of spring grain in western Oregon. Damage has varied with the seasons and between areas. The virus is carried by aphids, and infection can be serious whenever conditions favor mass movement of aphids into the grain in the early stages of growth. If virus infection occurs when the young grain plants have only two or three leaves, severe stunting and possible crop failure may result. Damage is less severe if the plants develop at least five or six leaves before the aphid infestation occurs.

Method of Applying Fertilizer

Banding the fertilizer close to the seed is essential for maximum seedling growth. Band applications of nitrogen, phosphorus, potassium, and sulfur have increased yields. Yield response of virus-susceptible varieties to banded phosphorus and potassium has been profitable in years when virus is present, even on soils with these nutrients at levels normally considered adequate.

Broadcast fertilizers may not be effective in increasing early seedling growth.

With early seeding in moist soil, up to 40 lb N/a + 40 lb P_2O_5/a + 40 lb K_2O/a have been banded with the seed without serious damage. Banding higher rates of fertilizer with the seed could decrease yields.

Urea and DAP (diammonium phosphate) can be toxic to seedlings and therefore should not be used as an N source when fertilizer is banded close to seed. Vigorous seedling growth has more than compensated for any fertilizer burn with other fertilizer materials.

The "burning" effect of banded fertilizer increases as the soil becomes drier and decreases when the band is located a short distance (1–2 inches) from the seed.

Nitrogen (N)

Spring grain yields are increased by the application of N.

The application of too much N can result in lodging, particularly where weaker strawed varieties are seeded.

The amount of N recommended depends on the preceding crop (Table 1).

Table 1.—N fertilization rates for spring grains.

	Apply this amount (lb N/a)[1]			
		Band and broadcast[2,3]		
Preceding crop	**Total**	**Close to seed**		**With seed**
Good stand of legumes or row crop	20	20(0)	or	20(0)
Grain or grass seed[4]	40–50	40(0–10)	or	20(20–30)

[1]The difference between total N and banded N should be broadcast before or at the time of planting.

[2]The figures in parentheses represent the lb N/a that should be broadcast.

[3]Urea should not be banded close to seed.

[4]Broadcast N should be increased by 10 lb/a for each ton of grain or grass straw incorporated in the spring.

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Prepared by E. Hugh Gardner, professor emeritus of soil science; T.L. Jackson, former Extension soil scientist; and W.E. Kronstad, professor of crop science; Oregon State University. Reviewed by a committee of western Oregon county Extension agents.

Estimating N Rates from Yield Potential

About 40 lb of added N are required for each 1,000 lb yield increase. Experienced growers can adjust N rates for maximum economic yield with this formula. However, you must be realistic when estimating maximum yield potentials. Yield potential varies with crop, soil depth, drainage, and previous management.

Example: The estimated yield is 2,000 lb/a with 40 lb of applied N on a field that should produce 3,000 lb/a. To increase the yield by 1,000 lb requires about 40 lb of additional N if other factors are not limiting.

Phosphorus (P)

Band applications of P, close to or with the seed, are much more effective than broadcast applications (Table 2). When P is broadcast, increase the rate by 50 percent.

Table 2.—Rate of band application of P for spring grains.

If the soil test for P is (ppm)	Band this amount of phosphate (P_2O_5) (lb/a)*
0–30	40–60
over 30	40

*These P rates assume that soil pH is 5.6 or higher.

When the soil test value for P exceeds 30 ppm, it is doubtful that a response to broadcast P will be obtained.

Potassium (K)

Band applications of K close to or with the seed are more effective than broadcast applications (Table 3).

With early planting and favorable soil moisture, up to 40 lb K_2O/a can be banded with the seed with little risk of seedling burn.

Table 3.—Rate of band application of K for spring grains.

If the soil test for K is (ppm)	Band this amount of potash (K_2O) (lb/a)
0–100	40
over 100	30

When K is broadcast, increase the rate to 70 lb/a.

When the soil test value for K is greater than 125 ppm, it is doubtful there will be a response to broadcast K.

Sulfur (S)

Plants absorb S in the form of sulfate. Fertilizer materials supply S in the form of sulfate and elemental S. Elemental S must be converted 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.

The S requirements of spring grains can be provided by:

1. Applying 15–20 lb S/a in the form of sulfate at planting time
2. Applying 30–40 lb S/a as fine-ground elemental S the preceding year
3. Applying coarser ground elemental S at higher rates and less frequently

Some S fertilizer materials, such as elemental S and ammonium sulfate, have an acidifying effect on soil.

Magnesium and Micronutients

To date, increases of spring grain yields from applications of magnesium and micronutrient elements have not been observed in western Oregon.

Lime

Lime application is not suggested if the soil pH is 5.8 or higher. Lime application rates can be estimated from Table 4.

Table 4.—Lime application rates for spring grains.

If the SMP buffer test for lime is	Apply this amount of lime (t/a)
under 5.5	3–4
5.5–5.8	2–3
5.8–6.2	1–2
over 6.2	0

Lime rate is based on 100-score lime.

Mix lime into the seedbed several weeks before seeding. Lime applications are effective for several years.

Some soils may have a fairly high SMP buffer value (over 6.2) and a low pH (below 5.3). This condition can be caused by the application of acidifying fertilizer. This temporary "active" acidity from fertilizer is found after applications of most nitrogen fertilizers. Acidifying fertilizers also have a long-term, cumulative acidifying effect on soils.

Recommendations based on experiments conducted by T.L. Jackson and W.H. Foote, Oregon Agricultural Experiment Station.

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Post-harvest Soil Nitrate Testing

for Manured Cropping Systems West of the Cascades

D.M. Sullivan and C.G. Cogger

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What's in this publication?

This publication describes the use of post-harvest soil nitrate testing as a tool for assessment of nitrogen (N) management in manured cropping systems west of the Cascade Mountains in Oregon, Washington, and south coastal British Columbia.

The first section of this publication gives general information on the test and is designed for use by growers and dairy operators. This section gives a brief introduction to soil sampling, but does not provide all of the technical details. The focus is on how to use the post-harvest test to improve nutrient management. This section describes:

- What the post-harvest test measures
- How to collect soil samples
- Units used in soil nitrate testing
- How to interpret soil nitrate test results for grass and silage corn crops

In addition, background information explains the rationale for the test:

- How to use the post-harvest test as a management tool (page 3)
- Crop and soil response to excess plant-available N (page 4)

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The second section of this publication is designed primarily for use by conservation planners and other agricultural professionals working with farmers to implement nutrient management plans. This section is also designed for dairy operators who do their own soil sampling. This section includes detailed suggestions for the following:

- ◆ Collecting, preserving, and analyzing the soil sample
- ◆ Developing a long-term soil sampling plan

The post-harvest test and how to use it

What the post-harvest test measures

The post-harvest soil nitrate test measures the quantity of plant-available nitrogen present in the nitrate form in the surface foot of soil in the late summer or early fall. The test measures nitrate-N not utilized by the recently harvested crop. Because crops differ in their ability to remove nitrate-N from the soil, test interpretation is crop-specific.

The test looks backward in time. It evaluates the balance between N supply and crop uptake for the crops produced during the summer. Nitrate-N accumulates in the soil when more plant-available N is supplied than can be utilized by the summer crop (see "Crop and soil response to excess plant-available N," page 4).

Use the post-harvest test to:

- ◆ Get a general idea of balance between N supply from manure and other sources and crop N demand
- ◆ Identify imbalances in N supply among fields on a farm
- ◆ Identify fields that may respond to changes in timing or amount of manure application or other agronomic practices

Soil sampling protocols

Sampling depth

Sample the 0- to 12-inch depth for the post-harvest test. This shallow sampling depth is a good predictor of nitrate in the rest of the soil profile when (1) in-season irrigation is not excessive, and (2) samples are taken prior to heavy rains in the fall.

Composite soil sample

Collect a composite soil sample consisting of a mixture of 15 to 30 soil cores from each field or management unit. See "Collecting, preserving, and analyzing the soil sample" (page 9) for detailed sampling instructions and suggestions for special situations.

What fields to sample

In general, it is not necessary to sample every field on a farm every year. Consult with your farm advisor to determine any regulatory requirements for sampling frequency. We recommend that you sample selected fields that represent typical manure and crop management practices each year to track long-term trends in post-harvest soil nitrate values. See "Developing a sampling plan" (page 11) for more information.

When to sample

In general, samples for the post-harvest test should be collected as soon as possible after a crop harvest. Avoid sampling a field that has had manure application within the past 30 days.

Samples must be taken before heavy fall rains move nitrate below the 12-inch depth. Because the timing of fall rainfall is unpredictable, the best strategy is to sample fields before October 1 whenever possible.

Collect samples from medium- to fine-textured soils (loams, clay loams, and clays) prior to 5 inches of cumulative fall rainfall. Sandy soils (sand, loamy sand, or sandy loam soil texture) have lower water-holding capacities and should be sampled prior to

continues on page 5

How to use the post-harvest test as a management tool

Sampling depth and timing are critical. Interpretation tables for this test apply only to samples taken to a 12-inch depth. Surface soil (0 to 12 inches) typically contains the highest nitrate-N levels and requires the least time and effort for sample collection. Samples must be taken before heavy fall rains move nitrate below the 12-inch depth. The target sampling period generally is August 15 to October 15.

To get the most value from this test, it is important to understand:

- How the test fits into an overall nutrient management program
- Limitations to interpretation of test results
- How *not* to use the test

Using the test as part of a nutrient management program

The post-harvest test is but one measure of success in nutrient management. Post-harvest nitrate test data should be assessed in the context of the current N management plan and records of manure application. Successful N management involves a number of components, including:

- Assessing crop N needs
- Planning manure application to meet crop N needs
- Applying manure according to the plan
- Recording manure application amount and estimated plant-available N amount
- Measuring crop yield and N content
- Monitoring success of the plan

All components of the nutrient management system should be evaluated together.

Limitations to test results

Interpretive values for post-harvest soil nitrate are:

- Calibrated only for high-rainfall portions of the Pacific Northwest (west of the Cascades). Extrapolation to other environments is not recommended.
- Provided only for corn silage and grass hay/silage crops. Field research has been used as the basis for interpretive levels for these crops. Applicable research data are not available for other crops to determine post-harvest nitrate-N levels associated with good crop and nutrient management practices. However, the test may be used for relative comparisons among fields planted to another crop (e.g., comparisons among grass pasture fields).
- Based on the assumption that summer irrigation is less than, or close to, evapotranspiration to ensure that significant nitrate leaching does not occur before the fall test.
- Designed for fields with a history of applied manure (more than 3 consecutive years of regular manure application). Lower post-harvest soil nitrate test values are attainable where only fertilizer N is used, or where manure is applied infrequently.
- Based on good management of the crop and normal yields. Crop moisture stress, insect damage, or plant disease will reduce crop yield and crop uptake of nitrogen, thus increasing post-harvest soil nitrate test levels.

How *not* to use the post-harvest test

The test will *not*:

- Detect a shortage of plant-available nitrogen for crop production. Continual mineralization of nitrogen (conversion of organic N forms to plant-available N forms in the soil) can provide enough plant-available nitrogen for a crop without accumulation of nitrate-N in soil.
- Determine the source(s) of excess plant-available N. Sources of N may include manure slurry, lagoon water, fertilizer, soil organic matter, or previous crop residues.
- Predict crop response to fall manure or N fertilizer applications. The test does not predict the amount of plant-available N that will be mineralized from soil organic matter or crop residues in the fall.

Crop and soil response to excess plant-available N

Crop response to applied N. Crop N uptake is controlled by the environment, crop N uptake potential, and management. Crops respond to plant-available nitrogen supply (ammonium + nitrate-N) by the law of diminishing returns (Figure 1). Without added N, some crop yield is produced from N supplied by soil organic matter, residual plant-available N, and other non-fertilizer sources (e.g., mineralization of crop residues). Additional N supplied from manure or fertilizer increases crop yield until site yield potential is reached.

The application rate of manure or N fertilizer needed to reach near-maximum yield is termed the *agronomic rate*. Rather than a single agronomic rate, the crop response to N is best described as an agronomic rate range (Figure 1). The agronomic rate range concept allows for variability in crop performance among years and for crop uptake of N beyond the yield maximum (increased protein).

Post-harvest soil nitrate test measures nitrate-N not used by the crop. At excessive plant-available N supply levels, crop yield and crop N uptake do not respond to further N additions. The extra soil N not used by the crop accumulates as nitrate-N.

Elevated post-harvest soil nitrate-N concentrations are an indicator of one or more of the following: (1) excess plant-available N, (2) N supplied too late in the season for crop utilization, or (3) poor crop growing conditions due to insect infestation, moisture/heat stress, plant disease, or other cultural problems. If crop yields are acceptable and crop protein is at typical levels, then the most likely explanation is that plant-available N was supplied in excess of crop needs.

Because grass is more efficient than corn at N uptake, target post-harvest soil nitrate levels given in this publication are lower for grass than for corn. There are two key reasons that grass is more efficient than corn in N removal.

- Grass has a greater capacity to take up N supplied in excess of that needed for maximum yield. After enough N has been supplied for maximum yield, grass protein content increases in response to increased N supply. With grass, soil nitrate increases only when the available N supply exceeds that required to produce near-maximum protein. Corn does not take up additional N after the maximum yield is reached. Corn silage protein does not increase much in response to excess N supply.
- Grass utilizes N mineralized late in the growing season more efficiently. Grass managed for silage or hay continues to take up N until harvest. Corn grown for silage completes its N uptake approximately 4 weeks before harvest. Some of the soil nitrate measured after corn harvest is produced by mineralization of soil organic N to available forms during the final weeks of the growing season.

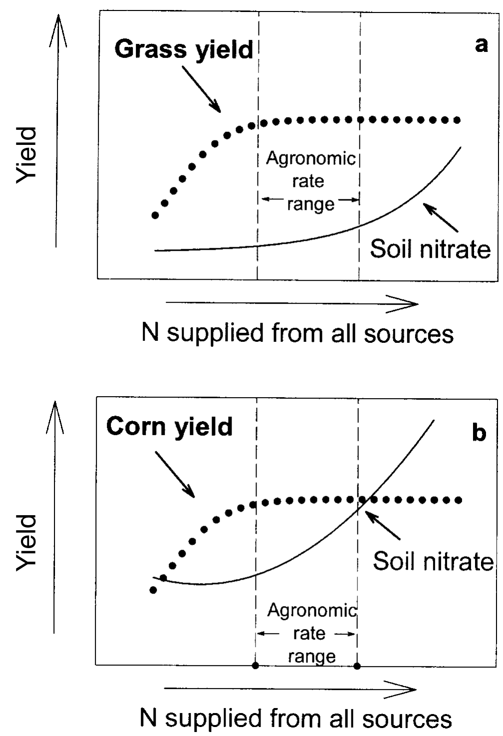

Figure 1.—Crop yield and soil nitrate response to increased N supply. Agronomic rate range = range of N supplied from all sources that results in near-maximum crop yield with acceptable post-harvest nitrate accumulation. Above the agronomic rate range, excess N accumulates as nitrate in soil. More nitrate accumulates in the agronomic rate range with corn (b) than with grass (a).

Table 1.—Average calendar date when cumulative rainfall (after September 1) reaches 5 inches west of the Cascades.[a]

Cumulative rainfall after Sept. 1	Calendar date to reach specified cumulative rainfall							
	Medford (OR)	Salem (OR)	Tillamook (OR)	Coupeville (WA)	Centralia (WA)	Lynden (WA) Abbotsford (BC)	Agassiz (BC)	Comox (BC)
(inches)								
3	10 Nov	20 Oct	26 Sep	31 Oct	8 Oct	1 Oct	26 Sep	10 Oct
5	29 Nov	1 Nov	8 Oct	24 Nov	23 Oct	15 Oct	9 Oct	25 Oct
7	16 Dec	13 Nov	18 Oct	15 Dec	4 Nov	27 Oct	19 Oct	6 Nov

[a]Average daily precipitation data for many other locations is available at: Western Regional Climate Center (http://wrcc.dri.edu) or Environment Canada (http://www.msc-smc.ec.gc.ca/climate/climate_normals/index_e.cfm).

3 inches of cumulative fall rainfall. The starting date for calculating cumulative fall rainfall is September 1. Include inches of irrigation water applied after September 1 in your estimate of cumulative rainfall.

Table 1 shows the average calendar date when cumulative fall rainfall (after September 1) reaches 5 inches at a variety of locations. For most locations, sampling prior to October 15 is acceptable in an average year. In high rainfall areas (coastal areas and the Cascade foothills), plan to sample earlier. A late October sampling date usually is acceptable in lower rainfall areas of southern Oregon, the Puget Sound islands, Olympic Peninsula, or Vancouver Island.

Units used in soil nitrate testing

In this publication, interpretation of a post-harvest soil nitrate test (Tables 3 and 4) is based on units of parts per million (ppm). Some labs report soil test nitrate-N in units of lb/acre by assuming a standard value for soil bulk density. If the lab reports nitrate-N results in pounds per acre, ask them to provide a conversion factor to express data in units of ppm. The conversion factor assumed by laboratories usually is between 3 and 4, because 1 acre-foot of dry soil usually weighs about 3.5 million pounds (3.5 lb per acre-foot = 1 ppm).

Table 2.—Units used to report soil nitrate analyses.

Name	Interpretation	Equivalent units
nitrate-N or NO_3-N	N present in the nitrate form, soil dry weight basis	mg/kg or ppm (dry weight basis)

Interpreting soil nitrate test results

Data quality and variability

The first step in evaluating your soil nitrate data is to verify data quality. Determine whether the sample collection method, timing of sample collection, sample preservation, and laboratory analysis methods are acceptable. Reject data that did not result from reasonable protocols. For example, Tables 3 and 4 should not be used for soil samples collected in November after heavy fall rains.

Make sure that you understand the units used to report test results. See Table 2 for an explanation of units found in soil test reports.

Response of post-harvest soil test N to changes in management

Success in N management is indicated by long-term trends in post-harvest soil nitrate (at least 3 to 5 years). **Because of the large pool of readily mineralizable N in manured soils, fall soil nitrate values may not decline for 3 to 5 years in response to improved management.** For multiyear comparisons, sampling methods and timing must be consistent.

Some portions of a crop rotation will have higher fall nitrate values because of rapid N mineralization stimulated by tillage or incorporation of crop residues. For example, soil nitrate concentrations typically are high, regardless of overall N management, after a perennial grass sod is plowed down and reseeded.

Reductions in fall soil N are most likely to be measured when (1) commercial N fertilizer amounts are reduced or eliminated, (2) cropping systems that maximize N removal in late summer and fall (August to October) are used, and (3) manure or N application is eliminated after August 1. It is more difficult to attain post-harvest soil nitrate-N values of less than 20 ppm for corn than for grass (see "Crop and soil response to excess plant-available N," page 4).

Interpretation for individual fields

Interpretations of soil test nitrate-N should be made first at the field level. You may be able to discover a probable cause for differences in test values among fields. Questions to ask include:

- ◆ Are relationships present between known management factors (e.g., manure application rate or timing, crop yield and quality, irrigation frequency, distance to the barn) and soil test values?
- ◆ Is a large amount of variation present between fields? Is there a logical explanation for unusual values?
- ◆ Are values for grass and corn fields similar?

Annual averages across grass and corn crops

After looking at test values for individual fields, it may be useful to look at averages across all grass or corn fields. You may want to calculate averages only for fields under similar management.

Average nitrate-N test values are most useful for consideration of changes in whole farm nutrient management. Tables 3 and 4 present interpretive information separately for grass and corn fields.

If a few fields have unusual test values, you may be justified in excluding those fields from an average. Although you may want to exclude unusually high test values from the farm average, you definitely should evaluate those fields further to determine the probable cause of the high soil test values. The unusually high test values may reflect the need for management changes or may reflect a soil sampling or analytical error.

Using the interpretive tables (Tables 3 and 4)

Interpretations and management suggestions given in Tables 3 and 4 (pages 7–8) are general in nature and should serve as only one portion of a nutrient management plan evaluation. Some of the management suggestions can be implemented for individual fields, while others need to be implemented on a whole farm basis.

Remember not to focus solely on post-harvest nitrate-N in evaluating N management. Include other important aspects of N management in your evaluation, such as success in following a plan for manure application, calibration of manure application equipment, maintaining good manure application records, and effective irrigation management.

Table 3.—Silage corn. Suggested interpretation for post-harvest soil nitrate-N (0- to 12-inch depth). [a]

If post-harvest nitrate-N is less than 20 ppm (less than approximately 70 lb N per acre)

◆ Continue present N management.

If post-harvest nitrate-N is 20 to 45 ppm (approximately 70 to 160 lb N per acre)

◆ Reduce or eliminate sidedress N fertilizer application. Use the pre-sidedress nitrate test (PSNT). Apply sidedress N only when PSNT indicates a need.

◆ Reduce lagoon water application after August 1.

◆ Keep records to document crop yield, dry matter, and crop N removal. Total applied manure-N + fertilizer-N should be less than 125 percent of documented crop N removal.

◆ Reduce manure application on fields where corn follows grass sod plow-down.

◆ Plan to reduce manure-N application by 10 to 25 percent.

◆ Improve whole farm N balance.

If post-harvest nitrate-N is greater than 45 ppm (greater than approximately 160 lb N per acre)

◆ Apply only starter N (20 to 40 lb N/acre at planting).

◆ Plan not to sidedress N fertilizer in June. Apply sidedress N only when PSNT indicates a need.

◆ Eliminate lagoon water application after August 1.

◆ Keep records to document crop yield, dry matter, and crop N removal. Apply manure N at a rate less than or equal to crop N removal (approximately 200 lb total N per acre).

◆ Eliminate manure application on a few fields or a few strips within a field next year to determine the contribution of mineralized N vs. current-season application of manure.

◆ Plan to reduce manure-N application by 25 to 40 percent.

◆ Consult experts to improve whole farm nutrient balance.

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[a]The post-harvest test values listed above are for the *end* of a growing season. Management changes (if needed) should be implemented in future years. Interpretive values assume near-optimum crop yields. If yield is below average, improve agronomic practices to increase crop yield and crop N uptake.

Table 4.—Grass for hay or silage. Suggested interpretation for post-harvest soil nitrate-N (0- to 12-inch depth).[a]

If post-harvest nitrate-N is less than 15 ppm (less than approximately 55 lb N per acre)

- Continue present N management.

