Exhibit E

This page intentionally left blank.

Manure Management Plan

Prepared for

Abalone Creek Ranch, Inc.

May 30, 2023

Prepared by

Lisa Rubin, CCA #364619

DELLAVALLE LABORATORY INC

1910 W. McKinley Avenue, Suite 110 ● Fresno, California 93728-1298
Phone (559) 233-6129 ● (800) 228-9896 ● Fax (559) 268-8174
Website: www.dellavallelab.com

Abalone Creek Ranch
Manure Management Plan

Table of Contents

Figures

Abalone Creek Ranch
Manure Management Plan

Table of Contents

Tables

Attachments

DELLAVALLE™
LABORATORY INC

May 30, 2023

Monterey Housing and Community Development (HCD)
Fionna Jensen, Senior Planner
1441 Schilling Place
Salinas, CA 93901

RE: Abalone Creek Ranch
Permit No. 2701700
Manure Management Plan

Dear Ms. Jensen:

As requested, this Manure Management Plan (MMP) summarizes the proposed agricultural operations for Abalone Creek Ranch, Permit No. 2701700 created on 16 February 2023. More specifically, the MMP was developed to evaluate proposed practices and how their design will be implemented to create a sustainable environment while protecting natural resources.

Summary

Abalone Creek Ranch is a proposed small family animal production farm located at 18000 Corral Del Cielo, Salinas, CA, 93908, in Monterey County. The proposed farm is a pasture/rotational grazing-based operation and open rangeland that will ultimately house approximately 500 poultry (layers/broilers), 200 sheep, 30 beef cattle, 10 pigs, 4 horses, and 6 llamas. Proposed management is free-range rotational pastured grazing. The seeded, rain-fed pastures will house poultry, swine, llamas, and horses. The poultry will be housed in portable 20'x48' structures that are moved daily throughout a 25-acre upper pasture; swine will also be contained within the 25-acre area. The horses are housed within a 5-acre lower pasture that includes a movable horse pen and movable trussed horse shelters. Guardian llamas will graze and protect animals throughout the whole of the property. The beef cattle and sheep will rotationally graze predominantly throughout the 192 acres of chaparral and woodlands. Manure generated in the upper pasture will be used to fertilize the seeded grass for the poultry, and manure generated from the lower pasture will be used to fertilize the seeded horse pasture and 5-acres of fruit trees surrounding the eastern border of the upper pasture and northern area of the lower pasture. Current zoning is restricted to permanent grazing, and the Abalone Creek Ranch is governed by the California Land Conservation Act which limits the ranch to the agricultural production of food and fiber.

Purpose

The purpose of the Manure Management Plan (MMP) is to provide the rancher with all the information necessary to manage agricultural waste in a manner which protects the air, soil, water, vegetation, and animal resources. Proper manure management mitigates adverse impacts to surface and ground water quality, as well as impacts, both on and off site, from objectionable odors, vectors, noise, and visual aesthetics.

The guiding principles of the Natural Resources Conservation Service (NRCS) are utilized in this MMP to achieve the following objectives:

- To budget and supply nutrients for pasture production.
- To properly utilize manure as an organic plant nutrient source.
- To minimize degradation of surface and ground water resources.
- To improve the physical, chemical. and biological condition of the soil.
- To protect air quality by reducing nitrogen emissions and the formation of atmospheric particulates.

Farmstead

The farmstead is located on Assessor Parcel Number 416-441-047 within Section 17, Township 16S, Range 3E in Monterey County, CA. (**Figure 1**). **Table 1** lists the person(s) in charge of agricultural operations.

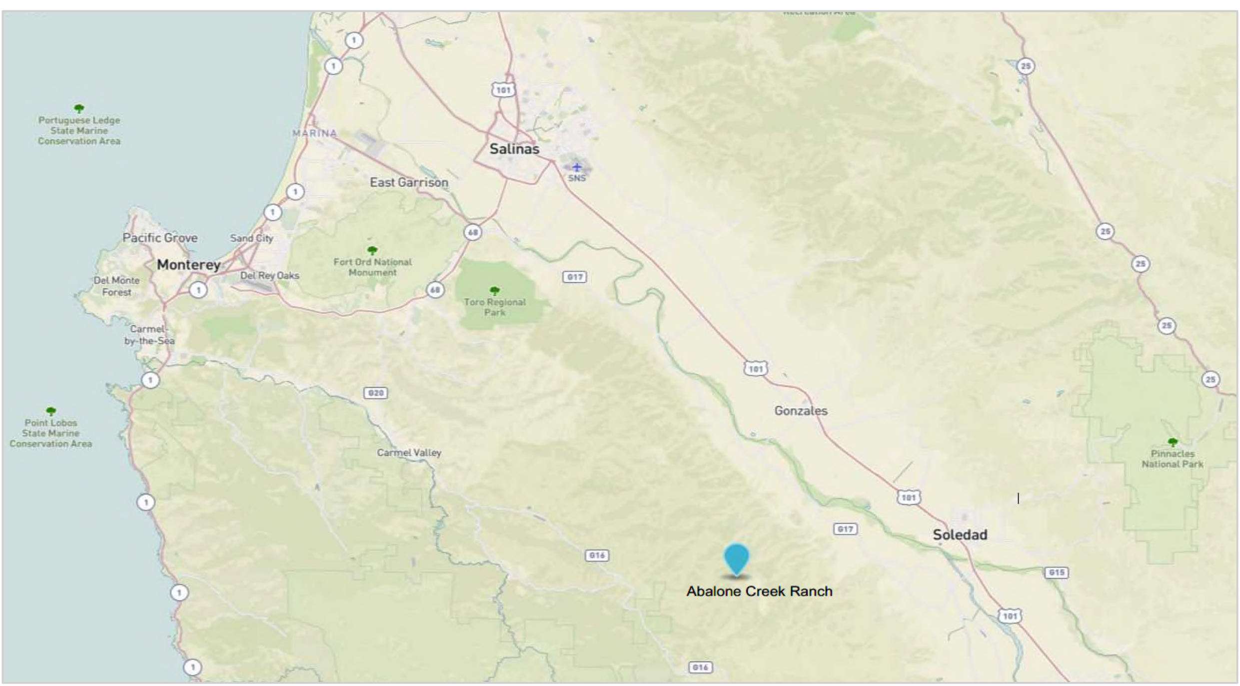


Figure 1. Vicinity Map

Table 1. Contact Information

Name	Title	Responsibility	Phone number	Email
Jordan Christensen	Ranch Manager	Oversees all operations	(831) 512-0726	jordan@abalonecreekranch.com

Proposed additions to the 222-acre ranch include the following:

- Livestock Barn
- Solar Farm
- Storage Shed
- Livestock Shed
- Machine Shed
- Potting Shed
- New Domestic Well
- Pond
- New Gravel Roads
- Fire Protection Storage Tank
- Food Forest (fruit trees)
- Trussed Horse Shelters
- Horse Manure Store Area
- Portable Chicken Coops

The proposed upper/lower pastures and food forest site plan is presented in **Figure 2** and in more detail in **Attachment 1 - Proposed Site Plan**.

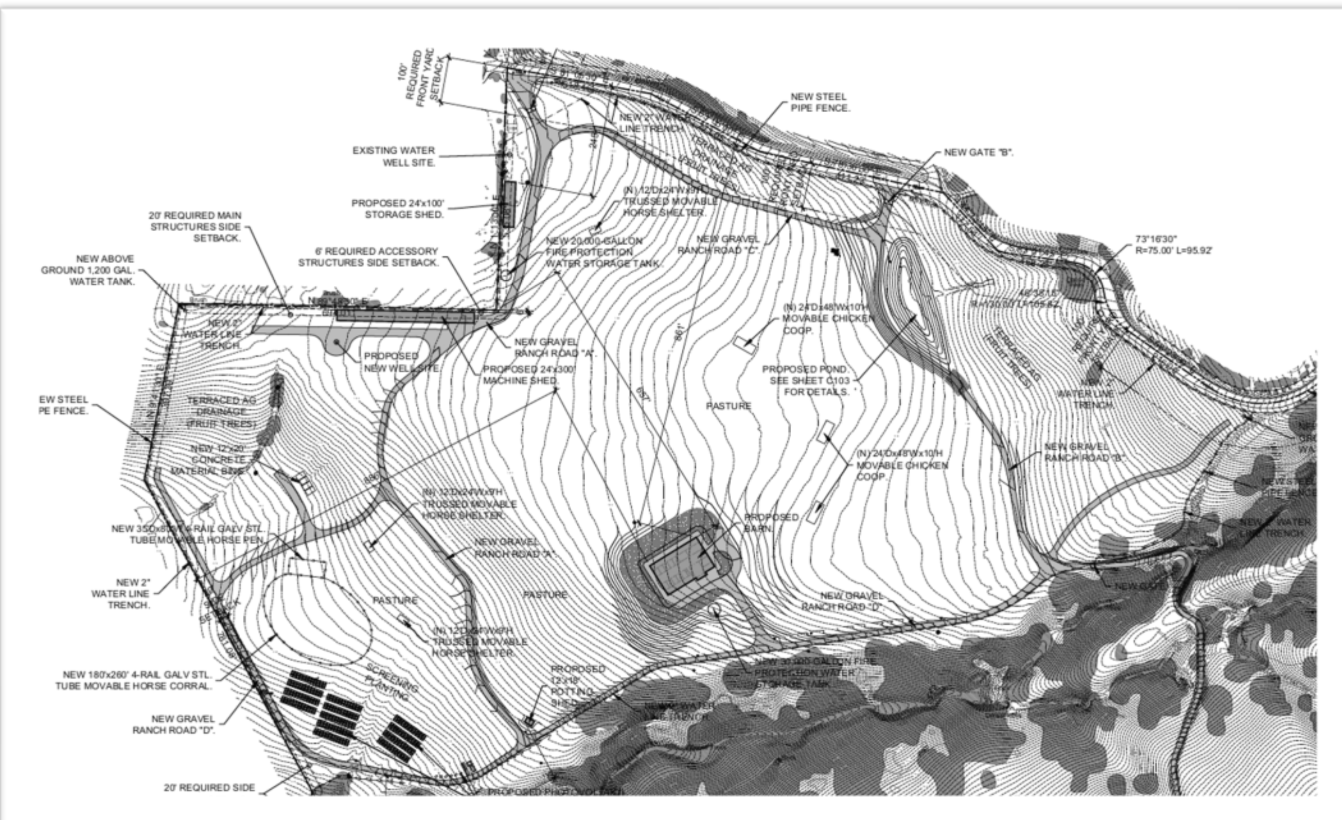


Figure 2. Proposed Pasture Site Plan

The proposed rangeland site plan for the cattle and sheep is presented in **Figure 3** and in more detail in Attachment 1 - Proposed Site Plan.

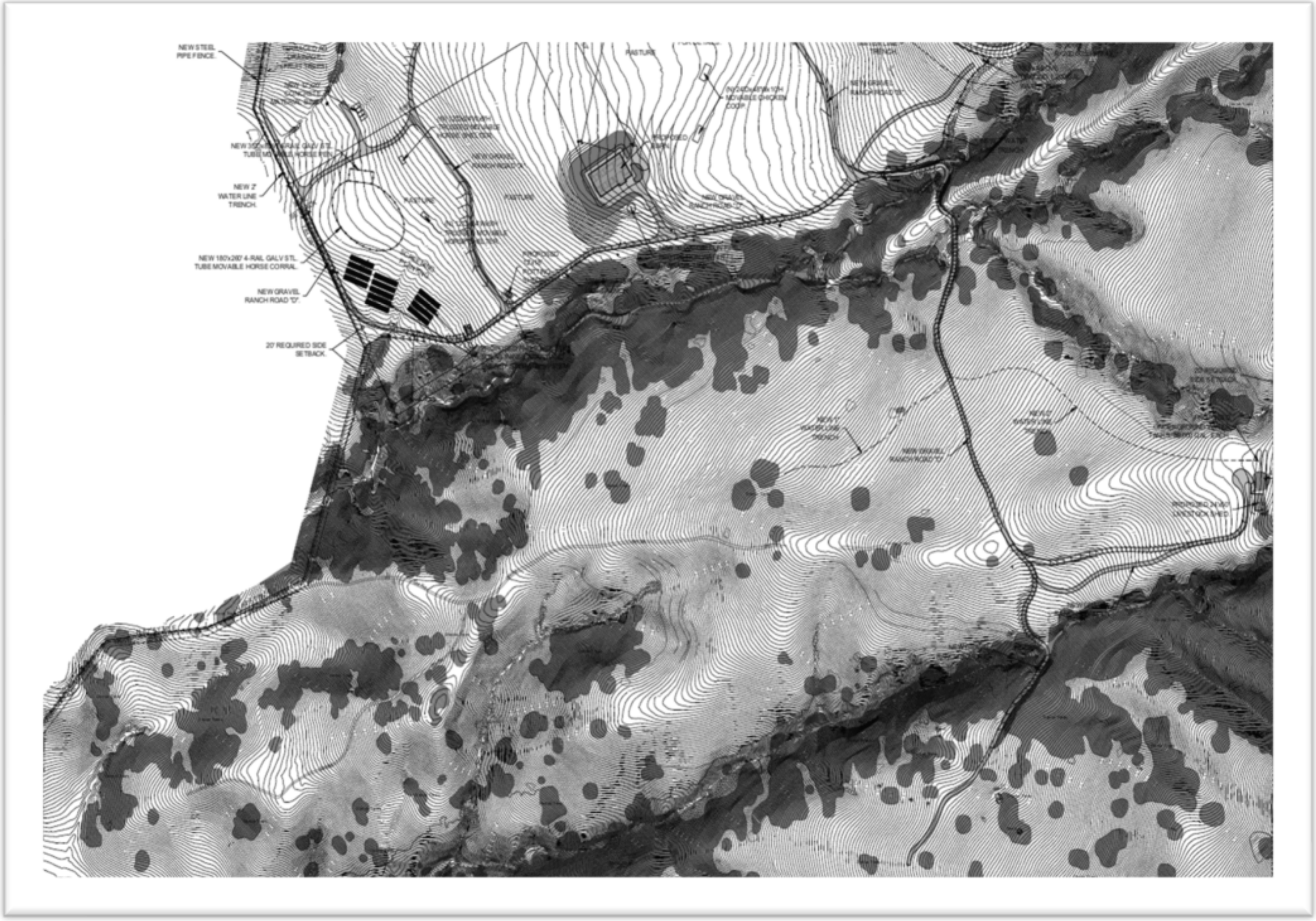


Figure 3. Proposed Rangeland Site Plan

Soils

A Custom Soil Resource Report was created for Abalone Creek Ranch on 9 May 2023 and is presented in **Attachment 2 - Custom Soil Resource Report**. The upper and lower pastures are predominately Placentia sandy loam (**PnC**), with slopes of 2-9%. It is classified as farmland of statewide importance. This sandy loam is well drained, classified as a low runoff potential class, with non-saline to moderately saline soils. The depth to water (DTW) is greater than 80 inches, and the frequency of flooding and ponding is none. Rangeland soils are predominately San Andreas fine sandy loam (**ScG**) with 30-75% slopes. It is classified as not prime farmland, well drained, and has a runoff class of medium. DTW is greater than 80 inches, and the frequency of flooding and ponding is none.

Pasture soils were sampled on 15 September 2021 and analyzed by Soil Control Lab. Lab results are presented in **Attachment 3 - Soil Lab Reports** and average results are listed in **Table 2**. Soils presently are low in nutrients and will benefit from manure fertilization.

Constituent	Results	Suggested Values
Nitrate-N	<4 lbs/acre 6”	20 -100
Extractable Phosphorus (P_2O_5)	112 lbs/acre 6”	100 -300
Extractable Potassium (K_2O)	370 lbs/acre 6”	450 -750
Organic Matter	4.4%	3 - 6%
Magnesium (Mg)	265 lbs/acre 6”	300 - 600
Sodium (Na)	30 lbs/acre 6”	<250
Sulfate (SO_4-S)	19 lbs/acre 6”	100 - 200
Calcium (Ca)	2,525 lbs/acre 6”	2,000 - 2,500
pH	6.0	6.5 - 7.5
Electrical Conductivity (EC)	0.6 mmhos/cm	0.2 - 4

Table 2. Average Soil Nutrient Concentrations

Topography and Vegetation

The upper and lower pastures, which will house the poultry, swine, and llamas, are relatively level with 2-9% slopes, rolling from flat pasture areas up into the low mountainous rangeland that will be occupied by the sheep and cattle (**Attachment 4 - USGS Topographic Map**).

The Custom Soil Resource Report (Attachment 2) lists the following native vegetation for the pasture areas:

- soft chess
- stork's bill
- wild oat
- clover
- ripgut brome
- blue oak
- burclover
- miniature lupine

In the rangeland areas, the following native vegetation is present:

- wild oat
- soft chess
- California live oak
- coastal sage scrub oak
- oak
- other annual grasses
- ripgut brome
- stork's bill

Cattle and sheep will readily consume wild oat, soft chess, red stork's bill, clover, and burclover during the green feed season and rely on their nutrients in the spring. Cattle will eat the ripgut brome early in the season when the leaves are still tender.

Water courses chiefly cross the rangelands in several locations. The Watson Creek, an intermittent waterway, runs below the dense vegetation south of the pastures.

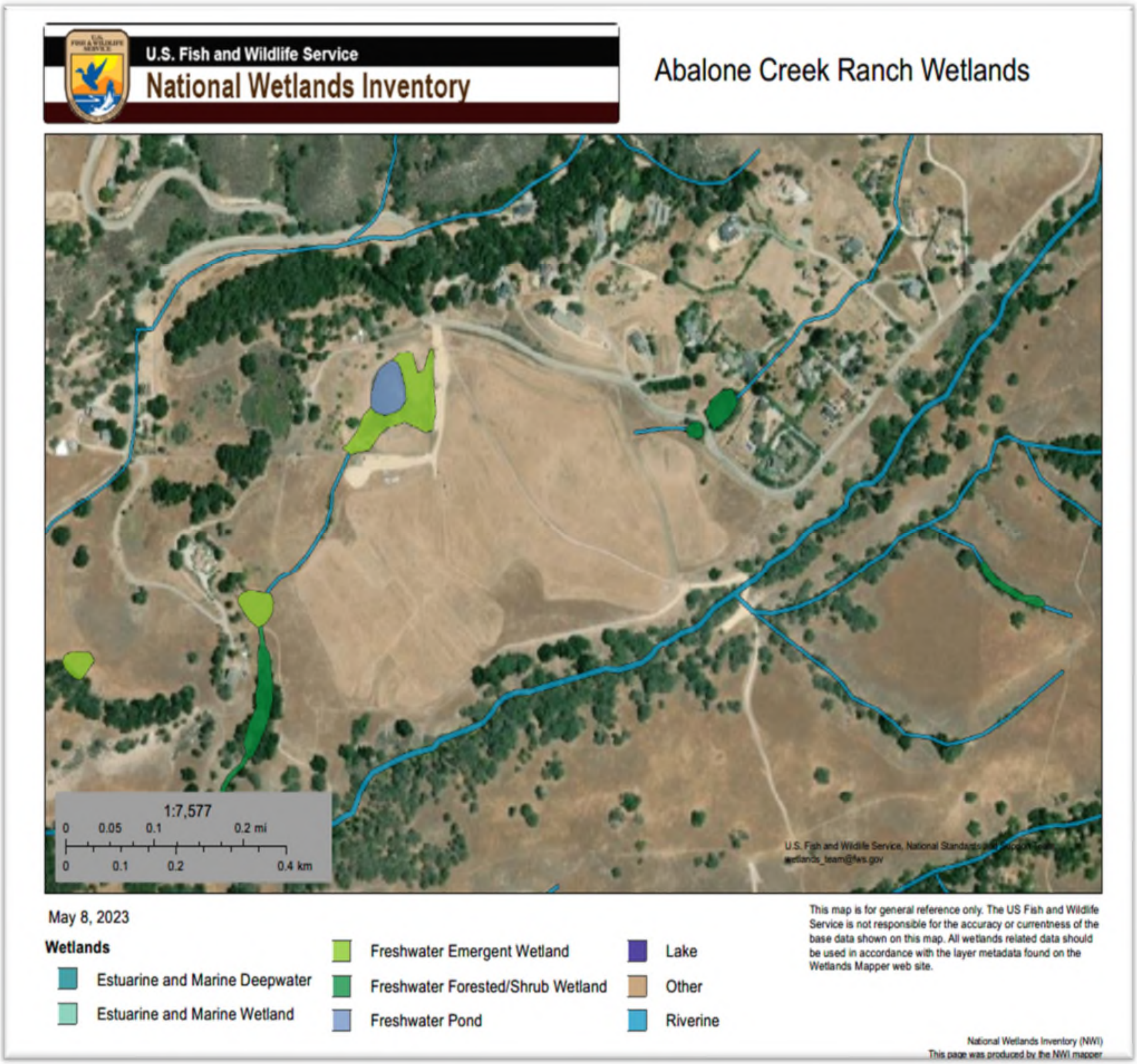


Figure 4. National Wetlands Inventory for Abalone Creek Ranch

Climate

Annual precipitation for the Salinas Valley is 16 inches with average temperatures between 40-74 ºF. Below in **Table 3**, the average precipitation from US Climate Data and average high and low temperatures are listed. Historically, precipitation is greatest from November through March.

The hottest months of the year are June through October, with average high temperatures from 70º F to 74º F.

Climate Salinas - California

	Jan	Feb	Mar	Apr	May	Jun
Average high in ºF	62	64	65	67	68	70
Average low in ºF	40	42	43	45	48	51
Av. precipitation in inch	3.09	2.98	2.74	1.03	0.45	0.09

	Jul	Aug	Sep	Oct	Nov	Dec
Average high in ºF	71	73	74	73	67	62
Average low in ºF	53	54	52	48	43	40
Av. precipitation in inch	0.00	0.04	0.19	0.64	1.76	2.44

Salinas Climate Graph - California Climate Chart

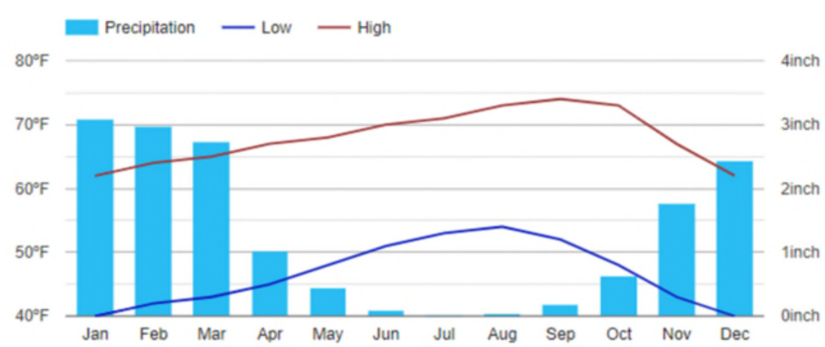


Table 3. US Climate Data Salinas Valley

Proposed Pasture Animal Units and Manure Production

The seeded upper pasture comprises approximately 25 acres of the proposed ranch (Figure 2) and will house poultry, swine, and the Guardian llamas. The swine will graze ahead of the chickens, allowing the pasture height to be lowered, provide feed droppings, and insect larvae for poultry feed. The swine and poultry manure will only be applied to the upper pasture. The seeded lower pasture comprises approximately 5 acres and will house the horses and llamas. Horse manure may be used throughout the pastures and fruit forests as needed for optimum plant nutrition. Llamas generally repeatedly defecate in piles in a few specific areas and the “llama beans” are collected and packaged for both sale and farm use (fruit forest) to create a “tea” fertilizer liquid. The proposed animal units (AU) and manure generation for the pastures are presented in **Tables 4** and **Attachment 5 - ASAE References for Manure Production and Characteristics**.

Table 4. Proposed Pastured Animal Units and Manure Generation

Animals in upper pasture	Poultry (broiler)	Swine	Horses	[6] Llamas
Open confinement (pasture)	0	10	4	6
Under roof (portable 20’x48’ structures)	500	0	0	0
Average animal weight (lbs)	5	154	1,100	350
[1] Animal Units (AU) per animal	0.005	0.15	1.1	0.35
[2] Total proposed AU	2.5	1.5	4.4	2.1
[3] Daily manure (lbs/AU)	85	84	51	11
[4] Daily manure (lbs)	213	126	224	22
[5] Annual manure production (lbs)	77,563	45,990	81,906	8,760
Annual manure production (tons)	39	23	41	4

[1] ASAE D384.2. Manure Production and Characteristics. One animal unit = 1,000 lbs.
[2] Total proposed AU = AU per animal x total proposed inventory
[3] ASAE D384.1. Manure Production and Characteristics.
[4] Daily manure (lbs.) = Daily manure (lbs./AU) x Proposed AU
[5] Annual manure production (lbs.) = Total daily manure (lbs.) x 365 days per year
[6] https://www.alpacainfo.com/academy/article/3272/environmental-impact-of-camelids
Alpaca Manure Management. Alpaca Magazine. 2003

Proposed Rangeland Animal Units and Manure Production

The Abalone Creek Ranch rangelands comprise approximately 192 acres of California montane chaparral and woodlands (Figure 3) and will be the home for the sheep and cattle. The proposed animal units (AU) and manure generation for the rangelands are presented in **Table 5** and Attachment 5**.**

Table 5. Proposed Rangeland Animal Units and Manure Generation

Rangeland Animals	Cattle	Sheep
Open confinement (rangeland)	30	200
Average animal weight (lbs)	963	200
[1] Animal Units (AU) per animal	0.99	0.2
[2] Total proposed AU	28.9	40
[3] Daily manure (lbs/AU)	58	40
[4] Daily manure (lbs)	1,676	1,600
[5] Annual manure production (lbs)	611,813	584,000
Annual manure production (tons)	306	292

[1] ASAE D384.2. Manure Production and Characteristics. One animal unit = 1,000 lbs.
[2] Total proposed AU = AU per animal x total proposed inventory
[3] ASAE D384.1. Manure Production and Characteristics.
[4] Daily manure (lbs.) = Daily manure (lbs./AU) x Proposed AU
[5] Annual manure production (lbs.) = Total daily manure (lbs.) x 365 days per year

Upper Pasture Animal Production and Manure Management

The proposed maximum number of poultry is 500 birds or 2.5 AUs. Birds will be raised in PastureTek portable chicken coops (20'x48' or 960 square-feet) that are moved daily to avoid over grazing, limit animal disease, and to allow only a small daily volume of manure (0.2 lbs/square-ft) to be distributed. Birds will be processed approximately every 4-10 weeks, once reaching a maturity weight of 4-5 lbs. Based on an average of 6 weeks to maturity, approximately nine (9) flocks can be maintained annually. The upper pasture occupies 25 acres (1,089,000 square-feet); therefore, only 350,400 square-feet (8 acres) is required for poultry production annually when a daily rotation is maintained. Subsequently, only 32% of the acreage is utilized on an annual basis, allowing the seeded rain-fed pasture to remain healthy.

Rotational grazing is planned with the swine and poultry. The swine will be followed by the birds. The proposed maximum number of swine is 10 pastured pigs or 1.5 AUs. Pigs will graze ahead of the chickens, offering predatory control, lowering the grass height, breaking down grass seed for poultry feed, and leaving behind manure containing grubs for proteins. NRCS recommends the following maximum stocking rate in conservation planning for pasture-based pork as the following:

 # Sows (including litters) = (Acres of Permanent Grass) + (Acres of Cropland/5)

Planned waste management practices for the upper pasture include manure spreading via a pull chain-harrow. The harrow breaks up the waste and evenly distributes the nutrients from the manure, allowing the pasture to breathe. This provides nutrient cycling in pastures and contributes to soil organic matter. Additionally, the grazing action on forage plants encourages root growth and root exudation of plant sugars that feed beneficial soil microorganisms. Dispersing manure piles also helps control parasites and pest insects, which prefer fresh manure for laying their eggs. Breaking apart piles reduces disease by exposing bacteria to sunlight which is essential for the health of the pasture. Harrowing also encourages new grass growth by removing the dead grass, which provides more space and aeration. Harrowing also facilitates drainage, helping to minimize muddy areas and standing water. Harrowing will not be completed during times of precipitation or when the ground is saturated to avoid compaction of the soil. Harrowing will only be completed when calm (0-2 mph) or light (2-5 mph) winds are occurring to avoid dust or odors from drifting.

Odors may also be controlled through the application of lime to the soil by a pull spreader. Based on soil results (Attachment 3), the soil pH in the pastures is moderately acidic (6.0). A soil amendment of 0.4 lbs/acre of lime (100 % calcium carbonate) was recommended to lower soil pH to 6.5. The application of lime is known to reduce odors, particularly hydrogen sulfide. In addition to raising soil pH, lime provides free calcium ions, which react and form complexes with odorous sulfur species. Thus, the biological waste odors are not just masked, but rather eliminated. Lime applications are recommended when precipitation is forecasted so that the lime may be incorporated into the soil.