If post-harvest nitrate-N is 15 to 30 ppm (approximately 55 to 105 lb N/acre)

- Apply manure earlier in the growing season.
- Keep records to document crop yield, dry matter, and crop N removal. Total applied manure-N + fertilizer-N should be less than 125 percent of documented crop N removal.
- Check protein levels in forage. Grass crude protein greater than 21 percent is associated with increased potential for nitrate toxicity to cows.
- Plan to reduce manure-N application by 10 to 25 percent.
- Improve whole farm nutrient balance.

If post-harvest nitrate-N is greater than 30 ppm N (greater than approximately 105 lb N/acre)

- Apply manure earlier in the growing season. Reduce manure application after August 1.
- Keep records to document crop yield, dry matter, and crop N removal. Total manure-N + fertilizer-N should be less than or equal to crop N removal. Even if calculated crop removal exceeds 400 lb N per acre, apply manure-N + fertilizer-N not to exceed 400 lb N per acre per year.
- Consider reseeding or interseeding if grass yield is limited by poor stand or undesirable species.
- Check protein levels in forage. Grass crude protein greater than 21 percent is associated with increased potential for nitrate toxicity to cows.
- Plan to reduce manure-N application by 25 to 40 percent.
- Consult experts to improve whole farm nutrient balance and reduce danger of nitrate toxicity to cows.

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[a] The post-harvest test values listed above are for the *end* of a growing season. Management changes (if needed) should be implemented in future years. Interpretive values assume near-optimum crop yields. If yield is below average, improve agronomic practices to increase crop yield and crop N uptake.

Detailed suggestions for soil sampling and planning

Collecting, preserving, and analyzing the soil sample

Tools for field sampling

Collect a sample that is representative of the entire sampling depth. For example, a representative sample for a 0- to 12-inch depth has the same amount of soil from the soil surface (0 to 6 inches) and from the bottom of the sampling depth (6 to 12 inches).

Always use a tool specifically designed for soil sampling. Don't use a shovel, because the samples won't be uniform with depth. Tools for soil sampling often are called soil probes or augers. There are several kinds available.

Push probes are tubes that you push into the soil. They have a T-shaped handle attached to a cylindrical tube (about 1 inch diameter) with a beveled tip. The tube collects a cylinder, or "core," of soil. Push probes work well in soft, uncompacted soils.

Hammer probes are designed for hard or compacted soils. They have a sliding weight (hammer) instead of a T-handle to drive the probe into soil.

Soil test consultants often use hydraulic probes mounted on a tractor or pickup to sample soils. These reduce the time and effort of sampling in hard soils. Gravelly and rocky soils are difficult to sample. A hydraulic probe with a rotating auger can sample some gravelly soils.

A mud auger or bucket auger is the best tool for hand-sampling at sites that are difficult to sample with push probes. Use an auger for compacted, muddy, rocky, or dry soils. Augers can be purchased from several manufacturers. A 2- to 4-inch diameter mud auger (open-sided) works best for most situations because it is easy to remove the sample from the bucket. Use a larger diameter auger for soils with large rocks. Augers sample a 4- to 6-inch depth. You will need to take several bites from the same hole to sample to 12-inch depth. You will collect a larger sample volume, about 5 to 10 times that collected with a push tube. Because of the extra effort required for auger sampling, use this method only if other sampling methods are difficult or impossible.

Field sampling protocol

Plan ahead. Use field maps and soil maps to divide the farm into different management units. A management unit is usually a field, but you may want to subdivide a large field if sections can be managed separately for nutrient application. The simplest approach is to collect a composite sample from the entire management unit. You may choose to restrict sampling to the dominant soil type if the management unit has soils that differ markedly in visual appearance (soil color, texture, organic matter).

Alternatively, you can restrict your sampling to a representative area (usually about an acre in size) within the management unit. Choosing a representative area within the field where manure application rate, timing, and uniformity are well documented is essential. If you use the "representative area" sampling approach, record the sampling location using a GPS receiver or record the distance from a fixed location (e.g., fenceline).

Avoid large buffer zones that are sometimes present adjacent to water bodies or roads, especially with big gun manure applicators. Avoid small atypical areas such as:

- ◆ Swales
- ◆ Very rocky or shallow soil (less than 12 inches deep)
- ◆ Site of an old manure pile or a feeding, watering, or resting area for livestock
- ◆ Abandoned field roads
- ◆ Field edges

Collect 15 to 30 soil cores from each management unit or representative sampling area with a push probe or similar tool. If you use an auger, 10 holes per management unit or zone is sufficient.

Choose sampling locations in a zigzag pattern across the field. Your general route of travel should be across rows, rather than down one row in the field. Make sure you sample within the part of the field where manure is routinely applied. For grazed pastures, choose sampling locations that have average crop growth and productive forage species.

Scrape away loose crop residues or manure present on the soil surface. Sample only the soil. Including the accumulated organic debris from the soil surface in the soil sample will increase variability in test results.

Once you are satisfied with a sampling strategy, repeat the same procedure each year. This will increase the validity of year-to-year comparisons of results.

Obtaining a representative sample from fields where manure has been injected into soil or placed in bands on the soil surface is difficult. The depth of manure injection, the width of injection zone, and the spacing between bands depend on equipment, soil, and the applicator. Some injection equipment can place manure below the 12-inch sampling depth used for the post-harvest nitrate test. Manure may be injected or banded more than one time per year, with several orientations in a field (e.g., north–south or east–west). Because of the added variability associated with manure injection or banding, plan to collect a larger number of soil cores to obtain a representative composite sample.

Sample handling

Mixing. If it is not too hard to break up the soil cores, break them, mix them all together, and homogenize thoroughly. Take a 1-cup subsample for shipment to the lab. If the soil cores are too hard to break apart, send the entire sample to the lab, where they can pass the sample through a mechanical grinder. Check with the lab to make sure they will grind and mix the *entire* sample before subsampling.

Preservation. Soils kept moist and warm continue to accumulate nitrate via biological activity after sampling. The simplest way to limit biological activity is to cool the soil after collection. Put the samples in plastic bags and place them in a cooler on ice while still in the field. Refrigerate them when you return from the field. Freeze the samples if they will be held longer than 48 hours before analysis.

Shipment. Keep the samples refrigerated or frozen until you deliver them to the lab. Contact the lab before you sample, so they will be prepared to receive the samples. Use a shipping method that will get the samples to the lab within 48 hours. You may want to freeze the samples before shipping to make sure they remain cool in transit.

Working with an analytical laboratory

Choose a laboratory that has experience with agricultural samples. Ask if they participate in the North American Proficiency Testing Program or a similar quality assurance program for agricultural testing labs. Find out what extraction and analytical procedures they use. Procedures should be consistent with those recommended for the western states (Gavlak et al., 1994).

Labs may use one of several colorimetric (color-based) lab procedures or they may use an electrode method to measure nitrate. Sample comparisons have shown that the colorimetric procedures usually are more precise than the electrode method.

Some testing labs also have sampling and consulting services. This can be convenient for people who have little experience in sampling or need help with sampling.

Find out how the lab reports soil test data. Standard units for soil nitrate-N are parts per million (ppm, Table 2). If you aren't familiar with the lab, it's a good idea to obtain a copy of a sample laboratory report.

Because you will use sample results to compare post-harvest soil nitrate across years, laboratory consistency over time is a major issue. A standard reference sample (soil sample with known concentration of nitrate) can help you assess laboratory variability. Consider submitting a standard reference sample (approximately 50 to 100 g dry weight) with a nitrate-N concentration of 20 to 45 ppm with each batch of soil samples. Keep track of test results for the standard reference sample over time. If you note a major error in the nitrate concentration reported for the standard reference sample, then the test data is questionable.

Standard reference samples are available from the North American Proficiency Testing Program (see "For more information," page 15). Standard reference samples must be dried, ground, and thoroughly mixed.

We do not recommend that you split a field sample to check laboratory consistency. The one-time nature of such comparisons, the uncertainty of obtaining a homogeneous sample, and the uncertainty of sample preservation in-transit to the lab limit the interpretation of split-sample data.

Developing a sampling plan

Nutrient management plans can be voluntary, required by regulatory agencies, or a part of an agreement with a conservation planning agency (e.g., Natural Resources Conservation Service or conservation district). If your nutrient management plan is not voluntary, consult the agency that supervises your nutrient management plan to determine whether they have specific requirements for how often fields must/should be sampled. Suggestions given here for sampling frequency are general in nature and are not intended to serve as policy for any agency.

Representative fields for long-term monitoring

Representative fields are fields that you sample every year to track trends in sample values over time. Select fields that represent typical management practices. Criteria that can be used to choose representative fields include: (1) records or estimates of annual manure application rate, (2) number of years of continuous manure application, (3) soil test values for P and K. On dairies where P and K fertilizers are not routinely applied, soil test values above 75 ppm P (Bray P1 method) and 400 ppm K (ammonium acetate method) usually reflect substantial manure application in the past.

Sample the representative fields every year to assess trends over time. If you grow corn silage and perennial grass forage, plan to sample at least four grass fields and four corn fields each year. At a small dairy (fewer than four fields), sample all fields each year.

Other fields

Periodically, you will need to evaluate the fields not designated as "representative" fields. Consider sampling all fields every 3 years. Compare whole farm soil data to representative field data.

If you have only a few fields with elevated soil test N, then focus management on those fields. If all fields on the farm give similar test data, then focus your N management efforts at the whole farm level. If representative fields consistently have test values of less than 15 ppm (grass) or less than 20 ppm (corn) over a 3-year period, and all other fields sampled have similar test values, consider reducing the number of post-harvest soil nitrate tests.

Sampling priority

Prioritize fields for fall sampling ahead of time so that you get high-priority fields sampled at an appropriate time. Highest priority should be given to representative fields used to track long-term trends. Fields with high manure application rates or elevated soil test N the previous year should also have a high priority.

Corn fields can be sampled for soil nitrate in June (PSNT, pre-sidedress nitrate test) or in the fall (post-harvest test described in this publication). You will get the most management information by sampling your high-priority representative corn fields both in June (PSNT) and after harvest. You also may want to sample fields with PSNT values greater than 45 ppm nitrate-N again in the fall.

For other corn fields where only one soil test per year is planned, we recommend using the PSNT in preference to the post-harvest soil nitrate test. The PSNT is preferred because test results are applicable to in-season N management. Growers can save money and reduce post-harvest nitrate by omitting sidedress N fertilizer application on fields where sufficient soil nitrate-N is present in June.

Sampling corn fields at PSNT time also will reduce the number of post-harvest samples that need to be collected during the short interval between harvest and the end of the fall sampling window (approximately October 15). If you miss a planned fall sampling on a corn field, consider sampling next year using the PSNT.

Grass fields are best sampled in the fall, using the protocols described in this publication. Think carefully about the best way to achieve consistent timing of sample collection for your fields. The timing of manure application and the timing of grass harvest are key variables to consider.

Samples collected shortly after manure application are not a good indicator of the balance between N supply and crop N demand over the entire growing season. If manure is applied late in the year, postpone soil sampling until after a fall grass harvest. Wait at least 30 days after a late-season manure application before sampling. Sampling need *not* be postponed until after the last manure application or until after the last grass harvest in the fall.

Questions and answers

Why is it difficult to achieve post-harvest nitrate-N less than 15 to 20 ppm with organic sources such as manure?

First, the timing and rate of application for organic sources is less flexible than for fertilizer N. Second, environmental processes that control the quantity and timing of N availability from organic sources are difficult to manage. The biggest factors controlling N availability are soil temperature and moisture. The timing of crop N uptake usually does not match the timing of N supplied from manure and other organic sources. Soil temperature and moisture often support continued release of available N after crop N uptake is complete.

Is there a relationship between soil organic matter content and potential N mineralization?

Research west of the Cascades has demonstrated a lack of correlation between soil organic matter content and N mineralization potential for soils having 3 to 8 percent organic matter. The active fraction of soil organic matter that controls annual N mineralization rates is a small proportion of total organic matter (usually less than 10 percent of total). Recent site management affects soil N mineralization potential; it does not have much effect on soil organic matter content. Because most soil total N is contained in soil organic matter, soil total N is also an unreliable indicator of mineralization potential.

What other soil tests can be used to provide information to guide N management for corn?

Soil nitrate testing in spring and early summer can assist with N management for silage corn. Test soil ammonium + nitrate-N several weeks after a spring manure application to track early-season N availability. Test soil nitrate when corn is at the four- to six-leaf stage (pre-sidedress nitrate test, PSNT) to determine the need for sidedress N application to corn.

How much variability should I expect in post-harvest nitrate-N test values for the same grass field sampled between August 15 and October 15?

It all depends on weather, soil biology, and crop management. A good stand of actively growing grass can maintain nitrate-N concentrations of less than 15 ppm throughout the post-harvest sampling period. Where soil is dry in late summer, increased N availability may occur for 2 or 3 weeks following the first heavy rain. It may be useful to take several soil nitrate tests from the same field in the fall to document changes in nitrate concentration with time. Soil nitrate values given in the interpretive table in this publication are for typical precipitation and sampling date.

Ammonium-N is plant-available. Why doesn't the post-harvest test include ammonium-N analysis?

Post-harvest ammonium-N analyses cost money, and they do not yield reliable interpretive information. Ammonium-N does not accumulate in soils supplied with an excess of plant-available N. It is rapidly converted to nitrate. Soil samples taken at least 30 days after manure application usually have negligible ammonium-N concentrations unless soil has remained dry.

Drying of soils after sampling releases ammonium-N from microbial biomass. Most dried soils have 2 to 20 ppm ammonium-N that is caused by the soil drying process. Dry soil ammonium-N concentrations are poorly correlated with other indices of N availability in controlled experiments.

Should post-harvest nitrate tests be used for fields with organic soils?

Other methods should be used to assess the success of nutrient management plans on organic soils. Goals for post-harvest nitrate-N of less than 20 ppm are difficult if not impossible to attain on organic soils, which contain more than 20 percent organic matter. These soils formed as organic matter accumulated under natural poorly drained conditions. Soil organic matter decomposition and N mineralization processes are greatly accelerated under typical farming practices such as artificial drainage and tillage.

Should I measure or estimate soil bulk density to estimate post-harvest nitrate-N in units of pounds per acre?

The variation in bulk densities among soils typically is less than the variation associated with soil nitrate sampling and testing. Interpretive information in this publication is based on units of parts per million (ppm; mg per kg dry soil). You can approximate soil nitrate-N in the surface foot of soil by assuming typical bulk density (ppm x 3.5 = lb/acre). This conversion factor is based on the weight of 1 acre-foot of soil at a bulk density of 1.3 g cm^3 (1 acre-foot = 3.5 million lb). Organic soils (more than 20 percent organic matter) have lower bulk density (0.6 to 0.8 g cm^3).

What is whole farm nutrient management?

The goals of whole farm management are: (1) to move toward a balance of nutrient imports and exports, and (2) to utilize nutrients on the farm at agronomic rates that minimize nutrient losses to the environment. Managing nutrients at the whole farm level requires knowledge of the major nutrient imports, major nutrient exports, crop utilization of nutrients on the farm, and nutrient losses to air and water.

The Livestock and Poultry Environmental Stewardship (LPES) Curriculum, available through the Midwest Plan Service, includes a Web presentation of whole farm nutrient management principles and a worksheet for evaluating whole farm nutrient balance. See "For more information" (page 15) for details.

What is the role of post-harvest nitrate testing in connection with Comprehensive Nutrient Management Plans (CNMPs)?

CNMPs, developed by the Natural Resources Conservation Service (NRCS) or other nutrient management professionals under NRCS supervision, are broader than just nutrient management. Other components of a CNMP are: (1) manure and wastewater handling and storage, (2) land treatment practices, (3) record-keeping, (4) feed management, and (5) other waste utilization options.

Post-harvest nitrate test values may be used as part of a process to develop a new CNMP or to update an existing CNMP. The CNMP typically includes a plan for regular soil testing. Appropriate timing of the post-harvest nitrate test is critical (see "When to sample," page 2), while soil samples for P and K analysis may be collected any time of the year. Soil samples collected for the post-harvest nitrate test can be analyzed by routine agronomic soil testing procedures and used in developing plans for P and K utilization in a CNMP.

What are the implications of high nitrate concentrations in forages?

Nitrate in ensiled forages can interfere with normal fermentation processes, resulting in poor-quality forage. Forage nitrate affects the distribution of nitrogen compounds in silage. It is difficult to use the silage to formulate rations that meet cow needs for specific protein fractions. Enough nitrate is sometimes present in the silage itself to create a health risk to the animal. Grass silage that is greater than 21 percent crude protein should be tested for the level of nitrate-N. See Johnson et al. (2002) for interpretation of forage nitrate concentrations.

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Many OSU Extension Service publications, as well as additional gardening information, may be viewed or downloaded from the Web (http://eesc.oregonstate.edu).

Copies of many of our publications and videos also are available from OSU Extension and Experiment Station Communications. For prices and ordering information, visit our online catalog (http://eesc.oregonstate.edu) or contact us by fax (541-737-0817), e-mail (puborders@oregonstate.edu), or phone (541-737-2513).

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Agricultural Composting and Water Quality

L. Brewer, N. Andrews, D. Sullivan, and W. Gehr

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Composting, a controlled process for stabilization of organic matter, can turn waste into a valuable soil amendment. Creating compost from waste materials provides an opportunity to return nutrients and organic matter to the soil, a proven practice for soil quality enhancement. Compost can improve crop growth and provide environmental benefits by improving soil tilth and its capacity to absorb and hold water and plant nutrients. A properly managed composting process can destroy weed seeds, plant pathogens, and human pathogens.

This publication is designed to assist farmers in conducting efficient, cost-effective, on-farm composting that presents reduced risk to surface and groundwater quality. It was written for operators of small to medium-size on-farm composting enterprises who handle about 100 to 5,000 tons of raw organic material per year.

Most on-farm composting enterprises are now required to operate under some form of permit. The type of permit, and the details specified in it, vary depending upon the situation. Before you begin composting, understand the regulations that apply to your activities.

The Oregon Department of Environmental Quality (DEQ) revised its composting regulations in 2009. This publication is intended to assist farmers who are regulated by DEQ rules to

Photo by Dan Sullivan, © Oregon State University

Compost can improve soil quality and plant growth. Sunflowers in compost-amended soil (right) vs. no compost (left).

Oregon State UNIVERSITY

Extension Service

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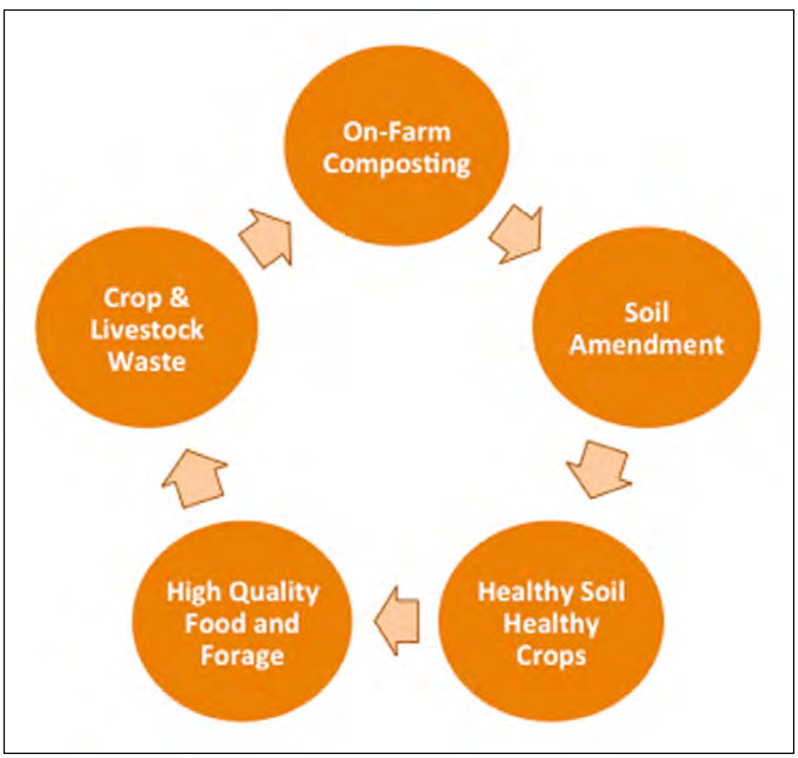
qualify for DEQ registration permits, the simplest DEQ composting permit. Livestock operations that compost manure under a permit from the Oregon Department of Agriculture may not need a DEQ permit.

This publication is organized into six interrelated chapters. We recommend that you spend a few minutes browsing the whole publication. If you are new to composting, some of the basic compost process terms and options are outlined in Chapters 1 and 4. If you are an experienced composter, you might want to view water quality issues first.

Inside, you'll find:

As you read these chapters, jot down notes and ideas. These can help you develop a site plan and management strategy that will maximize the efficiency of the composting process and minimize threats to water quality.



The compost cycle

Chapter 1

On-Farm Composting: What You Need to Know

Composting on the farm is an enterprise. This chapter discusses two important aspects of enterprise development: the potential value of compost, and regulatory considerations.

The value of composting

Composting waste from crops or livestock reduces the volume of the material, converting it from a potential problem into a valuable resource. Crop farmers value compost as an amendment for field soil or as an ingredient in potting mix. Livestock operations can turn manure into a value-added product such as bedding or a soil amendment. When applied to the soil, compost can:

- Improve soil physical properties like water infiltration, aggregate stability, and water-holding capacity
- Improve soil chemical properties like nutrient content and cation exchange capacity
- Improve soil biological properties like disease suppression and nutrient cycling

Photo by Nick Andrews, © Oregon State University

Making your own compost gives you control over feedstock. You also have control over the quality of the finished compost, such as its maturity, stability, weed seed and human pathogen content, nutrient and salt content, particle size, and herbicide residues.

Making your own compost may save money as well. Some farmers compost feedstock from their own farms and other nearby sources, using relatively low-cost methods to produce a valuable product. It's always recommended that you compare that cost to the ultimate value of the crops you produce.

Rules for Oregon composting facilities

Composting is the managed biological decomposition of feedstock that includes but is not limited to reducing particle size, adding moisture, manipulating piles, and performing procedures to achieve human pathogen reduction. **Leachate** is any water that has come into contact with compost or feedstock. Leachate can easily contaminate surface or groundwater and may pose risks to health and the environment.

The Oregon DEQ implemented composting rules in September 2009 that establish environmental performance standards and permit requirements for composting facilities. DEQ's goal is to promote composting while protecting public health and the environment, including water quality. You will find the complete rules on the DEQ website "Composting Program Policy and Composting Facility Rules" (see "References and Resources," page 27).

All non-CAFO operations (concentrated animal feeding operations) that compost 100 tons or more of feedstock per year, or more than 20 tons of animal carcasses or meat waste per year, must submit screening information and a Land Use Compatibility Statement to DEQ to apply for a composting permit. A Land Use Compatibility Statement is a document signed by a city or county planner after a period of public comment. DEQ reviews the application, conducts a site visit, and evaluates the level of environmental risk posed by the composting site. During the screening process, DEQ staff can help identify ways to minimize environmental risk.

Low-risk sites are issued a simple **registration permit**. These facilities must follow their composting plan and meet environmental standards. They must also notify DEQ of any changes to the plan.

If DEQ determines that your site poses greater environmental risk, you may be required to submit a site operations plan as a step toward receiving a **composting permit**. If you are required to develop permanent infrastructure at your composting site to protect the environment, seek professional guidance if needed. This publication does not address the technical details involved in designing composting pads, roofs, or leachate collection and treatment systems.

If you apply for a composting facility environmental risk screening, you may wish to review your plans with DEQ staff before you develop or modify your site. Detailed information about the DEQ rules is available at http://www.deq.state.or.us/lq/sw/compost/

Photo by Dan Sullivan, © Oregon State University

Seasonal runoff.

Chapter 2

Site Selection

Thoughtful site selection will minimize your composting operation's risk to surface and groundwater. It reduces the need for expensive infrastructure and improves process efficiency. When choosing a site for your on-farm composting operation, consider the following:

- Whether the site will operate seasonally or year-round
- The volume of materials to be processed, cured, and stored, and the space available for these activities
- Capacity of the site to support equipment traffic during the rainy season
- Depth of the seasonal high water table
- Proximity to drinking water wells and septic systems
- Topography of the site and its distance from surface water, including ditches, wells, and tile drains

Site infrastructure

Dedicated composting areas should be large enough to stockpile feedstock; blend, build, and manage actively composting piles; and store compost while it is curing and until use. The composting method you choose dictates the size of your site and whether it needs surface improvement, electricity, access for equipment, and a water source. See Chapter 4 for more detail on the requirements for the various composting methods.

The availability of feedstock and the need for storage before composting will clarify some requirements for site infrastructure. For example:

- Livestock operations produce manure year-round. Most raw manure requires covered storage or a year-round site for continuous composting.
- Food waste and yard debris rich with grass clippings require immediate incorporation into bulking materials to avoid problems with odors, rodents, and flies.

Choose a site with surface soil that is firm enough to support heavy equipment during periods of high use.

When you choose your site, be a good neighbor and reduce the potential for

Photo by Dan Sullivan, © Oregon State University

Roofed composting area

complaints. Use distance, trees, and existing buildings as buffers to keep noise, dust, and odors from neighboring properties.

Specialists at Oregon DEQ can assist you in choosing likely composting sites on your property, and advise you on the merits of one site over another to minimize water quality impacts.

Site features and management practices affecting water quality

Soil

The nature of the soils and geologic strata beneath your composting site determines the risk to groundwater and neighboring wells. Soils differ in many characteristics that control infiltration, drainage, and runoff. The NRCS Web Soil Survey provides general information about the soils beneath your site and what these soil characteristics mean for water movement. DEQ specialists will evaluate geologic strata underlying the site for their potential to allow leachate to reach groundwater.

Exposed feedstock

Raw feedstock exposed to wet weather can lead to surface or groundwater contamination. These materials and wet feedstock must be quickly combined with dry, high-carbon material to reduce leachate, odor, and fly problems. See Table 6 (page 24) for the relative water quality risk of contrasting feedstock.

In general, the risk of nutrients and pathogens reaching water is reduced during the dry season.

Proximity to surface water

There is no fixed distance-to-surface-water rule, but farther—100 feet or more—is usually better. See Chapter 6 for information on berms, filter strips, and other techniques, and their roles in protecting water quality.

Plug tile drains under or adjacent to the compost site to prevent transfer of runoff and leachate to surface water. Convert unvegetated drainage ditches to grassy swales.

Topography

Moderate slopes reduce pooling. Excessive slopes accelerate the rate at which water leaves the site and may promote erosion. Choose a site with a gentle slope, or grade a steeper site to a 1- to 2-percent slope to avoid erosion.

Site management

During site construction, take measures to prevent erosion and runoff. Common strategies include building silt fences and filter berms and re-establishing grass or other soil-retaining vegetation soon after construction.

Siting assistance

Without access to specialized information, it can be almost impossible to predict the likelihood of leachate reaching groundwater. While reviewing your application for environmental risk screening, DEQ staff can assist you in finding areas on your farm where you can compost with minimal environmental impact, and often with minimal infrastructure. If you provide them the legal description of your proposed site, they'll send you soil maps, soil descriptions, an indication of the depth to the aquifer, and characteristics of the overlying soil. This information can help you site the operation. It may help you think of ways to protect water quality during construction and use of the site.

The Natural Resources Conservation Service (NRCS) Web Soil Survey can help you identify the areas on your farm that have limitations for use as a composting site. http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx

Consider how you may use the site after the composting operation ends. Remediating compaction from heavy equipment may require extra effort.

See Chapter 6 for more information.

Keep these guidelines in mind when you choose your site.

- Consider space requirements, and accessibility and availability of electricity and water.
- Choose a site with surface soil that is dry and firm enough during the dry season to support heavy equipment during periods of high use.
- Minimize leachate potential by composting as much as possible during the dry season and managing water additions. Locate compost sites as far as possible from wells, drainage ditches, and surface water. Plug tile drains. Avoid sites with high seasonal water tables.
- A gentle slope and permanent grass filter strips reduce the risk of erosion.

Photo by Dan Sullivan, © Oregon State University

Even on well-drained soils, compaction can make the site unusable in midwinter.

Chapter 3

Compost Site Layout and Design

Thoughtful site layout and design promote the efficient production of quality compost and protect water quality. This chapter covers the characteristics of good composting sites, how to estimate the area required, and how to organize your site so that the work process flows smoothly. Be sure to choose your site and plan the layout and workflow before you collect any feedstock or begin composting.

Here we focus on site designs that do not require permanent structures. Temporary sites that will be returned to farming within a few years are designed differently than permanent sites. If your site requires permanent structures, seek professional guidance (as from a consulting engineer) if needed.

We recommend that you sketch your site and then stake it out before beginning construction.

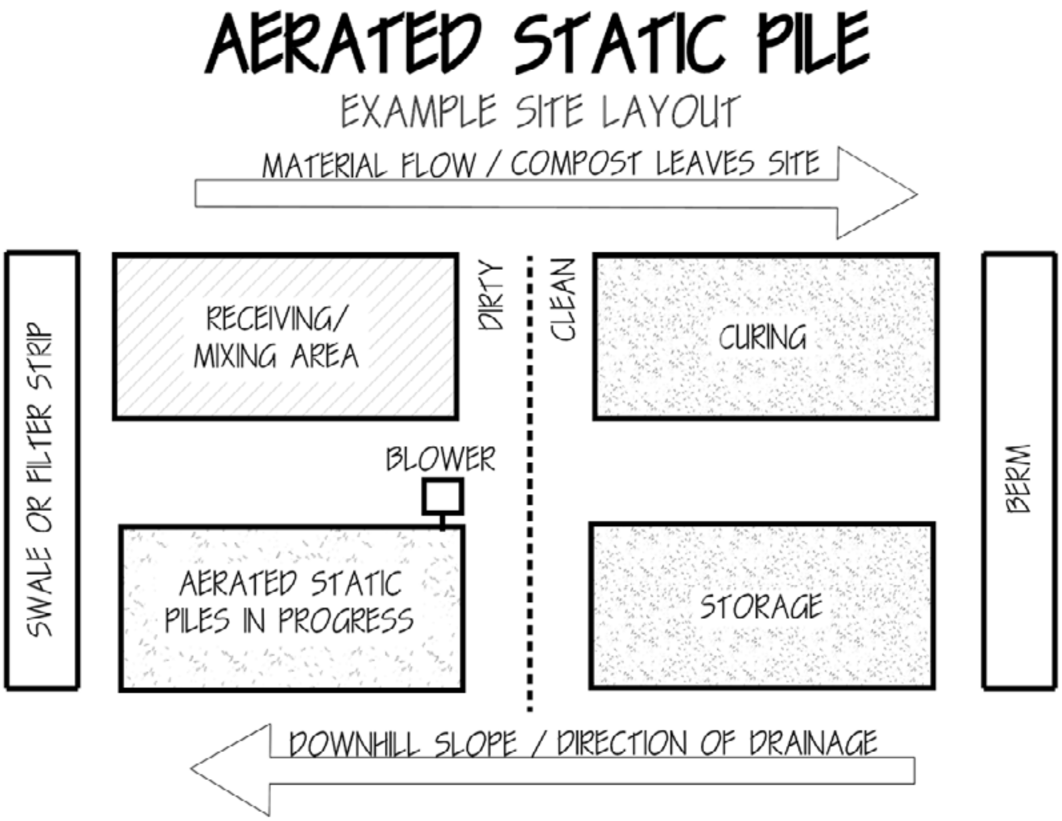
Site layout

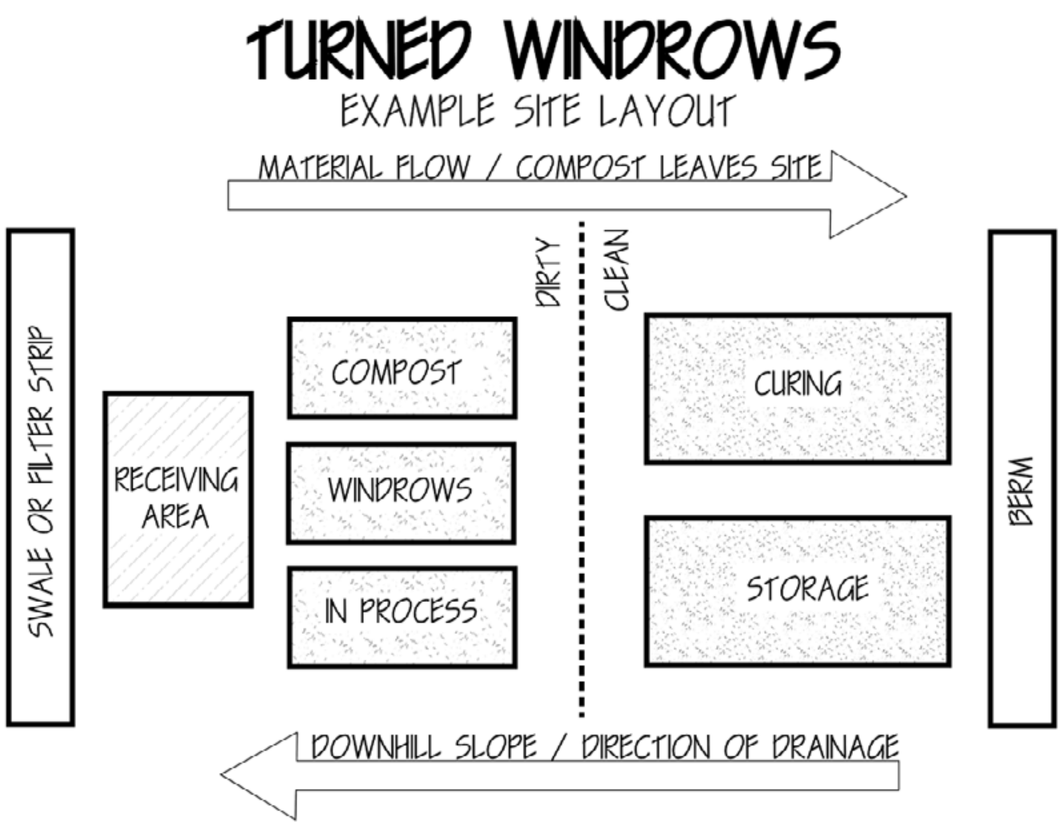
Plan the site so that material is easily handled and moved through the composting process. Adjust the length of piles and space between piles to minimize movement of materials. This approach maximizes the volume of compost produced per square foot of the site. Add the areas required for each phase and activity of the composting process to determine the total area for your operation.

Figure 1 (page 9) shows a typical site layout for two types of composting operations. Use these illustrations as a general guide when planning the layout of your compost site. Note the movement of materials across the site. Notice that finished and stored compost occupy the higher side of the site, and feedstock is received at the lower side. This prevents the finished compost from being contaminated by materials with higher pathogen content. (The dashed line divides the clean side from the dirty side.) If possible, select a site with a slope that follows the prevailing wind direction. This will minimize the spread of pathogens by wind and water within the production area.

Berms placed upslope from large piles divert water away from them. The illustrations show typical placement of berms to direct surface flows away from the composting site and swales or filter strips to filter or direct flows downstream from the composting site. See Chapter 6 for more ideas and information.

Figure 1. Concepts for site design.





Compute the size of your composting area

First, determine the volume of feedstock at peak times. Then, estimate the footprint of the receiving and mixing area, and of the active composting, curing, and storage areas. Finally, allow enough space between areas to manage the compost and maintain the site. Use Table 1 to calculate the footprint of a compost windrow. Pile volume and footprint vary with the shape of the pile. Table 1 assumes a compost windrow with a rounded top to be turned with a front-end loader. The *On-Farm Composting Handbook* (see "References and Resources," page 27) contains formulas and tables to help you calculate the footprint of other pile profiles.

Table 1. Calculate the footprint of a turned compost pile.

Line	Calculation	Formula	Example	Your pile
1	Volume of compost		200 yd^3	
2	Width of the base (yd)		4 yards	
3	Pile height (yd)		2 yards	
4	Area of cross section (yd^2)	⅔ x width x height	2 x 4 x ⅔ = 5⅓ yd^2	
5	Pile length (yd)	volume ÷ cross section Line 1 ÷ Line 4	200 ÷ 5⅓ = 37½ yd	
6	Area of footprint (yd^2)	width x length Line 2 ÷ Line 5	4 x 37½ = 150 yd^2	

Table 1 assumes you have an estimate of the volume of feedstock you will compost. You can adjust the measurements for the width of the base and the height of the pile to try out various site configurations.

Active composting reduces pile volume as carbon dioxide is released, particle size is reduced, and the pile settles. The amount of reduction depends on the type of feedstock. Plant materials reduce more than manure, which reduces more than wood products or soil. A rough guide to reduction might be that curing piles are about 55 percent of the original feedstock volume and finished compost is about 45 percent. Curing and storage piles can be as high as 12 to 18 feet, limited only by the lifting capacity of the loader or excavator. For piles to be at least 3 feet high after a month of active composting, build them higher than 3 feet initially.

In your plan, allow room for alleyways and pile edges. Driving on the edge of a pile creates undesirable compaction of the compost. Consider whether more than one piece of equipment may be operating at the same time. If so, allow enough space so that vehicles can pass. Windrow turners require 25 to 45 feet to turn at the end of each row. Allow enough room between piles to maneuver your tractor for front-end loader turned piles. See Chapter 4 for more detail on pile turning methods.

Combine small compost piles whenever possible. Their high surface-to-volume ratio and low water-holding capacity can generate high volumes of leachate.

Infrastructure for high-risk feedstock

There are several strategies for handling high-risk feedstock with the goal of protecting water quality. Each strategy has advantages and limitations. From most expensive to least expensive, options include:

- Build a feedstock handling facility with a roof and composting pad.
- Build a roof without a pad or a pad without a roof.
- Cover feedstock with a tarp.
- Store feedstock, such as deep bedded litter, in the barn until you actively compost it.
- Receive high-risk feedstock from off the farm only during the dry season.

High-risk feedstock that is exposed to wet weather can lead to surface or groundwater contamination. Some high-risk feedstock, such as food waste or livestock mortalities, is not amenable to storage and must be composted immediately. See Table 6 (page 24) for a comparison of feedstock and water quality risk.

Impermeable pads do not prevent leachate generation, but they can allow you to collect, store, and use this liquid appropriately. Compost pads allow material handling during wet weather, though they can be expensive. They limit infiltration of air and water into the soil, change the soil's microbial community, and prevent you from using the site for other purposes.

Covers prevent storm water from coming into contact with high-risk feedstock and can prevent leachate generation. Well-managed, active compost piles often generate enough heat to evaporate excess moisture and reduce the need for covers.

Keep these guidelines in mind when you design and lay out your site.

Pile orientation

- Choose a site with a gentle slope, or grade a 1- to 2-percent slope to avoid puddles or erosion. Orient piles parallel to the slope to minimize leachate production during high rainfall seasons.
- Place curing and storage piles at the top of the slope, with active composting areas just below, and feedstock receiving areas at the bottom. Runoff from curing and storage areas is generally much cleaner than runoff from the receiving and active composting areas.

Site size

- Feedstock availability and quantity dictate in part how much area you must devote to composting. Estimate the volume of material you plan to handle,

Erosion control

Prior to site construction, check state and local ordinances to see whether grading or erosion control permits are required. In these cases, the agency issuing the permit identifies and enforces the conditions to control erosion. Current regulations (2013) require that composting site preparation that disturbs an area larger than 1 acre requires a DEQ 1200C Erosion Control Permit.

Whether or not a permit is required, land stewardship dictates that erosion and impacts to surface water be minimized during site construction. Gentle, 1 to 2 percent slopes with straw or hay bales, filter berms, and filter strips can reduce erosion.

and calculate the area needed for feedstock, active composting, and curing piles.

- Make feedstock collection and handling areas as small as practical. Smaller areas force timely management of fresh feedstock and reduce the area to be cleaned and maintained.
- Combine small piles to minimize the area under cover. Small, unmanaged quantities of feedstock or compost can generate large volumes of leachate.
- Reserve uncovered storage space for bulking agents and very stable feedstock, such as leaves or straw.
- Work high-risk feedstock into bulking agents immediately upon arrival at your site; never store them.
- Plan a storage area for finished compost that can accommodate compost production sufficient for farm needs.

Site maintenance

- Create a layout that allows smooth movement of material and equipment through the site and minimizes leachate generation.
- Sod in alleyways may improve traction and reduce runoff. Mow the grass periodically during the growing season and compost it.
- Allow room to keep alleyways and areas near the piles clean. Small mounds of compost and the edges of piles have low water-holding capacity and can generate high volumes of leachate.
- Consider whether there may be more than one piece of equipment operating at the same time. If so, be sure access areas are wide enough to allow vehicles to pass.
- Allow enough space to maneuver equipment without compacting the edges of compost piles.

Photo by Nick Andrews, © Oregon State University

Sod may improve traction in alleyways.

Chapter 4

Choose the Composting Method That's Right for You

Choose a composting method that suits your farm, your feedstock, and your goals. Consider the characteristics you want in the finished compost and the equipment available to you. Manage your composting operation to meet the needs of your farm while protecting water quality.

Composting operations tend to evolve over time according to the manager's experience, the scale of the operation, and opportunities to reduce cost. The most common methods of on-farm composting are **turned windrows** and **aerated static piles**. They differ in aeration management.

Turned windrows

Compost managed as turned windrows is aerated by physically moving the composting feedstock. Turning a pile reduces particle size and breaks apart clumps of feedstock which can otherwise become anaerobic. Turning increases oxygen levels in the pile for a short time and provides a good opportunity to adjust pile moisture content and further mix materials. Common equipment for turning windrows includes front-end loaders and windrow turners.

Turning with a front-end loader

A front-end loader is a common piece of farm equipment that you may already own. It provides a convenient way to proportion and mix feedstock. Three to five turns may be required for adequate mixing. This is a slower process than other forms of mixing and requires more area per unit of feedstock. See Tables 2, 3, and 4 in this chapter (pages 15 and 16) for design limits and opportunities associated with using a front-end loader to turn piles.

An adaptation of this method turns compost with a front-end loader and a manure spreader. Although two tractors are required, it is a very effective method to build and turn compost windrows. The manure spreader is attached to one tractor and the front-end loader is attached to the other. The front-end loader loads feedstock into the manure spreader. As the spreader gradually moves forward, the feedstock is spun out, creating a windrow. The same technique is used to turn the windrow. A hose-fed metal water pipe with spray nozzles installed along its length can be added to the back of the manure spreader to add water while turning compost.

Photo by Nick Andrews, © Oregon State University

Turning with a windrow turner

A windrow turner is a piece of specialty equipment that enhances compost homogeneity and simplifies adding water. You'll need a front-end loader to proportion feedstock and shape the windrows so that they fit within the turner's capacity. The tractor that pulls the windrow turner must have creeper gears. Self-propelled units are available.

Photo by Nick Andrews, © Oregon State University

Windrow turner

Use the turner to mix and water the pile during the first 1 to 2 months. Base turning decisions on pile temperature and moisture levels; add water as needed during turning. In a typical turning schedule, you would turn weekly for the first month, and once or twice more after that as the pile begins to cool. Turning without watering reduces moisture content, which may or may not be desirable. If adding more water is not an option, conserve moisture levels by building larger piles and turning them less frequently.

Combine windrows as they shrink and stockpile them into curing or storage piles when they are finished. Because turning costs time and money, many on-farm composters seek to minimize this activity. See tables 2, 3, and 4 (pages 15 and 16) for design limits and opportunities associated with windrow turners.

Aerated static piles

Aerated static piles (ASP) are aerated with an electric blower connected to a network of aeration pipes. ASPs are turned much less frequently than turned windrows, and generally not at all during the first 30 days of composting.

Place a layer of coarse woodchips or other porous material over the pipes to allow even distribution of air at the base of the pile. Then use a front-end loader to proportion and mix feedstock and to shape piles. The air flows through the compost, maintaining aerobic conditions throughout the pile. After 1 month, remix the pile with a loader, adding water if needed. Energetic feedstock may reheat or generate odors after re-wetting, indicating that the composting process is not yet complete.

Blowers can be plumbed to push air through the pile, pull air from the pile, or alternate air flow direction. Cycle timers often are used to operate the blowers at desired intervals.

Photo by Nick Andrews, © Oregon State University

Blowers can be plumbed to push air through the pile, pull air from the pile, or alternate air flow direction.

Pulling air from the pile reduces moisture and helps manage odor, but it generates significant condensate that must be removed with a trap and treated as leachate. This condensate is corrosive, so blowers may require more frequent maintenance.

Ideally, freshly-built piles are covered with a 6- to 12-inch layer of clean woody feedstock or finished compost. See Chapter 5 for more detail about covering compost.

For highly engineered systems, seek professional guidance to correctly calculate pipe diameter-to-length ratio and the number and size of orifices and pump capacity. On a less complex system, with careful attention, trial and error may suffice. See Tables 2, 3, and 4 (page 16) for design limits and opportunities associated with aerated static piles.