A National Air Quality Site Assessment Report for Broilers (**Attachment 6**) was developed to assess proposed practices for the poultry. Practices assessed were animals and housing, feed and water, manure collection and transfer, land application, mortalities, and on-farm roads. The results indicated that the planned activities will be protective of air quality.

Lower Pasture Animal Production and Manure Management

The proposed maximum number of horses in the lower pasture is 4 or 4.4 AU and the maximum number of Guardian llamas is 6 or 2.1 AU. Because the Guardian llamas may roam throughout the upper and lower pastures, management of their manure production will be handled in both pastures. Planned waste management practices for the horses in the 5-acre lower pasture is manure cleanout twice weekly and transfer to a manure storage area containing 12’ x 20’ foot concrete bins with available coverage during precipitation events. The llama beans will be collected twice weekly. Horse manure will be spread onto the lower pasture as needed to meet the nutrient needs of the seeded pasture. A monthly manure tracking report will be completed each month for the horses and llamas and saved on the farm (**Attachment 7 - Monthly Manure Tracking Report**).

As previously discussed, lime may be spread to control odors and raise the pH of the soil to 6.5 pH units. Lime can be applied anytime to the horse pasture without affecting the animals; however, it is best to apply lime before a rainy period, so it breaks down faster. Aerating the pasture by harrowing before applying lime will help the lime work its way into the soil. It is advised to spread the recommended application of lime (0.4 lbs/acre) twice a year, half in the spring and half in the fall before forecasted rain and to apply during periods of light wind to avoid dust drift.

A National Air Quality Site Assessment Report for Horses (**Attachment 8**) was developed to assess proposed practices for the equine. Practices assessed were animals and housing, feed and water, manure collection and transfer, land application, mortalities, and on-farm roads. The results indicated that the planned activities will be protective of air quality.

It is understood that manure placement must be managed in a way that prevents runoff to wetlands and waterways and protects the water supply to the animals and workers. As presented in the Custom Soil Resource Report, the soil classification for the lower and upper pastures is Placentia Sandy Loam (PnC) with a runoff potential of “low” (Attachment 2 - Page 17). Figure 4 (National Wetlands Inventory for Abalone Creek Ranch) illustrates that there are not wetlands nor intermittent surface waterways within the boundaries of the upper and lower pastures. However, there are wetlands and intermittent streams that may be down slope from the proposed terraced fruit forests. It is recommended to not apply manure as fertilizer to these areas during precipitation events to deter any nutrient runoff into the protected areas. The site plan does indicate that a new well is being developed. GPS coordinates for the proposed domestic well are (36.540262, -121.663107). The proposed well is greater than 100 feet from the pastured areas.

Rangeland Animal Production and Grazing Management

The proposed maximum number of cattle is 30 head or 28.9 AU, and the planned maximum number of sheep is 200 or 40 AU to be housed within the 192-acres of California montane chaparral and woodlands. Resource concerns for rangeland management are focused on conditions that impair the sustainability or intended uses of natural resources. Desirable plant species for feed, live plant cover, plant diversity, plant residues as soil cover, grazing utilization, livestock concentration, soil compaction, plant vigor, and erosion have been identified and studied as the more conventional causes of degradation in rangelands. NRCS has developed a Pasture Conditions Scorecard (PCS) that is used to assess overall rangeland conditions to determine if improvements are needed that could benefit productivity and the environment (**Attachment 9 - Pasture Conditions Scorecard**).

NRCS has developed a general plant list for livestock species; highlighted plants listed are found in the central CA coastal region (**Attachment 10 - NRCS Plant List for Livestock Species in Central Coast CA**). The Custom Soil Resource Report (Attachment 2) lists native vegetation for the pasture and rangeland areas, and **Attachment 11- Field Guide to Common California Rangeland Plants** was prepared to assist the rancher with species identification for plant diversity. It is recommended that the PCS be completed annually to determine if any management activity changes are required that may improve production and natural resource conditions. A score of 45-50 requires no changes, 35-45 minor changes, 25-35 improvements would benefit productivity and /or environment, 15-25 needs immediate attention, and 10-15 major effort necessary. When PCS score drops below 35, seek the assistance of an NRCS rangeland specialist.

Nutrient Budget for Pastures

A standard broiler chicken reared in an enclosed house will require approximately 15 lbs. of lifetime feed to meet a market weight of five (5) lbs. Since 20% of the chicken’s diet can come from forage, approximately 6.75 tons of forage is needed to raise 9 flocks (4,500 birds) per year.

On average, a pasture raised growing swine requires 5 lbs. of feed per day, 50% of which can be pasture high in legumes to meet a market weight of 150-165 lbs. Since 50% of the swine’s diet can come from forage, approximately 9.125 tons of forage is needed to raise 20 pigs (10 pigs every 6 months).

On average, a pastured raised horse should eat up to 2% of its body weight per day in hay. With four horses at the ranch (1,100 lbs. each), 88 lbs. of hay per day are required for a total of 16 tons annually.

On average, a llama can eat up to 4% of their body weight. With six llamas at the ranch (350 lbs. each), 14 lbs. of hay are required per llama for a total of 15 tons annually. Therefore, the total tonnage required to feed the poultry, swine, horses, and llamas is 47 tons per year.

The total annual acreage used is 13 acres (8 for poultry/swine and 5 for horses/llamas). **Table 6** and **Attachment 12 - Information About Crops (MMP - Purdue)** lists the nitrogen (N), extractable phosphorus (P), and extractable potassium (K) requirements to achieve annually 47 tons of clover-grass hay forage production on 13 acres.

Table 6. Required Nutrient Fertilization for Pasture Hay (clover - grain mix)

Nutrient	[1] Required Amount for production of one ton pasture hay (lbs)	Required Amount for production of 47 tons of pasture hay (lbs)
N	38	1,786
P_2O_5	11.5	541
K_2O	50	2,350

[1] Information About Crops. Manure Management Planner 2022. NRCS.

Since site specific manure nutrient testing results are not available, book values for nitrogen, extractable phosphorus, and extractable potassium are utilized to calculate manure nutrient production (**Table 7 and Attachment 13 - Nutrient and Manure Management Tables**).

Animal Type	Proposed AU	Nitrogen (N) in Manure per AU in lbs/year	P_2O_5 in Manure per AU in lbs/year	K_2O in Manure per AU in lbs/year	Total N Produced	Total P_2O_5 Produced	Total K_2O Produced
Broiler	2.5	383	256	183	958	640	458
Finishing Pig	1.5	219	73	97	329	110	146
Horse	4.4	66	22	22	290	97	97
Total					**1,577**	**847**	**701**

Table 7. Annual Manure Nutrient Production for Proposed AUs

The llama manure generated was not used for nutrient loading of the hay since the “llama beans” are collected and packaged for sale or used as a liquid “tea” fertilizer on the fruit trees. In addition, current book values for llama manure could not be obtained. Further university-based research is needed in that area. However, it is recommended that all animal manures are sampled annually for nitrogen, potassium, ash, and moisture and records are maintained of amount collected and/or sold. Site specific nutrient data, along with plant health visual observations and animal production weight values at market time, will be recorded annually to assess production goals.

More nutrients are required to grow the 47 tons of clover-mix pasture than are produced in the animal manures; however, the clover-mix pasture contains 15% organic barley, 30% organic bell beans, 30% organic vetch, and 25% organic peas. The beans, vetch, and peas are legume plants. Legumes, with the symbiotic relationship of Rhizobium bacteria, can fix atmospheric nitrogen within their roots. Legume plants will remove nitrogen from the soil (manure-N) before using energy to obtain the nitrogen from the air through N_2-fixation. Interception of sunlight is very important to maintain a high growth rate supported by N_2-fixation. By utilizing daily rotation in the upper pasture, plenty of leaf area will remain.

Record Keeping

Abalone Creek Ranch will keep records of manure applications, manure exports, and manure storage observations for a period of 5 years.

Certification Statement

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete.

Abalone Creek Ranch Inc.

____

Tarin Christensen, Company Director Date
Office phone # (310) 951-6682

References

Alpaca Manure Management. Alpaca Magazine. 2003.

Calculating Pasture and Forage Consumption of Horses. Kentucky Equine Research. 2022.

Conservation Planning Guidelines for Outdoor Swine Operations. NRCS. August 2007.

Field Guide for Common California Rangeland and Pasture Plants. UCANR. 2020.

https://www.alpacainfo.com/academy/article/3272/environmental-impact-of-camelids

https://www.nationalgeographic.com/animals/mammals/facts/llama-1?loggedin=true&rnd=1684969855535

Introduction to Animal Units (AU) Concepts for Production of Sheep and Goats. University of Nebraska Extension. G2344 Index. May 2022.

Manure Management Planner (MMP) 2022 | version 4.0.3 | by Purdue University Department of Agronomy and the Natural Resources Conservation Service (NRCS)

Manure Production and its Characteristics. American Society of Agricultural Engineers. ASAE D384.2. March 2005.

Manure Production and its Characteristics. American Society of Agricultural Engineers. ASAE D384.1. February 2003.

Pastured Poultry Fact Sheet. Sustainable Farming Association.

Pasture Pig Basics. Utah State University. 2003.

US Climate Data 2023 | version 3.0 | by US Climate Data

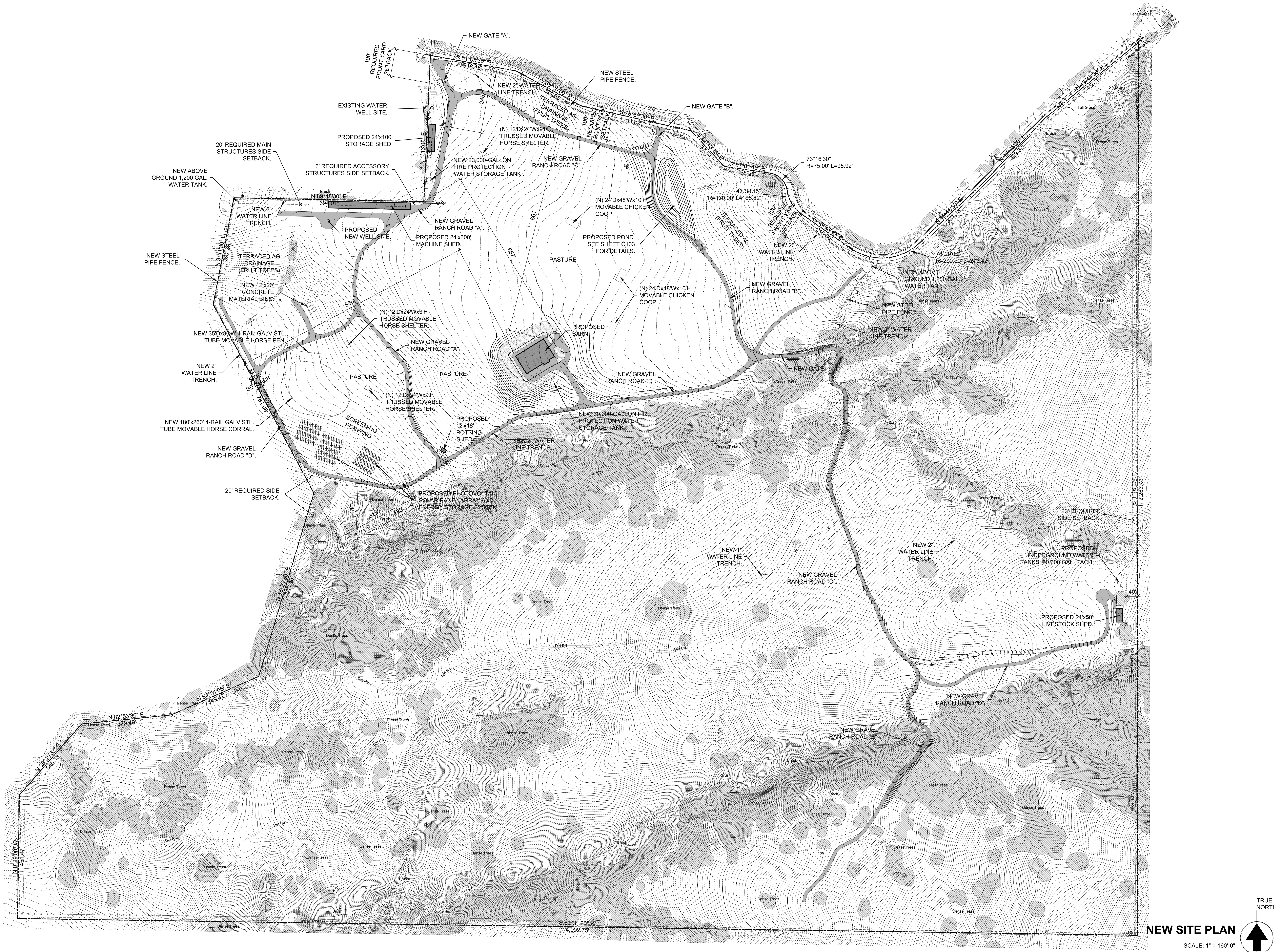
Uses of Lime in Animal Waste. The National Lime Association. 2003.

This Page Left Intentionally Blank

Attachment 1
Abalone Creek Ranch Proposed Site Plan

DELLAVALLE™
LABORATORY INC

1910 W. McKinley Avenue, Suite 110 ● Fresno, California 93728-1298
Phone (559) 233-6129 ● (800) 228-9896 ● Fax (559) 268-8174
Website: dellavallelab.com



NEW SITE PLAN

SCALE: 1" = 160'-0"

HOLDREN + LIETZKE ARCHITECTURE

225 CANNERY ROW - SUITE A
MONTEREY, CA 93940
PH: 831.649.6001
FAX: 831.649.6003
www.hl-arc.com

DATE:	09/19/2022
SCALE:	1"=160'-0"
DRAWN:	A.P.
JOB NUMBER:	20.09
REVISION	

PRELIMINARY - NOT FOR CONSTRUCTION
BUILDING OR PLANNING DEPARTMENT
SUBMITTAL OR REVIEW

NEW SITE PLAN

ABALONE CREEK RANCH

18000 CORRAL DE CIELO
SALINAS CA. 93908

A.P.N. 416-441-047

A1.3

11/29/2022 8:48:56 AM

Attachment 2
Custom Soil Resource Report

DELLAVALLE™
LABORATORY INC

1910 W. McKinley Avenue, Suite 110 ● Fresno, California 93728-1298
Phone (559) 233-6129 ● (800) 228-9896 ● Fax (559) 268-8174
Website: dellavallelab.com

United States Department of Agriculture

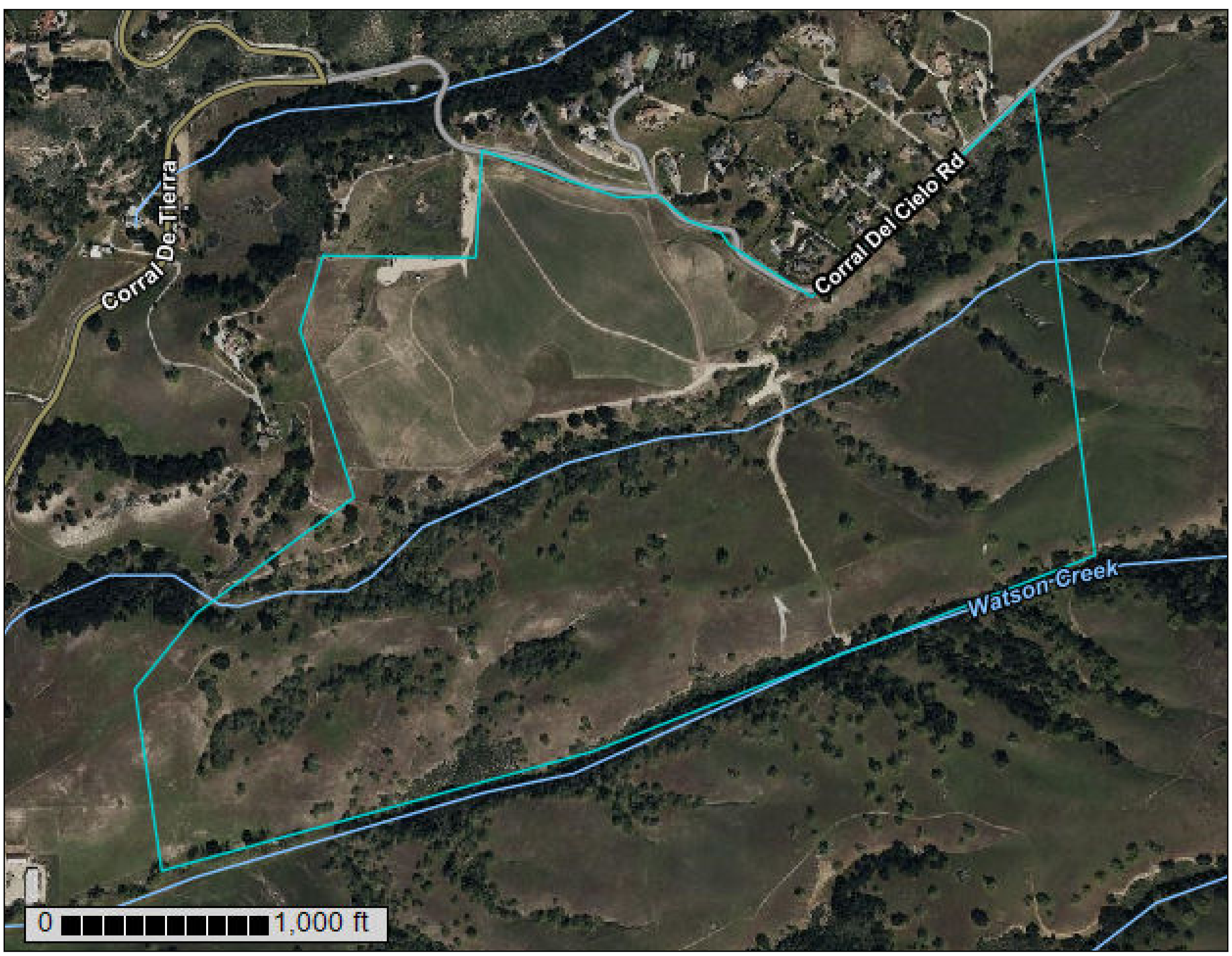
NRCS

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 Monterey County, California

Abalone Creek Ranch



May 9, 2023

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 (https://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.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination, write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410 or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.

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.

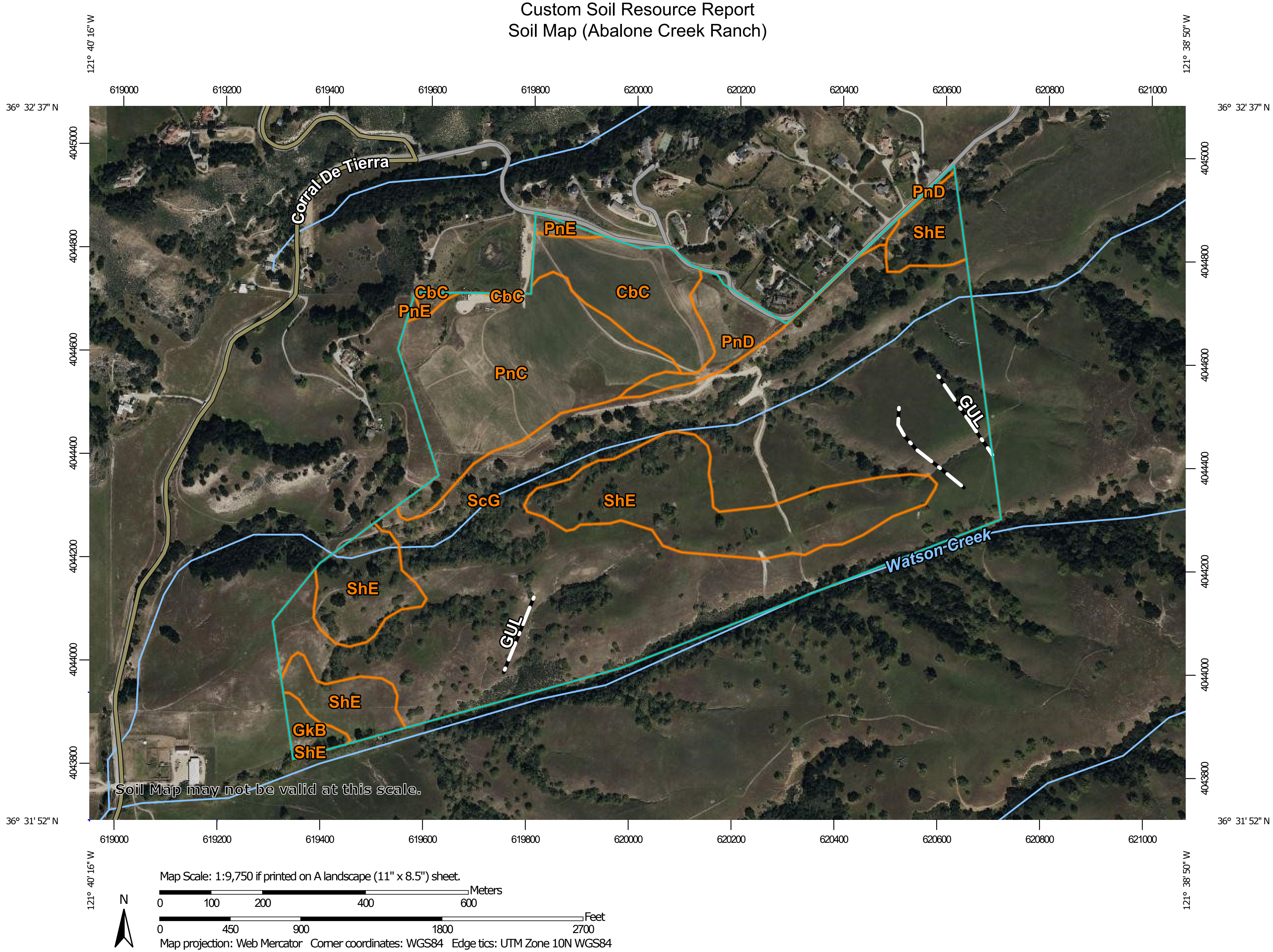
Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree 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.

Custom Soil Resource Report
Soil Map (Abalone Creek Ranch)



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 1:24,000.

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:
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: Monterey County, California
Survey Area Data: Version 19, Sep 14, 2022

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

Date(s) aerial images were photographed: Mar 11, 2022—May 29, 2022

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 (Abalone Creek Ranch)

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
CbC	Chualar loam, 5 to 9 percent slopes	13.3	6.0%
GkB	Gorgonio sandy loam, 0 to 5 percent slopes	1.9	0.8%
PnC	Placentia sandy loam, 2 to 9 percent slopes, MLRA 14	30.3	13.6%
PnD	Placentia sandy loam, 9 to 15 percent slopes	6.1	2.7%
PnE	Placentia sandy loam, 15 to 30 percent slopes	1.0	0.4%
ScG	San Andreas fine sandy loam, 30 to 75 percent slopes	129.2	58.0%
ShE	Santa Ynez fine sandy loam, 15 to 30 percent slopes	41.0	18.4%
Totals for Area of Interest		**222.6**	**100.0%**

Map Unit Descriptions (Abalone Creek Ranch)

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.

Monterey County, California

CbC—Chualar loam, 5 to 9 percent slopes

Map Unit Setting

National map unit symbol: h91s
Elevation: 50 to 2,000 feet
Mean annual precipitation: 12 to 25 inches
Mean annual air temperature: 57 to 61 degrees F
Frost-free period: 175 to 300 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Chualar and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Chualar

Setting

Landform: Terraces, alluvial fans
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Tread, talf
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Loamy alluvium derived from igneous and metamorphic rock

Typical profile

H1 - 0 to 21 inches: loam
H2 - 21 to 44 inches: sandy clay loam
H3 - 44 to 59 inches: gravelly sandy loam
H4 - 59 to 80 inches: gravelly coarse sand

Properties and qualities

Slope: 5 to 9 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Moderate (about 8.6 inches)

Interpretive groups

Land capability classification (irrigated): 2e
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: C
Ecological site: R014XG917CA - Dry Loamy Fan
Hydric soil rating: No

Minor Components

Badland

Percent of map unit: 2 percent
Hydric soil rating: No

Los osos

Percent of map unit: 2 percent
Hydric soil rating: No

Gloria

Percent of map unit: 2 percent
Hydric soil rating: No

Arroyo seco

Percent of map unit: 2 percent
Hydric soil rating: No

Nacimiento

Percent of map unit: 1 percent
Hydric soil rating: No

Xerorthents, sandy

Percent of map unit: 1 percent
Hydric soil rating: No

Vista

Percent of map unit: 1 percent
Hydric soil rating: No

Placentia

Percent of map unit: 1 percent
Hydric soil rating: No

San benito

Percent of map unit: 1 percent
Hydric soil rating: No

Xerorthents, dissected

Percent of map unit: 1 percent
Hydric soil rating: No

Tujunga

Percent of map unit: 1 percent
Hydric soil rating: No

GkB—Gorgonio sandy loam, 0 to 5 percent slopes

Map Unit Setting

National map unit symbol: h93f
Elevation: 0 to 3,460 feet
Mean annual precipitation: 10 to 25 inches
Mean annual air temperature: 57 to 61 degrees F

Frost-free period: 250 to 310 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Gorgonio and similar soils: 70 percent
Arroyo seco and similar soils: 15 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Gorgonio

Setting

Landform: Alluvial fans
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Coarse-loamy alluvium derived from igneous and metamorphic rock

Typical profile

H1 - 0 to 22 inches: gravelly sandy loam
H2 - 22 to 63 inches: gravelly loamy sand

Properties and qualities

Slope: 0 to 5 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 5.3 inches)

Interpretive groups

Land capability classification (irrigated): 3s
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: A
Ecological site: R014XG917CA - Dry Loamy Fan
Hydric soil rating: No

Description of Arroyo Seco

Setting

Landform: Alluvial fans
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Coarse-loamy alluvium derived from igneous and metamorphic rock

Typical profile

H1 - 0 to 42 inches: gravelly sandy loam

H2 - 42 to 60 inches: very gravelly coarse sandy loam

Properties and qualities

Slope: 0 to 5 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 4.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Hydrologic Soil Group: A
Ecological site: R014XG917CA - Dry Loamy Fan
Hydric soil rating: No

Minor Components

Elder

Percent of map unit: 5 percent
Hydric soil rating: No

Hanford

Percent of map unit: 3 percent
Hydric soil rating: No

Fluvents, stony

Percent of map unit: 3 percent
Landform: Flood plains
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

Salinas

Percent of map unit: 3 percent
Hydric soil rating: No

Tujunga

Percent of map unit: 1 percent
Hydric soil rating: No

PnC—Placentia sandy loam, 2 to 9 percent slopes, MLRA 14

Map Unit Setting

National map unit symbol: 2tyym

Elevation: 30 to 2,660 feet
Mean annual precipitation: 11 to 26 inches
Mean annual air temperature: 57 to 61 degrees F
Frost-free period: 240 to 360 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Placentia and similar soils: 84 percent
Minor components: 16 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Placentia

Setting

Landform: Terraces, alluvial fans
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Alluvium derived from schist and/or alluvium derived from granitoid

Typical profile

Ap1 - 0 to 5 inches: sandy loam
Ap2 - 5 to 13 inches: sandy loam
A - 13 to 13 inches: sandy loam
Bt1 - 13 to 20 inches: clay
Bt2 - 20 to 29 inches: clay
Btk - 29 to 36 inches: clay loam
B't1 - 36 to 42 inches: sandy clay loam
B't2 - 42 to 58 inches: sandy clay loam
C - 58 to 68 inches: gravelly sandy loam

Properties and qualities

Slope: 2 to 9 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Low
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: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to moderately saline (0.0 to 8.0 mmhos/cm)
Available water supply, 0 to 60 inches: Moderate (about 8.1 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: C
Ecological site: R015XD115CA - CLAYPAN
Hydric soil rating: No

Minor Components

Danville

Percent of map unit: 2 percent

Hydric soil rating: No

Pinnacles

Percent of map unit: 2 percent
Hydric soil rating: No

Chualar

Percent of map unit: 2 percent
Hydric soil rating: No

Gloria

Percent of map unit: 2 percent
Hydric soil rating: No

Cropley

Percent of map unit: 2 percent
Hydric soil rating: No

Antioch

Percent of map unit: 2 percent
Hydric soil rating: No

Rincon

Percent of map unit: 1 percent
Hydric soil rating: No

Typic haploxerolls

Percent of map unit: 1 percent
Hydric soil rating: No

Typic natrixeralfs, cobbley surface

Percent of map unit: 1 percent
Hydric soil rating: No

Typic natrixeralfs, very gravelly

Percent of map unit: 1 percent
Hydric soil rating: No

PnD—Placentia sandy loam, 9 to 15 percent slopes

Map Unit Setting

National map unit symbol: h95x
Elevation: 50 to 2,500 feet
Mean annual precipitation: 12 to 18 inches
Mean annual air temperature: 57 to 64 degrees F
Frost-free period: 250 to 300 days
Farmland classification: Not prime farmland

Map Unit Composition

Placentia and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Placentia

Setting

Landform: Terraces
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Coarse-loamy alluvium derived from igneous and metamorphic rock

Typical profile

H1 - 0 to 13 inches: sandy loam
H2 - 13 to 36 inches: clay
H3 - 36 to 58 inches: sandy clay loam
H4 - 58 to 68 inches: gravelly sandy loam

Properties and qualities

Slope: 9 to 15 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Very high
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: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to moderately saline (0.0 to 8.0 mmhos/cm)
Available water supply, 0 to 60 inches: Very low (about 2.3 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: D
Ecological site: R015XD115CA - CLAYPAN
Hydric soil rating: No

Minor Components

Chualar

Percent of map unit: 3 percent
Hydric soil rating: No

Gloria

Percent of map unit: 2 percent
Hydric soil rating: No

Mccoy

Percent of map unit: 2 percent
Hydric soil rating: No

Rincon

Percent of map unit: 2 percent
Hydric soil rating: No

Linne

Percent of map unit: 2 percent
Hydric soil rating: No

Placentia, sandy loam

Percent of map unit: 2 percent
Hydric soil rating: No

Nacimiento

Percent of map unit: 2 percent
Hydric soil rating: No

PnE—Placentia sandy loam, 15 to 30 percent slopes

Map Unit Setting

National map unit symbol: h95y
Elevation: 50 to 2,500 feet
Mean annual precipitation: 12 to 18 inches
Mean annual air temperature: 57 to 64 degrees F
Frost-free period: 250 to 300 days
Farmland classification: Not prime farmland

Map Unit Composition

Placentia and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Placentia

Setting

Landform: Terraces
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Coarse-loamy alluvium derived from igneous and metamorphic rock

Typical profile

H1 - 0 to 13 inches: sandy loam
H2 - 13 to 36 inches: clay
H3 - 36 to 58 inches: sandy clay loam
H4 - 58 to 68 inches: gravelly sandy loam

Properties and qualities

Slope: 15 to 30 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Very high
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: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None

Maximum salinity: Nonsaline to moderately saline (0.0 to 8.0 mmhos/cm)
Available water supply, 0 to 60 inches: Very low (about 2.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: D
Ecological site: R015XD115CA - CLAYPAN
Hydric soil rating: No

Minor Components

Chamise

Percent of map unit: 2 percent
Hydric soil rating: No

Chualar

Percent of map unit: 2 percent
Hydric soil rating: No

Diablo

Percent of map unit: 2 percent
Hydric soil rating: No

Arnold

Percent of map unit: 2 percent
Hydric soil rating: No

Gloria

Percent of map unit: 2 percent
Hydric soil rating: No

Pinnacles

Percent of map unit: 1 percent
Hydric soil rating: No

Nacimiento

Percent of map unit: 1 percent
Hydric soil rating: No

Santa ynez

Percent of map unit: 1 percent
Hydric soil rating: No

Rincon

Percent of map unit: 1 percent
Hydric soil rating: No

Placentia, sandy loam

Percent of map unit: 1 percent
Hydric soil rating: No

ScG—San Andreas fine sandy loam, 30 to 75 percent slopes

Map Unit Setting

National map unit symbol: h96g
Elevation: 200 to 2,500 feet
Mean annual precipitation: 12 to 35 inches
Mean annual air temperature: 57 to 64 degrees F
Frost-free period: 200 to 350 days
Farmland classification: Not prime farmland

Map Unit Composition

San andreas and similar soils: 60 percent
Minor components: 40 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of San Andreas

Setting

Landform: Mountains
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Mountainflank
Down-slope shape: Concave
Across-slope shape: Convex
Parent material: Coarse-loamy residuum weathered from sandstone

Typical profile

H1 - 0 to 22 inches: fine sandy loam
H2 - 22 to 26 inches: bedrock

Properties and qualities

Slope: 30 to 75 percent
Depth to restrictive feature: 22 inches to paralithic bedrock
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Low (about 3.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: B
Ecological site: R015XD011CA - COARSE LOAMY
Hydric soil rating: No

Minor Components

Gazos
Percent of map unit: 10 percent
Hydric soil rating: No

Pfeiffer
Percent of map unit: 10 percent
Hydric soil rating: No

Gaviota
Percent of map unit: 10 percent
Hydric soil rating: No

Sheridan
Percent of map unit: 5 percent
Hydric soil rating: No

Santa ynez
Percent of map unit: 5 percent
Hydric soil rating: No

ShE—Santa Ynez fine sandy loam, 15 to 30 percent slopes

Map Unit Setting
National map unit symbol: h96t
Elevation: 0 to 1,900 feet
Mean annual precipitation: 16 to 21 inches
Mean annual air temperature: 57 to 59 degrees F
Frost-free period: 310 to 365 days
Farmland classification: Not prime farmland

Map Unit Composition
Santa ynez and similar soils: 40 percent
Santa ynez and similar soils: 35 percent
San andreas and similar soils: 15 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Santa Ynez

Setting
Landform: Terraces
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Fine-loamy alluvium derived from igneous and sedimentary rock

Typical profile
H1 - 0 to 18 inches: fine sandy loam

H2 - 18 to 43 inches: clay
H3 - 43 to 61 inches: sandy clay loam

Properties and qualities

Slope: 15 to 30 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Moderately well drained
Runoff class: Very high
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: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Very low (about 2.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: D
Ecological site: R015XD115CA - CLAYPAN
Hydric soil rating: No

Description of Santa Ynez

Setting

Landform: Terraces
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Fine-loamy alluvium derived from igneous and sedimentary rock

Typical profile

H1 - 0 to 18 inches: fine sandy loam
H2 - 18 to 43 inches: clay
H3 - 43 to 61 inches: sandy clay loam

Properties and qualities

Slope: 15 to 30 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Moderately well 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: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Very low (about 2.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Hydrologic Soil Group: D
Ecological site: R014XG911CA - Dry Loamy Terrace
Hydric soil rating: No

Description of San Andreas

Setting

Landform: Hills

Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Fine-loamy residuum weathered from sandstone

Typical profile

H1 - 0 to 22 inches: fine sandy loam
H2 - 22 to 26 inches: bedrock

Properties and qualities

Slope: 15 to 30 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Low (about 3.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Hydrologic Soil Group: B
Ecological site: R014XG923CA - Dry Loamy Upland
Hydric soil rating: No

Minor Components

Antioch

Percent of map unit: 2 percent
Hydric soil rating: No

Snelling

Percent of map unit: 2 percent
Hydric soil rating: No

Elkhorn

Percent of map unit: 2 percent
Hydric soil rating: No

Haire

Percent of map unit: 2 percent
Hydric soil rating: No

Arnold

Percent of map unit: 2 percent
Hydric soil rating: No

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.

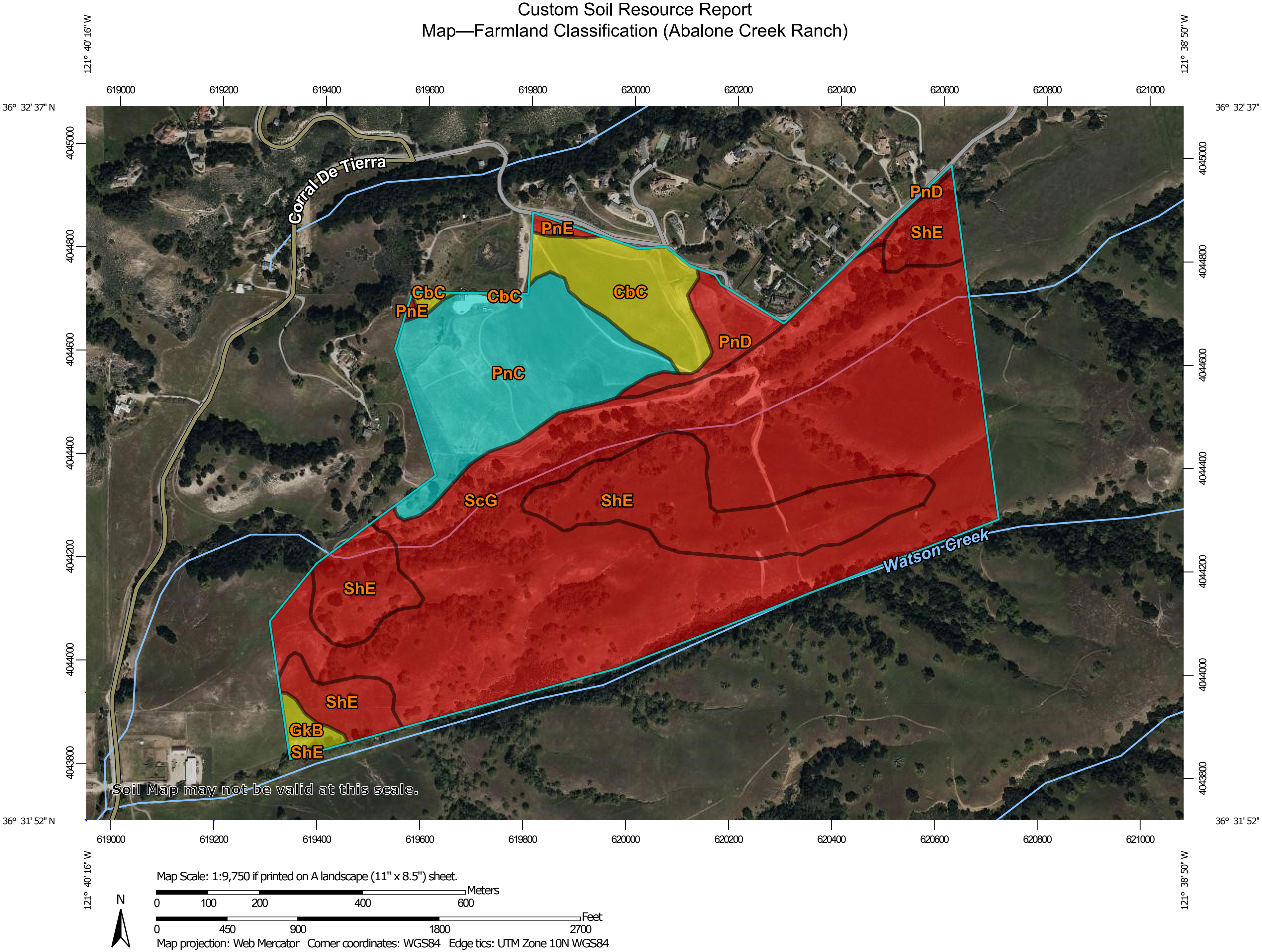
Land Classifications

Land Classifications are specified land use and management groupings that are assigned to soil areas because combinations of soil have similar behavior for specified practices. Most are based on soil properties and other factors that directly influence the specific use of the soil. Example classifications include ecological site classification, farmland classification, irrigated and nonirrigated land capability classification, and hydric rating.

Farmland Classification (Abalone Creek Ranch)

Farmland classification identifies map units as prime farmland, farmland of statewide importance, farmland of local importance, or unique farmland. It identifies the location and extent of the soils that are best suited to food, feed, fiber, forage, and oilseed crops. NRCS policy and procedures on prime and unique farmlands are published in the "Federal Register," Vol. 43, No. 21, January 31, 1978.

Map—Farmland Classification (Abalone Creek Ranch)



MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

Soil Rating Polygons

- Not prime farmland
- All areas are prime farmland
- Prime farmland if drained
- Prime farmland if protected from flooding or not frequently flooded during the growing season
- Prime farmland if irrigated
- Prime farmland if drained and either protected from flooding or not frequently flooded during the growing season
- Prime farmland if irrigated and drained
- Prime farmland if irrigated and either protected from flooding or not frequently flooded during the growing season
- Prime farmland if subsoiled, completely removing the root inhibiting soil layer
- Prime farmland if irrigated and the product of I (soil erodibility) x C (climate factor) does not exceed 60
- Prime farmland if irrigated and reclaimed of excess salts and sodium
- Farmland of statewide importance
- Farmland of statewide importance, if drained
- Farmland of statewide importance, if protected from flooding or not frequently flooded during the growing season
- Farmland of statewide importance, if irrigated
- Farmland of statewide importance, if drained and either protected from flooding or not frequently flooded during the growing season
- Farmland of statewide importance, if irrigated and drained
- Farmland of statewide importance, if irrigated and either protected from flooding or not frequently flooded during the growing season
- Farmland of statewide importance, if subsoiled, completely removing the root inhibiting soil layer
- Farmland of statewide importance, if irrigated and the product of I (soil erodibility) x C (climate factor) does not exceed 60
- Farmland of statewide importance, if irrigated and reclaimed of excess salts and sodium
- Farmland of statewide importance, if drained or either protected from flooding or not frequently flooded during the growing season
- Farmland of statewide importance, if warm enough, and either drained or either protected from flooding or not frequently flooded during the growing season
- Farmland of statewide importance, if warm enough
- Farmland of statewide importance, if thawed
- Farmland of local importance
- Farmland of local importance, if irrigated
- Farmland of unique importance
- Not rated or not available

Soil Rating Lines

- Not prime farmland
- All areas are prime farmland
- Prime farmland if drained
- Prime farmland if protected from flooding or not frequently flooded during the growing season
- Prime farmland if irrigated
- Prime farmland if drained and either protected from flooding or not frequently flooded during the growing season
- Prime farmland if irrigated and drained
- Prime farmland if irrigated and either protected from flooding or not frequently flooded during the growing season

Prime farmland if subsoiled, completely removing the root inhibiting soil layer

Prime farmland if irrigated and the product of I (soil erodibility) x C (climate factor) does not exceed 60

Prime farmland if irrigated and reclaimed of excess salts and sodium

Farmland of statewide importance

Farmland of statewide importance, if drained

Farmland of statewide importance, if protected from flooding or not frequently flooded during the growing season

Farmland of statewide importance, if irrigated

Farmland of statewide importance, if drained and either protected from flooding or not frequently flooded during the growing season

Farmland of statewide importance, if irrigated and drained

Farmland of statewide importance, if irrigated and either protected from flooding or not frequently flooded during the growing season

Farmland of statewide importance, if subsoiled, completely removing the root inhibiting soil layer

Farmland of statewide importance, if irrigated and the product of I (soil erodibility) x C (climate factor) does not exceed 60

Farmland of statewide importance, if irrigated and reclaimed of excess salts and sodium

Farmland of statewide importance, if drained or either protected from flooding or not frequently flooded during the growing season

Farmland of statewide importance, if warm enough, and either drained or either protected from flooding or not frequently flooded during the growing season

Farmland of statewide importance, if warm enough

Farmland of statewide importance, if thawed

Farmland of local importance

Farmland of local importance, if irrigated

Farmland of unique importance

Not rated or not available

Soil Rating Points

Not prime farmland

All areas are prime farmland

Prime farmland if drained

Prime farmland if protected from flooding or not frequently flooded during the growing season

Prime farmland if irrigated

Prime farmland if drained and either protected from flooding or not frequently flooded during the growing season

Prime farmland if irrigated and drained

Prime farmland if irrigated and either protected from flooding or not frequently flooded during the growing season

Prime farmland if subsoiled, completely removing the root inhibiting soil layer

Prime farmland if irrigated and the product of I (soil erodibility) x C (climate factor) does not exceed 60

Prime farmland if irrigated and reclaimed of excess salts and sodium

Farmland of statewide importance

Farmland of statewide importance, if drained

Farmland of statewide importance, if protected from flooding or not frequently flooded during the growing season

Farmland of statewide importance, if irrigated

Farmland of statewide importance, if drained and either protected from flooding or not frequently flooded during the growing season

Farmland of statewide importance, if irrigated and drained

Farmland of statewide importance, if irrigated and either protected from flooding or not frequently flooded during the growing season

Farmland of statewide importance, if subsoiled, completely removing the root inhibiting soil layer

Farmland of statewide importance, if irrigated and the product of I (soil erodibility) x C (climate factor) does not exceed 60

Farmland of statewide importance, if irrigated and reclaimed of excess salts and sodium

Farmland of statewide importance, if drained or either protected from flooding or not frequently flooded during the growing season

Farmland of statewide importance, if warm enough, and either drained or either protected from flooding or not frequently flooded during the growing season

Farmland of statewide importance, if warm enough

Farmland of statewide importance, if thawed

Farmland of local importance

Farmland of local importance, if irrigated

Farmland of unique importance

Not rated or not available

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

The soil surveys that comprise your AOI were mapped at 1:24,000.

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:
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: Monterey County, California
Survey Area Data: Version 19, Sep 14, 2022

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

Date(s) aerial images were photographed: Mar 11, 2022—May 29, 2022

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—Farmland Classification (Abalone Creek Ranch)

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
CbC	Chualar loam, 5 to 9 percent slopes	Prime farmland if irrigated	13.3	6.0%
GkB	Gorgonio sandy loam, 0 to 5 percent slopes	Prime farmland if irrigated	1.9	0.8%
PnC	Placentia sandy loam, 2 to 9 percent slopes, MLRA 14	Farmland of statewide importance	30.3	13.6%
PnD	Placentia sandy loam, 9 to 15 percent slopes	Not prime farmland	6.1	2.7%
PnE	Placentia sandy loam, 15 to 30 percent slopes	Not prime farmland	1.0	0.4%
ScG	San Andreas fine sandy loam, 30 to 75 percent slopes	Not prime farmland	129.2	58.0%
ShE	Santa Ynez fine sandy loam, 15 to 30 percent slopes	Not prime farmland	41.0	18.4%
Totals for Area of Interest			**222.6**	**100.0%**

Rating Options—Farmland Classification (Abalone Creek Ranch)

Aggregation Method: No Aggregation Necessary

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

A map unit is typically composed of one or more "components". A component is either some type of soil or some nonsoil entity, e.g., rock outcrop. For the attribute being aggregated, the first step of the aggregation process is to derive one attribute value for each of a map unit's components. From this set of component attributes, the next step of the aggregation process derives a single value that represents the map unit as a whole. Once a single value for each map unit is derived, a thematic map for soil map units can be rendered. Aggregation must be done because, on any soil map, map units are delineated but components are not.

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

The majority of soil attributes are associated with a component of a map unit, and such an attribute has to be aggregated to the map unit level before a thematic map can be rendered. Map units, however, also have their own attributes. An attribute of a map unit does not have to be aggregated in order to render a corresponding thematic map. Therefore, the "aggregation method" for any attribute of a map unit is referred to as "No Aggregation Necessary".

Tie-break Rule: Lower

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

Soil Properties and Qualities

The Soil Properties and Qualities section includes various soil properties and qualities 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 property or quality.

Water Features

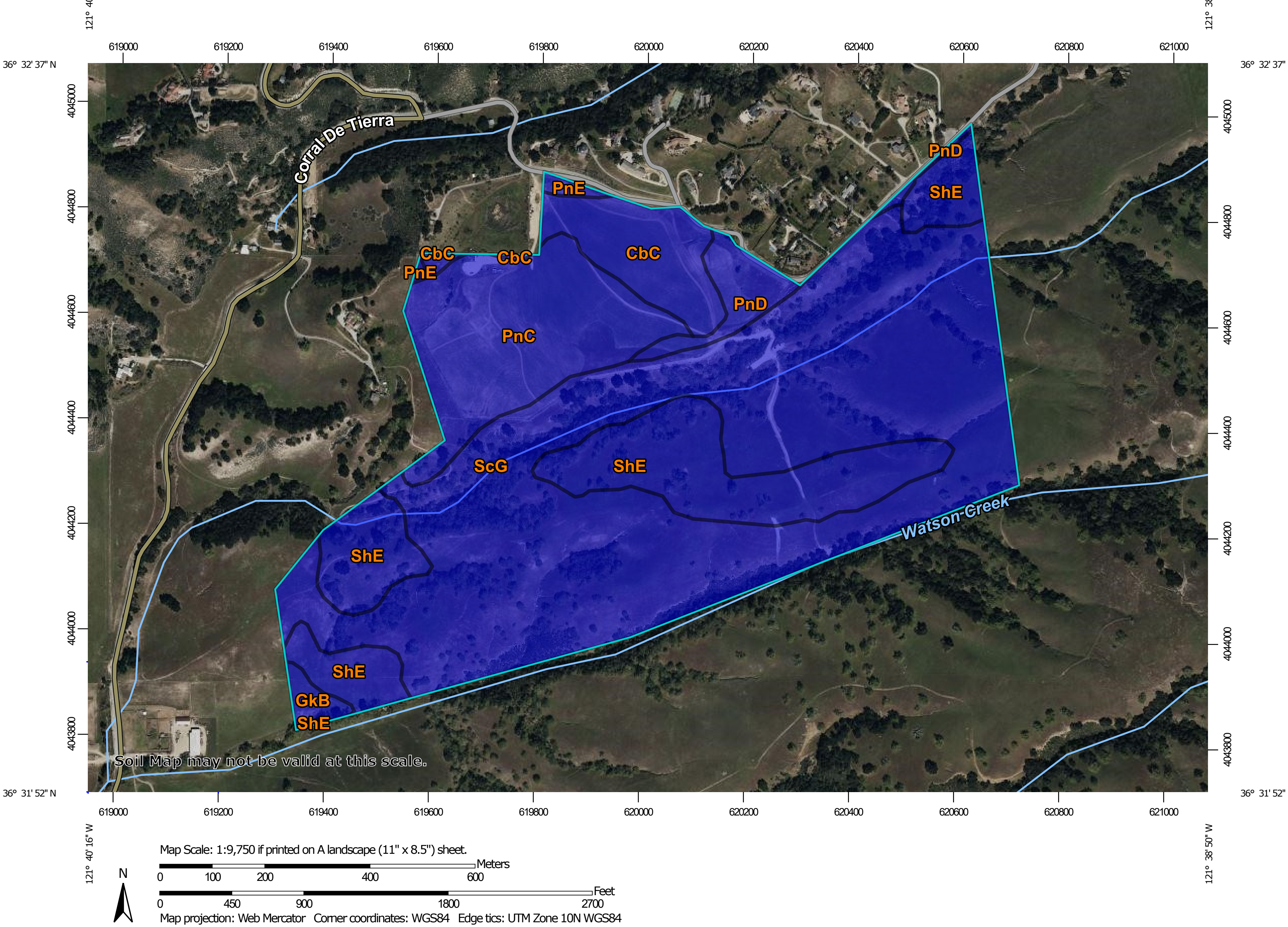
Water Features include ponding frequency, flooding frequency, and depth to water table.

Depth to Water Table (Abalone Creek Ranch)

"Water table" refers to a saturated zone in the soil. It occurs during specified months. Estimates of the upper limit are based mainly on observations of the water table at selected sites and on evidence of a saturated zone, namely grayish colors (redoximorphic features) in the soil. A saturated zone that lasts for less than a month is not considered a water table.

This attribute is actually recorded as three separate values in the database. A low value and a high value indicate the range of this attribute for the soil component. A "representative" value indicates the expected value of this attribute for the component. For this soil property, only the representative value is used.

Custom Soil Resource Report
Map—Depth to Water Table (Abalone Creek Ranch)



MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

0 - 25

25 - 50

50 - 100

100 - 150

150 - 200

> 200

Not rated or not available

Soil Rating Lines

0 - 25

25 - 50

50 - 100

100 - 150

150 - 200

> 200

Not rated or not available

Soil Rating Points

0 - 25

25 - 50

50 - 100

100 - 150

150 - 200

> 200

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 1:24,000.

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:
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: Monterey County, California
Survey Area Data: Version 19, Sep 14, 2022

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

Date(s) aerial images were photographed: Mar 11, 2022—May 29, 2022

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—Depth to Water Table (Abalone Creek Ranch)

Map unit symbol	Map unit name	Rating (centimeters)	Acres in AOI	Percent of AOI
CbC	Chualar loam, 5 to 9 percent slopes	>200	13.3	6.0%
GkB	Gorgonio sandy loam, 0 to 5 percent slopes	>200	1.9	0.8%
PnC	Placentia sandy loam, 2 to 9 percent slopes, MLRA 14	>200	30.3	13.6%
PnD	Placentia sandy loam, 9 to 15 percent slopes	>200	6.1	2.7%
PnE	Placentia sandy loam, 15 to 30 percent slopes	>200	1.0	0.4%
ScG	San Andreas fine sandy loam, 30 to 75 percent slopes	>200	129.2	58.0%
ShE	Santa Ynez fine sandy loam, 15 to 30 percent slopes	>200	41.0	18.4%
Totals for Area of Interest			**222.6**	**100.0%**

Rating Options—Depth to Water Table (Abalone Creek Ranch)

Units of Measure: centimeters

Aggregation Method: Dominant Component

Component Percent Cutoff: None Specified

Tie-break Rule: Lower

Interpret Nulls as Zero: No

Beginning Month: January

Ending Month: December

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.

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.

Rangeland and Forest Vegetation Classification, Productivity, and Plant Composition (Abalone Creek Ranch)

In areas that have similar climate and topography, differences in the kind and amount of rangeland or forest understory vegetation are closely related to the kind of soil. Effective management is based on the relationship between the soils and vegetation and water.

This table shows, for each soil that supports vegetation, the ecological site, plant association, or habitat type; the total annual production of vegetation in favorable, normal, and unfavorable years; the characteristic vegetation; and the average percentage of each species. An explanation of the column headings in the table follows.

An *ecological site, plant association, or habitat type* is the product of all the environmental factors responsible for its development. It has characteristic soils that have developed over time throughout the soil development process; a characteristic hydrology, particularly infiltration and runoff that has developed over time; and a characteristic plant community (kind and amount of vegetation). The hydrology of the site is influenced by development of the soil and plant community. The vegetation, soils, and hydrology are all interrelated. Each is influenced by the others and influences the development of the others. The plant community on an ecological site, plant association, or habitat type is typified by an association of species that differs from that of other ecological sites, plant associations, or habitat types in the kind and/or proportion of species or in total production. Descriptions of ecological sites are provided in the Field Office Technical Guide, which is available in local offices of the Natural Resources Conservation Service (NRCS). Descriptions of plant associations or habitat types are available from local U.S. Forest Service offices.

Total dry-weight production is the amount of vegetation that can be expected to grow annually in a well managed area that is supporting the potential natural plant community. It includes all vegetation, whether or not it is palatable to grazing animals. It includes the current year's growth of leaves, twigs, and fruits of woody plants. It does not include the increase in stem diameter of trees and shrubs. It is expressed in pounds per acre of air-dry vegetation for favorable, normal, and unfavorable years. In a favorable year, the amount and distribution of precipitation and the temperatures make growing conditions substantially better than average. In a normal year, growing conditions are about average. In an unfavorable year, growing conditions are well below average, generally because of low available soil moisture. Yields are adjusted to a common percent of air-dry moisture content.

Characteristic vegetation (the grasses, forbs, shrubs, and understory trees that make up most of the potential natural plant community on each soil) is listed by common name. Under *rangeland composition and forest understory*, the expected percentage of the total annual production is given for each species making up the characteristic vegetation. The percentages are by dry weight for rangeland. Percentages for forest understory are by either dry weight or canopy cover. The amount that can be used as forage depends on the kinds of grazing animals and on the grazing season.

Range management requires knowledge of the kinds of soil and of the potential natural plant community. It also requires an evaluation of the present range similarity index and rangeland trend. Range similarity index is determined by comparing the present plant community with the potential natural plant community on a particular rangeland ecological site. The more closely the existing community resembles the potential community, the higher the range similarity index. Rangeland trend is defined as the direction of change in an existing plant community relative to the potential natural plant community. Further information about the range similarity index and rangeland trend is available in the "National Range and Pasture Handbook," which is available in local offices of NRCS or on the Internet.

The objective in range management is to control grazing so that the plants growing on a site are about the same in kind and amount as the potential natural plant community for that site. Such management generally results in the optimum production of vegetation, control of undesirable brush species, conservation of water, and control of erosion. Sometimes, however, an area with a range similarity index somewhat below the potential meets grazing needs, provides wildlife habitat, and protects soil and water resources.

Reference:
United States Department of Agriculture, Natural Resources Conservation Service, National range and pasture handbook.