Comparison of composting methods

As you consider the composting opportunities, needs, and goals for your farm, use the following tables to determine the method that is right for you. These tables offer comparisons of overall performance, space requirements, and management tasks for windrows turned with a front-end loader or with a windrow turner, and for aerated static piles.

Table 2. Composting methods: compare overall performance

Method	Cost	PFRP[1]	Time to finished compost
Windrow—front-end loader	Minimal added investment	May not consistently meet PFRP with infrequent turning	6–12 months
Windrow—windrow turner	Specialty equipment	Routinely meets PFRP in 15 days with 5+ turns	2–6 months
Aerated static pile (ASP)	Engineering, design consultation advisable	Routinely meets PFRP in 3 days	2–4 months. Usually ASP for 2+ weeks, until temperature drops. Then, curing for 1–3 months.

[1] PFRP is a composting process that meets prescribed conditions for human pathogen control. See page 18 for details.

Table 3. Composting methods: compare space requirements

Method	Space	Height	Width	Distance between piles
Windrow—front-end loader	Largest site	5–8 feet	Base: 12–18 feet	Aisles wide enough for bucket loader and other equipment.
Windrow—windrow turner	Intermediate	Dictated by turner height	Dictated by turner width	Depends on turner. Self-propelled units allow narrow alleyways. Wider aisles for tractor-mounted units. Aisle clean-up may be hand labor.
Aerated static pile (ASP)	Smallest site for active (hot) composting. Same area needed for curing as with other methods.	8–12 feet	Dictated by pipe and blower capacity	Saves space because PFRP is rapidly met and active composting area is reused more often. Compost can be put into larger curing piles after about a month.

Table 4. Composting methods: compare management tasks

Method	Feedstock mixing	Turning frequency	Adding water
Windrow—front-end loader	Materials must be well mixed prior to forming windrows.	Usually turned two or three times.	Hard to do when turning.
Windrow—windrow turner	Turning provides additional mixing. Turning usually reduces particle size and porosity.	Usually turned more than four times during active composting, and several times during curing.	Most turners can be equipped with a water supply hose to wet feedstock when turning.
Aerated static pile (ASP)	Feedstock must be well mixed and raised to the proper moisture level before the ASP is formed.	Mix when ASP is taken down and moved to curing site.	Cannot add water after ASP is formed. Can add water when moving compost to curing site. Forced air movement through ASP increases rate of water loss.

Keep these guidelines in mind for all composting methods.

- Evenly shaped windrows have fewer dry spots and process more evenly.
- Plan ahead. Keep piles slightly drier before and during seasonal rains and wetter just before and during seasonal dry periods.
- Direct flowing water away from the edges of the piles and reduce leachate generation.

Photo by Nick Andrews, © Oregon State University

Perforated pipe laid at the angle of repose as the pile is built provides passive aeration.

Chapter 5

The Composting Process and its Impact on Water Quality

The practices that protect water quality also contribute to the production of high quality compost. Composting proceeds efficiently when there is adequate moisture and porosity, and a good carbon-to-nitrogen ratio.

Carbon and nitrogen

Think of compost feedstock as a food supply for decomposer bacteria and fungi. For humans, a quality diet is expressed as recommended daily allowances. For decomposer organisms, a quality diet is expressed as carbon-to-nitrogen ratio (C:N).With a balanced C:N, decomposer organisms efficiently use up the available nutrients and leave less nitrogen to escape into the environment.

The process of balancing the C:N of your available feedstock is like formulating a recipe. Starting with the right mix of carbon to nitrogen can contribute to an efficient composting process and quality compost. Consider whether the feedstock available on your farm requires supplemental feedstock to compost well. If it does, look for nearby feedstock that will provide the C or N you need. Many materials compost well without additional feedstock.

Mixtures of feedstock with 20 to 40 parts carbon to one part nitrogen (20:1 to 40:1) compost well. The WSU Compost Mix Calculator (see page 21) provides typical values for the C:N ratio of feedstock and calculates the C:N ratio of different feedstock combinations. Well-mixed piles use nitrogen efficiently, decompose feedstock quickly, and heat up enough to reduce plant and human pathogens and kill weed seeds. Agricultural testing laboratories can provide an analysis of C:N as well as other nutrients, permitting you to optimize feedstock mixtures. See the sidebar on page 21 for a summary of National Organic Program standards for compost.

Feedstock that contains more nitrogen than decomposers can use releases nitrogen as ammonia gas (NH_3) or as soluble nitrate (NO_3). Released nitrogen reduces air and water quality and wastes valuable plant nutrients. With too little nitrogen, much of the carbon goes undigested, and the compost pile may not heat up enough to kill weed seeds and pathogens. See the sidebar on page 18 about processes to further reduce pathogens (PFRP).

Water quality risks of contrasting feedstocks

Feedstock with higher nutrient content, lower C:N, or more pathogens poses greater risk to water quality than other feedstock. High-risk feedstock is more likely to require covers and pads or other infrastructure than low-risk feedstock. Table 6 (page 24) rates the relative environmental risk of common feedstock.

Use caution and experiment on a small scale with higher risk feedstock, until you understand how to manage it properly.

Herbicides in feedstock

It can be difficult to know whether feedstock originating off-farm has been exposed to herbicides that can persist through the composting process. Compost contaminated with some pyridine herbicides such as chloropyralid and aminopyralid can harm sensitive plants. These materials are active in compost at low concentrations.

The herbicide labels indicate that the feedstock provider must warn you at the time of transfer that persistent pesticides have been used on the feedstock. This often is not done, and if feedstock changes hands through a middleman or hauler, that person may not know. Washington State University Extension Service offers a simple bioassay for persistent herbicides at: http://www.puyallup.wsu.edu/soilmgt/clopyralid.htm

Aside from pesticides, you could bring disease or weed seeds onto your property in feedstock originating off-farm. The best way to avoid these problems is to talk to the feedstock provider about the source of materials, pesticide applications, and other contaminant risks.

The molecular form of carbon-rich material influences its susceptibility to decomposition. Fresh, soft, green leaves, fruits, and processed grains contain carbon in the form of simple sugars. Bacteria readily digest these materials, often within 2 to 10 days. This form of carbon is called **available carbon**. Straw, stems, hulls, bark, and wood are made of cellulose, hemi-cellulose, and lignin. These **complex carbons** are more resistant to decomposition. In active compost piles, many of these materials will decompose fairly quickly, but larger wood particles do not. Under dry conditions, fungi decompose woody structures over months or years.

What is PFRP?

PFRP stands for a "process to further reduce pathogens." The U.S. Environmental Protection Agency (EPA) developed standards for PFRPs to reduce human pathogens of concern in biosolids, including *E. coli* 0157:H7, *Salmonella, Staphylococcus, Bacillus, Clostridium, Lysteria,* roundworms, and tapeworms. These pathogens originate in manure and other animal byproducts.

In its composting rules, the Oregon DEQ adopted the EPA's time and temperature requirements (PFRPs) for commercial composting facilities. Commercial composters must meet PFRP before selling compost. Organic growers who include manure feedstock and apply compost less than 90 to 120 days before harvest must also meet these PFRPs, if crops are for human consumption. Commonly used PFRPs include:

Windrows: Compost temperatures must be measured at or above 55°C (131°F) for at least 3 days, between each of five consecutive turning events.

Static aerated piles with an insulation cover must reach 55°C (131°F) for 3 days.

Microbial studies have found that compost managed in windrows may leave viable pathogens in compost, even when PFRP has been met. This occurs because the cooler outer layers of the pile have not reached required temperatures when the internal temperature reading is at or above 55°C or 131°F. Pay careful attention to time, temperature, turning, and moisture levels.

Compost, food safety, and good agricultural practices

Compost use is one of many topics for self-assessment in the National Good Agricultural Practices (GAPs) food safety program: http://www.gaps.cornell.edu/farmassessmentws.html. The program's materials include some questions of importance for composters who apply compost to food crops or sell compost to farmers who do so. For composters, the goal of this program is to ensure that PFRP has been met, and that the compost has not been cross-contaminated after meeting PFRP.

The water used to moisten the curing piles must be clean. Usually, well water has fewer pathogens than surface water from a nearby creek or pond. Leachate from new piles usually has a high pathogen content, so if it is applied to compost, PFRP must be met after leachate application.

Food Safety Modernization Act (FSMA) requirements for composting are similar to those already mandated for compost allowed under the USDA-Organic rule, allowing either windrow or aerated static pile composting methods operated under prescribed time and temperature conditions, followed by adequate compost curing. Check current FSMA rules at the FDA website. http://www.fda.gov/Food/FoodSafety/FSMA/ucm334552.htm#F

Compost moisture content

Correct moisture content is the most important variable in compost management. Without enough water, even feedstock mixtures with ideal C:N will not compost. All compost piles develop dry spots over time. Thorough turning redistributes moisture.

A thin layer of moisture on particles of organic matter is essential for microbes to move and multiply. Excess water can prevent heating and limits the action of more efficient oxygen-breathing (aerobic) bacteria, leaving the pile wet and cold. Under these conditions, composting slows significantly and pathogens may survive in finished compost.

Water holds five times as much heat per gram as compost. Heat is transferred when water evaporates and condenses in a compost pile. When water evaporates in hot spots, heat energy is consumed. The water vapor condenses after rising into cooler spots. During condensation, energy is released and can warm the compost. High-energy feedstock that readily generates heat can lose moisture rapidly as compost heats up. Moisture content below 40 percent by weight severely limits composting. After moisture is provided, dry piles often reheat and complete the composting process.

If your feedstock is too dry or wet, look for supplemental feedstock to increase or decrease the moisture content of the pile. If needed, add water as you build a compost pile, and then adjust moisture as you turn it. Generally, a moisture content of 60 to 65 percent is ideal during the first 2 to 3 weeks of composting. As composting nears completion, consider allowing compost to dry enough for your intended use. For livestock bedding or screening (i.e., for potting soil), drier compost is normally preferred (40 to 45 percent moisture). For field application, avoid dusty or saturated compost and aim for 45 to 55 percent moisture.

Weather and moisture content

Use the weather to your advantage to maintain correct moisture levels. Changes in wind speed, relative humidity, and ambient temperature affect the rate of moisture loss. When the weather is very hot, actively composting piles can lose as much as 2 or 3 percent of their moisture per day. Under these conditions, moisture could decline from 60 percent to 40 percent — too dry to compost — in 1 week. Taller piles tend to conserve moisture.

Maintain moisture at recommended levels. Piles with too much moisture lack sufficient oxygen to support hot, aerobic decomposition, are prone to developing objectionable odors, and may not reach temperature targets. These anaerobic conditions are common with low-energy, uncovered piles in the wet season. Piles that are too dry will not sustain active composting. Manage your compost at optimum moisture ranges to avoid a host of problems, including leachate generation.

Tracking the temperature and moisture content of fresh compost piles through the seasons will sharpen your “composting sense” and support your decisions about when and how to turn or cover your piles relative to weather conditions.

Testing for moisture content

The following methods measure compost pile moisture accurately and consistently.

Hand squeeze test

You can develop the ability to estimate a compost pile's moisture level using the "hand-squeeze" test. With practice, and confirming your estimates with the drying test, your hand becomes "calibrated." This method is fast and useful, but you must practice and compare with results from oven drying.

Reach into the pile and grab a handful of composting material. Observe your fist while squeezing the material firmly. Release your grip, palm up, and observe the material and your hand. Scan the list of observations in Table 5 and estimate your moisture content.

Table 5. Hand squeeze test observation key

Observation	% Moisture
Material is crumbly; doesn't stick together; feels dusty; glove is dry	42 or less
Material feels mostly dry but has a hint of moisture in it	42 to 47
Material feels tacky	47 to 52
Material feels moist	52 to 58
Material sticks together; glove glistens or has a wet sheen	58 to 63
Squeezing releases one to two drops of water	63 to 68
Squeezing releases many drops of water	68 to 73
Squeezing releases a stream of water or material has a pudding texture	>73

Fine-textured materials can give accurate estimates. Coarse-textured materials result in low moisture estimates. Adjust upwards by as much as 4%.

Used with permission of Jeff Gage, Compost Design Services.

Drying test

You can accurately determine the moisture content of a compost sample by weighing it, then drying it with a silage (or similar) dryer. You can use oven or even sun drying if dryers are not available. Weigh and dry the compost repeatedly until the sample loses no additional weight. A reasonable temperature for drying compost is 110 to 140°F. Enter your wet and dry weights into this equation to calculate the percent moisture:

$$[(\text{wet weight} - \text{dry weight}) \div \text{wet weight}] \times 100 = \%\ \text{moisture}$$

The WSU Compost Mix Calculator (see page 21) can help you estimate the amount of water needed to establish good moisture content when mixing a pile.

Porosity and bulk density

Porosity is a measure of the free air space between compost particles. The more a feedstock weighs per unit volume, the less free air there is between its particles. **Bulk density** measures the weight per unit volume of a material. It is inversely related to porosity. The higher the porosity, the lower the bulk density.

An ideal feedstock balances porosity and density, and usually requires less frequent turning to maintain working temperatures. Feedstock porosity influences management of the composting process. High porosity promotes airflow through the pile, which in turn cools it and replenishes the oxygen supply. Because of their capacity to lose water, highly porous mixtures may require more careful moisture content monitoring.

Dense, low porosity feedstock requires more frequent turning or greater air pressure to assure adequate airflow. Detailed directions for measuring porosity and bulk density are included in the WSU Compost Mix Calculator.

WSU Compost Mix Calculator

To determine your feedstock recipe, see Washington State University's **Compost Mix Calculator**, available for download on their "Organic Farming Systems and Nutrient Management" website: http://www.puyallup.wsu.edu/soilmgmt/Pubs/Compost_Mix_Calculator_12dec12.xls. The calculator is an Excel file with six worksheets: a list of feedstock characteristics, a worksheet on which you enter your feedstock characteristics and their proportions in a proposed

What do the National Organic Program standards say about compost?

From §205.203, Soil fertility and crop nutrient management practice standard.

(c) The producer must manage plant and animal materials to maintain or improve soil organic matter content in a manner that does not contribute to contamination of crops, soil, or water by plant nutrients, pathogenic organisms, heavy metals, or residues of prohibited substances. Animal and plant materials include:

(2) Composted plant and animal materials produced through a process that:

(i) Established an initial C:N ratio of between 25:1 and 40:1; and

(ii) Maintained a temperature of between 131°F and 170°F for 3 days using an in-vessel or static aerated pile system; or

(iii) Maintained a temperature of between 131°F and 170°F for 15 days using a windrow composting system, during which period, the materials must be turned a minimum of five times.

(3) Uncomposted plant materials.

The National Organic Standards Board Compost Task Force final report includes the following policy statement that is used for guidance, but is subject to change as needed by the USDA:

Compost, in addition to that described in section 205.203(c)(2), is acceptable if (i) made from only allowed feedstock materials, except for incidental residues that will not lead to contamination, (ii) the compost undergoes an increase in temperature to at least 131°F (55°C) and remains there for a minimum of 3 days, and (iii) the compost pile is mixed or managed to ensure that all of the feedstock heats to the minimum temperature.

http://www.ecfr.gov/cgi-bin/retrieveECFR?gp=1&SID=d2c3a16922f77755841c75898e60283c&ty=HTML&h=L&n=7y3.1.1.9.32&r=PART#7:3.1.1.9.32.3.354.4

mix, a sheet that calculates C:N ratio and water needs of the proposed recipe, and sheets that calculate bulk density and free air space (porosity). Use the Calculator to optimize your compost recipe based on available feedstock, and to calculate bulk density and porosity. In calculations for C:N, ignore woody particles over ½ inch thick. These increase porosity and maintain airflow but provide little available carbon.

Equipment maintenance

When turning or managing your piles, begin with the more processed material (i.e., curing piles) before moving on to less processed, active piles and raw feedstock. Equipment can easily re-contaminate curing compost with pathogens. After handling feedstock or active piles that have not gone through PFRP, thoroughly clean equipment with a pressure washer before handling cured compost. Maintain your equipment so that fuels and lubricants do not contaminate your compost.

Covering piles

Most compost piles in the hot, active phase of composting won't require covering. Lower-risk feedstock, such as leaves and ground woody yard debris, may not require covering until the curing phase.

Carefully monitor a cooling or curing pile and cover it before it becomes saturated and generates leachate. Covered compost is less likely to be re-inoculated with weed seeds or pathogens from stray animals and wildlife, or become too wet for easy use.

The following factors influence how much and how quickly moisture levels increase and leachate can appear:

Composting stage. Fresh, energetic feedstock mixtures are likely to generate enough heat to drive off excess water. More mature piles are less likely to do so. Curing or storage piles may need covering in wet weather. After the end of the active composting phase, curing takes an additional 30 to 60 days.

Shape of the pile. Tall piles with narrow tops and steep sides catch less rainfall and shed rain more easily. Short piles with flatter sides catch more rainfall and shed less rain. Taller curing and storage piles retain moisture and can be covered with smaller tarps. With experience, you can manipulate pile shape to manage moisture content.

Clean pile edges. Compacted soil mixed with compost can quickly generate large amounts of leachate when saturated.

How to cover

Choose one of these methods:

Tarp. Position weighted or tied tarps over the pile so that it sheds water. Tarps must be secured against high winds. While tarping is not recommended for actively composting feedstock, finished compost can be tarped without negative effects.

Build a roof. Actively composting feedstock will benefit from the increased airflow that a roof permits. A roof permits you to easily maintain optimum composting conditions and avoid leachate.

Mulch. Aerated static piles may be covered with a 6- to 12-inch layer of fine, finished compost, sawdust, or other pathogen-free material. However, a mulch cover can be difficult to apply and can require a considerable volume of mulch. This cover layer serves several purposes:

- Retains heat and ensures that all raw materials meet criteria for pathogen destruction (PFRP)
- Reduces odors
- Retains nitrogen and moisture
- Reduces access for birds, rodents, and flies

Photo by Nick Andrews, © Oregon State University

Weighted tarps permit compost piles to shed storm water and reduce leachate generation.

Keep these guidelines in mind when building windrows and during the composting process

- A well-mixed compost recipe with good C:N ratio, moisture content, and porosity will decompose efficiently.
- Build and maintain piles that are large enough to retain moisture during dry weather and absorb moisture without becoming saturated during wet weather.
- Monitor moisture content and adjust as needed when turning.
- Mix and turn energetic or wet feedstock into an active compost pile soon after delivery to avoid strong odors, rodents, and large fly populations.
- Cover piles as needed to protect them from heavy rainfall.
- Control the direction of airflow in aerated static piles to manage moisture content.
- During a slow season, section off unused areas and sweep or scrape them clean. Divert surface water away from these areas.
- Water trucks or irrigation lines are a common way to provide sufficient water when and where it is needed.
- Make sure that the compost is protected from contamination from fueling stations or pesticide mixing areas. If you use compost in filter berms to absorb such spills, you must dispose of it in a landfill. Do not re-incorporate contaminated compost into active or finished compost piles.

Table 6. Relative water quality risk of contrasting feedstock			
Feedstock	**Nutrient content**	**Pathogen content**	**Relative risk to water quality**[1]
Ground wood or bark	Low	Low	Low
Fallen deciduous leaves	Low	Low	Low
Ground woody yard debris	Low	Low	Low
Ground leafy yard debris	Medium	Low	Medium
Wood shavings with some horse manure	Low	High	Medium
Separated dairy solids	Low	High	Medium
Vegetable packing waste	Medium	Low	Medium
Vegetative food waste	Medium	Low	Medium
Mixed food waste	High	Medium	High
Bedding and manure	Medium	High	High
Concentrated manure	High	High	High
Livestock mortalities and slaughterhouse waste	High	High	High

[1]Based on authors' professional experience and judgment.

Woody mulch and leaf mulch

Some farmers use woody materials and leaves as mulch for caneberries, rhubarb, fruit trees, or other perennial crops. These mulches typically do not need to be composted to meet pathogen elimination standards (PFRP) because they do not contain feedstocks that are a source of human pathogens.

Piling woody materials is usually called aging rather than composting, because it is not a managed process, and the end product does not have the properties of compost. Aged mulch typically is not well mixed, sometimes making it difficult to spread. Plant diseases carried by woody feedstock, such as *Phytophthora ramorum,* are not reliably eliminated by the aging process. For this reason, be cautious in choosing mulch feedstock and in selecting crops for mulch application. Consider composting instead of aging when there is significant risk of plant disease or weed seed spread.

Because woody materials and deciduous tree leaves have a high C:N (carbon to nitrogen ratio), they present a low risk to water quality when stored outdoors without cover. But, they should be stockpiled at farm locations that are not subject to flooding.

Chapter 6

Manage Runoff and Leachate

The best way to manage leachate is to prevent its production in the first place. Previous chapters discuss ways to minimize leachate production. This chapter introduces some strategies to manage any leachate that is produced.

Runoff and leachate

Photo by Nick Andrews, © Oregon State University

Saturated compost piles generate leachate, a threat to water quality.

Runoff is water that flows off-site. If runoff comes into contact with compost, it becomes leachate and must be managed.

Leachate is contaminated water that has been in direct contact with feedstock or composting materials. This water may be from the composting process itself, or precipitation. Most leachate comes from the alleyways between compost piles. If uncontrolled, leachate can contaminate surface or groundwater and affect human health. Regulators take leachate very seriously, as do managers of sustainable compost operations.

Biological oxygen demand (BOD) is a measure of the amount of oxygen that is consumed (demanded) by aerobic bacteria as they decompose organic matter in water. As material with high BOD decomposes, dissolved oxygen is depleted; this can be harmful to fish and other aquatic life.

Leachate may contain nitrate, pathogens, metals, salts, other nutrients, and organic compounds with high biological oxygen demand. The threat leachate poses to water quality varies depending on the type of feedstock and the stage of the composting process at which leachate is created. Ammonium-N is more prevalent in the early stages of composting. Nitrate-N is more prevalent as compost reaches maturity.

Compost in earlier processing stages produces higher biological oxygen demand in leachate than more mature compost. The BOD of leachate from food and yard waste compost can range from 2 to 500 mg/L or more. The BOD of clean rivers is less than 1 mg/L. The BOD of moderately polluted rivers may be 2 to 8 mg/L. You can see the potential for serious environmental impacts to water from uncontrolled leachate.

The best use of collected leachate is to moisten an actively composting pile early enough in the process to meet PFRP. Alternatively, collected leachate can be applied to cropland requiring water and nutrients. Determine application rates according to the nutrient content of the leachate and the nutrient requirements of the crop.