Rangeland and Forest Vegetation Classification, Productivity, and Plant Composition–Monterey County, California								
Map unit symbol and soil name	Ecological Site, Plant Association, or Habitat Type	Total dry-weight production			Characteristic rangeland or forest understory vegetation	Composition		
		Favorable year	Normal year	Unfavorable year			Rangeland	Forest understory
		Lb/ac	*Lb/ac*	*Lb/ac*		*Pct dry wt*	*Pct dry wt*	
CbC—Chualar loam, 5 to 9 percent slopes								
Chualar	Dry Loamy Fan (R014XG917CA)	—	—	—	—			
GkB—Gorgonio sandy loam, 0 to 5 percent slopes								
Gorgonio	Dry Loamy Fan (R014XG917CA)	—	—	—	—			
Arroyo seco	Dry Loamy Fan (R014XG917CA)	—	—	—	—			
PnC—Placentia sandy loam, 2 to 9 percent slopes, MLRA 14								
Placentia	CLAYPAN (R015XD115CA)	2,000	1,200	600	soft chess	20		
					stork's bill	20		
					wild oat	20		
					clover	10		
					ripgut brome	10		
					blue oak	5		
					burclover	5		
					miniature lupine	5		

Rangeland and Forest Vegetation Classification, Productivity, and Plant Composition–Monterey County, California								
Map unit symbol and soil name	Ecological Site, Plant Association, or Habitat Type	Total dry-weight production			Characteristic rangeland or forest understory vegetation	Composition		
		Favorable year	Normal year	Unfavorable year			Rangeland	Forest understory
		Lb/ac	*Lb/ac*	*Lb/ac*		*Pct dry wt*	*Pct dry wt*	
PnD—Placentia sandy loam, 9 to 15 percent slopes								
Placentia	CLAYPAN (R015XD115CA)	2,000	1,200	600	soft chess	20		
					stork's bill	20		
					wild oat	20		
					clover	10		
					ripgut brome	10		
					blue oak	5		
					burclover	5		
					miniature lupine	5		
PnE—Placentia sandy loam, 15 to 30 percent slopes								
Placentia	CLAYPAN (R015XD115CA)	2,000	1,200	600	soft chess	20		
					stork's bill	20		
					wild oat	20		
					clover	10		
					ripgut brome	10		
					blue oak	5		
					burclover	5		
					miniature lupine	5		

Rangeland and Forest Vegetation Classification, Productivity, and Plant Composition–Monterey County, California								
Map unit symbol and soil name	**Ecological Site, Plant Association, or Habitat Type**	**Total dry-weight production**			**Characteristic rangeland or forest understory vegetation**	**Composition**		
		Favorable year	**Normal year**	**Unfavorable year**			**Rangeland**	**Forest understory**
		Lb/ac	*Lb/ac*	*Lb/ac*		*Pct dry wt*	*Pct dry wt*	
ScG—San Andreas fine sandy loam, 30 to 75 percent slopes								
San andreas	COARSE LOAMY (R015XD011CA)	2,800	2,200	1,700	wild oat	20		
					soft chess	15		
					California live oak	10		
					coastal sage scrub oak	5		
					oak	5		
					other annual grasses	5		
					ripgut brome	5		
					stork's bill	5		
ShE—Santa Ynez fine sandy loam, 15 to 30 percent slopes								
Santa ynez	CLAYPAN (R015XD115CA)	2,000	1,500	1,000	soft chess	20		
					wild oat	20		
					clover	10		
					ripgut brome	10		
					stork's bill	10		
					blue oak	5		
					burclover	5		
					miniature lupine	5		
					purple tussockgrass	5		
Santa ynez	Dry Loamy Terrace (R014XG911CA)	—	—	—	—			
San andreas	Dry Loamy Upland (R014XG923CA)	—	—	—	—			

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.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deep-water habitats of the United States. U.S. Fish and Wildlife Service FWS/OBS-79/31.

Federal Register. July 13, 1994. Changes in hydric soils of the United States.

Federal Register. September 18, 2002. Hydric soils of the United States.

Hurt, G.W., and L.M. Vasilas, editors. Version 6.0, 2006. Field indicators of hydric soils in the United States.

National Research Council. 1995. Wetlands: Characteristics and boundaries.

Soil Survey Division Staff. 1993. Soil survey manual. Soil Conservation Service. U.S. Department of Agriculture Handbook 18. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_054262

Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service, U.S. Department of Agriculture Handbook 436. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053577

Soil Survey Staff. 2010. Keys to soil taxonomy. 11th edition. U.S. Department of Agriculture, Natural Resources Conservation Service. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053580

Tiner, R.W., Jr. 1985. Wetlands of Delaware. U.S. Fish and Wildlife Service and Delaware Department of Natural Resources and Environmental Control, Wetlands Section.

United States Army Corps of Engineers, Environmental Laboratory. 1987. Corps of Engineers wetlands delineation manual. Waterways Experiment Station Technical Report Y-87-1.

United States Department of Agriculture, Natural Resources Conservation Service. National forestry manual. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/home/?cid=nrcs142p2_053374

United States Department of Agriculture, Natural Resources Conservation Service. National range and pasture handbook. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/landuse/rangepasture/?cid=stelprdb1043084

United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/scientists/?cid=nrcs142p2_054242

United States Department of Agriculture, Natural Resources Conservation Service. 2006. Land resource regions and major land resource areas of the United States, the Caribbean, and the Pacific Basin. U.S. Department of Agriculture Handbook 296. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053624

United States Department of Agriculture, Soil Conservation Service. 1961. Land capability classification. U.S. Department of Agriculture Handbook 210. http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_052290.pdf

Glossary

Many of the terms relating to landforms, geology, and geomorphology are defined in more detail in the following National Soil Survey Handbook link: "National Soil Survey Handbook."

ABC soil

A soil having an A, a B, and a C horizon.

Ablation till

Loose, relatively permeable earthy material deposited during the downwasting of nearly static glacial ice, either contained within or accumulated on the surface of the glacier.

AC soil

A soil having only an A and a C horizon. Commonly, such soil formed in recent alluvium or on steep, rocky slopes.

Aeration, soil

The exchange of air in soil with air from the atmosphere. The air in a well aerated soil is similar to that in the atmosphere; the air in a poorly aerated soil is considerably higher in carbon dioxide and lower in oxygen.

Aggregate, soil

Many fine particles held in a single mass or cluster. Natural soil aggregates, such as granules, blocks, or prisms, are called peds. Clods are aggregates produced by tillage or logging.

Alkali (sodic) soil

A soil having so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that plant growth is restricted.

Alluvial cone

A semiconical type of alluvial fan having very steep slopes. It is higher, narrower, and steeper than a fan and is composed of coarser and thicker layers of material deposited by a combination of alluvial episodes and (to a much lesser degree) landslides (debris flow). The coarsest materials tend to be concentrated at the apex of the cone.

Alluvial fan

A low, outspread mass of loose materials and/or rock material, commonly with gentle slopes. It is shaped like an open fan or a segment of a cone. The material was deposited by a stream at the place where it issues from a narrow mountain valley or upland valley or where a tributary stream is near or at its junction with the main stream. The fan is steepest near its apex, which points upstream, and slopes gently and convexly outward (downstream) with a gradual decrease in gradient.

Alluvium

Unconsolidated material, such as gravel, sand, silt, clay, and various mixtures of these, deposited on land by running water.

Alpha,alpha-dipyridyl

A compound that when dissolved in ammonium acetate is used to detect the presence of reduced iron (Fe II) in the soil. A positive reaction implies reducing conditions and the likely presence of redoximorphic features.

Animal unit month (AUM)

The amount of forage required by one mature cow of approximately 1,000 pounds weight, with or without a calf, for 1 month.

Aquic conditions

Current soil wetness characterized by saturation, reduction, and redoximorphic features.

Argillic horizon

A subsoil horizon characterized by an accumulation of illuvial clay.

Arroyo

The flat-floored channel of an ephemeral stream, commonly with very steep to vertical banks cut in unconsolidated material. It is usually dry but can be transformed into a temporary watercourse or short-lived torrent after heavy rain within the watershed.

Aspect

The direction toward which a slope faces. Also called slope aspect.

Association, soil

A group of soils or miscellaneous areas geographically associated in a characteristic repeating pattern and defined and delineated as a single map unit.

Available water capacity (available moisture capacity)

The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field moisture capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil. The capacity, in inches, in a 60-inch profile or to a limiting layer is expressed as:

Very low: 0 to 3
Low: 3 to 6
Moderate: 6 to 9
High: 9 to 12
Very high: More than 12

Backslope

The position that forms the steepest and generally linear, middle portion of a hillslope. In profile, backslopes are commonly bounded by a convex shoulder above and a concave footslope below.

Backswamp

A flood-plain landform. Extensive, marshy or swampy, depressed areas of flood plains between natural levees and valley sides or terraces.

Badland

A landscape that is intricately dissected and characterized by a very fine drainage network with high drainage densities and short, steep slopes and narrow interfluves. Badlands develop on surfaces that have little or no vegetative cover overlying unconsolidated or poorly cemented materials (clays, silts, or sandstones) with, in some cases, soluble minerals, such as gypsum or halite.

Bajada

A broad, gently inclined alluvial piedmont slope extending from the base of a mountain range out into a basin and formed by the lateral coalescence of a series of alluvial fans. Typically, it has a broadly undulating transverse profile, parallel to the mountain front, resulting from the convexities of component fans. The term is generally restricted to constructional slopes of intermontane basins.

Basal area

The area of a cross section of a tree, generally referring to the section at breast height and measured outside the bark. It is a measure of stand density, commonly expressed in square feet.

Base saturation

The degree to which material having cation-exchange properties is saturated with exchangeable bases (sum of Ca, Mg, Na, and K), expressed as a percentage of the total cation-exchange capacity.

Base slope (geomorphology)

A geomorphic component of hills consisting of the concave to linear (perpendicular to the contour) slope that, regardless of the lateral shape, forms an apron or wedge at the bottom of a hillside dominated by colluvium and slope-wash sediments (for example, slope alluvium).

Bedding plane

A planar or nearly planar bedding surface that visibly separates each successive layer of stratified sediment or rock (of the same or different lithology) from the preceding or following layer; a plane of deposition. It commonly marks a change in the circumstances of deposition and may show a parting, a color difference, a change in particle size, or various combinations of these. The term is commonly applied to any bedding surface, even one that is conspicuously bent or deformed by folding.

Bedding system

A drainage system made by plowing, grading, or otherwise shaping the surface of a flat field. It consists of a series of low ridges separated by shallow, parallel dead furrows.

Bedrock

The solid rock that underlies the soil and other unconsolidated material or that is exposed at the surface.

Bedrock-controlled topography

A landscape where the configuration and relief of the landforms are determined or strongly influenced by the underlying bedrock.

Bench terrace

A raised, level or nearly level strip of earth constructed on or nearly on a contour, supported by a barrier of rocks or similar material, and designed to make the soil suitable for tillage and to prevent accelerated erosion.

Bisequum

Two sequences of soil horizons, each of which consists of an illuvial horizon and the overlying eluvial horizons.

Blowout (map symbol)

A saucer-, cup-, or trough-shaped depression formed by wind erosion on a preexisting dune or other sand deposit, especially in an area of shifting sand or loose soil or where protective vegetation is disturbed or destroyed. The adjoining accumulation of sand derived from the depression, where recognizable, is commonly included. Blowouts are commonly small.

Borrow pit (map symbol)

An open excavation from which soil and underlying material have been removed, usually for construction purposes.

Bottom land

An informal term loosely applied to various portions of a flood plain.

Boulders

Rock fragments larger than 2 feet (60 centimeters) in diameter.

Breaks

A landscape or tract of steep, rough or broken land dissected by ravines and gullies and marking a sudden change in topography.

Breast height

An average height of 4.5 feet above the ground surface; the point on a tree where diameter measurements are ordinarily taken.

Brush management

Use of mechanical, chemical, or biological methods to make conditions favorable for reseeding or to reduce or eliminate competition from woody vegetation and thus allow understory grasses and forbs to recover. Brush management increases forage production and thus reduces the hazard of erosion. It can improve the habitat for some species of wildlife.

Butte

An isolated, generally flat-topped hill or mountain with relatively steep slopes and talus or precipitous cliffs and characterized by summit width that is less than the height of bounding escarpments; commonly topped by a caprock of resistant material and representing an erosion remnant carved from flat-lying rocks.

Cable yarding

A method of moving felled trees to a nearby central area for transport to a processing facility. Most cable yarding systems involve use of a drum, a pole, and wire cables in an arrangement similar to that of a rod and reel used for fishing. To reduce friction and soil disturbance, felled trees generally are reeled in while one end is lifted or the entire log is suspended.

Calcareous soil

A soil containing enough calcium carbonate (commonly combined with magnesium carbonate) to effervesce visibly when treated with cold, dilute hydrochloric acid.

Caliche

A general term for a prominent zone of secondary carbonate accumulation in surficial materials in warm, subhumid to arid areas. Caliche is formed by both geologic and pedologic processes. Finely crystalline calcium carbonate forms a nearly continuous surface-coating and void-filling medium in geologic (parent) materials. Cementation ranges from weak in nonindurated forms to very strong in indurated forms. Other minerals (e.g., carbonates, silicate, and sulfate) may occur as accessory cements. Most petrocalcic horizons and some calcic horizons are caliche.

California bearing ratio (CBR)

The load-supporting capacity of a soil as compared to that of standard crushed limestone, expressed as a ratio. First standardized in California. A soil having a CBR of 16 supports 16 percent of the load that would be supported by standard crushed limestone, per unit area, with the same degree of distortion.

Canopy

The leafy crown of trees or shrubs. (See Crown.)

Canyon

A long, deep, narrow valley with high, precipitous walls in an area of high local relief.

Capillary water

Water held as a film around soil particles and in tiny spaces between particles. Surface tension is the adhesive force that holds capillary water in the soil.

Catena

A sequence, or “chain,” of soils on a landscape that formed in similar kinds of parent material and under similar climatic conditions but that have different characteristics as a result of differences in relief and drainage.

Cation

An ion carrying a positive charge of electricity. The common soil cations are calcium, potassium, magnesium, sodium, and hydrogen.

Cation-exchange capacity

The total amount of exchangeable cations that can be held by the soil, expressed in terms of milliequivalents per 100 grams of soil at neutrality (pH 7.0) or at some other stated pH value. The term, as applied to soils, is synonymous with base-exchange capacity but is more precise in meaning.

Catsteps

See Terracettes.

Cement rock

Shaly limestone used in the manufacture of cement.

Channery soil material

Soil material that has, by volume, 15 to 35 percent thin, flat fragments of sandstone, shale, slate, limestone, or schist as much as 6 inches (15 centimeters) along the longest axis. A single piece is called a channer.

Chemical treatment

Control of unwanted vegetation through the use of chemicals.

Chiseling

Tillage with an implement having one or more soil-penetrating points that shatter or loosen hard, compacted layers to a depth below normal plow depth.

Cirque

A steep-walled, semicircular or crescent-shaped, half-bowl-like recess or hollow, commonly situated at the head of a glaciated mountain valley or high on the side of a mountain. It was produced by the erosive activity of a mountain glacier. It commonly contains a small round lake (tarn).

Clay

As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay depletions

See Redoximorphic features.

Clay film

A thin coating of oriented clay on the surface of a soil aggregate or lining pores or root channels. Synonyms: clay coating, clay skin.

Clay spot (map symbol)

A spot where the surface texture is silty clay or clay in areas where the surface layer of the soils in the surrounding map unit is sandy loam, loam, silt loam, or coarser.

Claypan

A dense, compact subsoil layer that contains much more clay than the overlying materials, from which it is separated by a sharply defined boundary. The layer restricts the downward movement of water through the soil. A claypan is commonly hard when dry and plastic and sticky when wet.

Climax plant community

The stabilized plant community on a particular site. The plant cover reproduces itself and does not change so long as the environment remains the same.

Coarse textured soil

Sand or loamy sand.

Cobble (or cobblestone)

A rounded or partly rounded fragment of rock 3 to 10 inches (7.6 to 25 centimeters) in diameter.

Cobbly soil material

Material that has 15 to 35 percent, by volume, rounded or partially rounded rock fragments 3 to 10 inches (7.6 to 25 centimeters) in diameter. Very cobbly soil material has 35 to 60 percent of these rock fragments, and extremely cobbly soil material has more than 60 percent.

COLE (coefficient of linear extensibility)

See Linear extensibility.

Colluvium

Unconsolidated, unsorted earth material being transported or deposited on side slopes and/or at the base of slopes by mass movement (e.g., direct gravitational action) and by local, unconcentrated runoff.

Complex slope

Irregular or variable slope. Planning or establishing terraces, diversions, and other water-control structures on a complex slope is difficult.

Complex, soil

A map unit of two or more kinds of soil or miscellaneous areas in such an intricate pattern or so small in area that it is not practical to map them separately at the selected scale of mapping. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas.

Concretions

See Redoximorphic features.

Conglomerate

A coarse grained, clastic sedimentary rock composed of rounded or subangular rock fragments more than 2 millimeters in diameter. It commonly has a matrix of sand and finer textured material. Conglomerate is the consolidated equivalent of gravel.

Conservation cropping system

Growing crops in combination with needed cultural and management practices. In a good conservation cropping system, the soil-improving crops and practices more than offset the effects of the soil-depleting crops and practices. Cropping systems are needed on all tilled soils. Soil-improving practices in a conservation cropping system include the use of rotations that contain grasses and legumes and the return of crop residue to the soil. Other practices include the use of green manure crops of grasses and legumes, proper tillage, adequate fertilization, and weed and pest control.

Conservation tillage

A tillage system that does not invert the soil and that leaves a protective amount of crop residue on the surface throughout the year.

Consistence, soil

Refers to the degree of cohesion and adhesion of soil material and its resistance to deformation when ruptured. Consistence includes resistance of soil material to rupture and to penetration; plasticity, toughness, and stickiness of puddled soil material; and the manner in which the soil material behaves when subject to compression. Terms describing consistence are defined in the “Soil Survey Manual.”

Contour stripcropping

Growing crops in strips that follow the contour. Strips of grass or close-growing crops are alternated with strips of clean-tilled crops or summer fallow.

Control section

The part of the soil on which classification is based. The thickness varies among different kinds of soil, but for many it is that part of the soil profile between depths of 10 inches and 40 or 80 inches.

Coprogenous earth (sedimentary peat)

A type of limnic layer composed predominantly of fecal material derived from aquatic animals.

Corrosion (geomorphology)

A process of erosion whereby rocks and soil are removed or worn away by natural chemical processes, especially by the solvent action of running water, but also by other reactions, such as hydrolysis, hydration, carbonation, and oxidation.

Corrosion (soil survey interpretations)

Soil-induced electrochemical or chemical action that dissolves or weakens concrete or uncoated steel.

Cover crop

A close-growing crop grown primarily to improve and protect the soil between periods of regular crop production, or a crop grown between trees and vines in orchards and vineyards.

Crop residue management

Returning crop residue to the soil, which helps to maintain soil structure, organic matter content, and fertility and helps to control erosion.

Cropping system

Growing crops according to a planned system of rotation and management practices.

Cross-slope farming

Deliberately conducting farming operations on sloping farmland in such a way that tillage is across the general slope.

Crown

The upper part of a tree or shrub, including the living branches and their foliage.

Cryoturbate

A mass of soil or other unconsolidated earthy material moved or disturbed by frost action. It is typically coarser than the underlying material.

Cuesta

An asymmetric ridge capped by resistant rock layers of slight or moderate dip (commonly less than 15 percent slopes); a type of homocline produced by differential erosion of interbedded resistant and weak rocks. A cuesta has a long, gentle slope on one side (dip slope) that roughly parallels the inclined beds; on the other side, it has a relatively short and steep or clifflike slope (scarp) that cuts through the tilted rocks.

Culmination of the mean annual increment (CMAI)

The average annual increase per acre in the volume of a stand. Computed by dividing the total volume of the stand by its age. As the stand increases in age, the mean annual increment continues to increase until mortality begins to reduce the rate of increase. The point where the stand reaches its maximum annual rate of growth is called the culmination of the mean annual increment.

Cutbanks cave

The walls of excavations tend to cave in or slough.

Decreasers

The most heavily grazed climax range plants. Because they are the most palatable, they are the first to be destroyed by overgrazing.

Deferred grazing

Postponing grazing or resting grazing land for a prescribed period.

Delta

A body of alluvium having a surface that is fan shaped and nearly flat; deposited at or near the mouth of a river or stream where it enters a body of relatively quiet water, generally a sea or lake.

Dense layer

A very firm, massive layer that has a bulk density of more than 1.8 grams per cubic centimeter. Such a layer affects the ease of digging and can affect filling and compacting.

Depression, closed (map symbol)

A shallow, saucer-shaped area that is slightly lower on the landscape than the surrounding area and that does not have a natural outlet for surface drainage.

Depth, soil

Generally, the thickness of the soil over bedrock. Very deep soils are more than 60 inches deep over bedrock; deep soils, 40 to 60 inches; moderately deep, 20 to 40 inches; shallow, 10 to 20 inches; and very shallow, less than 10 inches.

Desert pavement

A natural, residual concentration or layer of wind-polished, closely packed gravel, boulders, and other rock fragments mantling a desert surface. It forms where wind action and sheetwash have removed all smaller particles or where rock fragments have migrated upward through sediments to the surface. It typically protects the finer grained underlying material from further erosion.

Diatomaceous earth

A geologic deposit of fine, grayish siliceous material composed chiefly or entirely of the remains of diatoms.

Dip slope

A slope of the land surface, roughly determined by and approximately conforming to the dip of the underlying bedrock.

Diversion (or diversion terrace)

A ridge of earth, generally a terrace, built to protect downslope areas by diverting runoff from its natural course.

Divided-slope farming

A form of field stripcropping in which crops are grown in a systematic arrangement of two strips, or bands, across the slope to reduce the hazard of water erosion. One strip is in a close-growing crop that provides protection from erosion, and the other strip is in a crop that provides less protection from erosion. This practice is used where slopes are not long enough to permit a full stripcropping pattern to be used.

Drainage class (natural)

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

Drainage, surface

Runoff, or surface flow of water, from an area.

Drainageway

A general term for a course or channel along which water moves in draining an area. A term restricted to relatively small, linear depressions that at some time move concentrated water and either do not have a defined channel or have only a small defined channel.

Draw

A small stream valley that generally is shallower and more open than a ravine or gulch and that has a broader bottom. The present stream channel may appear inadequate to have cut the drainageway that it occupies.

Drift

A general term applied to all mineral material (clay, silt, sand, gravel, and boulders) transported by a glacier and deposited directly by or from the ice or transported by running water emanating from a glacier. Drift includes unstratified material (till) that forms moraines and stratified deposits that form outwash plains, eskers, kames, varves, and glaciofluvial sediments. The term is generally applied to Pleistocene glacial deposits in areas that no longer contain glaciers.

Drumlin

A low, smooth, elongated oval hill, mound, or ridge of compact till that has a core of bedrock or drift. It commonly has a blunt nose facing the direction from which the ice approached and a gentler slope tapering in the other direction. The longer axis is parallel to the general direction of glacier flow. Drumlins are products of streamline (laminar) flow of glaciers, which molded the subglacial floor through a combination of erosion and deposition.

Duff

A generally firm organic layer on the surface of mineral soils. It consists of fallen plant material that is in the process of decomposition and includes everything from the litter on the surface to underlying pure humus.

Dune

A low mound, ridge, bank, or hill of loose, windblown granular material (generally sand), either barren and capable of movement from place to place or covered and stabilized with vegetation but retaining its characteristic shape.

Earthy fill

See Mine spoil.

Ecological site

An area where climate, soil, and relief are sufficiently uniform to produce a distinct natural plant community. An ecological site is the product of all the environmental factors responsible for its development. It is typified by an association of species that differ from those on other ecological sites in kind and/or proportion of species or in total production.

Eluviation

The movement of material in true solution or colloidal suspension from one place to another within the soil. Soil horizons that have lost material through eluviation are eluvial; those that have received material are illuvial.

Endosaturation

A type of saturation of the soil in which all horizons between the upper boundary of saturation and a depth of 2 meters are saturated.

Eolian deposit

Sand-, silt-, or clay-sized clastic material transported and deposited primarily by wind, commonly in the form of a dune or a sheet of sand or loess.

Ephemeral stream

A stream, or reach of a stream, that flows only in direct response to precipitation. It receives no long-continued supply from melting snow or other source, and its channel is above the water table at all times.

Episaturation

A type of saturation indicating a perched water table in a soil in which saturated layers are underlain by one or more unsaturated layers within 2 meters of the surface.

Erosion

The wearing away of the land surface by water, wind, ice, or other geologic agents and by such processes as gravitational creep.

Erosion (accelerated)

Erosion much more rapid than geologic erosion, mainly as a result of human or animal activities or of a catastrophe in nature, such as a fire, that exposes the surface.

Erosion (geologic)

Erosion caused by geologic processes acting over long geologic periods and resulting in the wearing away of mountains and the building up of such landscape features as flood plains and coastal plains. Synonym: natural erosion.

Erosion pavement

A surficial lag concentration or layer of gravel and other rock fragments that remains on the soil surface after sheet or rill erosion or wind has removed the finer soil particles and that tends to protect the underlying soil from further erosion.

Erosion surface

A land surface shaped by the action of erosion, especially by running water.

Escarpment

A relatively continuous and steep slope or cliff breaking the general continuity of more gently sloping land surfaces and resulting from erosion or faulting. Most commonly applied to cliffs produced by differential erosion. Synonym: scarp.

Escarpment, bedrock (map symbol)

A relatively continuous and steep slope or cliff, produced by erosion or faulting, that breaks the general continuity of more gently sloping land surfaces. Exposed material is hard or soft bedrock.

Escarpment, nonbedrock (map symbol)

A relatively continuous and steep slope or cliff, generally produced by erosion but in some places produced by faulting, that breaks the continuity of more gently sloping land surfaces. Exposed earthy material is nonsoil or very shallow soil.

Esker

A long, narrow, sinuous, steep-sided ridge of stratified sand and gravel deposited as the bed of a stream flowing in an ice tunnel within or below the ice (subglacial) or between ice walls on top of the ice of a wasting glacier and left behind as high ground when the ice melted. Eskers range in length from less than a kilometer to more than 160 kilometers and in height from 3 to 30 meters.

Extrusive rock

Igneous rock derived from deep-seated molten matter (magma) deposited and cooled on the earth's surface.

Fallow

Cropland left idle in order to restore productivity through accumulation of moisture. Summer fallow is common in regions of limited rainfall where cereal grain is grown. The soil is tilled for at least one growing season for weed control and decomposition of plant residue.

Fan remnant

A general term for landforms that are the remaining parts of older fan landforms, such as alluvial fans, that have been either dissected or partially buried.

Fertility, soil

The quality that enables a soil to provide plant nutrients, in adequate amounts and in proper balance, for the growth of specified plants when light, moisture, temperature, tilth, and other growth factors are favorable.

Fibric soil material (peat)

The least decomposed of all organic soil material. Peat contains a large amount of well preserved fiber that is readily identifiable according to botanical origin. Peat has the lowest bulk density and the highest water content at saturation of all organic soil material.

Field moisture capacity

The moisture content of a soil, expressed as a percentage of the ovendry weight, after the gravitational, or free, water has drained away; the field moisture content 2 or 3 days after a soaking rain; also called *normal field capacity, normal moisture capacity,* or *capillary capacity*.

Fill slope

A sloping surface consisting of excavated soil material from a road cut. It commonly is on the downhill side of the road.

Fine textured soil

Sandy clay, silty clay, or clay.

Firebreak

An area cleared of flammable material to stop or help control creeping or running fires. It also serves as a line from which to work and to facilitate the movement of firefighters and equipment. Designated roads also serve as firebreaks.

First bottom

An obsolete, informal term loosely applied to the lowest flood-plain steps that are subject to regular flooding.

Flaggy soil material

Material that has, by volume, 15 to 35 percent flagstones. Very flaggy soil material has 35 to 60 percent flagstones, and extremely flaggy soil material has more than 60 percent flagstones.

Flagstone

A thin fragment of sandstone, limestone, slate, shale, or (rarely) schist 6 to 15 inches (15 to 38 centimeters) long.

Flood plain

The nearly level plain that borders a stream and is subject to flooding unless protected artificially.

Flood-plain landforms

A variety of constructional and erosional features produced by stream channel migration and flooding. Examples include backswamps, flood-plain splays, meanders, meander belts, meander scrolls, oxbow lakes, and natural levees.

Flood-plain splay

A fan-shaped deposit or other outspread deposit formed where an overloaded stream breaks through a levee (natural or artificial) and deposits its material (commonly coarse grained) on the flood plain.

Flood-plain step

An essentially flat, terrace-like alluvial surface within a valley that is frequently covered by floodwater from the present stream; any approximately horizontal surface still actively modified by fluvial scour and/or deposition. May occur individually or as a series of steps.

Fluvial

Of or pertaining to rivers or streams; produced by stream or river action.

Foothills

A region of steeply sloping hills that fringes a mountain range or high-plateau escarpment. The hills have relief of as much as 1,000 feet (300 meters).

Footslope

The concave surface at the base of a hillslope. A footslope is a transition zone between upslope sites of erosion and transport (shoulders and backslopes) and downslope sites of deposition (toeslopes).

Forb

Any herbaceous plant not a grass or a sedge.

Forest cover

All trees and other woody plants (underbrush) covering the ground in a forest.

Forest type

A stand of trees similar in composition and development because of given physical and biological factors by which it may be differentiated from other stands.

Fragipan

A loamy, brittle subsurface horizon low in porosity and content of organic matter and low or moderate in clay but high in silt or very fine sand. A fragipan appears cemented and restricts roots. When dry, it is hard or very hard and has a higher bulk density than the horizon or horizons above. When moist, it tends to rupture suddenly under pressure rather than to deform slowly.

Genesis, soil

The mode of origin of the soil. Refers especially to the processes or soil-forming factors responsible for the formation of the solum, or true soil, from the unconsolidated parent material.

Gilgai

Commonly, a succession of microbasins and microknolls in nearly level areas or of microvalleys and microridges parallel with the slope. Typically, the microrelief of clayey soils that shrink and swell considerably with changes in moisture content.

Glaciofluvial deposits

Material moved by glaciers and subsequently sorted and deposited by streams flowing from the melting ice. The deposits are stratified and occur in the form of outwash plains, valley trains, deltas, kames, eskers, and kame terraces.

Glaciolacustrine deposits

Material ranging from fine clay to sand derived from glaciers and deposited in glacial lakes mainly by glacial meltwater. Many deposits are bedded or laminated.

Gleyed soil

Soil that formed under poor drainage, resulting in the reduction of iron and other elements in the profile and in gray colors.

Graded stripcropping

Growing crops in strips that grade toward a protected waterway.

Grassed waterway

A natural or constructed waterway, typically broad and shallow, seeded to grass as protection against erosion. Conducts surface water away from cropland.

Gravel

Rounded or angular fragments of rock as much as 3 inches (2 millimeters to 7.6 centimeters) in diameter. An individual piece is a pebble.

Gravel pit (map symbol)

An open excavation from which soil and underlying material have been removed and used, without crushing, as a source of sand or gravel.

Gravelly soil material

Material that has 15 to 35 percent, by volume, rounded or angular rock fragments, not prominently flattened, as much as 3 inches (7.6 centimeters) in diameter.

Gravelly spot (map symbol)

A spot where the surface layer has more than 35 percent, by volume, rock fragments that are mostly less than 3 inches in diameter in an area that has less than 15 percent rock fragments.

Green manure crop (agronomy)

A soil-improving crop grown to be plowed under in an early stage of maturity or soon after maturity.

Ground water

Water filling all the unblocked pores of the material below the water table.

Gully (map symbol)

A small, steep-sided channel caused by erosion and cut in unconsolidated materials by concentrated but intermittent flow of water. The distinction between a gully and a rill is one of depth. A gully generally is an obstacle to farm machinery and is too deep to be obliterated by ordinary tillage whereas a rill is of lesser depth and can be smoothed over by ordinary tillage.

Hard bedrock

Bedrock that cannot be excavated except by blasting or by the use of special equipment that is not commonly used in construction.

Hard to reclaim

Reclamation is difficult after the removal of soil for construction and other uses. Revegetation and erosion control are extremely difficult.

Hardpan

A hardened or cemented soil horizon, or layer. The soil material is sandy, loamy, or clayey and is cemented by iron oxide, silica, calcium carbonate, or other substance.

Head slope (geomorphology)

A geomorphic component of hills consisting of a laterally concave area of a hillside, especially at the head of a drainageway. The overland waterflow is converging.

Hemic soil material (mucky peat)

Organic soil material intermediate in degree of decomposition between the less decomposed fibric material and the more decomposed sapric material.

High-residue crops

Such crops as small grain and corn used for grain. If properly managed, residue from these crops can be used to control erosion until the next crop in the rotation is established. These crops return large amounts of organic matter to the soil.

Hill

A generic term for an elevated area of the land surface, rising as much as 1,000 feet above surrounding lowlands, commonly of limited summit area and having a well defined outline. Slopes are generally more than 15 percent. The distinction between a hill and a mountain is arbitrary and may depend on local usage.

Hillslope

A generic term for the steeper part of a hill between its summit and the drainage line, valley flat, or depression floor at the base of a hill.

Horizon, soil

A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes. In the identification of soil horizons, an uppercase letter represents the major horizons. Numbers or lowercase letters that follow represent subdivisions of the major horizons. An explanation of the subdivisions is given in the “Soil Survey Manual.” The major horizons of mineral soil are as follows:

O horizon: An organic layer of fresh and decaying plant residue.

L horizon: A layer of organic and mineral limnic materials, including coprogenous earth (sedimentary peat), diatomaceous earth, and marl.

A horizon: The mineral horizon at or near the surface in which an accumulation of humified organic matter is mixed with the mineral material. Also, a plowed surface horizon, most of which was originally part of a B horizon.

E horizon: The mineral horizon in which the main feature is loss of silicate clay, iron, aluminum, or some combination of these.

B horizon: The mineral horizon below an A horizon. The B horizon is in part a layer of transition from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics, such as (1) accumulation of clay, sesquioxides, humus, or a combination of these; (2) prismatic or blocky structure; (3) redder or browner colors than those in the A horizon; or (4) a combination of these.

C horizon: The mineral horizon or layer, excluding indurated bedrock, that is little affected by soil-forming processes and does not have the properties typical of the overlying soil material. The material of a C horizon may be either like or unlike that in which the solum formed. If the material is known to differ from that in the solum, an Arabic numeral, commonly a 2, precedes the letter C.

Cr horizon: Soft, consolidated bedrock beneath the soil.

R layer: Consolidated bedrock beneath the soil. The bedrock commonly underlies a C horizon, but it can be directly below an A or a B horizon.

M layer: A root-limiting subsoil layer consisting of nearly continuous, horizontally oriented, human-manufactured materials.

W layer: A layer of water within or beneath the soil.

Humus

The well decomposed, more or less stable part of the organic matter in mineral soils.

Hydrologic soil groups

Refers to soils grouped according to their runoff potential. The soil properties that influence this potential are those that affect the minimum rate of water infiltration on a bare soil during periods after prolonged wetting when the soil is not frozen. These properties include depth to a seasonal high water table, the infiltration rate, and depth to a layer that significantly restricts the downward movement of water. The slope and the kind of plant cover are not considered but are separate factors in predicting runoff.

Igneous rock

Rock that was formed by cooling and solidification of magma and that has not been changed appreciably by weathering since its formation. Major varieties include plutonic and volcanic rock (e.g., andesite, basalt, and granite).

Illuviation

The movement of soil material from one horizon to another in the soil profile. Generally, material is removed from an upper horizon and deposited in a lower horizon.

Impervious soil

A soil through which water, air, or roots penetrate slowly or not at all. No soil is absolutely impervious to air and water all the time.

Increasers

Species in the climax vegetation that increase in amount as the more desirable plants are reduced by close grazing. Increasers commonly are the shorter plants and the less palatable to livestock.

Infiltration

The downward entry of water into the immediate surface of soil or other material, as contrasted with percolation, which is movement of water through soil layers or material.

Infiltration capacity

The maximum rate at which water can infiltrate into a soil under a given set of conditions.

Infiltration rate

The rate at which water penetrates the surface of the soil at any given instant, usually expressed in inches per hour. The rate can be limited by the infiltration capacity of the soil or the rate at which water is applied at the surface.

Intake rate

The average rate of water entering the soil under irrigation. Most soils have a fast initial rate; the rate decreases with application time. Therefore, intake rate for design purposes is not a constant but is a variable depending on the net irrigation application. The rate of water intake, in inches per hour, is expressed as follows:

Very low: Less than 0.2
Low: 0.2 to 0.4
Moderately low: 0.4 to 0.75
Moderate: 0.75 to 1.25
Moderately high: 1.25 to 1.75
High: 1.75 to 2.5
Very high: More than 2.5

Interfluve

A landform composed of the relatively undissected upland or ridge between two adjacent valleys containing streams flowing in the same general direction. An elevated area between two drainageways that sheds water to those drainageways.

Interfluve (geomorphology)

A geomorphic component of hills consisting of the uppermost, comparatively level or gently sloping area of a hill; shoulders of backwearing hillslopes can narrow the upland or can merge, resulting in a strongly convex shape.

Intermittent stream

A stream, or reach of a stream, that does not flow year-round but that is commonly dry for 3 or more months out of 12 and whose channel is generally below the local water table. It flows only during wet periods or when it receives ground-water discharge or long, continued contributions from melting snow or other surface and shallow subsurface sources.

Invaders

On range, plants that encroach into an area and grow after the climax vegetation has been reduced by grazing. Generally, plants invade following disturbance of the surface.

Iron depletions

See Redoximorphic features.

Irrigation

Application of water to soils to assist in production of crops. Methods of irrigation are:

Basin: Water is applied rapidly to nearly level plains surrounded by levees or dikes.

Border: Water is applied at the upper end of a strip in which the lateral flow of water is controlled by small earth ridges called border dikes, or borders.

Controlled flooding: Water is released at intervals from closely spaced field ditches and distributed uniformly over the field.

Corrugation: Water is applied to small, closely spaced furrows or ditches in fields of close-growing crops or in orchards so that it flows in only one direction.

Drip (or trickle): Water is applied slowly and under low pressure to the surface of the soil or into the soil through such applicators as emitters, porous tubing, or perforated pipe.

Furrow: Water is applied in small ditches made by cultivation implements. Furrows are used for tree and row crops.

Sprinkler: Water is sprayed over the soil surface through pipes or nozzles from a pressure system.

Subirrigation: Water is applied in open ditches or tile lines until the water table is raised enough to wet the soil.

Wild flooding: Water, released at high points, is allowed to flow onto an area without controlled distribution.

Kame

A low mound, knob, hummock, or short irregular ridge composed of stratified sand and gravel deposited by a subglacial stream as a fan or delta at the margin of a melting glacier; by a supraglacial stream in a low place or hole on the surface of the glacier; or as a ponded deposit on the surface or at the margin of stagnant ice.

Karst (topography)

A kind of topography that formed in limestone, gypsum, or other soluble rocks by dissolution and that is characterized by closed depressions, sinkholes, caves, and underground drainage.

Knoll

A small, low, rounded hill rising above adjacent landforms.

Ksat

See Saturated hydraulic conductivity.

Lacustrine deposit

Material deposited in lake water and exposed when the water level is lowered or the elevation of the land is raised.

Lake plain

A nearly level surface marking the floor of an extinct lake filled by well sorted, generally fine textured, stratified deposits, commonly containing varves.

Lake terrace

A narrow shelf, partly cut and partly built, produced along a lakeshore in front of a scarp line of low cliffs and later exposed when the water level falls.

Landfill (map symbol)

An area of accumulated waste products of human habitation, either above or below natural ground level.

Landslide

A general, encompassing term for most types of mass movement landforms and processes involving the downslope transport and outward deposition of soil and rock materials caused by gravitational forces; the movement may or may not involve saturated materials. The speed and distance of movement, as well as the amount of soil and rock material, vary greatly.

Large stones

Rock fragments 3 inches (7.6 centimeters) or more across. Large stones adversely affect the specified use of the soil.

Lava flow (map symbol)

A solidified, commonly lobate body of rock formed through lateral, surface outpouring of molten lava from a vent or fissure.

Leaching

The removal of soluble material from soil or other material by percolating water.

Levee (map symbol)

An embankment that confines or controls water, especially one built along the banks of a river to prevent overflow onto lowlands.

Linear extensibility

Refers to the change in length of an unconfined clod as moisture content is decreased from a moist to a dry state. Linear extensibility is used to determine the shrink-swell potential of soils. 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. Volume change is influenced by the amount and type of clay minerals in the soil. The volume change is the percent change for the whole soil. If it is expressed as a fraction, the resulting value is COLE, coefficient of linear extensibility.

Liquid limit

The moisture content at which the soil passes from a plastic to a liquid state.

Loam

Soil material that is 7 to 27 percent clay particles, 28 to 50 percent silt particles, and less than 52 percent sand particles.

Loess

Material transported and deposited by wind and consisting dominantly of silt-sized particles.

Low strength

The soil is not strong enough to support loads.

Low-residue crops

Such crops as corn used for silage, peas, beans, and potatoes. Residue from these crops is not adequate to control erosion until the next crop in the rotation is established. These crops return little organic matter to the soil.

Marl

An earthy, unconsolidated deposit consisting chiefly of calcium carbonate mixed with clay in approximately equal proportions; formed primarily under freshwater lacustrine conditions but also formed in more saline environments.

Marsh or swamp (map symbol)

A water-saturated, very poorly drained area that is intermittently or permanently covered by water. Sedges, cattails, and rushes are the dominant vegetation in marshes, and trees or shrubs are the dominant vegetation in swamps. Not used in map units where the named soils are poorly drained or very poorly drained.

Mass movement

A generic term for the dislodgment and downslope transport of soil and rock material as a unit under direct gravitational stress.

Masses

See Redoximorphic features.

Meander belt

The zone within which migration of a meandering channel occurs; the flood-plain area included between two imaginary lines drawn tangential to the outer bends of active channel loops.

Meander scar

A crescent-shaped, concave or linear mark on the face of a bluff or valley wall, produced by the lateral erosion of a meandering stream that impinged upon and undercut the bluff.

Meander scroll

One of a series of long, parallel, close-fitting, crescent-shaped ridges and troughs formed along the inner bank of a stream meander as the channel migrated laterally down-valley and toward the outer bank.

Mechanical treatment

Use of mechanical equipment for seeding, brush management, and other management practices.

Medium textured soil

Very fine sandy loam, loam, silt loam, or silt.

Mesa

A broad, nearly flat topped and commonly isolated landmass bounded by steep slopes or precipitous cliffs and capped by layers of resistant, nearly horizontal rocky material. The summit width is characteristically greater than the height of the bounding escarpments.

Metamorphic rock

Rock of any origin altered in mineralogical composition, chemical composition, or structure by heat, pressure, and movement at depth in the earth's crust. Nearly all such rocks are crystalline.

Mine or quarry (map symbol)

An open excavation from which soil and underlying material have been removed and in which bedrock is exposed. Also denotes surface openings to underground mines.

Mine spoil

An accumulation of displaced earthy material, rock, or other waste material removed during mining or excavation. Also called earthy fill.

Mineral soil

Soil that is mainly mineral material and low in organic material. Its bulk density is more than that of organic soil.

Minimum tillage

Only the tillage essential to crop production and prevention of soil damage.

Miscellaneous area

A kind of map unit that has little or no natural soil and supports little or no vegetation.

Miscellaneous water (map symbol)

Small, constructed bodies of water that are used for industrial, sanitary, or mining applications and that contain water most of the year.

Moderately coarse textured soil

Coarse sandy loam, sandy loam, or fine sandy loam.

Moderately fine textured soil

Clay loam, sandy clay loam, or silty clay loam.

Mollic epipedon

A thick, dark, humus-rich surface horizon (or horizons) that has high base saturation and pedogenic soil structure. It may include the upper part of the subsoil.

Moraine

In terms of glacial geology, a mound, ridge, or other topographically distinct accumulation of unsorted, unstratified drift, predominantly till, deposited primarily by the direct action of glacial ice in a variety of landforms. Also, a general term for a landform composed mainly of till (except for kame moraines, which are composed mainly of stratified outwash) that has been deposited by a glacier. Some types of moraines are disintegration, end, ground, kame, lateral, recessional, and terminal.

Morphology, soil

The physical makeup of the soil, including the texture, structure, porosity, consistence, color, and other physical, mineral, and biological properties of the various horizons, and the thickness and arrangement of those horizons in the soil profile.

Mottling, soil

Irregular spots of different colors that vary in number and size. Descriptive terms are as follows: abundance—*few, common,* and *many;* size—*fine, medium,* and *coarse;* and contrast—*faint, distinct,* and *prominent*. The size measurements are of the diameter along the greatest dimension. *Fine* indicates less than 5 millimeters (about 0.2 inch); *medium,* from 5 to 15 millimeters (about 0.2 to 0.6 inch); and *coarse,* more than 15 millimeters (about 0.6 inch).

Mountain

A generic term for an elevated area of the land surface, rising more than 1,000 feet (300 meters) above surrounding lowlands, commonly of restricted summit area (relative to a plateau) and generally having steep sides. A mountain can occur as a single, isolated mass or in a group forming a chain or range. Mountains are formed primarily by tectonic activity and/or volcanic action but can also be formed by differential erosion.

Muck

Dark, finely divided, well decomposed organic soil material. (See Sapric soil material.)

Mucky peat

See Hemic soil material.

Mudstone

A blocky or massive, fine grained sedimentary rock in which the proportions of clay and silt are approximately equal. Also, a general term for such material as clay, silt, claystone, siltstone, shale, and argillite and that should be used only when the amounts of clay and silt are not known or cannot be precisely identified.

Munsell notation

A designation of color by degrees of three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color with hue of 10YR, value of 6, and chroma of 4.

Natric horizon

A special kind of argillic horizon that contains enough exchangeable sodium to have an adverse effect on the physical condition of the subsoil.

Neutral soil

A soil having a pH value of 6.6 to 7.3. (See Reaction, soil.)

Nodules

See Redoximorphic features.

Nose slope (geomorphology)

A geomorphic component of hills consisting of the projecting end (laterally convex area) of a hillside. The overland waterflow is predominantly divergent. Nose slopes consist dominantly of colluvium and slope-wash sediments (for example, slope alluvium).

Nutrient, plant

Any element taken in by a plant essential to its growth. Plant nutrients are mainly nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, copper, boron, and zinc obtained from the soil and carbon, hydrogen, and oxygen obtained from the air and water.

Organic matter

Plant and animal residue in the soil in various stages of decomposition. The content of organic matter in the surface layer is described as follows:

Very low: Less than 0.5 percent
Low: 0.5 to 1.0 percent
Moderately low: 1.0 to 2.0 percent
Moderate: 2.0 to 4.0 percent
High: 4.0 to 8.0 percent
Very high: More than 8.0 percent

Outwash

Stratified and sorted sediments (chiefly sand and gravel) removed or “washed out” from a glacier by meltwater streams and deposited in front of or beyond the end moraine or the margin of a glacier. The coarser material is deposited nearer to the ice.

Outwash plain

An extensive lowland area of coarse textured glaciofluvial material. An outwash plain is commonly smooth; where pitted, it generally is low in relief.

Paleoterrace

An erosional remnant of a terrace that retains the surface form and alluvial deposits of its origin but was not emplaced by, and commonly does not grade to, a present-day stream or drainage network.

Pan

A compact, dense layer in a soil that impedes the movement of water and the growth of roots. For example, *hardpan, fragipan, claypan, plowpan,* and *traffic pan*.

Parent material

The unconsolidated organic and mineral material in which soil forms.

Peat

Unconsolidated material, largely undecomposed organic matter, that has accumulated under excess moisture. (See Fibric soil material.)

Ped

An individual natural soil aggregate, such as a granule, a prism, or a block.

Pedisediment

A layer of sediment, eroded from the shoulder and backslope of an erosional slope, that lies on and is being (or was) transported across a gently sloping erosional surface at the foot of a receding hill or mountain slope.

Pedon

The smallest volume that can be called “a soil.” A pedon is three dimensional and large enough to permit study of all horizons. Its area ranges from about 10 to 100 square feet (1 square meter to 10 square meters), depending on the variability of the soil.

Percolation

The movement of water through the soil.

Perennial water (map symbol)

Small, natural or constructed lakes, ponds, or pits that contain water most of the year.

Permafrost

Ground, soil, or rock that remains at or below 0 degrees C for at least 2 years. It is defined on the basis of temperature and is not necessarily frozen.

pH value

A numerical designation of acidity and alkalinity in soil. (See Reaction, soil.)

Phase, soil

A subdivision of a soil series based on features that affect its use and management, such as slope, stoniness, and flooding.

Piping

Formation of subsurface tunnels or pipelike cavities by water moving through the soil.

Pitting

Pits caused by melting around ice. They form on the soil after plant cover is removed.

Plastic limit

The moisture content at which a soil changes from semisolid to plastic.

Plasticity index

The numerical difference between the liquid limit and the plastic limit; the range of moisture content within which the soil remains plastic.

Plateau (geomorphology)

A comparatively flat area of great extent and elevation; specifically, an extensive land region that is considerably elevated (more than 100 meters) above the adjacent lower lying terrain, is commonly limited on at least one side by an abrupt descent, and has a flat or nearly level surface. A comparatively large part of a plateau surface is near summit level.

Playa

The generally dry and nearly level lake plain that occupies the lowest parts of closed depressions, such as those on intermontane basin floors. Temporary flooding occurs primarily in response to precipitation and runoff. Playa deposits are fine grained and may or may not have a high water table and saline conditions.

Plinthite

The sesquioxide-rich, humus-poor, highly weathered mixture of clay with quartz and other diluents. It commonly appears as red mottles, usually in platy, polygonal, or reticulate patterns. Plinthite changes irreversibly to an ironstone hardpan or to irregular aggregates on repeated wetting and drying, especially if it is exposed also to heat from the sun. In a moist soil, plinthite can be cut with a spade. It is a form of laterite.

Plowpan

A compacted layer formed in the soil directly below the plowed layer.

Ponding

Standing water on soils in closed depressions. Unless the soils are artificially drained, the water can be removed only by percolation or evapotranspiration.

Poorly graded

Refers to a coarse grained soil or soil material consisting mainly of particles of nearly the same size. Because there is little difference in size of the particles, density can be increased only slightly by compaction.

Pore linings

See Redoximorphic features.

Potential native plant community

See Climax plant community.

Potential rooting depth (effective rooting depth)

Depth to which roots could penetrate if the content of moisture in the soil were adequate. The soil has no properties restricting the penetration of roots to this depth.

Prescribed burning

Deliberately burning an area for specific management purposes, under the appropriate conditions of weather and soil moisture and at the proper time of day.

Productivity, soil

The capability of a soil for producing a specified plant or sequence of plants under specific management.

Profile, soil

A vertical section of the soil extending through all its horizons and into the parent material.

Proper grazing use

Grazing at an intensity that maintains enough cover to protect the soil and maintain or improve the quantity and quality of the desirable vegetation. This practice increases the vigor and reproduction capacity of the key plants and promotes the accumulation of litter and mulch necessary to conserve soil and water.

Rangeland

Land on which the potential natural vegetation is predominantly grasses, grasslike plants, forbs, or shrubs suitable for grazing or browsing. It includes natural grasslands, savannas, many wetlands, some deserts, tundras, and areas that support certain forb and shrub communities.

Reaction, soil

A measure of acidity or alkalinity of a soil, expressed as pH values. A soil that tests to pH 7.0 is described as precisely neutral in reaction because it is neither acid nor alkaline. The degrees of acidity or alkalinity, expressed as pH values, are:

Ultra acid: Less than 3.5
Extremely acid: 3.5 to 4.4
Very strongly acid: 4.5 to 5.0
Strongly acid: 5.1 to 5.5
Moderately acid: 5.6 to 6.0
Slightly acid: 6.1 to 6.5
Neutral: 6.6 to 7.3
Slightly alkaline: 7.4 to 7.8
Moderately alkaline: 7.9 to 8.4
Strongly alkaline: 8.5 to 9.0
Very strongly alkaline: 9.1 and higher

Red beds

Sedimentary strata that are mainly red and are made up largely of sandstone and shale.

Redoximorphic concentrations

See Redoximorphic features.

Redoximorphic depletions

See Redoximorphic features.

Redoximorphic features

Redoximorphic features are associated with wetness and result from alternating periods of reduction and oxidation of iron and manganese compounds in the soil. Reduction occurs during saturation with water, and oxidation occurs when the soil is not saturated. Characteristic color patterns are created by these processes. The reduced iron and manganese ions may be removed from a soil if vertical or lateral fluxes of water occur, in which case there is no iron or manganese precipitation in that soil. Wherever the iron and manganese are oxidized and precipitated, they form either soft masses or hard concretions or nodules. Movement of iron and manganese as a result of redoximorphic processes in a soil may result in redoximorphic features that are defined as follows:

1. Redoximorphic concentrations.—These are zones of apparent accumulation of iron-manganese oxides, including:
   A. Nodules and concretions, which are cemented bodies that can be removed from the soil intact. Concretions are distinguished from nodules on the basis of internal organization. A concretion typically has concentric layers that are visible to the naked eye. Nodules do not have visible organized internal structure; *and*
   B. Masses, which are noncemented concentrations of substances within the soil matrix; *and*
   C. Pore linings, i.e., zones of accumulation along pores that may be either coatings on pore surfaces or impregnations from the matrix adjacent to the pores.
2. Redoximorphic depletions.—These are zones of low chroma (chromas less than those in the matrix) where either iron-manganese oxides alone or both iron-manganese oxides and clay have been stripped out, including:
   A. Iron depletions, i.e., zones that contain low amounts of iron and manganese oxides but have a clay content similar to that of the adjacent matrix; *and*
   B. Clay depletions, i.e., zones that contain low amounts of iron, manganese, and clay (often referred to as silt coatings or skeletans).
3. Reduced matrix.—This is a soil matrix that has low chroma *in situ* but undergoes a change in hue or chroma within 30 minutes after the soil material has been exposed to air.

Reduced matrix

See Redoximorphic features.

Regolith

All unconsolidated earth materials above the solid bedrock. It includes material weathered in place from all kinds of bedrock and alluvial, glacial, eolian, lacustrine, and pyroclastic deposits.

Relief

The relative difference in elevation between the upland summits and the lowlands or valleys of a given region.

Residuum (residual soil material)

Unconsolidated, weathered or partly weathered mineral material that accumulated as bedrock disintegrated in place.

Rill

A very small, steep-sided channel resulting from erosion and cut in unconsolidated materials by concentrated but intermittent flow of water. A rill generally is not an obstacle to wheeled vehicles and is shallow enough to be smoothed over by ordinary tillage.

Riser

The vertical or steep side slope (e.g., escarpment) of terraces, flood-plain steps, or other stepped landforms; commonly a recurring part of a series of natural, steplike landforms, such as successive stream terraces.

Road cut

A sloping surface produced by mechanical means during road construction. It is commonly on the uphill side of the road.

Rock fragments

Rock or mineral fragments having a diameter of 2 millimeters or more; for example, pebbles, cobbles, stones, and boulders.

Rock outcrop (map symbol)

An exposure of bedrock at the surface of the earth. Not used where the named soils of the surrounding map unit are shallow over bedrock or where “Rock outcrop” is a named component of the map unit.

Root zone

The part of the soil that can be penetrated by plant roots.

Runoff

The precipitation discharged into stream channels from an area. The water that flows off the surface of the land without sinking into the soil is called surface runoff. Water that enters the soil before reaching surface streams is called ground-water runoff or seepage flow from ground water.

Saline soil

A soil containing soluble salts in an amount that impairs growth of plants. A saline soil does not contain excess exchangeable sodium.

Saline spot (map symbol)

An area where the surface layer has an electrical conductivity of 8 mmhos/cm more than the surface layer of the named soils in the surrounding map unit. The surface layer of the surrounding soils has an electrical conductivity of 2 mmhos/cm or less.

Sand

As a soil separate, individual rock or mineral fragments from 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz. As a soil textural class, a soil that is 85 percent or more sand and not more than 10 percent clay.

Sandstone

Sedimentary rock containing dominantly sand-sized particles.

Sandy spot (map symbol)

A spot where the surface layer is loamy fine sand or coarser in areas where the surface layer of the named soils in the surrounding map unit is very fine sandy loam or finer.

Sapric soil material (muck)

The most highly decomposed of all organic soil material. Muck has the least amount of plant fiber, the highest bulk density, and the lowest water content at saturation of all organic soil material.

Saturated hydraulic conductivity (Ksat)

The ease with which pores of a saturated soil transmit water. Formally, the proportionality coefficient that expresses the relationship of the rate of water movement to hydraulic gradient in Darcy's Law, a law that describes the rate of water movement through porous media. Commonly abbreviated as "Ksat." Terms describing saturated hydraulic conductivity are:

Very high: 100 or more micrometers per second (14.17 or more inches per hour)

High: 10 to 100 micrometers per second (1.417 to 14.17 inches per hour)

Moderately high: 1 to 10 micrometers per second (0.1417 inch to 1.417 inches per hour)

Moderately low: 0.1 to 1 micrometer per second (0.01417 to 0.1417 inch per hour)

Low: 0.01 to 0.1 micrometer per second (0.001417 to 0.01417 inch per hour)

Very low: Less than 0.01 micrometer per second (less than 0.001417 inch per hour).

To convert inches per hour to micrometers per second, multiply inches per hour by 7.0572. To convert micrometers per second to inches per hour, multiply micrometers per second by 0.1417.

Saturation

Wetness characterized by zero or positive pressure of the soil water. Under conditions of saturation, the water will flow from the soil matrix into an unlined auger hole.

Scarification

The act of abrading, scratching, loosening, crushing, or modifying the surface to increase water absorption or to provide a more tillable soil.