Landscape features to protect water quality

Several methods can prevent leachate from reaching surface and groundwater. The key is to ask yourself in advance where runoff or leachate from your site would go. Site slope, soil type, and the type of vegetation in buffer areas dictate the distance needed to separate the composting site from surface water and aquifers.

Filter berms are mesh bags filled with mature compost, woodchips, woody overs, or other coarse material. They filter out large sediment or slow sediment-laden water and allow particulates to settle out. You can place filter berms almost anywhere, and they are particularly useful downslope of the composting site.

Berms are raised banks, usually of soil and compost with grass or other plant cover. Berms provide a second line of defense against leachate migration. Packed soil or fine compost berms can direct water downslope along a desirable path. Berms restrict flow and cause leachate to pool, providing time for it to infiltrate and for sediment to settle out.

A **swale** is a shallow channel that captures and slows runoff and leachate, allowing them to infiltrate. Swales can be planted to grasses or other water-tolerant plants that take up excess nutrients. Sometimes, rock check dams are placed across a swale to increase ponding and infiltration.

A **filter strip** is an area of thick vegetation, typically grass, at least 50 feet wide and perpendicular to the direction of flow. Steeper grades require wider filter strips. The vegetation in the filter strip protects underlying soil from erosion, permits leachate to infiltrate, and takes up nutrients.

Contaminated water spreads evenly over a well-constructed filter strip or swale, further slowing the water and promoting settling of contaminants. If leachate reaches the end of an effective filter strip or swale, it carries less sediment, nutrients, metals, and pathogens, though it will not be free of these contaminants.

Filter strips and swales are most effective after a filter berm has removed gross sediments. Place filter strips and swales downslope of composting operations and filter berms. They are best as permanent installations at the low points on the property, and should be located some distance from surface water.

These features must be properly designed and built to be effective. Seek professional guidance if needed.

Keep these guidelines in mind for managing leachate

- Prevent stormwater and runoff from coming into contact with compost that is likely to generate leachate.
- Grade the site and use diversion ditches or berms to reduce water flowing through the composting area.
- Use filter berms, berms, filter strips, or swales to keep leachate out of surface water.

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Well Log Database: http://apps.wrd.state.or.us/apps/gw/well_log/

Resources

Oregon Department of Agriculture Natural Resources Division: 503-986-4700

Oregon Department of Environmental Quality (DEQ)

These regional offices can connect you to a hydro-geologist:

- Eastern Region: Bend, 541-633-2025
  Providing services to Baker, Crook, Deschutes, Gilliam, Grant, Harney, Hood River, Jefferson, Klamath, Lake, Malheur, Morrow, Sherman, Umatilla, Union, Wallowa, Wasco, and Wheeler counties
- Northwest Region: Portland, 503-229-5562
  Providing services to Clackamas, Clatsop, Columbia, Multnomah, Tillamook, and Washington counties
- Western Region: Eugene, 541-687-7342
  Providing services to Benton, Coos, Curry, Douglas, Jackson, Josephine, Lane, Lincoln, Linn, Marion, Polk, and Yamhill counties

Composting Facility Risk Screening Checklist, Oregon Department of Environmental Quality. http://www.deq.state.or.us/lq/sw/permitcompinstructions.htm

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Silage Corn Nutrient Management Guide for Western Oregon

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Figure 1. Silage corn is an excellent feed for dairy cattle.

Credit: Troy Downing, © Oregon State University

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Oregon State University

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Silage corn quick reference

Soil testing. Apart from nitrogen (N), nutrient recommendations in this guide are based on a preplant soil test. Collect the preplant soil sample in the fall or in spring prior to corn seeding. Recommendations in this guide are valid only when the laboratory employs soil test methods as described for western Oregon in the *Soil Test Interpretation Guide*, (https://catalog.extension.oregonstate.edu/ec1478) EC 1478.

Liming. Silage corn grows best at a soil pH greater than 5.5. Apply lime, based on soil test, according to Table 2.

Nitrogen. On dairy farm fields that receive annual manure or lagoon water application, additional N fertilizer application in the form of urea or ammonium sulfate is usually not required to meet crop N need.

Soil nitrate testing is recommended to determine the balance between N supply and crop N requirement. The most important time to collect a soil sample for nitrate analysis is when the corn has four to six collared leaves (V4 to V6 growth stage). Soil nitrate-N greater than 25 ppm at this stage indicates that N supply is sufficient; additional N will not increase crop yield.

Several diagnostic tests can be used to determine balance between N supply from all sources and crop N uptake capacity. See "Monitoring soil and crop N."

Phosphorus. If soil test P is below 50 ppm, apply P according to Table 9.

Potassium. If soil test K is below 200 ppm, apply K according to Table 10.

Magnesium. If soil test Mg is below 100 ppm or 0.8 meq/100 g soil, band 10 to 15 lb Mg/acre at planting or apply 1 t dolomitic lime/acre and incorporate it in fall.

Zinc. If soil test Zn is below 0.8 ppm (1.5 ppm in the Stayton area), band 3 to 4 lb Zn/acre at planting or broadcast 10 lb Zn/acre before planting. (Table 12)

Soil, climate, crop rotation and corn variety all affect silage corn yield potential. Silage corn yields are greater in the Willamette Valley than near the coast in Tillamook and Coos counties because the longer growing season is suited to higher-yielding corn varieties.

Most silage corn in western Oregon is grown on soils with silt loam or silty clay loam surface horizons. These soils have a high water-holding capacity but vary in drainage. Soils with better drainage (NRCS Hydrologic Group B) are usually more productive than more poorly drained soils (Hydrologic Groups C and D). Soils used for silage corn production in the Willamette Valley include Amity, Chehalis, Cloquato, Coburg, Concord, Helvetia, McAlpin, Willamette and Woodburn. Soils used for silage corn production near the coast in Tillamook and Coos counties include Kirkendall, Nestucca, Nehalem and Quosatana.

Silage corn is an excellent feed for dairy cattle because of its high dry-matter yield, energy content and palatability, especially when supplemented by other feed. This guide addresses silage corn produced in western Oregon with conventional tillage or by direct seeding using a no-till drill.

This guide is applicable to fields that receive manure and for those that do not. Recommendations in this guide are adequate to produce high yields where weeds, insects and diseases do not limit crop yield. Soil pH above 5.5 is required for maximum crop yield response to nitrogen and other nutrient inputs.

Nutrient removal

Table 1 shows typical nutrient removal values for silage corn at a high yield level. Here, *high yield* means 8-ton DM/acre or approximately 32 ton *as harvested* silage. Nutrient concentrations in biomass remain relatively constant across silage yield levels; use the *concentration in DM* column to calculate expected nutrient removal for site-specific silage DM yields.

Table 1. Nutrient removal by silage corn, based on estimated yield of 8-ton DM/acre

Nutrient	Yield, ton DM/acre	Concentration, % in DM	Nutrient removed in lb/ton (100%DM)	Nutrient removed in lb/ton (25% DM)	Nutrient removed in lb/acre
N	8	1.3	26	6.5	205
P	8	0.2	4	1.0	32
K	8	1.2	24	6.0	192

Silage corn removes approximately the same amounts of N and K, while P removal is lower (Table 1). When applied nutrients are not removed by harvest, they are lost to air or to water or they accumulate in soil. The major pathways for N loss are 1) ammonia loss to the atmosphere during the first days after manure application, and 2) nitrate leached during fall and winter months. About half of the total N applied in manure is in organic form. Some of the organic N is converted to nitrate in the year of application; the remainder is incorporated into soil organic matter. The amount of manure N that is held in soil organic matter for longer than a year is approximately 10–30% of manure N applied. By contrast, P and K are not lost to the atmosphere, and they are relatively insoluble in soil. Therefore, P and K accumulate in topsoil when inputs (manure) exceed nutrients removed in the harvested crop.

On dairy farms, silage corn is often double-cropped with annual ryegrass or a cereal cover crop. This protects soil from erosion and increases annual crop nutrient removal. A fall-seeded annual ryegrass cover crop, when harvested in April with a dry matter yield of 3-ton/acre, removes approximately 115 lb N, 18 lb P and 150 lb K per acre.

Manure also supplies other nutrients that are required for corn, including sulfur (S), calcium (Ca), magnesium (Mg), zinc (Zn) and micronutrients. Usually, when manure has been applied annually, application of these nutrients does not increase silage corn yield.

Soil pH and liming

Corn for silage grows best at a soil pH greater than 5.5. When soil pH is less than 5.5, silage corn yields can be reduced by excess aluminum (Al) or manganese (Mn) in soil solution. Soil pH less than 5.5 can also inhibit root growth to the point that plants appear to be P deficient, exhibiting purple color early in the growing season.

Lime application increases soil pH (reduces soil acidity). To be effective, incorporate lime into the soil by tillage prior to seeding. To determine the need for lime, we recommend testing soil for pH (1:2 soil:water method) and for lime requirement (SMP buffer method or other OSU Extension-approved test method).

The lime requirement test does not measure the actual soil pH in the field; it only serves as an index value for a lime rate recommendation (Table 2). If soil pH in water is greater than 5.5), no lime is required.

Keep in mind that soil pH fluctuates 0.3 to 0.5 units seasonally. It is lowest (most acidic) in late August and September, before the fall rains begin, and highest in February or March, when the soil is wettest. To track trends in soil pH across years, sample at the same time each year.

Applying Lime to Raise Soil pH for Crop Production (Western Oregon) (https://catalog.extension.oregonstate.edu/em9057), EM 9057, provides additional details on interpretation of lime requirement test results.

Table 2. Lime rate recommendations for western Oregon using the SMP buffer lime requirement test

Apply lime to maintain soil pH (in water) above 5.5.

Lime requirement test result (SMP buffer)	Apply this amount of lime (ton/acre) Based on 100-score lime
Below 5.5	3–4
5.5–5.8	2–3
5.8–6.2	1–2
Over 6.2	none

Calcium and magnesium

Calcium is an essential plant nutrient. Agricultural lime is calcium carbonate, so it supplies calcium as it increases soil pH. Some sandy soils such as the Newberg series have a soil pH above 5.5 but have less than 5 meq Ca/100 g soil. In such cases, 1-ton lime/acre is recommended to supply Ca, even if the SMP buffer test is above 6.2.

Manure supplies Mg. Soil test values less than 0.8 meq/100g are unusual in manured fields. Apply Mg when soil test indicates that Mg is below 100 ppm (0.8 meq/100 g soil). When Mg need is identified by a spring soil test, apply magnesium sulfate as a banded starter fertilizer application at 10 to 15 lb Mg/acre at seeding. If magnesium deficiency is identified by a fall soil test and the field will benefit from liming, fall-applied dolomitic lime can be used to supply Mg.

Nitrogen

Timing of corn N uptake

Corn grows slowly during the first 30–40 days after seeding. At the six-leaf growth stage (V6), corn contains 15 to 25 lb N per acre. Corn N uptake is most rapid from V6 to silking (VT). Between the six-leaf and silking growth stages, corn accumulates N at a rate of 3–4 lb N per acre per day. Crop N uptake rate declines as ears mature. Crop N uptake nears completion at the milk stage (R3).

The line in Figure 2 represents average crop N uptake values determined in three grower fields near Modesto, California (Geisseler et al., 2012). Unharvested stubble contained approximately 25 lb N per acre.

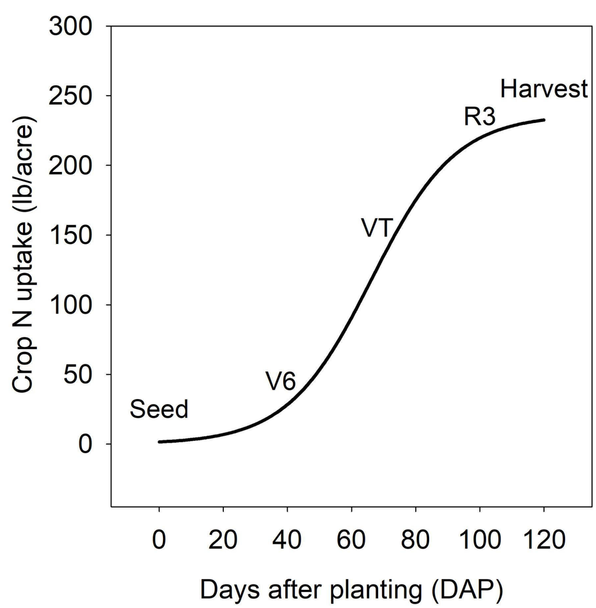

Figure 2. Cumulative crop N uptake for silage corn.

Credit: Geisseler et al., 2012

Nitrogen supplied by manure

The most common time to broadcast manure is prior to seeding. Base manure application rate on manure N analyses. Table 3 shows the volume of liquid or slurry manure required to achieve N application rates of 50, 100 and 150 lb/acre. Table 3 is based on manure N analyses. Units shown for manure N analysis in the same row (left side of the table) are equivalent. For example, an N concentration of 2 lb N per thousand gallons equals 240 ppm N. To use Table 3, find a manure analysis value in lb per thousand gallons or ppm in the columns on left. Then choose an application rate (50, 100, or 150 lb/acre) in the row at the top of the table. Find the volume of manure to apply in the body of the table. *Calculating Dairy Manure Nutrient Application Rates,* (https://catalog.extension.oregonstate.edu/em8768) EM 8768, provides guidance for calibration of manure application equipment.

The amount of N supplied by manure, as indicated in Table 3, is an approximate value that may vary by + or -30% from the target value. This variability in actual N application is due to manure N analyses variability and the lack of precision in manure application methods. We strongly recommend a midseason soil nitrate test (also referred to as a pre-sidedress nitrate test or PSNT) to assess the balance between soil N supply and crop N requirements.

Most fields with a history of manure application require no starter N fertilizer at planting. Fields that have not received manure for more than three years may require a small amount of N (20–40 lb/acre) at planting time.

Table 3. Volume of lagoon water or slurry manure required to achieve N application rates of 50, 100 and 150 lb/acre, based on manure N analyses

Manure analysis		Target manure N application rate (lb/acre)		
Lagoon water				
lb N per thousand gal	**Parts per million (ppm)**	**Acre-inches to apply**		
2	240	0.9	1.8	2.8
4	480	0.5	0.9	1.4
6	720	0.3	0.6	0.9
8	960	0.2	0.5	0.7
Slurry				
lb N per thousand gal	**Parts per million (ppm)**	**Thousand gal/acre to apply**		
10	1,200	5	10	15
15	1,800	3	7	10
20	2,400	3	5	8
25	2,990	2	4	6
30	3,590	2	3	5

Using soil nitrate testing to fine-tune N management

Soil nitrate testing is a valuable diagnostic tool to measure nitrate present at the time of sampling. Interpretations of a soil nitrate test vary, depending upon when the sample is collected.

In western Oregon, most nitrate moves below the rooting zone in winter by leaching. In February, soil nitrate concentrations are low, regardless of manure applied during the previous year.

Table 4. Midseason nitrogen application recommendations for western Oregon, based on the pre-sidedress nitrate test (PSNT)

Soil test nitrate-N (NO3-N)	Apply this amount of N
0-10 ppm	100-175 lb/acre
11-20	50-100
21-25	0-50
Above 25	None

Based on a soil sample collected between rows (0–12 inch depth) when corn has four to six collared leaves (V4–V6 growth stage)

Preplant soil nitrate in May usually underestimates the amount of nitrate available to the crop for the full growing season. Additional nitrate is mineralized after planting, as the soil warms. Therefore, a preplant soil test cannot accurately determine the need for additional N inputs.

Table 5. Overview of soil and plant tissue testing methods for monitoring N

Method	Test reliability (1 = most reliable)	Timing	Sample instructions	Target nitrate-N value	Additional comments
PSNT (pre-sidedress soil nitrate test)	1	Corn at V4–V6 growth stage	15 cores. 0–12 inch depth. Sample between rows.	25–30 ppm	Avoid starter fertilizer bands when sampling
PHNT (post-harvest soil nitrate test)	2	Sample before Oct. 1 at the coast (Tillamook), or by Oct. 15 (Willamette Valley)	15 cores. 0–12 inch depth. Sample between rows.	Less than 20 ppm	See Postharvest Soil Nitrate Testing for Manured Grass and Silage Corn (West of the Cascades), EM 8832
At-harvest cornstalk nitrate test	3	7 days before or after harvest	15 stalks	3,500 to 5,000 ppm	Submit an 8-inch length of stalk cut 6–14 inches above the ground for sampling. See Figures 1 and 2.

Soil nitrate measured at midseason (PSNT, described below) provides the most useful management information for the current year (Tables 4 and 6).

Postharvest soil nitrate tests are not useful for this year's N management decisions but can provide feedback to use in planning for future years (Table 7).

Midseason soil nitrate testing

The recommended timing for PSNT soil sample collection is at the four- to six-leaf growth stage, before the period of rapid N uptake in corn (Figure 1).

Soil nitrate-N values of 5-15 ppm at planting can increase to over 30 ppm by PSNT sampling time, because of mineralization of soil organic matter to nitrate.

PSNT sampling protocol

Collect PSNT samples when the corn has four to six collared leaves (V4-V6 growth stage). This usually coincides with a plant height of about 12 inches at the center of the whorl.

Sample between rows, away from any fertilizer bands. Avoid irregular areas, such as low spots, field entries or places where manure accumulates.

- Collect at least 15 cores.
- Sample soil to a depth of 12 inches.
- Mix the sample thoroughly in a clean container.
- Fill a soil sample bag with a subsample of the composite soil sample.

The sample should be delivered to the lab immediately. Keep the sample cool until it arrives at the laboratory. Changes in N occur as the soil warms. To avoid shipping delays over the weekend, do not mail samples on Thursday or Friday. Send the sample to a soil testing lab to be analyzed for nitrate-N (NO_3-N). Request results from the laboratory in units of ppm or mg/kg, not lb/acre.

Soils that are high in clay may pose difficulty in sampling to the 12-inch depth at PSNT sampling time. PSNT soil test interpretations (Tables 4 and 6) should be used with caution when soil samples were collected from 0–6 or 0–8 inches, as all PSNT calibration research employed a soil sampling depth of 12 inches. Soil nitrate concentrations generally are highest in the plow layer near the soil surface.

Using PSNT to determine midseason N application rate

Table 4 shows recommended midseason sidedress N inputs (fertilizer or lagoon water) based on PSNT testing. If soil nitrate is below 25 ppm, additional N from fertilizer or lagoon water is likely to increase silage corn yield. Table 3 shows the volume of lagoon water required to supply a target amount of N, based on water or slurry N analysis. If PSNT values are greater than 25 ppm, additional in-season N application as fertilizer or as lagoon water is *not* recommended.

The following sections provide additional details on interpretation of N monitoring tests.

Pre-sidedress nitrate test, or PSNT

Soil samples are collected for the PSNT when corn has four to six collared leaves (V4–V6 growth stage). Although the main purpose of the PSNT is to determine the need for in-season lagoon water or N fertilizer application (Table 4), it can also serve as an indicator of excess N supply for silage corn. PSNT values above 45 ppm NO_3-N (0–12 inch depth) indicate excess soil N supply relative to corn uptake capacity (Table 6).

Table 6. Interpretation of the PSNT as a predictor of postharvest soil nitrate for silage corn produced on manured fields in western Oregon

PSNT (ppm)	Category	Interpretation
Less than 25	Deficient	Crop yield increase expected in response to N input (fertilizer or lagoon water).
25–30	Target	Crop N requirement met. Minimal postharvest nitrate accumulation expected if no additional N inputs are applied after PSNT.
30–45	Above target	Soil nitrate is above crop N uptake capacity. Any additional fertilizer or lagoon water application applied after PSNT will likely increase postharvest nitrate-N.
More than 45	Excess	Soil nitrate exceeds crop N uptake capacity by a considerable margin. Any additional fertilizer or lagoon water applied after PSNT will almost always increase postharvest nitrate-N.

Postharvest soil nitrate test, or PHNT

The PHNT measures soil nitrate-N not used by the crop. The PHNT is a look backward in time to evaluate the balance between N supply and crop N uptake. Nitrate accumulates in the soil when the total of applied N plus plant-available N mineralized from soil organic matter exceeds corn N uptake. Although we are inclined to think of this as an annual process being evaluated, it's important to remember that soil organic matter content and manure application history over the past five to 10 years also influence PHNT results.

Low postharvest soil nitrate concentrations are difficult to achieve in fields that have been manured for many years. In manured fields, late summer soil N mineralization is often rapid. At the same time, crop N uptake capacity is limited as the crop matures (Figure 1). This late season imbalance between N supplied by mineralization and N removed by the crop results in an accumulation of soil nitrate in August and September. Silage corn grown in fields that have not been manured can often achieve maximum yield with low postharvest soil nitrate-N concentrations (less than 10 ppm NO_3-N), because late-season N mineralization rates in such fields are lower.

Table 7. Interpretation of the Postharvest Nitrate Test (PHNT) (0–12-inch depth) for silage corn on western Oregon dairy farms

Postharvest soil nitrate-N (ppm)	Interpretation
Less than 20	Target
20-45	Above target
Over 45	Excess

See Postharvest Soil Nitrate Testing for Manured Grass and Silage Corn (West of the Cascades), EM 8832, for additional context to interpret the PHNT and suggested management actions to reduce PHNT values in future years.

Target soil test values listed in Table 7 are based on best professional judgment, as informed by field research studies (Source: Marx; Cogger; See Appendix 1). Target values listed in the table assume near-maximum crop yield, with some late season nitrate release via soil organic matter mineralization in manured soils.

If postharvest soil nitrate-N is above target, consider ways to reduce the N surplus in the future. Evaluate the overall N supply, including the timing and amount of current-season application(s) of N fertilizer, manure or lagoon water. Also consider managing corn and a winter cover crop to maximize crop N removal. See *Postharvest Soil Nitrate Testing for Manured Grass and Silage Corn (West of the Cascades),* (https://catalog.extension.oregonstate.edu/em8832) EM 8832, for management options to reduce fall soil nitrate concentrations.

Note that a low PHNT test value (less than 20 ppm NO_3-N) does not indicate that too little N was applied. Continual mineralization of plant-available N from soil organic matter can provide enough N to meet crop need without accumulation of high concentrations of nitrate-N in the soil in the fall. Heavy rainfall or excess irrigation can also leach nitrate below the 12-inch PHNT soil sampling depth.

Cornstalk nitrate test

The cornstalk nitrate-N test is performed at harvest and can be a valuable diagnostic tool to determine the N status of the corn crop. Unlike soil nitrate tests, the stalk nitrate test will identifies whether N supply limited crop yield. If silage yield is low, but the stalk nitrate-N test is adequate, an N deficiency was not the cause of the low yield.

For this test, collect an 8-inch-long section of stalk from 15 plants. Make the lower cut in the stalk about 6 inches above the soil surface. Submit samples to the laboratory immediately. See *End-of-Season Corn Stalk Nitrate-Nitrogen Test for Postharvest Evaluation,* (https://pubs.extension.wsu.edu/end-of-season-corn-stalk-nitrate-nitrogen-test-for-post-harvest-evaluation-2) WSU FS336E, for sample preparation details. A 2017 study (Source: Ketterings) reported that stalks could be stored at room temperature or in a refrigerator for up to eight days after collection without affecting nitrate test values.

Figure 3. Collect an 8-inch portion of the cornstalk between 6 and 14 inches above the ground.

Credit: Haiying Tao

Figure 4. Prepare cornstalk for analysis by removing leaves and leaf sheaths.

Credit: Haiying Tao.

Interpretive categories in Table 8 reflect Oregon-based research (Source: Marx). Research findings from Iowa showed a similar target value (3,500 ppm) for cornstalk nitrate in manured fields (Source: Kyverga). Iowa researchers also found a strong correlation between soil nitrate at the six-leaf stage (PSNT) and the cornstalk nitrate test values taken from the same fields at harvest (Source: Balkcom). Oregon-based research confirmed this finding (Appendix 2).

Table 8. Interpretation of at-harvest cornstalk nitrate test for silage corn grown on dairy fields receiving manure in western Oregon

Cornstalk nitrate-N (ppm)	Category	Interpretation
Below 3,500	Low	Nitrogen supply may have been inadequate or late. Poor root growth may have reduced crop capacity for N uptake.
3,500–5,000	Target	Adequate N supply at time of maximum crop N demand. Nitrogen did not limit crop yield.
Above 5,000	Excess	Nitrogen supply was excessive, late or both.

Interpretive values based on Marx (1995)

Phosphorus

Manure is an excellent source of phosphorus for silage corn. Phosphorus from manure or lagoon water is 100% plant-available and equivalent to P from mineral fertilizer. When manure is applied at a rate to satisfy the silage corn N requirement, the amount of manure P applied often exceeds the amount of P removed by the crop. On dairy farms, soil test P is an indicator of the long-term balance between P inputs from manure and fertilizer versus crop removal of P via silage harvest.

Too much P in soil is not a crop production issue. However, P lost from the field and transported to surface water can stimulate algal or other aquatic plant growth and reduce water quality. Often, P is the limiting nutrient for aquatic plant growth. Soil phosphorus is only very slightly soluble in water, so P loss via leaching is small. Phosphorus can be lost from fields via soil erosion and surface runoff. When fields are not tilled routinely, P can also move through soil cracks or vole holes to reach subsurface tile drains.

Table 9. Phosphorus recommendations based on soil text

Soil test P, Bray P1 soil test method	Apply this rate to maximize silage corn yield*	
ppm	**lb P_2O_5/acre**	**lb P/acre**
8-15	60-80	26-35
16-30	40-60	17-26
31-50	20-40	9-17
Over 50	None required; soil alone will supply sufficient P	

*1 lb P_2O_5 = 0.44 lb P. Fertilizers are marketed in units of P_2O_5. Manure P analyses may be expressed in units of P_2O_5 or in units of elemental P.

Table 9 shows that when soil test P exceeds 50 ppm, applied P is not expected to benefit corn yields. Elevated soil P levels are slow to change in response to management actions; it cannot be easily or quickly reduced. Soil test P in western Oregon soils typically declines at a rate of approximately 10–20 ppm *per decade* in response to forage crop P removal, provided no additional P input is provided. Annual soil testing is not useful to document changes in soil test P in response to management. A big change in soil test P over a few years is likely caused by inconsistency in soil sampling methods or in laboratory analytical techniques.

Temporary phosphorus deficiency in young corn plants

Although manure usually provides more than enough P, silage corn occasionally appears P deficient. Purple leaves at the three- to six-leaf stage (Figure 5) indicate P deficiency. This symptom is rarely visible before development of three leaves, and typically disappears as the corn "grows out of" the problem as the season advances and the soil warms. Research in British Columbia indicates that the purple color is associated with tissue P deficiency even when the Bray soil test for P is in the adequate range—above 50 ppm (Source: Bittman). Symptoms of early season P deficiency are common with early planting dates, cool and wet spring weather, and in areas of compacted soil such as field entry and exit areas.

Figure 5. Young corn plant with the purple leaves typical of a phosphorus deficiency.

Photo: John Hart, © Oregon State University

Corn roots must be colonized by mycorrhizal fungi if corn is to grow normally without turning purple. These mycorrhizal fungi extract nutrients from soil and deliver it to the crop, in exchange for carbohydrates – the products of photosynthesis. On the commercial scale, amending soils with mycorrhizal fungi has not been successful. Rather, crop rotation and reduced tillage practices are the best ways to encourage mycorrhizal fungi. Mycorrhizal fungi will be present in soil if the previous crop was a host. Annual ryegrass is commonly grown in rotation with silage corn on dairies. It is a host of mycorrhizal fungi. Planting corn after fallow provides fewer mycorrhizal fungi for corn root colonization. In research trials conducted in lower mainland British Columbia, minimum tillage was superior to plowing for reducing the incidence of purple color in young corn plants (Source: Bittman). Mycorrhizal fungi grow much like roots and must remain intact to function. Tillage disrupts the fungal network in the soil.

Recommendation: If silage corn turns purple between the three- and six-leaf stages, even when soil test P exceeds 50 ppm, adopt the following management practices in subsequent years:

- Plant corn after a crop that hosts mycorrhizal fungi. Most crops support mycorrhizal fungi. However, crops in the beet and brassica families do not.
- Reduce tillage. Most important, do not plow.
- At planting, apply P fertilizer in a band 2 inches from the seed at a rate of 30 lb P_2O_5/acre.

Potassium

Manured soils usually supply adequate or excess potassium (K). When manure is used as an N source for silage corn, more K is added than the crop can remove. Soil test K is often highest in fields near the barn and in fields that receive the most manure. Potassium has limited mobility in soil and remains near the site of placement. Soil test K is usually highest in the surface foot of soil or to the tillage depth.

High soil K concentrations in forage can contribute to milk fever (hypocalcaemia) and other metabolic disorders in dry cows. However, silage corn does not accumulate high levels of K in forage as cool-season grasses do. Even when soil test K is high, K concentration in silage corn is usually between 0.8 and 1.8% and is typically 1.2%. Cool-season grasses can contain 5% K in fields receiving manure. The lower K concentration in corn silage compared to grasses is related to crop growth stage at harvest. Leaf K in young corn plants 18 to 24 inches tall can be greater than 4.5%.

Table 10. Potassium recommendations based on soil test

Soil test K, ammonium acetate extraction method	method Apply this rate to maximize corn silage yield*	
ppm	**lb K_2O/acre**	**lb K/acre**
0-75	80-120	66-100
76-100	60-80	50-66
101-150	40-60	33-50
151-200	0-40	0-33
Over 200	None required; soil alone will supply sufficient K	

*1 lb K_2O = 0.83 lb K. Fertilizers are marketed in units of K_2O. Manure K analyses may be expressed in units of K_2O or in units of elemental K.

If a soil test indicates that K is needed (Table 10), it can be supplied by banding or broadcasting mineral fertilizer (K chloride or K sulfate) or by manure or lagoon water application. Potassium from manure or lagoon water is 100%

plant-available and is considered equivalent to K from mineral fertilizer.

Corn is sensitive to salt damage from fertilizer, especially at germination. Potassium and nitrogen fertilizers are water soluble, so placing too much near the seed can kill or injure seedings. Table 11 shows maximum N plus K application rates.

Table 11. Maximum application rates of banded nitrogen plus potassium for silage corn

Distance between fertilizer band and seed row	Do not apply more than:
1 inch	40 lb (N + K_2O)/acre
2 inches	100 lb (N + K_2O)/acre

Micronutrients

Because western Oregon soils are acidic and contain relatively high amounts of organic matter, metal micronutrients such as Mn, Zn, Cu and Fe are usually adequate for corn production. These micronutrients are more soluble in acidic soils and are thus more available to plants. Manure application also supplies these micronutrients. Micronutrient deficiencies are rare. Corn research trials conducted in western Oregon have not shown economic benefit from fertilization with micronutrients other than Zn.

Commercial soil testing laboratories working under OSU guidelines use a chelate extractant (DTPA) when analyzing soil for metal micronutrients (Zn, Mn, Fe and Cu).

Zinc

It is unusual to observe zinc deficiency on manured soils in western Oregon. Manure is considered an excellent source of plant-available zinc because the organic matter from manure can serve to chelate Zn and maintain it in plant-available form in soil solution. When corn is severely deficient in zinc, the upper leaves are yellow between the veins. Zinc deficiency in corn is likely when the uppermost fully expanded leaves contain less than 25 ppm Zn. Corn plants with a poorly developed root system may exhibit zinc deficiency symptoms, even when there is plenty of plant-available Zn present in soil.

Sweet corn and field corn have similar Zn requirements. OSU research conducted with sweet corn is the basis for the recommendations in Table 12. When the Zn soil test results are less than 0.8 ppm, a yield increase from Zn application is expected on any soil. Where Zn is required, broadcast 10 lb Zn/acre and incorporate into soil before planting to meet crop requirements for two or three years. An alternative approach is to band 3 to 4 lb Zn/acre at planting. Gravelly, dark-colored soil such as the Sifton and Salem series in the Stayton area require higher Zn application rates to supply the crop with adequate Zn. The reduced plant-availability of Zn in these soils is probably associated with the presence of volcanic ash in the soil parent material.

Figure 6. Young corn plant with stripes typical of zinc deficiency.

Credit: Troy Downing, © OSU

Table 12. Zinc fertilizer recommendations for silage corn in western Oregon based on the DTPA soil test

Soil	Soil test Zn (ppm)	Apply this amount Zn (lb/acre)	
		Banded Zn	Broadcast Zn
Sifton and similar dark-colored gravelly soils near Stayton*	Below 1.6	3-4	10
Other soils	Below 0.8	3-4	10

* Field research on dark-colored gravelly soils in the Stayton area demonstrated that these soils required a higher Zn soil test level for maximum corn yields.

Figure 7. Typical zinc and copper footbath in a dairy barn. Applying footpath solutions to the field with manure increases zinc and copper levels.

Credit: © Oregon State University

Dairy farms sometimes employ foot baths containing Cu and Zn sulfate to maintain hoof health. Footbath effluent is often mixed with slurry manure or lagoon water, and then applied to fields.

Although Cu and Zn are plant-essential nutrients, in excess they can injure plants and produce feed with elevated Cu and Zn concentrations. Elevated soil test Cu and Zn have been measured in western Oregon fields where footbath Cu and Zn have been routinely applied (Source: Downing). More than 75% of soil samples collected from western Oregon dairy farms in 2010 had soil test Cu concentrations (DTPA method) considered high (greater than 2 ppm), and 38% of the soil samples had extremely high Cu (greater than 5 ppm). This interpretation is of DTPA Cu and Zn soil tests is based on *Soil Test Interpretation Guide,* (https://catalog.extension.oregonstate.edu/ec1478) EC 1478. To avoid buildup of Cu and Zn to excessive levels in soil, we recommend regular monitoring of soil test Cu and Zn in fields receiving footbath effluent.

A summary of published research (Source: Reuter) provides general guidance for interpretation of corn leaf Zn and Cu concentrations:

- Typical Zn concentrations in corn leaf tissue are 25–50 ppm.
- Leaf Zn concentration above 100–300 ppm can reduce yields.
- Leaf Zn concentrations greater than 500 ppm can severely reduce yields.
- Leaf Cu concentrations above 20 ppm can reduce yields.
- Leaf Cu above 50 ppm can severely reduce yields.

Appendix 1: Postharvest soil nitrate distribution in soil profiles

The recommended sampling depth for the PHNT is 12 inches. This appendix provides supporting data for the choice of a 12-inch sampling depth. This data was collected from N monitoring trials on Willamette Valley dairies (Source: Marx). At harvest, an auger mounted on a tractor was used to collect soil samples in 12-inch depth increments.

At all field locations, the 0–12-inch depth contained the highest concentration of postharvest soil nitrate in the top 36 inches of the soil (Figure 8). On average, nitrate in the top 12 inches represented 78% of the total nitrate present in the top 36 inches of soil. Postharvest nitrate-N was at or below the target PHNT concentration (20 ppm in 0–12 inches; Table 7) in eight of 26 fields.

Postharvest soil nitrate showed a similar distribution with depth (highest concentrations in 0–12 inch depth) in field trials conducted near Lynden in Whatcom County, Washington (Source: Cogger).

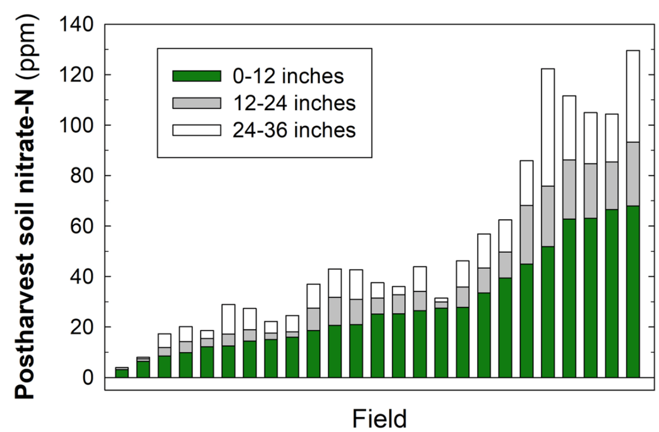

Figure 8. Postharvest soil nitrate-N measured at 25 field sites in the Willamette Valley. Each bar represents one field site-year. Soils were sampled in 12-inch depth increments. Fields are sorted left to right on the x axis by nitrate-N concentration in 0–12 inch depth. Data for one field with very high soil nitrate (90 ppm in 0–12 inch depth) is not shown. Source: Marx, 1995.

Credit: © Oregon State University

Appendix 2: Relationship between midseason and postharvest indicators of N sufficiency

A series of N monitoring trials was conducted on dairy farms producing silage corn in the Willamette Valley in 1993–94 (Source: Marx). Twenty-six replicated field experiments were conducted on 17 dairy farms. Most trials (24 out of 26) were conducted in fields receiving manure application. Dairy farmers applied manure and lagoon water according to their usual crop production practices. Data was collected on crop yield response to N fertilizer (urea) applied at sidedress time (V6 growth stage) to small plots within each field. Soil nitrate was measured near the time of planting, just prior to sidedress N fertilizer application, and at harvest. These trials provided an opportunity to evaluate the relationships among three N monitoring tests: PSNT, PHNT and stalk nitrate concentration at harvest. The guidance provided in the *Monitoring soil and crop N* section of this publication is based on these field trials.

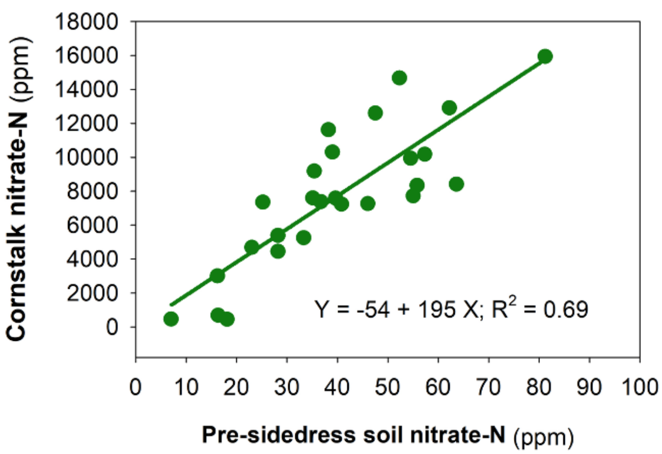

Figure 9. Relationship between pre-sidedress soil nitrate (PSNT; 0–12-inch depth) collected at V6, and cornstalk nitrate concentrations at harvest. Soil samples were collected from dairy farm fields in the Willamette Valley. Each data point represents a field site-year. Eight of the 26 data points represent fields that received lagoon water application after the PSNT soil sample was collected. Source: Marx, 1995.

Credit: © Oregon State University

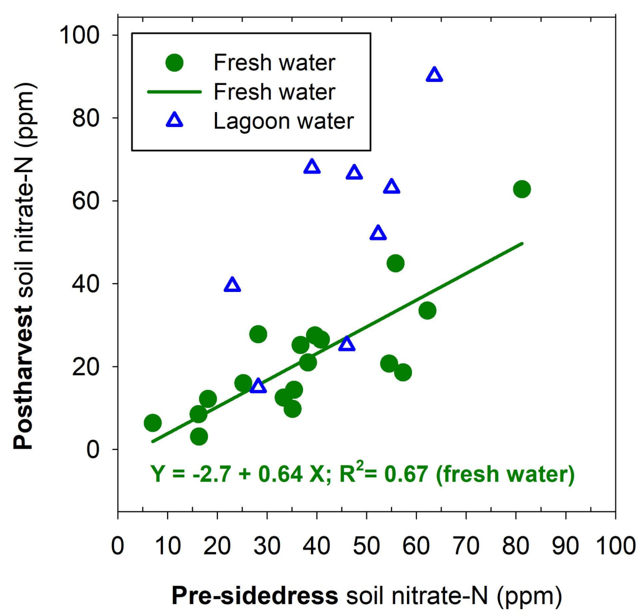

Figure 10. Relationship between pre-sidedress soil nitrate (collected at V6) and postharvest soil nitrate concentrations in 26 field experiments on Willamette Valley dairies. Each data point represents a field site-year. Both PSNT and PHNT samples were collected from 0–12 inch depth. Eighteen fields were irrigated solely with fresh water and eight fields received some dairy lagoon water application during the growing season. The regression line shown above is based on data from fields irrigated with fresh water. Source: Marx, 1995.

Credit: © Oregon State University

Silage corn yields demonstrated that in most fields, N supply from manure plus other nonfertilizer N sources (for example, N mineralization from organic matter) was adequate or more than adequate to maximize crop yield. Silage corn yield was increased by sidedress N fertilizer application at four of 26 field sites. At the other 22 sites, there was no statistical difference between silage yield with or without sidedress N fertilizer. When PSNT soil nitrate concentrations at the 0–12-inch depth were greater than 25 ppm, sidedress N fertilizer application did not increase corn yield. Interpretive ranges for the PSNT (Tables 4 and 6) are based on data from this study.

A linear relationship was demonstrated between soil PSNT concentrations (V6 growth stage) and stalk nitrate at harvest for field plots that did not receive N fertilizer application at midseason (after the PSNT soil sample was collected; Figure 9). A soil nitrate-N concentration of 25–30 ppm at the recommended level at PSNT time resulted in a stalk nitrate-N concentration of about 5,000 ppm at harvest (Figure 9). Stalk nitrate-N concentrations of 3,500 to 5,000 ppm are considered adequate (Table 8). When soil nitrate-N at PSNT was considered excessive (greater than 45 ppm; Table 6), stalk nitrate-N was also at a level considered excessive (above 5,000 ppm; Table 8).

Soil nitrate concentrations in fields receiving irrigation from fresh water only demonstrated a strong correlation between midseason (PSNT) and at harvest (PHNT, Figure 10) values. Postharvest soil nitrate concentrations represented two-thirds (64%) of PSNT values (slope of line in Figure 10). A PSNT test value at the recommended concentration (less than 30 ppm; Table 6) was correlated with postharvest soil nitrate-N concentrations of less than 20 ppm (Figure 10).

Fields that received dairy lagoon water applications had some of the highest postharvest soil nitrate values (Figure 10). For these fields, the PSNT was not a reliable indicator of postharvest soil nitrate.

Basis for recommendations given in this publication

This publication is an update of the 2009 guide. John Hart, Extension soil fertility specialist (emeritus), led the preparation of the 2009 guide, based on research published in 1997 and 1995 (Source: Hart; Marx) and on recommendations in *Field Corn—Western Oregon*, FG-10. OSU has not conducted field research with silage corn in western Oregon since 2009. The nutrient recommendations for liming, P, K, Mg and Zn presented in this guide are similar to those in the 2009 guide. Recommendations in the *Monitoring soil and crop N* section in this guide have been updated to reflect the professional judgment of the primary author (Sullivan).

The nutrient recommendations presented here for liming and N, P, K, Mg, S and Zn management are similar to those in *Nutrient and Soil Health Management for Sweet Corn (Western Oregon)* (https://catalog.extension.oregonstate.edu/em9272), EM 9272, published in 2020, and summarize research conducted in 2010–2016. Silage corn growers may be interested in information presented in the sweet corn guide. The 2020 sweet corn guide includes research findings on midseason soil nitrate test calibration, crop response to banded P fertilizer, crop response to urea treated with urease or nitrification inhibitors, and the establishment of winter crops by interseeding (relay cropping).

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FG 63
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Pastures

Western Oregon and Western Washington

J. Hart, G. Pirelli, L. Cannon, and S. Fransen

In western Oregon and Washington, forage shortages typically occur in late fall and early spring. In contrast, an excess supply may exist in late spring. By fertilizing in early fall and late winter, you can increase forage supply in deficient times. To reduce production in times of excess, reduce or eliminate late spring fertilization.

A single fertilization program will not fit all pastures. Determine which combination of grazing management, fertilization, and irrigation fits your resources and environment. Use a soil test and an assessment of forage supply and forage species to determine fertilizer need.

If suitable species are not present, fertilization will not compensate. In this case, consider renovating the pasture.

New Seedings

Match the pasture species to site conditions and livestock needs when renovating a pasture. Cows prefer grasses over legumes and graze perennial ryegrass before tall fescue. Sheep graze selectively, preferring clover and grass mixtures with short, lush feed to tall, coarse plants.

Horses are selective grazers, eating a wide range of plants. The horse digestive system cannot handle large amounts of legumes. Small and frequent amounts of forage are best. Horses avoid grazing near their own manure and urine; therefore, managing grazing on horse pastures is difficult.

Cool season forages such as tall fescue, perennial ryegrass, orchardgrass, subclover, and white clover are suited for our climate.

After choosing the appropriate forage species and planting method, use a soil test as the basis for fertilization. EC 628, *How to Take a Soil Sample . . . and Why*, contains instructions for obtaining a soil sample.