Sedimentary rock

A consolidated deposit of clastic particles, chemical precipitates, or organic remains accumulated at or near the surface of the earth under normal low temperature and pressure conditions. Sedimentary rocks include consolidated equivalents of alluvium, colluvium, drift, and eolian, lacustrine, and marine deposits. Examples are sandstone, siltstone, mudstone, claystone, shale, conglomerate, limestone, dolomite, and coal.

Sequum

A sequence consisting of an illuvial horizon and the overlying eluvial horizon. (See Eluviation.)

Series, soil

A group of soils that have profiles that are almost alike, except for differences in texture of the surface layer. All the soils of a series have horizons that are similar in composition, thickness, and arrangement.

Severely eroded spot (map symbol)

An area where, on the average, 75 percent or more of the original surface layer has been lost because of accelerated erosion. Not used in map units in which “severely eroded,” “very severely eroded,” or “gullied” is part of the map unit name.

Shale

Sedimentary rock that formed by the hardening of a deposit of clay, silty clay, or silty clay loam and that has a tendency to split into thin layers.

Sheet erosion

The removal of a fairly uniform layer of soil material from the land surface by the action of rainfall and surface runoff.

Short, steep slope (map symbol)

A narrow area of soil having slopes that are at least two slope classes steeper than the slope class of the surrounding map unit.

Shoulder

The convex, erosional surface near the top of a hillslope. A shoulder is a transition from summit to backslope.

Shrink-swell

The shrinking of soil when dry and the swelling when wet. Shrinking and swelling can damage roads, dams, building foundations, and other structures. It can also damage plant roots.

Shrub-coppice dune

A small, streamlined dune that forms around brush and clump vegetation.

Side slope (geomorphology)

A geomorphic component of hills consisting of a laterally planar area of a hillside. The overland waterflow is predominantly parallel. Side slopes are dominantly colluvium and slope-wash sediments.

Silica

A combination of silicon and oxygen. The mineral form is called quartz.

Silica-sesquioxide ratio

The ratio of the number of molecules of silica to the number of molecules of alumina and iron oxide. The more highly weathered soils or their clay fractions in warm-temperate, humid regions, and especially those in the tropics, generally have a low ratio.

Silt

As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a soil textural class, soil that is 80 percent or more silt and less than 12 percent clay.

Siltstone

An indurated silt having the texture and composition of shale but lacking its fine lamination or fissility; a massive mudstone in which silt predominates over clay.

Similar soils

Soils that share limits of diagnostic criteria, behave and perform in a similar manner, and have similar conservation needs or management requirements for the major land uses in the survey area.

Sinkhole (map symbol)

A closed, circular or elliptical depression, commonly funnel shaped, characterized by subsurface drainage and formed either by dissolution of the surface of underlying bedrock (e.g., limestone, gypsum, or salt) or by collapse of underlying caves within bedrock. Complexes of sinkholes in carbonate-rock terrain are the main components of karst topography.

Site index

A designation of the quality of a forest site based on the height of the dominant stand at an arbitrarily chosen age. For example, if the average height attained by dominant and codominant trees in a fully stocked stand at the age of 50 years is 75 feet, the site index is 75.

Slickensides (pedogenic)

Grooved, striated, and/or glossy (shiny) slip faces on structural peds, such as wedges; produced by shrink-swell processes, most commonly in soils that have a high content of expansive clays.

Slide or slip (map symbol)

A prominent landform scar or ridge caused by fairly recent mass movement or descent of earthy material resulting from failure of earth or rock under shear stress along one or several surfaces.

Slope

The inclination of the land surface from the horizontal. Percentage of slope is the vertical distance divided by horizontal distance, then multiplied by 100. Thus, a slope of 20 percent is a drop of 20 feet in 100 feet of horizontal distance.

Slope alluvium

Sediment gradually transported down the slopes of mountains or hills primarily by nonchannel alluvial processes (i.e., slope-wash processes) and characterized by particle sorting. Lateral particle sorting is evident on long slopes. In a profile sequence, sediments may be distinguished by differences in size and/or specific gravity of rock fragments and may be separated by stone lines. Burnished peds and sorting of rounded or subrounded pebbles or cobbles distinguish these materials from unsorted colluvial deposits.

Slow refill

The slow filling of ponds, resulting from restricted water transmission in the soil.

Slow water movement

Restricted downward movement of water through the soil. See Saturated hydraulic conductivity.

Sodic (alkali) soil

A soil having so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that plant growth is restricted.

Sodic spot (map symbol)

An area where the surface layer has a sodium adsorption ratio that is at least 10 more than that of the surface layer of the named soils in the surrounding map unit. The surface layer of the surrounding soils has a sodium adsorption ratio of 5 or less.

Sodicity

The degree to which a soil is affected by exchangeable sodium. Sodicity is expressed as a sodium adsorption ratio (SAR) of a saturation extract, or the ratio of Na^{+} to Ca^{++} + Mg^{++}. The degrees of sodicity and their respective ratios are:

Slight: Less than 13:1

Moderate: 13-30:1

Strong: More than 30:1

Sodium adsorption ratio (SAR)

A measure of the amount of sodium (Na) relative to calcium (Ca) and magnesium (Mg) in the water extract from saturated soil paste. It is the ratio of the Na concentration divided by the square root of one-half of the Ca + Mg concentration.

Soft bedrock

Bedrock that can be excavated with trenching machines, backhoes, small rippers, and other equipment commonly used in construction.

Soil

A natural, three-dimensional body at the earth's surface. It is capable of supporting plants and has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief and by the passage of time.

Soil separates

Mineral particles less than 2 millimeters in equivalent diameter and ranging between specified size limits. The names and sizes, in millimeters, of separates recognized in the United States are as follows:

Very coarse sand: 2.0 to 1.0

Coarse sand: 1.0 to 0.5

Medium sand: 0.5 to 0.25

Fine sand: 0.25 to 0.10

Very fine sand: 0.10 to 0.05

Silt: 0.05 to 0.002

Clay: Less than 0.002

Solum

The upper part of a soil profile, above the C horizon, in which the processes of soil formation are active. The solum in soil consists of the A, E, and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the material below the solum. The living roots and plant and animal activities are largely confined to the solum.

Spoil area (map symbol)

A pile of earthy materials, either smoothed or uneven, resulting from human activity.

Stone line

In a vertical cross section, a line formed by scattered fragments or a discrete layer of angular and subangular rock fragments (commonly a gravel- or cobble-sized lag concentration) that formerly was draped across a topographic surface and was later buried by additional sediments. A stone line generally caps material that was subject to weathering, soil formation, and erosion before burial. Many stone lines seem to be buried erosion pavements, originally formed by sheet and rill erosion across the land surface.

Stones

Rock fragments 10 to 24 inches (25 to 60 centimeters) in diameter if rounded or 15 to 24 inches (38 to 60 centimeters) in length if flat.

Stony

Refers to a soil containing stones in numbers that interfere with or prevent tillage.

Stony spot (map symbol)

A spot where 0.01 to 0.1 percent of the soil surface is covered by rock fragments that are more than 10 inches in diameter in areas where the surrounding soil has no surface stones.

Strath terrace

A type of stream terrace; formed as an erosional surface cut on bedrock and thinly mantled with stream deposits (alluvium).

Stream terrace

One of a series of platforms in a stream valley, flanking and more or less parallel to the stream channel, originally formed near the level of the stream; represents the remnants of an abandoned flood plain, stream bed, or valley floor produced during a former state of fluvial erosion or deposition.

Stripcropping

Growing crops in a systematic arrangement of strips or bands that provide vegetative barriers to wind erosion and water erosion.

Structure, soil

The arrangement of primary soil particles into compound particles or aggregates. The principal forms of soil structure are:

Platy: Flat and laminated
Prismatic: Vertically elongated and having flat tops
Columnar: Vertically elongated and having rounded tops
Angular blocky: Having faces that intersect at sharp angles (planes)
Subangular blocky: Having subrounded and planar faces (no sharp angles)
Granular: Small structural units with curved or very irregular faces

Structureless soil horizons are defined as follows:

Single grained: Entirely noncoherent (each grain by itself), as in loose sand
Massive: Occurring as a coherent mass

Stubble mulch

Stubble or other crop residue left on the soil or partly worked into the soil. It protects the soil from wind erosion and water erosion after harvest, during preparation of a seedbed for the next crop, and during the early growing period of the new crop.

Subsoil

Technically, the B horizon; roughly, the part of the solum below plow depth.

Subsoiling

Tilling a soil below normal plow depth, ordinarily to shatter a hardpan or claypan.

Substratum

The part of the soil below the solum.

Subsurface layer

Any surface soil horizon (A, E, AB, or EB) below the surface layer.

Summer fallow

The tillage of uncropped land during the summer to control weeds and allow storage of moisture in the soil for the growth of a later crop. A practice common in semiarid regions, where annual precipitation is not enough to produce a crop every year. Summer fallow is frequently practiced before planting winter grain.

Summit

The topographically highest position of a hillslope. It has a nearly level (planar or only slightly convex) surface.

Surface layer

The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, ranging in depth from 4 to 10 inches (10 to 25 centimeters). Frequently designated as the “plow layer,” or the “Ap horizon.”

Surface soil

The A, E, AB, and EB horizons, considered collectively. It includes all subdivisions of these horizons.

Talus

Rock fragments of any size or shape (commonly coarse and angular) derived from and lying at the base of a cliff or very steep rock slope. The accumulated mass of such loose broken rock formed chiefly by falling, rolling, or sliding.

Taxadjuncts

Soils that cannot be classified in a series recognized in the classification system. Such soils are named for a series they strongly resemble and are designated as taxadjuncts to that series because they differ in ways too small to be of consequence in interpreting their use and behavior. Soils are recognized as taxadjuncts only when one or more of their characteristics are slightly outside the range defined for the family of the series for which the soils are named.

Terminal moraine

An end moraine that marks the farthest advance of a glacier. It typically has the form of a massive arcuate or concentric ridge, or complex of ridges, and is underlain by till and other types of drift.

Terrace (conservation)

An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surface runoff so that water soaks into the soil or flows slowly to a prepared outlet. A terrace in a field generally is built so that the field can be farmed. A terrace intended mainly for drainage has a deep channel that is maintained in permanent sod.

Terrace (geomorphology)

A steplike surface, bordering a valley floor or shoreline, that represents the former position of a flood plain, lake, or seashore. The term is usually applied both to the relatively flat summit surface (tread) that was cut or built by stream or wave action and to the steeper descending slope (scarp or riser) that has graded to a lower base level of erosion.

Terracettes

Small, irregular steplike forms on steep hillslopes, especially in pasture, formed by creep or erosion of surficial materials that may be induced or enhanced by trampling of livestock, such as sheep or cattle.

Texture, soil

The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying “coarse,” “fine,” or “very fine.”

Thin layer

Otherwise suitable soil material that is too thin for the specified use.

Till

Dominantly unsorted and nonstratified drift, generally unconsolidated and deposited directly by a glacier without subsequent reworking by meltwater, and consisting of a heterogeneous mixture of clay, silt, sand, gravel, stones, and boulders; rock fragments of various lithologies are embedded within a finer matrix that can range from clay to sandy loam.

Till plain

An extensive area of level to gently undulating soils underlain predominantly by till and bounded at the distal end by subordinate recessional or end moraines.

Tilth, soil

The physical condition of the soil as related to tillage, seedbed preparation, seedling emergence, and root penetration.

Toeslope

The gently inclined surface at the base of a hillslope. Toeslopes in profile are commonly gentle and linear and are constructional surfaces forming the lower part of a hillslope continuum that grades to valley or closed-depression floors.

Topsoil

The upper part of the soil, which is the most favorable material for plant growth. It is ordinarily rich in organic matter and is used to topdress roadbanks, lawns, and land affected by mining.

Trace elements

Chemical elements, for example, zinc, cobalt, manganese, copper, and iron, in soils in extremely small amounts. They are essential to plant growth.

Tread

The flat to gently sloping, topmost, laterally extensive slope of terraces, flood-plain steps, or other stepped landforms; commonly a recurring part of a series of natural steplike landforms, such as successive stream terraces.

Tuff

A generic term for any consolidated or cemented deposit that is 50 percent or more volcanic ash.

Upland

An informal, general term for the higher ground of a region, in contrast with a low-lying adjacent area, such as a valley or plain, or for land at a higher elevation than the flood plain or low stream terrace; land above the footslope zone of the hillslope continuum.

Valley fill

The unconsolidated sediment deposited by any agent (water, wind, ice, or mass wasting) so as to fill or partly fill a valley.

Variegation

Refers to patterns of contrasting colors assumed to be inherited from the parent material rather than to be the result of poor drainage.

Varve

A sedimentary layer or a lamina or sequence of laminae deposited in a body of still water within a year. Specifically, a thin pair of graded glaciolacustrine layers seasonally deposited, usually by meltwater streams, in a glacial lake or other body of still water in front of a glacier.

Very stony spot (map symbol)

A spot where 0.1 to 3.0 percent of the soil surface is covered by rock fragments that are more than 10 inches in diameter in areas where the surface of the surrounding soil is covered by less than 0.01 percent stones.

Water bars

Smooth, shallow ditches or depressional areas that are excavated at an angle across a sloping road. They are used to reduce the downward velocity of water and divert it off and away from the road surface. Water bars can easily be driven over if constructed properly.

Weathering

All physical disintegration, chemical decomposition, and biologically induced changes in rocks or other deposits at or near the earth's surface by atmospheric or biologic agents or by circulating surface waters but involving essentially no transport of the altered material.

Well graded

Refers to soil material consisting of coarse grained particles that are well distributed over a wide range in size or diameter. Such soil normally can be easily increased in density and bearing properties by compaction. Contrasts with poorly graded soil.

Wet spot (map symbol)

A somewhat poorly drained to very poorly drained area that is at least two drainage classes wetter than the named soils in the surrounding map unit.

Wilting point (or permanent wilting point)

The moisture content of soil, on an ovendry basis, at which a plant (specifically a sunflower) wilts so much that it does not recover when placed in a humid, dark chamber.

Windthrow

The uprooting and tipping over of trees by the wind.

Attachment 3
Soil Lab Reports

DELLAVALLE
LABORATORY INC

1910 W. McKinley Avenue, Suite 110 ● Fresno, California 93728-1298
Phone (559) 233-6129 ● (800) 228-9896 ● Fax (559) 268-8174
Website: dellavallelab.com

ANALYTICAL CHEMISTS
and
BACTERIOLOGISTS
Approved by State of California

SOIL CONTROL LAB

42 HANGAR WAY
WATSONVILLE
CALIFORNIA
95076
USA

TEL: 831-724-5422
FAX: 831-724-3188

Work Order #: 1090353
Account #: 8927
Date Received: Sep 15, 2021
Date Reported: Sep 23, 2021

Soil Report

Black Diamond Vermicompost
5325 Brokin Spur Pl.
Paso Robles, CA 93446
Attn: Cristy Christie

Lab Number: 1090353-1/4
Project #/Name: None / None
Sample ID: Plot 1

	Your Values (lbs/acre 6" deep)	Suggested Values	
Ammonia (NH_3-N)	15	10-50	OK
Nitrate (NO_3-N)	< 4	20-100	Low
Total Available N	15	75-150	Low
Phosphorous(P_2O_5)	230	100-300	OK
Potassium (K_2O)	530	450-750	OK
Calcium (Ca)	3400	2544-3180	High
Magnesium (Mg)	350	300-600	OK
Sulfate (SO_4-S)	19	100-200	Low
Sodium (Na)	41	< 250	See SAR
Chloride (Cl)	54	1-100	OK
ECe (dS/m)	0.74	0.2-4	OK
Copper (Cu)	1.5	1 +	OK
Zinc (Zn)	6.1	3 +	OK
Iron (Fe)	910	8 +	OK
Manganese (Mn)	130	4 +	OK
Boron (B)	0.56	1-4	Low
SAR	0.47	0-6	OK
CEC (meq/100gms)	11	10-20	OK
ESP (%)	0.83	0-10	OK
pHs Value	6.1	6.5-7.5	Low
Organic Matter (%)	4.4		

RECOMMENDATIONS
ALL VALUES lbs/acre 6" deep

125	Nitrogen (N)
50	Phosphorous (P_2O_5)
200	Potassium (K_2O)
0	Gypsum ($CaSO_4$)
2000	Lime ($CaCO_3$)
0	Dolomite ($CaCO_3$ & $MgCO_3$)
0	Sulfur

*Gypsum adds Ca and doesn't affect pH; Lime adds Ca and raises pH; Dolomite adds Ca & Mg & raises pH.

Lime Requirement:
Tons of 100% $CaCO_3$ Lime per Acre 6" deep needed to raise pH of soil to:

pH 6.0 needs	0.0
pH 6.5 needs	0.4
pH 7.0 needs	0.9

Gypsum Requirement (needed for clay treatment)
0.5 tons per acre 6" deep
Gypsum helps the soil structure by "loosening" the soil

Data:			Method
NO_3-N	< 2	mg/Kg	KCl
NH_3-N	7.6	mg/Kg	KCl
P	53	mg/Kg	Olsen
SP	57	%	Sat
pHs	6.1	unit	Sat
ECe	0.74	dS/m	Sat
Ca	5.6	meq/L	Sat
Mg	1.8	meq/L	Sat
Na	0.91	meq/L	Sat
K	1.2	meq/L	Sat
Cl	1.3	meq/L	Sat
SO_4-S	0.53	meq/L	Sat
SAR	0.47	ratio	Calc
B	0.28	mg/Kg	CaCl2
Cu	0.77	mg/Kg	DTPA
Zn	3.0	mg/Kg	DTPA
Fe	460	mg/Kg	DTPA
Mn	66	mg/Kg	DTPA

Data:			Method
OrgMat	4.4	%	DryComb.
Org-C	2.6	%	DryComb.
SMP Bufffer pH	6.96	unit	SMP
GypReq	0.54	meq/100g	GypSol
Ca	1700	mg/Kg	NH_4OAc
Mg	180	mg/Kg	NH_4OAc
Na	20	mg/Kg	NH_4OAc
K	220	mg/Kg	NH_4OAc

Cation Exchange Capacity (CEC) and Base Saturation Percentages

CEC	11	meq/100gm	Calc.
NH_3-N	0.5	% of CEC	Calc.
Ca	79.6	% of CEC	Calc.
Mg	13.8	% of CEC	Calc.
Na	0.8	% of CEC	Calc.
K	5.3	% of CEC	Calc.
H	0.0	% of CEC	Calc.

Lab Analyst: Mike Galloway

ANALYTICAL CHEMISTS
and
BACTERIOLOGISTS
Approved by State of California
SOIL CONTROL LAB
42 HANGAR WAY
WATSONVILLE
CALIFORNIA
95076
USA

TEL: 831-724-5422
FAX: 831-724-3188

Work Order #: 1090353
Account #: 8927
Date Received: Sep 15, 2021
Date Reported: Sep 23, 2021

Soil Report

Black Diamond Vermicompost
5325 Brokin Spur Pl.
Paso Robles, CA 93446
Attn: Cristy Christie

Lab Number: 1090353-2/4
Project #/Name: None / None
Sample ID: Plot 2

	Your Values (lbs/acre 6" deep)	Suggested Values	
Ammonia (NH_3-N)	13	10-50	OK
Nitrate (NO_3-N)	< 4	20-100	Low
Total Available N	13	75-150	Low
Phosphorous(P_2O_5)	330	100-300	High
Potassium (K_2O)	430	450-750	Low
Calcium (Ca)	2800	2053-2567	High
Magnesium (Mg)	270	300-600	Low
Sulfate (SO_4-S)	13	100-200	Low
Sodium (Na)	28	< 250	See SAR
Chloride (Cl)	20	1-100	OK
ECe (dS/m)	0.51	0.2-4	OK
Copper (Cu)	2.1	1 +	OK
Zinc (Zn)	6.9	3 +	OK
Iron (Fe)	560	8 +	OK
Manganese (Mn)	170	4 +	OK
Boron (B)	0.32	1-4	Low
SAR	0.36	0-6	OK
CEC (meq/100gms)	8.6	10-20	OK
ESP (%)	0.72	0-10	OK
pHs Value	6.0	6.5-7.5	Low
Organic Matter (%)	4.4		

RECOMMENDATIONS
ALL VALUES lbs/acre 6" deep

125	Nitrogen (N)
0	Phosphorous (P_2O_5)
250	Potassium (K_2O)
0	Gypsum ($CaSO_4$)
3000	Lime ($CaCO_3$)
0	Dolomite ($CaCO_3$ & $MgCO_3$)
0	Sulfur

*Gypsum adds Ca and doesn't affect pH; Lime adds Ca and raises pH; Dolomite adds Ca & Mg & raises pH.

Lime Requirement:
Tons of 100% $CaCO_3$ Lime per Acre 6" deep
needed to raise pH of soil to:

pH 6.0 needs	0.3
pH 6.5 needs	0.3
pH 7.0 needs	0.3

Gypsum Requirement (needed for clay treatment)
0.2 tons per acre 6" deep
Gypsum helps the soil structure by "loosening" the soil

Data:			Method
NO_3-N	< 2	mg/Kg	KCl
NH_3-N	6.3	mg/Kg	KCl
P	75	mg/Kg	Olsen
SP	58	%	Sat
pHs	6.0	unit	Sat
ECe	0.51	dS/m	Sat
Ca	4.1	meq/L	Sat
Mg	1.3	meq/L	Sat
Na	0.58	meq/L	Sat
K	0.85	meq/L	Sat
Cl	0.49	meq/L	Sat
SO_4-S	0.35	meq/L	Sat
SAR	0.36	ratio	Calc
B	0.16	mg/Kg	CaCl2
Cu	1.0	mg/Kg	DTPA
Zn	3.4	mg/Kg	DTPA
Fe	280	mg/Kg	DTPA
Mn	85	mg/Kg	DTPA

Data:			Method
OrgMat	4.4	%	DryComb.
Org-C	2.6	%	DryComb.
SMP Bufffer pH	6.90	unit	SMP
GypReq	0.20	meq/100g	GypSol
Ca	1400	mg/Kg	NH_4OAc
Mg	130	mg/Kg	NH_4OAc
Na	14	mg/Kg	NH_4OAc
K	180	mg/Kg	NH_4OAc

Cation Exchange Capacity (CEC) and Base Saturation Percentages

CEC	8.6	meq/100gm	Calc.
NH_3-N	0.5	% of CEC	Calc.
Ca	80.5	% of CEC	Calc.
Mg	12.9	% of CEC	Calc.
Na	0.7	% of CEC	Calc.
K	5.4	% of CEC	Calc.
H	0.0	% of CEC	Calc.

Lab Analyst:
Mike Galloway

ANALYTICAL CHEMISTS
and
BACTERIOLOGISTS
Approved by State of California

SOIL CONTROL LAB

42 HANGAR WAY
WATSONVILLE
CALIFORNIA
95076
USA

TEL: 831-724-5422
FAX: 831-724-3188

Work Order #: 1090353
Account #: 8927
Date Received: Sep 15, 2021
Date Reported: Sep 23, 2021

Soil Report

Black Diamond Vermicompost
5325 Brokin Spur Pl.
Paso Robles, CA 93446
Attn: Cristy Christie

Lab Number: 1090353-3/4
Project #/Name: None / None
Sample ID: Plot 3

	Your Values (lbs/acre 6" deep)	Suggested Values	
Ammonia (NH_3-N)	14	10-50	OK
Nitrate (NO_3-N)	< 4	20-100	Low
Total Available N	14	75-150	Low
Phosphorous(P_2O_5)	300	100-300	OK
Potassium (K_2O)	370	450-750	Low
Calcium (Ca)	1900	2000-2500	Low
Magnesium (Mg)	210	300-600	Low
Sulfate (SO_4-S)	12	100-200	Low
Sodium (Na)	27	< 250	See SAR
Chloride (Cl)	33	1-100	OK
ECe (dS/m)	0.55	0.2-4	OK
Copper (Cu)	1.3	1 +	OK
Zinc (Zn)	4.9	3 +	OK
Iron (Fe)	430	8 +	OK
Manganese (Mn)	160	4 +	OK
Boron (B)	0.43	1-4	Low
SAR	0.44	0-6	OK
CEC (meq/100gms)	6.1	10-20	OK
ESP (%)	0.96	0-10	OK
pHs Value	5.8	6.5-7.5	Low
Organic Matter (%)	3.8		

RECOMMENDATIONS
ALL VALUES lbs/acre 6" deep

125	Nitrogen (N)
0	Phosphorous (P_2O_5)
250	Potassium (K_2O)
0	Gypsum ($CaSO_4$)
2000	Lime ($CaCO_3$)
0	Dolomite ($CaCO_3$ & $MgCO_3$)
0	Sulfur

*Gypsum adds Ca and doesn't affect pH; Lime adds Ca and raises pH; Dolomite adds Ca & Mg & raises pH.

Lime Requirement:
Tons of 100% $CaCO_3$ Lime per Acre 6" deep
needed to raise pH of soil to:

pH 6.0 needs	0.4
pH 6.5 needs	0.5
pH 7.0 needs	0.5

Gypsum Requirement (needed for clay treatment)
0.0 tons per acre 6" deep
Gypsum helps the soil structure by "loosening" the soil

Data:			Method
NO_3-N	< 2	mg/Kg	KCl
NH_3-N	7.0	mg/Kg	KCl
P	68	mg/Kg	Olsen
SP	54	%	Sat
pHs	5.8	unit	Sat
ECe	0.55	dS/m	Sat
Ca	4.1	meq/L	Sat
Mg	1.5	meq/L	Sat
Na	0.73	meq/L	Sat
K	1.1	meq/L	Sat
Cl	0.86	meq/L	Sat
SO_4-S	0.35	meq/L	Sat
SAR	0.44	ratio	Calc
B	0.21	mg/Kg	CaCl2
Cu	0.66	mg/Kg	DTPA
Zn	2.5	mg/Kg	DTPA
Fe	220	mg/Kg	DTPA
Mn	81	mg/Kg	DTPA

Data:			Method
OrgMat	3.8	%	DryComb.
Org-C	2.2	%	DryComb.
SMP Bufffer pH	6.88	unit	SMP
GypReq	0.0040	meq/100g	GypSol
Ca	950	mg/Kg	NH_4OAc
Mg	100	mg/Kg	NH_4OAc
Na	14	mg/Kg	NH_4OAc
K	150	mg/Kg	NH_4OAc

Cation Exchange Capacity (CEC) and Base Saturation Percentages

CEC	6.1	meq/100gm	Calc.
NH_3-N	0.8	% of CEC	Calc.
Ca	77.6	% of CEC	Calc.
Mg	14.2	% of CEC	Calc.
Na	1.0	% of CEC	Calc.
K	6.5	% of CEC	Calc.
H	0.0	% of CEC	Calc.

Lab Analyst: Mike Galloway

ANALYTICAL CHEMISTS and BACTERIOLOGISTS
Approved by State of California
SOIL CONTROL LAB
42 HANGAR WAY
WATSONVILLE
CALIFORNIA
95076
USA

TEL: 831-724-5422
FAX: 831-724-3188

Work Order #: 1090353
Account #: 8927
Date Received: Sep 15, 2021
Date Reported: Sep 23, 2021

Soil Report

Black Diamond Vermicompost
5325 Brokin Spur Pl.
Paso Robles, CA 93446
Attn: Cristy Christie

Lab Number: 1090353-4/4
Project #/Name: None / None
Sample ID: Plot 4

	Your Values (lbs/acre 6" deep)	Suggested Values	
Ammonia (NH_3-N)	13	10-50	OK
Nitrate (NO_3-N)	< 4	20-100	Low
Total Available N	13	75-150	Low
Phosphorous(P_2O_5)	170	100-300	OK
Potassium (K_2O)	830	450-750	High
Calcium (Ca)	2000	2000-2500	OK
Magnesium (Mg)	230	300-600	Low
Sulfate (SO_4-S)	13	100-200	Low
Sodium (Na)	24	< 250	See SAR
Chloride (Cl)	27	1-100	OK
ECe (dS/m)	0.59	0.2-4	OK
Copper (Cu)	1.5	1 +	OK
Zinc (Zn)	5.0	3 +	OK
Iron (Fe)	410	8 +	OK
Manganese (Mn)	200	4 +	OK
Boron (B)	0.34	1-4	Low
SAR	0.41	0-6	OK
CEC (meq/100gms)	6.8	10-20	OK
ESP (%)	0.76	0-10	OK
pHs Value	5.9	6.5-7.5	Low
Organic Matter (%)	3.9		

RECOMMENDATIONS
ALL VALUES lbs/acre 6" deep

125	Nitrogen (N)
100	Phosphorous (P_2O_5)
0	Potassium (K_2O)
0	Gypsum ($CaSO_4$)
2000	Lime ($CaCO_3$)
0	Dolomite ($CaCO_3$ & $MgCO_3$)
0	Sulfur

*Gypsum adds Ca and doesn't affect pH; Lime adds Ca and raises pH; Dolomite adds Ca & Mg & raises pH.

Lime Requirement:
Tons of 100% $CaCO_3$ Lime per Acre 6" deep needed to raise pH of soil to:

pH 6.0 needs	0.1
pH 6.5 needs	0.0
pH 7.0 needs	0.0

Gypsum Requirement (needed for clay treatment)
0.4 tons per acre 6" deep
Gypsum helps the soil structure by "loosening" the soil

Data:			Method
NO_3-N	< 2	mg/Kg	KCl
NH_3-N	6.3	mg/Kg	KCl
P	39	mg/Kg	Olsen
SP	57	%	Sat
pHs	5.9	unit	Sat
ECe	0.59	dS/m	Sat
Ca	3.7	meq/L	Sat
Mg	1.4	meq/L	Sat
Na	0.66	meq/L	Sat
K	2.0	meq/L	Sat
Cl	0.67	meq/L	Sat
SO_4-S	0.34	meq/L	Sat
SAR	0.41	ratio	Calc
B	0.17	mg/Kg	CaCl2
Cu	0.77	mg/Kg	DTPA
Zn	2.5	mg/Kg	DTPA
Fe	210	mg/Kg	DTPA
Mn	99	mg/Kg	DTPA

Data:			Method
OrgMat	3.9	%	DryComb.
Org-C	2.3	%	DryComb.
SMP Bufffer pH	6.93	unit	SMP
GypReq	0.42	meq/100g	GypSol
Ca	980	mg/Kg	NH_4OAc
Mg	110	mg/Kg	NH_4OAc
Na	12	mg/Kg	NH_4OAc
K	350	mg/Kg	NH_4OAc

Cation Exchange Capacity (CEC) and Base Saturation Percentages

CEC	6.8	meq/100gm	Calc.
NH_3-N	0.7	% of CEC	Calc.
Ca	71.7	% of CEC	Calc.
Mg	13.9	% of CEC	Calc.
Na	0.8	% of CEC	Calc.
K	13.0	% of CEC	Calc.
H	0.0	% of CEC	Calc.

Lab Analyst: Mike Galloway

Attachment 4
USGS Topographic Map

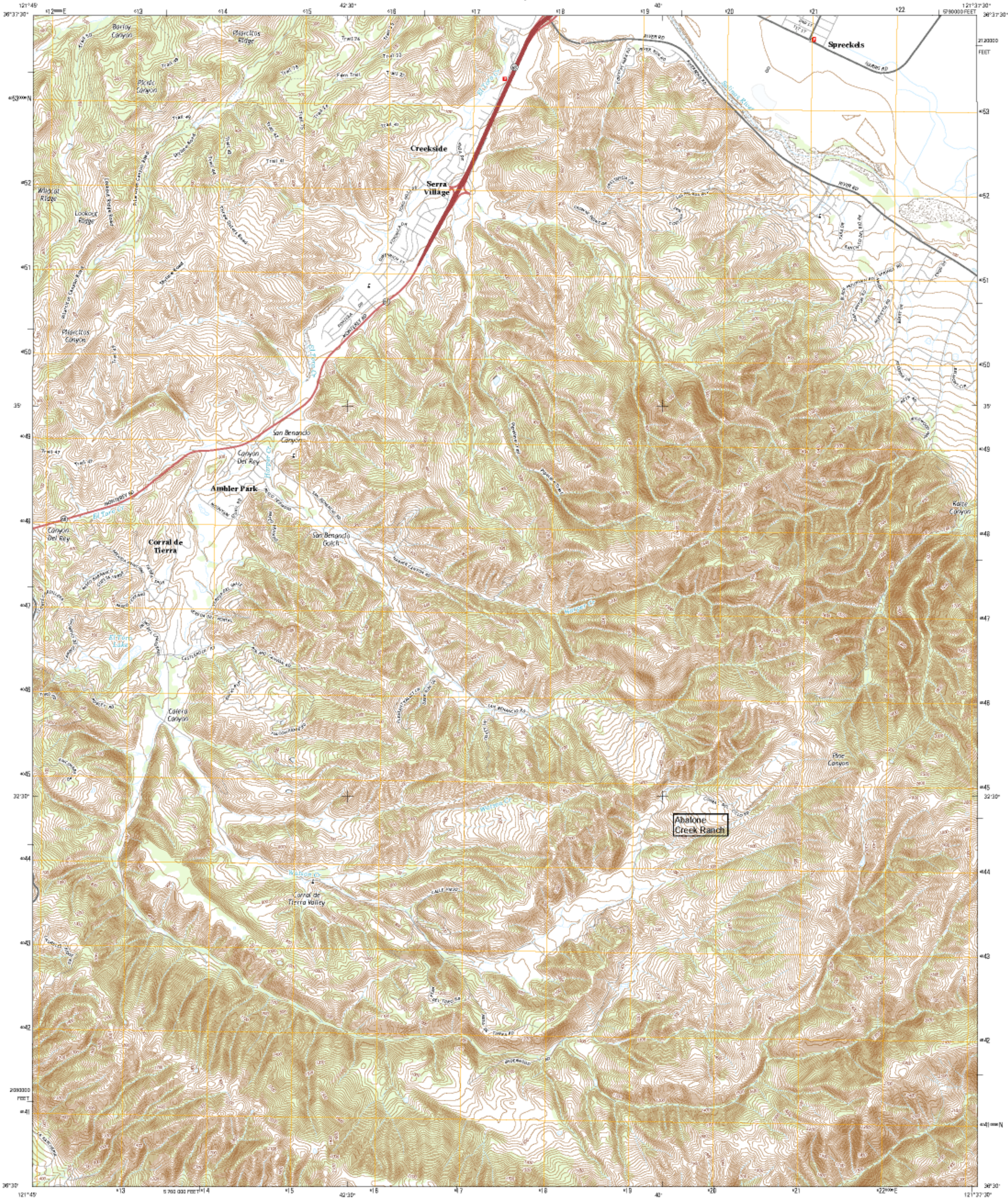
DELLAVALLE™
LABORATORY INC

1910 W. McKinley Avenue, Suite 110 ● Fresno, California 93728-1298
Phone (559) 233-6129 ● (800) 228-9896 ● Fax (559) 268-8174
Website: dellavallelab.com

U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

The National Map
US Topo

SPRECKELS QUADRANGLE
CALIFORNIA-MONTEREY CO.
7.5-MINUTE SERIES



Produced by the United States Geological Survey
North American Datum of 1983 (NAD83)
World Geodetic System of 1984 (WGS84). Projection and
1 000-meter grid: Universal Transverse Mercator, Zone 10S
10 000-foot ticks: California Coordinate System of 1983 (zone 4)

This map is not a legal document. Boundaries may be generalized for this map scale. Private lands within government reservations may not be shown. Obtain permission before entering private lands.

Imagery....................NAIP, May 2012
Roads....................HERE, ©2013 - 2014
Names....................GNIS, 2015
Hydrography....................National Hydrography Dataset, 2012
Contours....................National Elevation Dataset, 2008
Boundaries....................Multiple sources; see metadata file 1972 - 2015
Public Land Survey System....................BLM, 2011

UTM GRID AND 2015 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

U.S. National Grid
100,000-m Square ID
FF
Grid Zone Designation
10S

SCALE 1:24 000

CONTOUR INTERVAL 20 FEET
NORTH AMERICAN VERTICAL DATUM OF 1988

This map was produced to conform with the National Geospatial Program US Topo Product Standard, 2011.
A metadata file associated with this product is draft version 0.6.18

QUADRANGLE LOCATION

ROAD CLASSIFICATION
Expressway
Secondary Hwy
Ramp
Local Connector
Local Road
4WD
Interstate Route
US Route
State Route

ADJOINING QUADRANGLES
1 Marina
2 Salinas
3 Natividad
4 Seaside
5 Chualar
6 Mount Carmel
7 Carmel Valley
8 Rana Creek

SPRECKELS, CA
2015

NSN. 7643016357608
NGA REF NO. USGSX24K72698

Attachment 5
References for Manure Production and Characteristics

DELLAVALLE™
LABORATORY INC

1910 W. McKinley Avenue, Suite 110 ● Fresno, California 93728-1298
Phone (559) 233-6129 ● (800) 228-9896 ● Fax (559) 268-8174
Website: dellavallelab.com

ASAE D384.2 MAR2005
Manure Production and Characteristics

American Society of Agricultural Engineers

STANDARD

ASAE is a professional and technical organization, of members worldwide, who are dedicated to advancement of engineering applicable to agricultural, food, and biological systems. ASAE Standards are consensus documents developed and adopted by the American Society of Agricultural Engineers to meet standardization needs within the scope of the Society; principally agricultural field equipment, farmstead equipment, structures, soil and water resource management, turf and landscape equipment, forest engineering, food and process engineering, electric power applications, plant and animal environment, and waste management.

ASAE-The Society for engineering in agricultural, food, and biological systems
2950 Niles Rd., St. Joseph, MI 49085-9659, USA ph. 269-429-0300, fax 269-429-3852, hq@asae.org

Manure Production and Characteristics

Developed by the Engineering Practices Subcommittee of the ASAE Agricultural Sanitation and Waste Management Committee; approved by the Structures and Environment Division Standards Committee; adopted by ASAE December 1976; reconfirmed December 1981, December 1982, December 1983, December 1984, December 1985, December 1986, December 1987; revised June 1988; revised editorially and reaffirmed December 1993; revised editorially March 1995; reaffirmed December 1998, December 1999, December 2001, February 2003; revised March 2005 by a joint committee of ASAE and Federation of Animal Science Societies members.

1.0 Purpose

1.1 This standard provides three types of information for estimating characteristics of livestock and poultry manure:

- Typical characteristics for manure ''as-excreted'' by livestock and poultry based on typical diets and animal performance levels in 2002 (Section 3);
- Equations for estimating manure excretion characteristics based on animal performance and dietary feed and nutrient intake specific to an individual situation (Sections 4 through 9);
- Typical characteristics for manure ''as-removed'' from manure storage or animal housing (Section 10).

1.2 Typical or average estimates of manure excreted become obsolete due to changes in animal genetics, performance potential, feeding program strategies, and available feeds. To minimize future concerns, a set of equations for predicting nutrient excretion (primarily nitrogen and phosphorus), dry matter, and, depending upon species, other potential characteristics have been assembled for beef, dairy, swine, horses and poultry. The Equation Estimates sections (Sections 4 through 9) allow an estimate of manure characteristics that is relevant to a wide range of dietary options and animal performance levels commonly observed in commercial production.

1.3 It is more appropriate to use the equations in Sections 4 through 9 for the following situations:

- When comprehensive nutrient management plans are being developed specific to an individual animal feeding operation (AFO);
- When farm specific data is available for an AFO's feeding program and animal performance;
- When feed intake, feed nutrient concentration, feed digestibility, or animal performance varies from the assumptions used to estimate the typical values in Table 1.
- When Table 1 has not been updated to address industry trends.

1.4 It may be more appropriate to use the typical values found in Table 1 for the following situations:

- When planning estimates are being made on a scale larger than a single farm (e.g. county or regional estimate of nutrient excretion)
- When a rough approximation is needed for farm planning;
- When farm-specific information of animal performance and feed intake is not available.

2.0 Caution

2.1 Section 3. Typical As-Excreted Manure Production and Characteristics. The user of these data should recognize that the reported typical values may become obsolete with time due to changes in animal genetics, feeding programs, alternative feeding technologies, and available feeds. In addition, users should also recognize that under current conditions, excretion of nutrients and other related characteristics will vary for individual situations from the currently listed values due to variations in animal feed nutrient intake, animal performance, and individual farm management. Sections 4 – 9 provide an alternative, and often more accurate, methodology for estimating nutrient excretion for individual production systems.

Table 1. Section 3 – Estimated typical manure (urine and feces combined) characteristics as excreted[1] by:

Table 1.a – Meat-producing livestock and poultry. Diet based numbers are in **BOLD.** See footnotes 2 and 3 for source of non-bold values.

Animal Type and Production Grouping	Total solids[3]	Volatile solids[3]	COD[3,4]	BOD[3,4]	Nitrogen	P	K	Ca	Total Manure[5]		Moisture[6]	Assumed Finishing Time Period (days)
	kg / finished animal (f.a.)								kg / f.a.	liter / f.a.	% w.b.	
Beef - Finishing cattle	**360**	**290**	300	67	**25**	**3.3**	17.1	**7.7**	4,500	4,500	92	153
Poultry - Broiler	**1.3**	0.95	1.05	0.30	**0.053**	**0.016**	**0.031**		4.9	4.9	74	48
Poultry - Turkey (male)	**9.2**	7.4	8.5	2.4	**0.55**	**0.16**	0.26		36	36	74	133
Poultry - Turkey (females)	**4.4**	3.5	4.0	1.1	**0.26**	**0.074**	0.11		17	17	74	105
Poultry - Duck	**1.7**	1.0	1.4	0.28	**0.062**	**0.022**	0.031		6.5	6.5	74	39
Swine - Nursery pig (12.5 kg)	4.8	4.0	4.4	1.5	**0.41**	**0.068**	0.16		48	48	90	36
Swine - Grow-finish (70 kg)	**56**	45	47	17	**4.7**	**0.76**	2.0		560	560	90	120
	lb / finished animal (f.a.)									ft^3 / f.a.	% w.b.	
Beef - Finishing cattle	**780**	**640**	670	150	**55**	**7.3**	38	**17**	9,800	160	92	153
Poultry - Broiler	**2.8**	2.1	2.3	0.66	**0.12**	**0.035**	**0.068**		11	0.17	74	48
Poultry - Turkey (male)	**20**	16	19	5.2	**1.2**	**0.36**	0.57		78	1.3	74	133
Poultry - Turkey (females)	**9.8**	7.8	8.8	2.4	**0.57**	**0.16**	0.25		38	0.61	74	105
Poultry - Duck	**3.7**	2.2	3.0	0.61	**0.14**	**0.048**	0.068		14	0.23	74	39
Swine - Nursery pig (27.5 lb)	10	8.7	9.7	3.4	**0.91**	**0.15**	0.35		87	1.4	90	36
Swine - Grow-finish (154 lb)	**120**	99	104	38	**10**	**1.7**	4.4		1200	20	90	120

Table 1.b – Section 3 – All other livestock and poultry. Diet based numbers are in **BOLD.** See footnotes 2 and 3 for source of non-bold values.

Animal Type and Production Grouping	Total solids[3]	Volatile solids[3]	COD[3,4]	BOD[3,4]	Nitrogen	P	K	Ca	Mg	Total Manure[5]		Moisture[6]
	kg / day-animal (d-a)									kg / (d-a)	liter / d-a.	% w.b.
Beef - Cow (confinement)[7,10]	**6.6**	**5.9**	6.2	1.4	**0.19**	**0.044**	0.14	**0.089**		-	-	88
Beef - Growing Calf (confinement)	**2.7**	**2.3**	2.3	0.52	**0.13**	**0.025**	0.085	**0.040**		22	22	88
Dairy - Lactating cow	**8.9**	7.5	8.1	1.30	**0.45**	**0.078**	**0.103**			68	68	87
Dairy - Dry cow	**4.9**	4.2	4.4	0.626	**0.23**	0.03	0.148			38	3	87
Dairy - Milk fed calves					0.0079							
Dairy - Calf-150 kg	1.4				0.063					8.5	8.5	83
Dairy - Heifer-440 kg	3.7	3.2	3.4	0.54	**0.12**	**0.020**				22	22	83
Dairy - Veal-118 kg	0.12				0.015	0.0045	0.0199			3.5	3.5	96
Horse - Sedentary-500 kg[8]	**3.8**	3.0		0.48	**0.089**	**0.013**	**0.027**	**0.023**	**0.009**	25	25	85
Horse - Intense exercise -500 kg[8]	**3.9**	3.1		0.49	**0.15**	**0.033**	**0.095**	**0.069**	**0.018**	26	26	85
Layer	**0.022**	0.016	0.018	0.0050	**0.0016**	**0.00048**	0.00058	**0.0022**		0.088	0.088	75
Swine - Gestating sow-200 kg	0.50	0.45	0.47	0.17	**0.032**	**0.009**	0.022			5.0	5.0	90
Swine - Lactating sow[9] -192 kg	1.2	1.0	1.1	0.38	**0.085**	**0.025**	.053			12	12	90
Swine - Boar-200 kg	0.38	0.34	0.27	0.13	0.028	0.0097	.0176			3.8	3.8	90
	lb / day-animal (d-a)									lb / d-a.	ft^3 / d-a.	% w.b.
Beef - Cow (confinement)[7,10]	**15**	**13**	14	3.0	**0.42**	**0.097**	0.30	**0.20**		-	-	88
Beef - Growing Calf (confinement)	**6.0**	**5.0**	5.2	1.1	**0.29**	**0.055**	0.19	**0.088**		50	0.81	88
Dairy - Lactating cow	**20**	17	18	2.9	**0.99**	**0.17**	**0.23**			150	2.4	87
Dairy - Dry cow	**11**	9.2	9.7	1.4	**0.50**	**0.066**	0.33			83	1.3	87
Dairy - Milk fed calves					0.017							
Dairy - Calf-330lb	3.2				0.14					19	0.30	83
Dairy - Heifer-970 lb	8.2	7.1	7.5	1.2	**0.26**	**0.044**				48	0.78	83
Dairy - Veal-260 lb	0.27				0.033	0.0099	0.044			7.8	0.12	96
Horse - Sedentary-1,100 lb[8]	**8.4**	6.6		1.1	**0.20**	**0.029**	**0.060**	**0.051**	**0.020**	56	0.90	85
Horse - Intense exercise -1,100 lb[8]	**8.6**	6.8		1.1	**0.34**	**0.073**	**0.21**	**0.15**	**0.040**	57	0.92	85
Layer	**0.049**	0.036	0.039	0.011	**0.0035**	**0.0011**	0.0013	0.0048		0.19	0.0031	75
Swine - Gestating sow-440 lb	1.1	0.99	1.0	0.37	**0.071**	**0.020**	0.048			11	0.18	90
Swine - Lactating sow[9] 423 lb	2.5	2.3	2.4	0.84	**0.19**	**0.055**	0.12			25	0.41	90
Swine - Boar-440 lb	0.84	0.75	0.60	0.29	0.061	0.021	0.039			8.4	0.13	90

[1] Prior to any changes due to dilution water addition, drying, volatilization or other physical, chemical or biological processes.

[2] Non-bold table numbers indicate that predictive equations were not available from Sections 4 – 9 for estimating this characteristic. These numbers are average values taken from MWPS-18 Section 1, NRCS Agricultural Waste Management Field Handbook, and the previous version ASAE D384.1 or calculated based upon procedures used in footnote 3.

[3] Total Solids (TS) is estimated for most animal groups by equations in Sections 4 – 9. For beef cattle, volatile solids is also based upon equations. For all other species, volatile solids are calculated from TS and literature values of the ratio of VS to TS. Similarly, BOD and COD values are calculated using VS and the literature values of the ratio of BOD and COD to VS. Literature values are taken from MWPS-18 Section 1, NRCS Agricultural Waste Management Field Handbook, and the previous version ASAE D384.1.

[4] BOD – Biochemical oxygen demand, 5-day, COD – Chemical oxygen demand.

[5] Total manure is calculated from Total Solids and manure moisture content.

[6] As-excreted manure moisture contents range from 75 to 90 percent. At these moisture levels as-excreted manure has a density nearly equal to that of water, and a specific gravity of 1.0 was assumed in calculation of manure volume.

[7] Solids estimates (TS, VS, COD, and BOD) do not include solids in urine.

[8] These values apply to horses 18 months of age or older that are not pregnant or lactating. The representative number applies to 500 kg horses and the range represents horses from 400 to 600 kg. "Sedentary" would apply to horses not receiving any imposed exercise. Dietary inputs are based on minimum nutrient requirements specified in "Nutrient Requirements of Horses" (NRC, 1989). "Intense" represents horses used for competitive activities such as racing. Dietary inputs are based on a survey of race horse feeding practices (Gallagher et al, 1992) and typical feed compositions (forage = 50% alfalfa, 50% timothy; concentrate = 30% oats, 70% mixed performance horse concentrate).

[9] Bold values include contribution of nursing pigs.

[10] Beef cows values are representative of animals during non-lactating period and first six months of gestation.

Table 2. Definition of Variables – As Excreted - Beef – Section 4.

Variable	Description	Units
Animal performance characteristics input		
BW_F	Live body weight at finish of feeding period (market weight)[2]	kg
BW_I	Live body weight at start of feeding period (purchase weight)[2]	kg
BW_{AVG}	Average live body weight for feeding period [2]	kg
SRW[3]	Standard reference weight for expected final body fat	478 kg for Choice (28% marbling) 462 kg for Select (26.8% marbling)
Feed program characteristics inputs		
DMI	Dry matter intake	g dry feed / day
DMD	Dry matter digestibility of total ration	% of DMI
OMD	Organic matter digestibility of total ration	% of OMI
ASH	Ash concentration of total ration	% of DMI
C_{cp}	Concentration of crude protein of total ration	g of protein / g of dry feed
C_P	Concentration of phosphorus of total ration	g of phosphorus / g of dry feed
DOF	Days on feed for individual ration	days
x	Ration number	
n	Total number of rations fed	
Excretion outputs		
N_{E-T}	Total nitrogen excretion per finished animal	g of nitrogen / finished animal
P_{E-T}	Total phosphorus excretion per finished animal	g of phosphorus / finished animal
Ca_{E-T}	Total calcium excretion per finished animal	g of calcium / finished animal
DM_E	Dry matter excretion per animal per day	g of dry matter / day / animal
DM_{E-T}	Total dry matter excretion per finished animal	g of dry matter / finished animal
OM_E	Organic matter (or volatile solids) excretion per animal per day	g of organic matter / day / animal
OM_{E-T}	Total organic matter (or volatile solids) excretion per finished animal	g of organic matter / finished animal

[1] Data specific to individual herd performance or feed analysis should be used when data is available. If situation specific information is not available, a default value from the Assumptions Table for Typical Manure Characteristics at the conclusion of this section may be the next best alternative.
[2] For beef cow/calf pairs (including pregnancy), assume $BW_F - BW_I$ equals weaning weight of calves. For beef cows on maintenance diet, assume the $BW_F - BW_I$ equals 0.
[3] If SRW is unknown, recommend using 478 kg as standard reference weight.

2.2 Sections 4 – 9. Equations for As-Excreted Manure Characteristics Estimates for Individual Species. These sections demonstrate the impact of dietary changes on nutrient excretion. However, this is not intended to be used as a ration-balancing tool, nor is this the appropriate tool for estimating the nutrient needs of the animal. Nutrient needs are best defined in the National Research Council's publication series or by using University recommendations. Both sources of information can provide estimates that reflect biological inefficiencies and digestibility limitations.

2.3 In using Sections 4 – 9 to evaluate the impact of alternative rations, it is important to recognize that these equations accurately estimate excretion only when animals are fed diets that meet or exceed the animal's minimum nutrient requirements. Estimates of excretion based on dietary options that do not meet an animal's minimum needs will not be accurate. Sections 4 – 9 are to be used following ration development by an animal nutrition professional.

2.4 New research data on excretion will be of value for confirming or improving the accuracy of the equations estimating excreting. The authors of this standard are very interested in comparing new research data with these equations. Authors can be contacted through the ASAE Standards staff.

2.5 Section 10. Typical As-Removed Manure Production and Characteristics. Many physical, chemical, and biological processes can alter manure characteristics from its original as-excreted form. The as-removed manure production and characteristics values reported in this table allow for common modifications to excreted manure (Section 3) resulting from water addition or removal, bedding addition, and/or treatment processes. These values represent typical values based on available data sources (see end of Section 10). These estimates may be helpful for individual farm long-term planning prior to any samples being available and for planning estimates addressing regional issues. Whenever possible, site-specific samples or other more localized estimates should be used in lieu of national tabular estimates. **This table should not be used to develop individual year nutrient management plans for defining field specific application rates, unless absolutely**

Table 3a: Estimated manure (urine and feces combined) characteristics as excreted based upon equations in Section 4 and assumptions in Table 3b.

Animal Type and Production Grouping	Total solids	Volatile Solids	Nitrogen	Phosphorus	Calcium	Total Manure[1]
	kg / finished animal					
Finishing cattle	360	290	25	3.3	7.7	3,400
	lb / finished animal					
Finishing cattle	780	640	55	7.3	17	7,400

[1] Total manure is calculated from total solids and assumed moisture of 92%.

Table 3b – Dietary and performance assumptions – Section 4.

Animal Type and Production Grouping	Live Weight (kg) In	Live Weight (kg) Out	Average Daily Gain (kg/da)	Days on Feed	Feed Conversion (kg of feed per kg of gain)	Dietary Assumptions: DMI (% of avg. body weight)	DMD	OMD	Crude Protein (g/day)	P (g/day)	Ca (g/day)	Ash
Finishing cattle	338	554	1.42	153	6.3	2.0%	80%	83%	1200	28	62	4%
Range: Only feed conversion efficiency and dietary nutrient content or digestibility were varied to determine range for N, P, and Ca.					5.8–6.8		70 – 85%	75 – 88%	1100 – 1300	22 – 45	53 – 80	

no site-specific manure analysis data are available. However, where site-specific data are unavailable, this table may provide initial estimates for planning purposes until those site-specific values are available.

3.0 Typical As-Excreted Manure Production and Characteristics

3.1 Two approaches were used for estimating typical characteristics summarized in Table 1.

1) Manure characteristics listed in **BOLD** are estimated for dietary intake and animal performance levels common for livestock and poultry management in 2003 using the equations listed in Sections 4 through 9. Beef, poultry and swine excretion characteristics are based on a calculation of dietary nutrient intake minus animal nutrient retention using dietary and performance measurements typical for the industry at the time these data were published. Nutrient retention estimates followed common industry methodologies used for recommending feeding programs. Dry matter excretion is estimated to be a function of dry matter intake minus dry matter digestibility (see equations in Sections 4 and 9).

   For estimating dairy and equine manure characteristics, existing research data and regression analysis were used to identify relationship between feeding programs, animal performance, and excretion.

   Total nitrogen, total phosphorus, and dry matter excretion were estimated by these methods for all species. Available research data or models allowed additional excretion estimates for some species. All data in Table 1 based upon animal dietary intake and performance measure is illustrated in **BOLD** with supporting assumptions for dietary intake and performance assumptions and references listed in Sections 4 through 9.

2) Where dietary intake and animal performance level based excretion estimates could not be made, a review of current references including the USDA Agricultural Waste Management Field Handbook, previous ASAE D384 standard, and Manure Characteristics (MWPS-18, Section 1). Those values in Table 1 that are not bold are based upon these references.

3.2 Caution

3.2.1 Manure and nutrient production characteristics for meat producing animals are reported on a unit mass excreted per finished animal. Manure excretion by meat producing animals varies with stage of growth. This format was selected to minimize misuse of a daily average values to represent an entire production phase. Sizing of treatment systems based upon instantaneous loading rates should use the equations in Sections 4 through 9 with appropriate feeding program and performance inputs typical of the later stages of growth. Manure excretion rates for other animals are more constant and thus reported on a daily basis.

3.2.2 In addition, facilities for meat producing animals are rarely in full production 365 days per year due to uneven growth rates of animals, time required for facility cleaning after a group, and availability of animals for restocking a facility. Planning based on number of finished animals provides a more realistic planning estimate for annual manure volume and nutrient production.

3.2.3 It should also be noted that Table 1 estimates and predictive equations in Sections 4 through 9 provide an as-excreted estimate of manure production, excluding any additions of waste feed or dilution water, biochemical degradation of solids, or volatilization of nitrogen and carbon. Manure characteristics after storage and/or treatment of manures are better estimated by site-specific manure samples or, when farm specific information is not available, by the typical as-removed values listed in Section 10.

3.3 References

3.3.1 Fulhage, C. D., 2003. Proposed Revision to ASAE D384.1 for Representative Values of "As-Excreted" Manure Production. Proceedings of the International Symposium for Animal, Agricultural, and Food Processing Wastes IX. ASAE. St. Joseph, MI. 269–276.

4.0 Equations for As-Excreted Manure Characteristics Estimates for Beef

4.1 Fundamental Model

Nutrient Excretion = Feed Nutrient Intake – Nutrient Retention
Dry Matter Excretion = Feed Dry Matter Intake X (1 – Dry Matter Digestibility)*

* Same relationship for organic matter or volatile solids excretion

4.2 See 2.0 Caution

See Table 2, Definitions of Variables – As Excreted – Beef.

4.3 Equations for Estimating Excretions

Equations from the 1996 NRC Nutrient Requirements of Beef Cattle for retained protein and energy equations provide the basis for estimating nitrogen retention. Supplemental information referenced by this publication provides background information on validation of this approach for estimating retained nitrogen.