For a preplant soil test, obtain samples from the tillage depth, generally the surface to 6 inches. If you use a minimum tillage method of planting, you may wish to divide the sample into two parts: the top 2 inches and the lower 4 inches.

Analyze the soil sample for the following:
- pH
- Lime requirement (SMP or LR)
- Phosphorus (P)
- Potassium (K)
- Calcium (Ca)
- Magnesium (Mg)

Soil pH indicates whether lime is needed, and the SMP buffer or lime requirement (LR) test estimates the amount of lime needed. Estimate the rate of lime application from the following SMP buffer table.

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

If soil pH is below 5.5, incorporate lime for stand establishment and longevity. Mix lime into the seedbed before seeding to allow time for lime to neutralize soil acidity.

Exceptions to Table 1 are subclover seedings and pastures on coastal county bottomland soils. For new subclover seedings where the pH of the top 2 to 3 inches of soil is 5.5 or lower, mix 1 to 2 t lime/a into the surface 2 inches of soil before seeding. Using lime-pelleted seed also can improve seedling establishment on acidic soils.

If your pasture is on coastal county bottomland soils, apply a maximum of 2 t lime/a if the soil pH is below 5.5.

Additional information about lime requirement and the SMP buffer is in FG 52, *Fertilizer and Lime Materials*.

Nitrogen fertilization usually is necessary to establish grass forages in western Oregon and Washington. Broadcast 20 to 40 lb N/a at planting, or band this amount 1 to 2 inches below the seed. When P or K is needed, N can be banded with these nutrients. The total N plus K_2O in the band should not exceed 100 lb/a. *Do not include B in band applications because this concentration of B can be toxic to seedlings.*

Working P into the top 2 inches of the soil during seedbed preparation is more effective than broadcasting after seeding. The most effective P application method is banding.

If you band P, place the band 1 to 2 inches to the side or below the seed. Some soil should separate seed from fertilizer. Phosphorus fertilization rates are given in Table 2.

In new clover or clover and grass seedings, broadcast K and work it into the seedbed anytime before seeding. See Table 3 for fertilization rates based on a soil test.

John Hart, Extension soil scientist; Gene Pirelli, Extension agent, Polk County; Lynn Cannon, Extension agent emeritus, Coos County; Oregon State University; and Steve Fransen, Washington State University. Reviewed by western Oregon county Extension agents.

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If soil test K is below 125 ppm, band an additional 20 lb K_2O/a at the time of planting. At least 1 inch of soil should separate the seed and fertilizer. Potassium can be banded with N and P. Potassium fertilization at planting will not meet the need for K in subsequent years.

Inoculate legume seed immediately before planting to ensure an adequate supply of nitrogen-fixing bacteria. Use fresh, effective live culture of the correct rhizobial strain.

Established Pastures

Manage fertilization and grazing jointly in established pastures. Although growth rates are influenced by temperature, moisture, solar radiation, and soil fertility, grazing management has a profound impact on pasture production.

New Zealand sheep producers use plant growth phases in ryegrass pastures to manage pasture growth, grazing, and fertilizer applications. Phase I (lag phase), Phase II (vegetative phase), and Phase III (maturity) describe the stages of growth and the impact on grazing and dry matter production.

Grass-clover pastures in Phase II provide high-quality feed. The goal is to graze before excess forage is produced (Phase III) and to supply fertilizer for rapid regrowth after grazing.

Figure 1 is an example of how this works with a perennial ryegrass pasture grazed by sheep or cattle. In Phase I (3/4 inch, 550 lb of dry matter), the plants grow very slowly because they lack sufficient leaf area for photosynthesis.

Phase II (3/4 to 4 1/4 inches high, 550 to 1,900 lb of dry matter/a) growth is desired in pastures. Plants grow most rapidly and efficiently in this stage. Their leaf area is great enough for efficient use of sunlight.

Growth slows in Phase III (greater than 4 1/4 inches), as lower leaves become shaded and die, and the plant moves toward maturity and seed production.

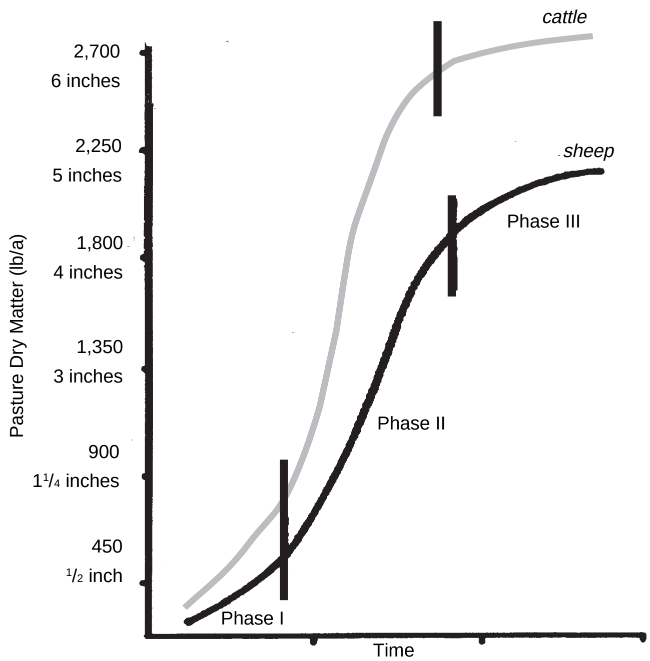

Figure 1.—Rate of perennial ryegrass pasture regrowth following grazing. For other grasses, multiply height by 2.

The grey line represents Phases I, II, and III if the pasture were managed for cattle. Cattle do not graze as closely as sheep, so the growth curve is based on higher initial and residual dry matter amounts. Other grass species such as orchardgrass and tall fescue have similar growth phases, but the grass heights listed for perennial ryegrass should be multiplied by two.

Fertilization of established pastures should be based on a soil test and the amount of forage needed. Obtain soil samples the year after establishment and every 2 to 3 years thereafter. Obtain samples from the top 3 inches of established pastures.

Nitrogen (N)

N fertilization should be based on moisture and temperature, which control pasture growth. Time N applications to crop and forage production needs. Avoid the following:

- *N applications in November and December*. N applied to cold, wet soils in winter can be leached beyond the root zone before slow-growing plants can use the fertilizer.
- *Late winter or early spring N application to saturated soils*. Soils that are too wet to drive on with a tractor may be too wet for plant growth. The plants may be yellow due to lack of oxygen from wet conditions and not lack of fertilizer. Wait for conditions conducive to plant growth before applying fertilizer.

See Figure 2 for an application schedule.

Fall

Assume the growing season begins with the fall rains. If sufficient rain falls in September to initiate growth, apply 40 to 60 lb N/a for the fall growing season (September and October). Do not apply N if adequate rain does not fall until late October or if the air temperature drops to or below freezing in October.

Many growers apply fertilizer to dry soil and note that the granules disappear before any rain. They fear volatile N loss. Nitrogen fertilizers, especially ammonium nitrate, often disappear overnight. Usually, this N has dissolved in dew and has moved onto the surface soil.

Winter

In cold conditions, pastures will not grow enough to use fertilizer. Forages in southwest coastal sites generally grow throughout winter, while conditions in the northern Willamette Valley allow only occasional winter growth.

For warm winters in the south coastal counties, apply 50 to 60 lb N/a in January or February (in addition to fall N application). Apply 50 to 60 lb N/a in the Willamette Valley or other cooler areas when a temperature of 40 to 45°F is maintained in the surface 2 inches.

Another method to estimate nitrogen demand is to monitor air temperature, then change the air temperature into heat units. A heat unit is the average of the high and low temperature for the day (in centigrade) and is a way to measure heat accumulation over time.

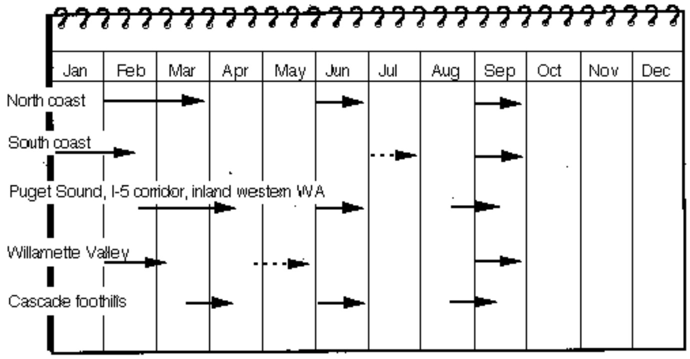

Figure 2.—Pasture nitrogen application calendar. Apply 50 to 60 lb N/a each time a solid arrow appears for your region. Additional applications for irrigated pastures are indicated by dotted lines. See nitrogen section in text for an explanation.

Table 4 shows a sample calculation of heat units. The process is as follows:

1. Beginning January 1, add together each day's maximum temperature and minimum temperature, and divide this total by 2. The result is the day's average temperature (column 4).
2. If this average temperature is in Fahrenheit, convert it to centigrade (column 5). To convert to centigrade, subtract 32 from the Fahrenheit temperature and then multiply by 0.556. For example:

   42°F - 32 = 10

   10 x 0.556 = 5.6°C

   The centigrade average temperature is the number of heat units accumulated for that day. (If the average temperature is below freezing, give it a heat unit value of zero.)
3. To find the number of heat units that have accumulated since January 1, add together the heat units for each day (column 6).

Apply nitrogen when 200 heat units are accumulated or soon thereafter. The 30-year average for accumulation of 200 heat units is January 30 to February 14 in the Willamette Valley. Foothill temperatures and pasture growth typically lag 2 to 3 weeks behind the Willamette Valley.

Spring

Intensively grazed pastures that are expected to produce a high level of forage through June should receive a second application of nitrogen. Apply nitrogen only if moisture is sufficient for additional growth after mid-May. Apply summer N in July on irrigated coastal pastures.

Phosphorus (P)

Adequate P fertilization is particularly important for clover. Estimate the need for P fertilization with a soil test.

Table 2.—Phosphorus application rates for pastures.

If the Bray soil test for P is (ppm)	Apply this amount of phosphate (P_2O_5) (lb/a)
0–15	60–100
15–30	0–60
over 30	0

Apply P on established pastures in the fall or spring before growth begins. When using ammonium phosphate materials, do not over-apply N to supply adequate P.

Moderate rates of N and P (40 to 60 lb/a) applied together sometimes have a synergistic effect on plant growth. Fall applications of N and P from ammonium phosphate materials on south coastal Oregon pastures produced more forage than individual applications of either N or P.

Potassium (K)

An adequate level of available K is essential for optimal growth of clover-grass pastures. Potassium is particularly important for clover. Grass competes vigorously with clover for K. High-producing pastures can rapidly deplete soil test K. Test soil every 2 years to determine available K levels.

Potassium deficiency is indicated by light-colored spots around the margins of clover leaves and yellow to brown coloring of grass leaf tips. Growth responses to K fertilizer often can be obtained before deficiency symptoms are seen.

Table 3.—Potassium application rates for pastures.

If the soil test for K is (ppm)	Apply this amount of potash (K_2O) (lb/a)
0–125	100–150
125–200	70–100
over 200	None—Watch soil tests for K depletion

We suggest split applications of K for established, high-yielding irrigated pastures, with the first application in late

Table 4.—Sample heat unit calculation.

Day	Max Temp. (°F)	Min Temp. (°F)	Average Temp (°F) (Max T + Min T)/2	Average Temp. (°C) = Daily Heat Units	Cumulative Heat Units
Jan 1	47	37	42	5.6	5.6
Jan 2	46	32	39	3.9	9.5
Jan 3	45	36	40	4.7	14.2

heat unit = (Max T + Min T)/2. Convert temperatures to centigrade to determine heat units. The equation to convert Fahrenheit to centigrade is: (°F - 32) x 0.556.

spring to avoid tetany and the second in midsummer. For other pasture types, apply K in the fall or spring.

Sulfur (S)

Plants absorb S as sulfate. Most fertilizer materials (ammonium sulfate, gypsum, sulpomag) supply S as sulfate.

Soil sulfate, which increases in the fall, is decreased by leaching in November and December and use by microorganisms in the spring. Thus, we recommend late winter or spring applications unless there is a severe deficiency, which may require additional fall or spring applications.

You can meet pasture S requirements by applying 20 to 30 lb S/a annually as sulfate or by applying 30 to 40 lb S/a as sulfate every other year.

Boron (B)

Clover-grass pastures need adequate B. Clovers have a higher B requirement than grasses. Too much B can be highly toxic to plants; therefore, do not exceed suggested rates of B application. Distribute B evenly over the field. *Never band B-containing fertilizer materials.*

If the soil test for B is below 0.7 ppm, we suggest an application of 2 to 3 lb B/a. Mix thoroughly when applying B with other fertilizers. Spring applications are preferred. Apply B in the fall only when B is critically low.

Lime, Calcium (Ca), and Magnesium (Mg)

Soils west of the Cascades are naturally acidic. Lime applications overcome soil acidity, allowing for increased grass and legume growth. Determine the need for lime by soil pH or a calcium (Ca) soil test. The amount of lime required to raise soil pH is determined by the SMP buffer or lime requirement (LR) test. Additional information is available in FG 52, *Fertilizer and Lime Materials*.

Grass pastures have a moderate tolerance to soil acidity. We suggest a lime application if the soil pH is below 5.4 or the Ca soil test is below 5 meq Ca/100 g of soil. For acidic soils low in Mg (less than 0.8 meq Mg/100 g of soil), use 1 t/a of dolomitic lime as an Mg source. Dolomitic lime and ground limestone have about the same ability to neutralize soil acidity. Liming rate is based on 100-score lime.

Subclover is an annual, reseeding itself each year. We recommend lime on subclover pastures where soil pH in the surface 2 to 3 inches of soil is below 5.5. Broadcast 1 t lime/a on established stands.

Clovers other than subclover are more responsive to liming than grasses. We recommend a 1–2 t/a lime application when soil pH is below 5.8. Broadcasting lime on established pastures is not as effective as mixing lime with the soil at planting, but is the only alternative on established pastures.

Pasture yield responses to Mg have not been observed in western Oregon and Washington. We suggest trial applications of a soluble Mg fertilizer where soil test levels are below 0.8 meq/100 g soil.

Incidence of grass tetany, however, may make Mg applications desirable. If tetany is a problem, do not apply K fertilizer until after the tetany period, since K reduces plant Mg and can induce tetany.

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Gardner, E.H., and J. Hart. *How to take a soil sample. . . and why*, EC 628 (Revised 1995). No charge

Hart, J. *Fertilizer and lime materials,* FG 52, (Reprinted 1998). No charge

Hart, J. *A List of Analytical Laboratories Serving Oregon*, EM 8677 (reprinted 1999). No charge

Other publications

Controlled Grazing Systems, Farm Production and Practice 681, New Zealand Ministry of Agriculture and Fisheries, P.O. Box 2526 (Wellington, New Zealand, 1983).

Dawson, M.D., and W.S. McGuire. *Recycling nitrogen and sulfur in grass-clover pastures,* Agricultural Experiment Station Bulletin 610 (Oregon State University, Corvallis, 1972).

Jackson, T.L., H.H. Rampton, and J. McDermid. *The effect of lime and phosphorus on the yield and phosphorus content of legumes in western Oregon,* Agricultural Experiment Station Technical Bulletin 83 (Oregon State University, Corvallis, 1964).

Kilgour, R., and C. Dalton. *Livestock behavior, a practical guide*. Mathuen Publications (New Zealand, 1942).

McCarthy, M.J. *Some effects of sulfur fertilization on the nutrient value of subclover-grass forage.* M.S. thesis (Oregon State University, Corvallis, 1976).

Rogers, J. *The Effect of Topdressed Lime Upon Pasture Production and Quality.* M.S. thesis (Oregon State University, 1996).

Suggested P, K, Mg, B, and lime applications are based on soil test methods used in the Central Analytical Laboratory, OSU, Corvallis, OR. This fertilizer guide is based on experiments and field trials conducted by Lynn Cannon, M.D. Dawson, E. Hugh Gardner, John Hart, T.L. Jackson, W.S. McGuire, and Gene Pirelli, Agricultural Experiment Station and Extension Service, Oregon State University. This guide replaces FG 1, *Irrigated Clover-Grass Pastures (W. Ore.)*; FG 4, *Subclover-Grass Pasture (W. Ore.)*; FG 16, *Perennial Grass Pasture (W. Ore.)*; FG 58, *Irrigated Clover-Grass Pastures (SW Ore.)*; and FG 63, *Subclover-Grass Pastures (W. Ore.)*.

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PNW 615

Nutrient Management for Field Corn Silage and Grain
in the Inland Pacific Northwest

By Brad Brown, John Hart, Don Horneck, and Amber Moore

CORN ACREAGE AND PRODUCTION has increased in the Pacific Northwest (PNW) with growth of the dairy industry. This is particularly true in southern Idaho, where acreage increased from 125,000 in 1997 to 300,000 in 2008.

Adequate nutrition is essential if productive new corn hybrids are to realize their full yield potential. The following fertilizer guidelines are based on land-grant university research. The fertilizer rates suggested are designed to produce above-average yields if other factors do not limit production. The rates will be appropriate provided (1) the soil samples are properly taken and represent the field or management unit to be fertilized; (2) the crop history information is complete and accurate; (3) the yield goal is realistic; and (4) good crop management practices are used.

NITROGEN

Nitrogen (N) is generally the most limiting nutrient for corn production, and is the most frequently applied nutrient. Fertilizer N represents by far the largest share of total fertilization costs for field corn. High fertilizer prices and groundwater quality concerns make it essential that this nutrient be managed to optimize economic returns while protecting groundwater resources.

Field corn lacking sufficient N at early growth stages is stunted and light green in color, especially in lower leaves. The difference in appearance between lower and upper leaves is more pronounced as the plant develops. Lower leaves indicate a N shortage when the leaves are a light green, the leaf tip becomes yellow, and the yellow extends from the leaf tip into the leaf along the midrib.

The amount of fertilizer N required, if any, depends on many factors that influence total corn production, including length of growing season, corn hybrid, previous crop and residue management, past fertilizer and manure/compost use, soil type, and the leaching potential. Estimates of the N available to corn from the soil during the season and the yield potential of the crop should be considered when determining N fertilizer rates. High plant populations of field corn are more susceptible to N shortages because of greater competition among plants for limited N. Corn yield potential reduced by poor stands or delayed plantings will have reduced N requirements.

Several tools can be used to refine N management for field corn. They include pre-plant, post-emergence (pre-side-dress), and end-of-season soil N testing; and in-season plant analysis of lower stalk, ear leaves, or whole plants. In-field estimates of N shortages are also possible based on chlorophyll meter readings and the number of green leaves below the ear, although there is limited experience with these in the PNW.

Pre-plant N soil test

In the inland irrigated PNW, limited rainfall normally precludes appreciable loss of nitrogen from leaching caused by winter precipitation. A pre-plant N soil test can evaluate the carryover nitrate-N (NO_3-N) and ammonium-N (NH_4-N) from previous crops, as well as the N mineralized since the last crop was actively growing. Most of the carryover inorganic N is present in the NO_3-N form and N recommendations generally focus on the NO_3-N concentrations. In fact, many soil testing laboratories report only the NO_3-N results. However, appreciable NH_4-N concentrations can occur as a result of ammonium-N fertilizer N (or manure) that has not converted fully to the NO_3-N form, or other conditions (e.g. colder soils) that slow the normal conversion of NH_4-N to NO_3-N. Therefore, we recommend testing for both nitrate-N and ammonium-N.

Soil samples should be collected before planting. Sample in foot increments to a depth of 2 feet, unless roots are limited by restrictive soil horizons or high water tables. Deeper sampling may be justified if the effective rooting depth extends below 2 feet and appreciable N is suspected at those depths due to high N fertilization of previous shallow-rooted crops (carrots, onions, potatoes).

In practice, many pre-plant soil samples are collected from only the first foot. In some cases this may be adequate because nitrate-N measured in the first foot is often related to nitrate-N in the second foot. For example, in low rainfall southern Idaho field corn trials, pre-plant nitrate-N measurements in the second foot averaged about 90% of those in the first foot. However, in western Oregon soil nitrate-N in the first foot at planting was not well correlated to nitrate-N in the second foot, and second-foot nitrate-N averaged only about 40% of that in the first foot. Sampling both depths is the most accurate measure of available N for corn. Fall sampling of soil for carryover nitrate-N has not been evaluated for field corn in the PNW. Early fall sampling would not reflect the N mineralized from organic matter during the fall and spring before corn planting, or the N immobilized by microbial activity. Late fall sampling could reflect available N in the early spring if it is not affected by over-winter precipitation. Collect soil samples in the spring for the best indication of pre-plant available N.

Pre-plant soil N tests are reasonably effective for identifying sites that are not likely to need fertilizer N, especially in non-manured soil. However, pre-plant soil test N is less effective for predicting the amount of fertilizer N required when fertilizer N is needed. While the pre-plant soil N test reflects the readily available N at the time of sampling, it may not reflect the N that will be mineralized during the season. Therefore, the pre-plant soil N test tends to over-estimate the fertilizer N required in manured fields, or other fields with high N mineralization potential. Post-emergence or pre-side-dress N tests can give a better idea of how much N is being mineralized.

Pre-side-dress soil nitrate-N test (PSNT)

Soil test nitrate-N in the first foot at the V5/V6 growth stage may also be useful for predicting fields that need N. The test at this growth stage reflects the pre-plant carryover N from the previous season, as well as the N mineralized to that point from the organic fraction. In fact, the PSNT often does not differ much from the pre-plant sampling. However, an N test at this stage can be useful if there was an intervening irrigation (especially using furrows), or if there is appreciable N mineralized from organic N, as with manured soils. Another potential advantage of the PSNT is that it may better reflect the N immobilized by microbial decomposition of late fall or spring incorporated corn residues.

The PSNT is especially useful for identifying manured sites where field corn silage or grain yield is not likely to increase with applied fertilizer N. For this determination, it is more effective than pre-plant N testing. Western Oregon research suggests that soil with 25 ppm or above of N in the first foot at the V5/V6 stage will likely not require additional fertilizer N. Unfortunately, if the soil is low in N and needs fertilizer N, the PSNT does not accurately predict the rate of N required to maximize corn production any better than pre-plant soil N testing.

Pre-side-dress samples should be collected prior to the first irrigation. If furrows are irrigated before collecting the pre-side-dress sample, nitrate-N movement can affect nitrate-N concentrations between corn rows.

Since the PSNT is based on a sampling of only the first foot of soil, it may not reflect nitrate-N at lower depths. For PSNT samples collected earlier than V5/V6, critical values may be slightly lower than at the V5/V6 stage.

Fertilizer N requirement

Potential yield—Southern Idaho and western Oregon research (1983 to 2000) suggests that N requirements are affected by yield potential. The greatest yield potential factor in this region is the growing season. Corn is grown in the PNW from near sea level in coastal valleys to the higher elevations (5000 ft) in eastern Idaho. Corn hybrid maturity ratings range from 85 days in eastern Idaho to 135 days in the Columbia Basin. Even with longer growing seasons, shorter season hybrids may be used for double cropping (corn planted after crops harvested earlier during the same growing season). Conceptualized N uptake for corn within a range of maturities and yield potentials is shown in figure 1. Other factors also influence potential yield; these include plant population and hybrid selection.

Fertilizer N rates should reflect the corn yield that growers can reasonably expect under their soil, climate, and management conditions. The historic yield obtained in a specific field or management unit provides a fair approximation of yield potential, given a grower's traditional crop management. Changes in crop management designed to appreciably alter production may require adjustment of yield potential and the N requirement.

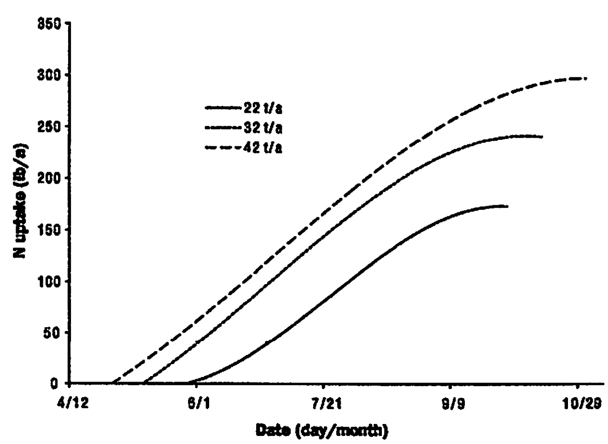

Figure 1. Conceptualized field corn nitrogen uptake (lb/acre) throughout the growing season, as affected by silage yield in tons per acre (t/a) limited by growing seasons in the PNW. When yield is limited by the growing season, note that N uptake is both reduced and delayed, and the N uptake period is shortened.

The N rates that maximize economic returns don't differ much as the ratio of the corn price (per bushel) to cost of fertilizer N (per pound) ranges from 9 to 16. When the ratio falls below 9, reduce the recommended N rate by 10 to 15%.

Non-manured soils—The fertilizer N requirements for non-manured field corn silage or grain based on pre-plant soil test N and potential yield are shown in tables 1 and 2. The fertilizer N requirements in the tables are based solely on soil test N and yield potential, and do not reflect differences in organic N release among soils. Consequently, heavily manured soils may not require nearly as much fertilizer N as indicated in the tables, or any N fertilizer at all. Research has not shown soil organic matter (SOM) to be an accurate estimate of organic N release in irrigated southern Idaho soils, though SOM is routinely measured by soil testing laboratories.

The recommended N rates for non-manured soil are based on the assumption that it takes about 9 lb of readily available N (pre-plant soil test N and fertilizer N) or less to produce a ton of fresh chopped corn (67% moisture) and 1.4 to 1.5 lb of available N to produce a bushel of corn. The recommendations also assume that pre-plant N is measured to a two-foot depth and that soil test N and fertilizer N are equally effective at producing corn. Using table 1 or 2 based only on a soil sample collected from the first foot will likely overestimate the N required.

Table 1. Recommended fertilizer N rates for field corn harvested for silage in non-manured soil (lb/acre).

Pre-plant soil test N at 0-2 ft (ppm)[1]	Silage yield (ton/acre)				
	20	25	30	35	40
0	180	225	270	310	340
10	140	185	230	270	300
20	100	145	190	230	260
30	60	105	150	190	220
40	20	65	110	150	180
50	0	25	70	110	140
60	0	0	30	70	100
70	0	0	0	30	60
80	0	0	0	0	20

Note: Adjust the recommended N rates for the effects of previous crop and residue management. (See text section, "Nitrogen credits for previous crop"). Adjustment may also be required for samples collected only from the first foot.

[1] Soil test N values (NO_3-N and NH_4-N) summed for the 0 to 12 and 12 to 24 inch depths.

Table 2. Recommended fertilizer N rates for field corn harvested for grain in non-manured fields (lb/acre).

Pre-plant soil test N at 0-2 ft (ppm)[1]	Grain yield (bu/acre)						
	100	130	160	190	220	250	280
0	150	195	240	285	315	360	405
10	110	155	200	245	275	320	365
20	70	115	160	205	235	280	325
30	30	75	120	165	195	240	285
40	0	35	80	125	155	200	245
50	0	0	40	85	115	160	205
60	0	0	0	45	75	120	165
70	0	0	0	5	35	80	125
80	0	0	0	0	0	40	85
90						0	45
100							5

Note: Adjust the recommended N rates for the effects of previous crop and residue management. (See text section, "Nitrogen credits for previous crop"). Adjustment may also be required for samples collected only from the first foot.

[1] Soil test N values summed for the 0 to 12 and 12 to 24 inch depths.

Nitrogen credits for previous crop—The recommended fertilizer N rates (tables 1 and 2) do not account for N cycling from some previous crop residues. Add 20 pounds N per acre for each ton of corn stover or small grain residue plowed under in late fall, to a maximum of 50 pounds N per acre. Wheat and barley residue incorporated the previous summer or early fall will largely immobilize N by the following spring due to microbial activity. The N immobilization is normally reflected as lower pre-plant soil test N which leads to higher N fertilizer recommendations. More N is required for residue incorporated in late fall or spring than residue incorporated in early fall. Residue of irrigated winter wheat is normally 3 to 4 tons per acre (assuming none is baled), and is not always related to grain yields. Winter wheat normally produces more straw than spring wheat or barley.

Fertilizer N rates should be reduced 60 to 100 pounds per acre when field corn follows alfalfa grown for forage or seed. Shorter growing seasons likely will not mineralize as much N from alfalfa residues as longer growing seasons. Also, poor alfalfa stands won't release as much N the following year as good stands. Reduce the alfalfa N credit by 20 to 30 lb N per acre if the alfalfa stand is less than two plants per square foot.

Residues of grain legumes such as peas or beans are normally incorporated in late summer or early fall with ample time for decomposition and N release to occur. Consequently, N contributions from these legumes are largely reflected in the pre-plant or pre-side-dress soil N test, so further adjustment of fertilizer N rates is not required.

Manured soils—Corn silage is one of the most common forages used in the Pacific Northwest for dairy and beef rations. Since the forage is typically grown as a part of the livestock operation, there is appreciable manure applied to fields where the corn is grown. Depending on the history of manure applications, manured fields frequently do not require fertilizer N. Western Oregon research indicated that yield increased in only two of 23 manured fields in the Willamette Valley with fertilizer N applications. If N is required, it is typically only a portion of that indicated for non-manured soils. The pre-plant soil N test is not the most appropriate test for indicating the N required for manured soils, unless they were only lightly manured. The PSNT is the more appropriate soil test for manured soils, as it better reflects N derived from manure and more accurately identifies fields likely to be N sufficient.

The fertilizer N requirements for corn in manured soils based on the PSNT are shown in table 3. For additional information on manure N contributions see the appendix below.

Nitrogen timing and placement—Applying N using sprinkler irrigation of corn under center pivots or linear move systems is an efficient, flexible way to provide N during the season, match N applied with corn N uptake requirements, and minimize N losses from leaching or denitrification. For maximum application uniformity of water (and possibly late applied N), sprinkler nozzles should be higher than the corn canopy. Otherwise, the canopy at full height interferes with the wetting pattern.

Table 3. Recommended fertilizer N rates for field corn harvested for silage in soils manured for extended periods (lb/acre).

Pre-side-dress soil nitrate-N (ppm)[1]	Silage yield (tons/acre)				
	20	25	30	35	40
0-10	100-175	140-215	180-255	220-295	260-335
10-20	50-100	90-140	130-180	170-220	210-260
20-25	0-50	40-90	80-130	120-170	160-210
25-30	0	0	30-80	70-120	110-160
>30	0	0	0	30-80	70-120

[1] Soil test nitrate-N values for only the first foot of soil.

The N management options during the season are more limited for furrow-irrigated corn. Nitrogen applications with furrow-irrigated corn are typically accomplished with pre-plant and side-dress applications of N. There is limited opportunity to apply N after corn growth precludes additional trips through the field with equipment. Soluble N is at times added to the irrigation water applied in the furrows, but there is risk of the N loss in the runoff from field ends. With furrow irrigation, losses of N from leaching are greater in coarse-textured soils, including sandy loams, loamy sands, and sands. For these soils, side-dress a portion of the N at the time of the last cultivation. On silt loam and other fine-textured soils, split applications of N in the spring have not proven more effective than pre-plant N, as long as pre-plant broadcast N is adequately incorporated, and early season irrigation minimizes N leaching. Fertilizer N applied early the previous fall has not been as effective as late fall or spring applied N, especially where previous crop residues are returned to the soil.

Modern corn hybrids with narrow rows (22-inch vs. traditional 30- or 32-inch rows), high plant populations (36,000 to 40,000 plants per acre vs. 30,000), and high yield potential can have high fertilizer N requirements. However, only a limited amount of N can be applied preplant to field corn without stunting seedlings, slowing initial growth, or reducing stands.

If high N rates (greater than 240 lb/acre) are needed, split applications should be considered. Split the applications between pre-plant broadcast and post-emergence side-dressings or applications through sprinkler lines. Side-dressing may cause root pruning depending on plant size, distance of applicator shank or knife from the row, and placement depth. Side-dressing N no closer than 7 inches from the corn row will avoid root pruning of plants that are 10 to12 inches tall.

Moreover, modern hybrids may not only have higher N requirements, they may also take up a larger portion of their N requirements after silking than older hybrids. This provides all the more incentive to consider split applications where feasible.

Closer row spacing (22-inch) is more common in some PNW corn production systems, particularly where corn is grown by producers using 22-inch row spacing for other rotation crops of beans, onions, alfalfa seed, and sugarbeets. Narrower row spacing and beds of furrow-irrigated corn can increase the potential for nitrate-N leaching unless irrigation or N management is adapted to the narrower beds. Irrigating every furrow or even alternating between furrows can lead to greater nitrate leaching with 22-inch beds than in more traditional 30-inch beds. In narrow beds, placement of N as a band on the side of the corn row away from a consistently wetted furrow increased N effectiveness more than broadcast N in southern Idaho research.

Crop residues on the soil surface can reduce broadcast fertilizer N effectiveness by either increasing ammonia N volatilization from urea, or by increasing microbial N immobilization. When previous crop residues remain at the surface, as with direct seeded or no-till planted corn, banding or shanking N below the residue is more effective.

Enhanced N fertilizers—Enhanced N fertilizers include "controlled release" or "stabilized" N fertilizers. The N release is controlled or stabilized using coating technology or adding compounds to the N formulation that affect conversion rates from the urea or ammonium-N form to the nitrate form. Pre-plant controlled-release or stabilized N sources can improve applied N effectiveness under conditions that normally cause N losses from leaching, denitrification, volatilization, or immobilization when using conventional products. These are marketed as dry or solution N formulations. They are typically more expensive than conventional N fertilizers such as urea, ammonium sulfate, Solution 32 (urea - ammonium nitrate solution), or anhydrous ammonia. When N losses are minimized, either lower N rates can be used or additional application costs avoided. However, the modes of action differ among these products, and they can't always substitute for each other. For example, coated fertilizers may control the release of the nutrient, while others contain compounds that affect microbial or enzymatic processes.

Research and experience with enhanced N fertilizers in the PNW for field corn are limited. Some have proven effective in high rainfall areas of the Midwest where early season applied N is lost due to leaching. Information is needed on these materials in the irrigated PNW. Enhanced N fertilizers are likely most effective when the N released from them is slow enough initially to reduce leaching early in the season, but is rapid enough not to limit N uptake from the ten leaf stage through silking, which is the period of maximum N uptake.

Monitoring N management

Formulating N rate decisions based on soil test N, either pre-plant or pre-side-dress, is an inexact science and involves some risk. Therefore, monitoring the effectiveness of the N management practices used is wise in order to make mid-season corrections or refine future N management. A variety of monitoring tools have been proposed for this purpose, ranging from plant-based monitoring at midseason, to soil-based post-harvest monitoring.

Monitoring plant tissues for their N status is possible at various growth stages. Early season (12 inches tall) whole plant tissues should have from 3.5 to 5.0% total N. For midseason growth stages, use ear leaf tissue total N concentrations (sufficiency N level is 2.7 to 3.5% N). While most in-season monitoring procedures can identify N shortages, unfortunately we cannot give recommendations for the exact amount of N to apply to correct an N shortage.

For end-of-season indicators, measuring whole plant N or nitrate-N concentrations at harvest in lower stalks can be useful. Whole plant N of 1.0 to 1.2% N, or 6.5 to 7.5% protein, indicates that the N fertilization was adequate for maximum yield, as does nitrate-N concentrations in the lower stalks of 3500 to 5500 ppm.

If you find that your residual soil nitrate-N at harvest is above 20 ppm in sprinkler irrigated fields, N was most likely adequate for near maximum yield. A rough visual measure of N adequacy at silage harvest is the number of green leaves below the ear (more than 3.5 is desired).

PHOSPHORUS

Adequate phosphorus (P) is necessary for maximum production of corn, although field corn is not as sensitive to low P as are vegetable crops such as potatoes and onions, or small grains produced under cooler soil conditions. Phosphorus-deficient corn is stunted and seedlings may have purple pigment as a result of increased anthocyanin content. However, higher anthocyanin content is a response to general plant stress, and may not be specific to a P deficiency. A shortage of P causes a delay in the development of corn, and thus later maturity. Plant symptoms should be used along with soil testing to confirm a P shortage.

Soil test P provides a reasonable indication of whether field corn requires P fertilization. In neutral to calcareous soils, the Olsen P (sodium bicarbonate extractable P) soil test is used. In more neutral to acid soils, the Bray (NH_4F and HCl extractable P) test is used. Soil samples should be collected from the first foot of soil. Cost effective response to fertilizer P is more likely with (1) early plantings where cooler soil temperatures may limit P availability, (2) soils with appreciable lime content, or (3) where longer season hybrids may have difficulty maturing in the season available.

Soils that regularly or periodically receive manures to satisfy field corn N requirements often do not require fertilizer P. The contributions from manures and composts should be reflected by the soil test, though possibly not to the extent that fertilizer P additions are, depending on the time since the applications. Soil test P may respond more slowly with manures and composts.

Fertilizer P application rates based on soil test P are given in table 4. Phosphorus is an immobile nutrient that does not move appreciably from where it is placed. It should be mixed into the seedbed or banded within easy reach of the seedling roots before or during the planting operation. Banding P fertilizer to provide early access to developing roots typically improves P fertilizer effectiveness, in some cases by two fold in soils requiring P. Banded P fertilizer should be applied at half the recommended broadcast rate.

Banding P with the seed can be effective, but the rates are limited by the type of mixed fertilizer used. Seed germination can be reduced by excessive N and potassium (K) fertilizer salts, or by high ammonia or ammonium concentrations. Urea and diammonium P should be avoided as seed popup or starter placements. Total N amounts in mixed fertilizers banded with seed should not exceed 5 to 10 lb N plus K per acre.

Soils with higher free lime content (>5%) can reduce the effectiveness of applied P. Phosphorus fertilization rates should be increased 30 to 60 lb P_2O_5 per acre for each 5% increase in lime content.

Specialty P fertilizers are marketed to increase applied P effectiveness. However, there is little field corn research in the PNW with these products.

Table 4. Broadcast fertilizer P_2O_5 rates based on soil test P.

Soil test P (ppm)		Application rate (lb/acre)
Olsen[1]	Bray[2]	
0	0	120
5	8	80
10	16	40
15	24	0

Note: $P_2O_5 \times 0.44 = P$, or $P \times 2.29 = P_2O_5$

[1] Soil extractant for the Olsen test used in slightly acid and calcareous soil is $NaHCO_3$.

[2] Soil extractant for the Bray test used in acid soils is NH_4F and HCl.

POTASSIUM

Field corn requires adequate potassium (K) for optimum growth. Soil test K can be useful in determining the need for K fertilizers. The soil sample is taken from the first foot of soil and extracted with sodium bicarbonate in Idaho, and ammonium acetate in Oregon. Fertilizer K rates based on soil test K are given in table 5. Potassium should be plowed down or banded well away from seed to avoid salt injury. Manured soils should not require K fertilizer.

Potassium fertilizers can differ in their performance. Potassium sulfate (0-0-52) provides sulfur in a readily available form and is useful for soils low in sulfur. Potassium chloride (0-0-62) provides chloride, which has been shown to reduce corn stalk rot.

MICRONUTRIENTS

The DTPA extraction is normally used to test for the micronutrients copper (Cu), zinc (Zn), iron (Fe), and manganese (Mn). Soil samples should be collected from the first foot of soil. Zinc deficiencies occur primarily in soils that are eroded, leveled, or where the exposed subsoil is higher in lime. Apply 10 lb Zn per acre when the soil test measures less than 0.6 ppm.

Other micronutrients have not been shown to limit corn production. "Shotgun" applications of micronutrient mixtures containing Fe, Mn, Cu, and boron (B) "for insurance" have not been shown to be economical, and are not recommended.

Copper foot baths are commonly used in dairies for controlling foot-related maladies in the livestock. Lagoon water high in Cu that is applied to soils can increase soil Cu well above normal concentrations. It is not clear whether higher soil Cu from lagoon waste applications is detrimental to corn, but additional Cu should not be applied to these soils.

SULFUR

The major irrigated corn-growing regions of the PNW should not experience shortages of sulfur (S). Irrigation water from the Snake River and other rivers receiving irrigation return flows are known to have high S concentrations. Soils receiving periodic potassium sulfate or ammonium sulfate fertilizer should not require additional S applications. Sulfur deficiencies can occur in some irrigated areas where both the soil and irrigation water are low in S. Coarse-textured soils including sandy loams, loamy sands, and sands will be more susceptible to S shortages than silt loam soils because S in the readily available sulfate form (SO_4-S) is a mobile nutrient that can leach to lower depths. Where the need for S is evident, use 30 pounds per acre of sulfate-S (SO_4-S).

Table 5. Fertilizer K_2O rates based on soil test K.

Soil test K (ppm)[1]		Application rate
Olsen	Acetate	(lb/acre)
0	0	240
50	60	160
100	120	80
150	180	0

Note: $K_2O \times 0.83 = K$, or $K \times 1.20 = K_2O$

[1] Soil extractant is sodium bicarbonate or ammonium acetate.

Soil testing for S in the first foot alone is not a reliable indicator of the need for S. Deeper sampling may be necessary to identify S available in the second foot.

SALINITY

Field corn has a low to moderate tolerance to accumulated salts. Salts in soil are measured using an electrical conductivity (EC) test. Soils with EC readings above 3 or 4 mmhos/cm can be cropped effectively with good water management. Corn can even handle readings of up to 6 mmhos per cm, if water is managed very carefully. Typically, with high salts present, soil moisture should be maintained at higher available moisture values.

APPENDIX

MANURES AS NUTRIENT SOURCES FOR CORN

When managed properly, manures can be inexpensive and effective sources of plant nutrients for corn. Compiled averages can be used as a starting point for estimating nutrient content in manures. See the publication *Fertilizing with Manure*, PNW No. 533 for averages:
http://cru.cahe.wsu.edu/CEPublications/pnw0533/pnw0533.pdf. However, unlike chemical fertilizers, nutrient concentrations among liquid manures sampled from even the same farm can vary tenfold or more. Factors such as animal species, feed ration, maturation of manure, storage method, time of year, amount and type of bedding added, location within a pile or a lagoon, and many others will impact nutrient concentrations.

To obtain a reliable value for nutrient content, follow procedures outlined in *Manure and Wastewater Sampling*, University of Idaho CIS 1139 (http://www.cals.uidaho.edu/edComm/detail.asp?IDnum=1393). Samples should be submitted to a manure testing laboratory certified by the Minnesota Dept. of Agriculture (MDA). Requested analyses should include total nitrogen, ammonium-N, total phosphorus, total potassium, salts (EC), and dry matter or dry solids. When submitting composted manures, also request a test for nitrate-N. The most current list of MDA-approved manure testing labs can be found at: http://www2.mda.state.mn.us/webapp/lis/manurelabs.jsp.

A large proportion of nitrogen in manures is organic nitrogen in undigested forage, which cannot be used by plants until converted through the microbial process of mineralization to the plant-available forms of ammonium and nitrate. Organic nitrogen content can be calculated by subtracting the ammonium and nitrate-N content from the total nitrogen. There is no quick test for readily mineralizable organic nitrogen in manures. Therefore, we must rely on research and personal experience when estimating plant-available nitrogen. For example, despite lower C-N ratios in dairy manures, organic nitrogen is mineralized more slowly than organic nitrogen in poultry litter. To learn more about how to predict nitrogen mineralization rates in manures, refer to *Estimating Plant Available Nitrogen from Manure*, Oregon State University EM No. 8954-E: http://extension.oregonstate.edu/catalog/pdf/em/em8954-e.pdf.

Excessive manuring can result in soil that is highly enriched with phosphorus and other nutrients. Phosphorus (P) is a particular concern because with runoff from fields it can be transported to surface waters and cause nuisance aquatic growth, increased biological oxygen demand, and fish kills. Consequently, manuring rates are subject to state and federal rules and regulations. The regulations often differ for each state. In Idaho, the manuring rate can be limited by the P removed with crop removal (manure P applied=crop P removal). To comply with local manuring statutes, and to avoid costly fines and negative environmental impacts, learn the phosphorus regulations for your state. On-line state guidelines are available at:

Idaho
http://efotg.nrcs.usda.gov/references/public/ID/590.pdf

Oregon/Washington
http://extension.oregonstate.edu/catalog/html/em/em8848-e/

To learn more about strategies for reducing the environmental impact of phosphorus in manures, refer to *Mitigating High-Phosphorus Soils*, University of Idaho BUL 851: http://www.cals.uidaho.edu/edComm/pdf/BUL/BUL0851.pdf.

Manures and lagoon waters can also contain salts and other constituents that can affect soil productivity with repeated application. For information on the risks of excessive manuring refer to *Dairy Manure Field Applications- How Much Is Too Much*, University of Idaho CIS 1156: http://www.cals.uidaho.edu/edComm/pdf/CIS/CIS1156.pdf.

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