Retained phosphorus is generally recognized as 3.9 g of retained P per 100 g of retained protein. Retained calcium is generally recognized as 7.1 g per 100 g of retained protein. Therefore, P and Ca retention are calculated as a function of retained protein. Both assumptions originate from the 1996 NRC Nutrient Requirements of Beef Cattle. Additional supporting information is sited by this publication.

4.3.1 *Dry Matter Excretion Equation for Calves and Finishers*[1]

$$DM_E = [DMI * (1 - DMD / 100)] + 20.3 * (0.06 * BW_{AVG}) \quad (1)$$

$$DM_{E-T} = \sum_{x=1}^{n} DMI_x * DOF_x * (1 - DMD_x / 100) + \sum_{x=1}^{n} DOF_x * 20.3 * (0.06 * BW_{AVG}) \quad (2)$$

[1] Estimates dry matter for 1) feces baed upon indigestibility of feed and for 2) urine based upon regression equation from 300 observations of urine excretion by beef cattle finishers ranging in weight from 100 to 620 kg and urine solids content of 6%.

Table 4 – Definition of Variables – As Excreted – Dairy Cattle – Section 5.

Variable	Description	Units
Animal performance characteristics inputs		
Milk	Milk production	kg of milk / animal / day
MF	Milk fat	g / g milk / day
MTP	Milk true protein	g / g milk / day
DIM	Days in milk	days
DP	Dry period length	days
BW	Average live body weight	kg
Feed program characteristics inputs		
DMI	Dry matter intake	kg dry feed / animal / day
DMD	Dry matter digestibility of total ration	% of DMI
OMD	Organic matter digestibility of total ration	% of of OM intake
ASH	Ash concentration of total ration	% of DMI
C_{cp}	Concentration of crude protein of total ration	g crude protein / g dry feed
C_P	Concentration of phosphorus of total ration	g phosphorus / g dry feed
C_K	Concentration of potassium of total ration	g potassium / g dry feed
Excretion outputs		
M_E	Total manure excretion per animal per day	kg / animal / day
N_E	Total nitrogen excretion per animal per day	g / animal / day
P_E	Total phosphorus excretion per animal per day	g / animal / day
K_E	Total potassium excretion per animal per day	g / animal / day
DM_E	Dry matter (solids) excretion per animal per day	kg / animal / day
OM_E	Organic matter (or volatile solids) excretion per animal per day	kg / animal / day
U_E	Urine excretion per animal per day	liters / animal / day

4.3.2 *Organic Matter (or volatile solids) Excretion Equation*

$$OM_E = [DMI*(1-ASH / 100)]*(1-OMD / 100) + 17*(0.06*BW_{AVG}) \quad (3)$$

$$OM_{E-T} = \sum_{x=1}^{n} [DMI_x*DOF_x*(1-ASH_x / 100)]*(1-OMD_x / 100) + \sum_{x=1}^{n} DOF_x*17*(0.06*BW_{AVG}) \quad (4)$$

4.3.3 *Nitrogen Excretion Equation*

$$N_{E-T} = \sum_{x=1}^{n}(DMI_x*C_{cp-x}*DOF_x*/6.25)-[41.2*(BW_F - BW_I)] + [0.243*DOF_{Tt}*[(BW_F + BW_I)/2]^{0.75}*(SRW/(BW_F*0.96))^{0.75}*[(BW_F - BW_I)/DOF_T]^{1.097}] \quad (5)$$

4.3.4 *Phosphorus Excretion Equation*

$$P_{E-T} = \sum_{x=1}^{n}(DMI_x*C_{P-x}*DOF_x)-[10.0*(BW_F-BW_I)] + \{5.92*10^{-2}*DOF_T*[(BW_F + BW_I)/2]^{0.75}*(SRW/BW_F*0.96)^{0.75}*[(BW_F - BW_I)/DOF_T]^{1.097}\} \quad (6)$$

4.3.5 *Calcium Excretion Equation*

$$Ca_{E-T} = \sum_{x=1}^{n}(DMI_x*C_{Ca-x}*DOF_x)-[18.33*(BW_F-BW_I)] + 0.445*\{0.243*DOF_T*[(BW_F + BW_I)/2]^{0.75}*(SRW/(BW_F*0.96))^{0.75}*[(BW_F - BW_I)/DOF_T]^{1.097}\} \quad (7)$$

4.4 Manure Characteristics Based Upon Typical Performance and Diets – See Tables 3a and 3b.

4.5 References

4.5.1 Anrique, R. G., M. L. Thonney, and H. J. Ayala. 1990. Dietary energy losses of cattle influenced by body type, size, sex, and intake. Anim. Prod. 50:467–474.

4.5.2 Danner, M. L., D. G. Fox, and J. R. Black. 1980. Effect of feeding system on performance and carcass characteristics of yearling steers, steer calves and heifer calves. J. Anim. Sci. 50:394–404.

4.5.3 Ellenberger, H. G., J. A. Newlander, and C. H. Jones. 1950. Composition of the bodies of dairy cattle. Vt. Agric. Exp. Sta. Bull. 558.

4.5.4 Erickson, G. E., B. Auvermann, R. Eigenberg, L.W. Greene, T. Klopfenstein, R. Koelsch. 2003. Proposed Beef Cattle Manure Excretion and Characteristics Standard for ASAE. Proceedings of the International Symposium for Animal, Agricultural, and Food Processing Wastes IX. ASAE. St. Joseph, MI. 269–276.

4.5.5 Fortin, A., S. Simpfendorfer, J. T. Reid, H. J. Ayala, R. Anrique, and A. F. Kertz. 1980. Effect of level of energy intake and influence of breed and sex on the chemical composition of cattle. J. Anim. Sci. 51:604–614.

4.5.6 Garrett, W. N. 1980. Energy utilization by growing cattle as determined in 72 comparative slaughter experiments. Energy Metab. Proc. Symp. 26:3–7.

4.5.7 Harpster, H. W. 1978. Energy requirements of cows and the effect of sex, selection, frame size, and energy level on performance of calves of four genetic types. Ph.D. dissertation. Michigan State University, East Lansing, MI.

4.5.8 Lomas, L. W., D. G. Fox, and J. R. Black. 1982. Ammonia treatment of corn silage. I. Feedlot performance of growing and finishing cattle. J. Anim. Sci. 55:909–923.

4.5.9 NRC. 1996 (2000 update). Nutrient Requirements for Beef Cattle. Seventh Revised Edition. National Academy Press. 242 pages.

4.5.10 Tylutki, T. P., D. G. Fox, and R. G. Anrique. 1994. Predicting net energy and protein requirements for growth of implanted and nonimplanted heifers and steers and nonimplanted bulls varying in body size. J. Anim. Sci. 72:1806–1813.

4.5.11 Woody, H. D., D. G. Fox, and J. R. Black. 1983. Effect of diet grain content on performance of growing and finishing cattle. J. Anim. Sci. 57:717–728.

5.0 Equations for As-Excreted Manure Characteristics Estimates for Dairy Cattle

5.1 Fundamental Model

5.1.1 The estimates for manure and nutrient excretion were derived from the combination of multiple data sets from Washington State University, University of California – Davis, The Ohio State University, and Pennsylvania State University. The data sets contain records from Holstein cattle and include a wide variety of animal ages, ranging from calves to multiparous lactating cows.

5.1.2 The data for the calves and heifers were divided according to animal body weight and includes four groups, milk fed calves, weaned calves weighing less than 204 kg, heifers weighing between 274 to 613 kg, and veal calves. Excretion estimates for veal calves were adapted from Sutton et al., 1989. Additional classifications of animals include non-lactating and lactating cows.

5.1.3 Lactating cow excretion estimates were derived from regression equations developed using lactating Holstein cows regardless of body weight or milk production. The data set for lactating cows was evaluated to compare the amount of metabolizable protein (MP) required to the MP supplied to the cow using the 2001 Dairy NRC Model. Only cows fed less than 112% of MP requirements were included in the data set. The average values reported for lactating cows were determined using the regression equation for a cow producing 40 kg of milk. The regression equations were developed using PROC MIXED of SAS, with study included as a random variable (St-Pierre, 2001).

5.2 See 2.0 Caution

See Table 4, Definitions of Variables – As Excreted – Dairy Cattle.

5.3 Equations for Estimating Excretion

In many cases, multiple prediction equations are presented. Note, that while the more simplistic equation requires fewer inputs, the result could be less precise due to the influence of dietary intake of nutrients (more developed equation). Regression equations developed using the data set include both residual errors and errors from the variation between the research trials (inter-study errors). Equations with the lowest residual error should be used whenever the input variables are available.

Assumptions:

1) Urine dry matter, estimated at 4.5%, was used for total solids and moisture calculations. The urine volume was calculated by using a specific gravity of 1.038 g/ml.
2) Milk crude protein was converted to milk true protein using a conversion factor for the Holstein breed of 0.940 (http://www.aipl.arsusda.gov/reference/trueprot.htm).

5.3.1 *Total Manure – Lactating cow regression equations:*[1]

$$M_E = (\text{Milk} \times 0.172) + (\text{DMI} \times 2.207) + (\text{MF} \times 171.830) + (\text{MTP} \times 505.310) - 8.170 \quad (1)$$

Inter-study error = 8.50
Residual error = 7.00

$$M_E = (\text{Milk} \times 0.954) + (\text{BW} \times 0.037) + (\text{DIM} \times 0.017) + (\text{MF} \times 186.720) + (\text{MTP} \times 1141.480) - 33.06 \quad (2)$$

Inter-study error = 5.08
Residual error = 8.33

$$M_E = (\text{Milk} \times 0.647) + 43.212 \quad (3)$$

Inter-study error = 6.94
Residual error = 9.19

5.3.2 *Total Manure – Dry cow regression equation:*[1]

$$M_E = (\text{BW} \times 0.022) + 21.844 \quad (4)$$

Inter-study error = 5.93
Residual error = 5.71

5.3.3 *Total Manure – Heifer regression equations:*[1]

$$M_E = (\text{DMI} \times 3.886) - (\text{BW} \times 0.029) + 5.641 \quad (5)$$

Inter-study error = 5.34
Residual error = 2.61

$$M_E = (\text{BW} \times 0.018) + 17.817 \quad (6)$$

Inter-study error = 4.02
Residual error = 3.55

5.3.4 *Total Solids – Lactating cow regression equations:* [2]

$$DM_E = (\text{DMI} \times 0.350) + 1.017 \quad (7)$$

Inter-study error = 1.13
Residual error = 0.76

$$DM_E = (\text{Milk} \times 0.135) + (\text{BW} \times 0.004) + (\text{DIM} \times 0.004) + (\text{MTP} \times 118.370) - 2.456 \quad (8)$$

Inter-study error = 0.63
Residual error = 1.03

$$DM_E = (\text{Milk} \times 0.096) + 5.073 \quad (9)$$

Inter-study error = 0.78
Residual error = 1.13

[1] Total manure equals actual fecal excretion plus actual urine excretion from individual cows collected and weighted on a daily basis.
[2] DM_E = actual fecal dry matter + urine dry matter.

Table 5a – Estimated typical manure (urine and feces combined) characteristics as excreted based upon equations in Section 5 and assumptions in Table 5c.

Animal Type and Production Grouping	Total solids	Nitrogen	P	K	Total Manure[1]	Assumed Moisture
	kg / da-animal					% w.b.
Dairy - Lactating cow	8.9	0.45	0.078	0.10	69	87
Dairy - Dry cow	4.9	0.23			38	87
Dairy - Heifer-440 kg	3.7	0.12	0.020		22	83
	lb / da- animal					% w.b.
Dairy - Lactating cow	20	0.99	0.17	0.23	150	87
Dairy - Dry cow	11	0.50			83	87
Dairy - Heifer-440 kg	8.2	0.26	0.044		48	83
Equation Used for Excretion Estimate						
Dairy - Lactating cow	9	16	22	26	-	
Dairy - Dry cow	11	17	-	-	-	
Dairy - Heifer-440 kg	No Equation	19	24	-	-	

[1] Total manure is calculated from total solids and assumed moisture.

Table 5b – Estimated typical manure (urine and feces combined) characteristics as excreted based upon sources cited in Table 5c.

Animal Type and Production Grouping	Total solids	Nitrogen	P	K	Total Manure[1]	Assumed Moisture
	kg / da-animal					% w.b.
Dairy - Milk fed calves		0.0079				
Dairy - Calf-150 kg	1.4	0.063			8.5	83
Dairy - Veal-118 kg	0.12	0.015	0.0045	0.020	3.5	96.5
	lb / da- animal					% w.b.
Dairy - Milk fed calves		0.017				
Dairy - Calf-150 kg	3.2	0.14			19	83
Dairy - Veal-118 kg	0.27	0.033	0.0099	0.044	7.8	96.5

Table 5c – Dietary and performance assumptions.

Animal Type and Production Grouping	Average Live Weight (kg)	Milk Production (kg)	Dietary Assumptions				Comments or Written Description of Assumptions
			Dry Matter Intake (% of average body weight)	Crude Protein (g/day)	P (g/day)	K (g/day)	
Lactating cow Range	624 437–810	40 9.8–86.1	3.4 1.1–4.9	3720 1356–5250	94.7 40–144	283 168–443	Averages are based on 367 cows
Dry cow Range	755 413–934	NA	1.4 0.7-2.2	1525			Averages are based on 18 cows
Milk Fed Calves	57.1	NA	1.0	136			Averages based on 16 calves
Calf-150 kg Range	153 86–204	NA	2.21 1.56–3.37	558 275–880			Averages based on 46 calves
Dairy Veal	40 to 85 85 to 150	NA	1.89 2.09	284 491	10 18		
Heifer-420 kg Range	437 274–613	NA	1.91 1.43–2.44	923 500–1688			Averages are based on 60 heifers

963 lbs

5.3.5 *Total Solids – Dry cow regression equation:*[1]

$$DM_E = (DMI \times 0.178) + 2.733 \quad (10)$$

Inter-study error = 0.74
Residual error = 0.45

$$DM_E = (BW \times 0.004) + 1.863 \quad (11)$$

Inter-study error = 0.42
Residual error = 0.59

5.3.6 *Urine Volume – Lactating cow regression equations:*

$$U_E = (Milk \times 0.114) + (BW \times 0.016) + (MF \times 97.709) + (MTP \times 353.280) + (C_{CP} \times 62.036) - 16.389 \quad (12)$$

Inter-study error = 3.87
Residual error = 5.56

$$U_E = (BW \times 0.017) + 11.704 \quad (13)$$

Inter-study error = 4.67
Residual error = 5.68

(Note: Urine volume could be considerably different, depending on ration mineral content. Insufficient data were available to derive regression equations based on intake of minerals)

5.3.7 *Nitrogen Excretion – Lactating cow regression equations:* [2]

$$N_E = (Milk \times 2.303) + (DIM \times 0.159) + (DMI \times C_{CP} \times 70.138) + (BW \times 0.193) - 56.632 \quad (14)$$

Inter-study error = 53.07
Residual error = 102.71

$$N_E = (Milk \times 5.959) + (DIM \times 0.237) + (BW \times 0.347) + (MTP \times 4547.910) + (C_{CP} \times 1793.730) - 476.530 \quad (15)$$

Inter-study error = 42.48
Residual error = 107.01

$$N_E = (Milk \times 4.204) + 283.300 \quad (16)$$

Inter-study error = 57.8
Residual error = 110.8

5.3.8 *Nitrogen Excretion – Dry cow regression equation:* [2]

$$N_E = (DMI \times 12.747) + (C_{CP} \times 1606.290) - 117.500 \quad (17)$$

Residual error = 45.51

5.3.9 *Nitrogen Excretion – Heifer regression equations:* [2]

$$N_E = ((DMI \times 1000) \times (C_{CP} / 6.25) \quad (18)$$

$$N_E = (DMI \times C_{CP} \times 78.390) + 51.350 \quad (19)$$

Inter-study error = 24.47
Residual error = 10.76

5.3.10 *Phosphorus Excretion – Lactating cow regression equations:*[1]
If diets contain less than 0.004 g P/g dry feed[1]*:*

$$P_E = ((DMI \times 1000) \times \mathbf{C_P}) - (Milk \times 0.9) \quad (20)$$

If diets contain 0.004 g P/g dry feed or greater:

$$P_E = (Milk \times 0.565) + (MTP \times 816.260) + (DMI \times \mathbf{C_P} \times 421.410) - 9.697 \quad (21)$$

Inter-study error = 10.81
Residual error = 11.47

$$P_E = (Milk \times 0.773) + 46.015 \quad (22)$$

Inter-study error = 10.83
Residual error = 14.48

5.3.11 *Phosphorus Excretion – Dry cow regression equation:*[1,2]

$$P_E = (((DMI \times 1000) \times \mathbf{C_P} \times DP) - 264.386) / DP \quad (23)$$

5.3.12 *Phosphorus Excretion – Heifer regression equation:*[1]

$$P_E = ((DMI \times 1000) \times \mathbf{C_P}) \quad (24)$$

5.3.13 *Potassium – Lactating cow regression equations:* [3]

$$K_E = (Milk \times 1.822) + (MTP \times 2688.880) + (DMI \times \mathbf{C_K} \times 156.930) - 91.755 \quad (25)$$

Inter-study error = 16.77
Residual error = 25.27

$$K_E = (Milk \times 1.800) + 31.154 \quad (26)$$

Inter-study error = 18.89
Residual error = 26.94

5.3.14 *Potassium – Dry cow and heifer regression equation:*[3]

$$K_E = ((DMI \times 1000) \times \mathbf{C_K}) \quad (27)$$

5.4 Manure Characteristics Based Upon Typical Performance and Diets – See Tables 5a, 5b, and 5c.

5.5 Reference

5.5.1 Nennich, T., J Harrison, D. Meyer, W. Weiss, A. Heinrichs, R. Kincaid, W. Powers, R. Koelsch, P. Wright. 2003. Development of Standards Method to Estimate Manure Production and Nutrient Characteristics from Dairy Cattle. Proceedings of the International Symposium for Animal, Agricultural, and Food Processing Wastes IX. ASAE. St. Joseph, MI. 263–268.

6.0 Equations for As-Excreted Manure Characteristics Estimates for Horses

6.1 Fundamental Model

Equations for as-excreted manure characteristics are based upon regression analysis from available data sets for N, P, K, Ca and Mg. Other estimates are based on survey data or dietary recommendations (NRC, 1989). The nitrogen data set contained 46-paired values (intake and excretion), with intakes ranging from 130 to 530 mg/kg BW/day (median = 250 g N/kg BW). For P, 128 paired values were used (range = 19–121 mg/kg BW/day; median = 42.8 mg P/kg BW). For K, 28 paired values were used (range 50–404 mg/kg BW/day; median = 193.3 mg K/kg Bw). For Ca, 106 paired values were used (range 9.1 to 247 mg/kg BW/d; median 69.7 mg Ca/kg BW). For Mg, 50 paired values were used (range 18.6 to 131.6 mg Mg/kg BW/d; median 28.2 mg Mg/kg BW).

[1] DM_E = actual fecal dry matter + urine dry matter.
[2] Nitrogen excretion = actual fecal N + actual urine N.

[1] Phosphorus excretion = actual fecal P + actual urine P.
[2] The constant was derived from the 2001 Dairy NRC equation (p. 112) for absorbed phosphorus and assumes a 60 day dry period.
[3] Potassium excretion = actual fecal K + actual urine K.

Table 6 – Definition of Variables – As Excreted - Horses – Section 6.

Variable	Description	Units
	Animal performance characteristics input	
BW	Average live body weight	Kg
	Feed program characteristics inputs	
DMI	Dry matter intake	g dry feed / day
DMD	Dry matter digestibility of total ration	%
OMD	Organic matter digestibility of total ration	%
ASH	Ash concentration of total ration	%
C_{cp}	Concentration of crude protein of total ration	g of protein / g of dry feed
C_P	Concentration of phosphorus of total ration	g of phosphorus / g of dry feed
C_K	Concentration of potassium of total ration	g of potassium / g of dry feed
C_{Ca}	Concentration of calcium of total ration	g of calcium / g of dry feed
C_{Mg}	Concentration of magnesium of total ration	g of magnesium / g of dry feed
	Excretion outputs	
N_E	Total nitrogen excretion per animal per day	g / animal / day
P_E	Total phosphorus excretion per animal per day	g / animal / day
K_E	Total potassium excretion per animal per day	g / animal / day
Ca_E	Total calcium excretion per animal per day	g / animal / day
Mg_E	Total magnesium excretion per animal per day	g / animal / day
DM_E	Dry matter excretion (feces + urine) per animal per day	g / animal / day
DM_F	Dry matter excretion (feces only) per animal per day	g / animal / day
F_E	Feces (wet weight) excretion per animal per day	g / animal / day
U_E	Urine excretion per animal per day	g / animal / day

6.2 See 2.0 Caution

See Table 6, Definition of Variables – As Excreted - Horses.

6.3 Equations for Estimating Excretions

6.3.1 *Nitrogen Excretion*

#1: Sedentary horses: $N_E = (55.4*BW*10^{-3}) + (0.586*DMI*C_{cp})/6.25$

$(R^2 = 0.76)$

#2: Exercised horses: $N_E = (42.9*BW*10^{-3}) + (0.492*DMI*C_{cp})/6.25$

$(R^2 = 0.94)$

6.3.2 *Phosphorus Excretion*

#3: Sedentary or exercised horses: $P_E = (4.56*BW*10^{-3}) + (0.793*DMI*C_p)$ (1)

$(R^2 = 0.85)$

6.3.3 *Potassium Excretion*

#4: Sedentary or exercised horses: $K_E = (19.4*BW*10^{-3}) + (0.673*DMI*C_k)$ (2)

$(R^2 = 0.62)$

6.3.4 *Calcium Excretion*

#5: Sedentary horses: $Ca_E = (26.6*BW*10^{-3}) + (0.497*DMI*C_{Ca})$ (3)

$(R^2 = 0.65)$

#6: Exercised horses: $Ca_E = (-5.98*BW*10^{-3}) + (0.804*DMI*C_{Ca})$ (4)

$(R^2 = 0.73)$

6.3.5 *Magnesium Excretion*

#7: Sedentary or exercised horses: $Mg_E = (9.08*BW*10^{-3}) + (0.545*DMI*C_{Mg})$ (5)

$(R^2 = 0.68)$

6.3.6 *Dry Matter Excretion (feces)*

#8: Sedentary: $DM_F = [(0.03*BW + 1.4)/2.0]*425$ (6)

#9: Exercised: $DM_F = \{[2.0*(0.03*BW + 1.4)]/2.85\}*310$ (7)

6.3.7 *Dry Matter Excretion (combined urine and feces):*[1]

#10: Sedentary: $DM_E = 7.2*BW + 220$ (8)

#11: Exercised: $DM_E = 7.3*BW + 230$ (9)

6.3.8 *Optional estimate of dry matter excretion (feces) for all horses:*

#12: $DM_F = DMI*(1 - DMD/100)$ (10)

6.3.9 *Optional estimate of dry matter excretion (combined urine and feces) for all horses:* [2]

#13: $DM_E = [DMI*(1 - DMD/100)] + 0.64*BW$ (11)

[1] Sum of total feces and total urine (equations 12 and 13) and multiplied by an assumed moisture content of 15%.

[2] Alternate approach: Sum of total urine (equation 13) multiplied by assumed urine solids content of 4% and dry matter excretion (equaiton 10).

6.3.10 *Total Feces*

Sedentary or exercised horses: $F_E = DM_E/0.20$ (12)

6.3.11 *Total Urine*

Sedentary or exercised horses: $U_E = 16*BW$ (13)

6.4 Manure Characteristics Based Upon Typical Performance and Diets – See Tables 7a and 7b.

6.5 References

6.5.1 Lawrence, L., J. Bicudo, E. Wheeler. 2003. Horse Manure Characteristics Literature and Database Review. Proceedings of the International Symposium for Animal, Agricultural, and Food Processing Wastes IX. ASAE. St. Joseph, MI. 277–284.

6.5.2 Gallagher, K., J. Leech and H. Stowe. 1992. Protein, energy and dry matter consumption by racing thoroughbreds: A field survey. J. Equine Vet Sci. 12:43–48.

6.5.3 NRC. 1989. Nutrient Requirements of Horses. National Academy Press, Washington DC.

Table 7a – Estimated typical manure (urine and feces combined) characteristics as excreted based upon equations in Section 6 and assumptions in Table 7b.

Animal Type and Production Grouping	Total Solids	Nitrogen	P	K	Ca	Mg
	g / da-animal					
Horse-Sedentary-500 kg [1]	3,800	89	13	27	23	9
Horse-Intense exercise-500 kg [1]	3,900	150	33	95	69	18
	lb / da-animal					
Horse-Sedentary-1,100 lb [1]	8.4	0.20	0.029	0.060	0.051	0.020
Horse-Intense exercise-1,100 lb[1]	8.6	0.34	0.073	0.21	0.15	0.040

[1] These values apply to horses 18 months of age or older that are not pregnant or lactating. The representative number applies to 500 kg horses. Under type of horse, classifications are made on amount of regular exercise imposed on horses.

Table 7b – Dietary and performance assumptions.

Animal Type and Production Grouping[1]	Average Live Weight (kg)	Dietary Assumptions						
		Dry Matter Intake (% of average body weight)	Dry Matter Digestibility	Crude Protein (g/day)	P (g/day)	K (g/day)	Ca (g/day	Mg (g/day)
Sedentary- mature[2]	500	1.6	57.5%	656	14	25	20	7.5
Range	400–600	1.6–1.7	57.5%	536–776	11–17	20–30	16–24	6–9
Intense exercise (race horses)[3]	500	2.3	69%	1660	39	127	89	25.3
Range	400–600	2.3–2.4	69%	1328–1992	31–47	101–152	71–106	20–30

[1] These values apply to horses 18 months of age or older that are not pregnant or lactating. The representative number applies to 500 kg horses and the range represents horses from 400 to 600 kg.

[2] “Sedentary” would apply to horses not receiving any imposed exercise. Dietary inputs are based on minimum nutrient requirements specified in “Nutrient Requirements of Horses” (NRC, 1989).

[3] “Intense” represents horses used for competitive activities such as racing. Dietary inputs are based on a survey of race horse feeding practices (Gallagher et al, 1992) and typical feed compositions (forage = 50% alfalfa, 50% timothy; concentrate = 30% oats, 70% mixed performance horse concentrate).

Table 8 – Definition of Input Variables – As Excreted – Poultry (Broilers, Turkeys, and Ducks) – Section 7.

Variable	Description	Units
Feed program characteristics		
FI_{PH}	Feed intake per phase. Dry matter intake assumed to be 88% of feed intake.	g feed / phase (wet basis)
C_{cp}	Concentration of crude protein of total ration	g of protein / g of feed (wet basis)
C_P	Concentration of phosphorus of total ration	g of phosphorus / g feed (wet basis)
x	Phase number (e.g. number assigned to starter, grower, finisher, withdrawal phase rations)	
n	Total number of phases fed	
DM_{RF}	Retention Factor for dry matter	fraction
N_{RF}	Retention Factor for nitrogen	fraction
P_{RF}	Retention Factor for phosphorus	fraction
K_{RF}	Retention Factor for potassium	fraction
Excretion outputs		
$N_{E\text{-}PH}$	Nitrogen excretion per phase	g of nitrogen / phase
$N_{E\text{-}T}$	Total nitrogen excretion per finished animal	g of nitrogen / finished animal
$P_{E\text{-}PH}$	Phosphorus excretion per phase	g of phosphorus / per phase
$P_{E\text{-}T}$	Total phosphorus excretion per finished animal	g of phosphorus / finished animal
$K_{E\text{-}PH}$	Potassium excretion per phase	g of potassium / per phase
$K_{E\text{-}T}$	Total potassium excretion per finished animal	g of potassium / finished animal
$DM_{E\text{-}PH}$	Dry matter excretion per phase	g of dry matter / per phase
$DM_{E\text{-}T}$	Total dry matter excretion per finished animal	g of dry matter / finished animal

7.0 Equations for As-Excreted Manure Characteristics Estimates for Poultry (Broilers, Turkeys, and Ducks)

7.1 Fundamental Model

Nutrient Excretion = Feed Nutrient Intake − Nutrient Retention

7.2 See 2.0 Caution

See Table 8, Definition of Input Variables – As excreted – Poultry (Broilers, Turkeys, and Ducks).

7.3 Equations for Estimating Excretions – See Table 9 – Retention Factors for Broilers, Turkeys, and Ducks.

7.3.1 *Dry Matter Excretion Equation*

$$DM_{E-PH} = FI_{PH} * 0.88 * (1 - DM_{RF}) \quad (1)$$

$$DM_{E-T} = \sum_{x=1}^{n} FI_x * 0.88 * (1 - DM_{RF}) \quad (2)$$

7.3.2 *Nitrogen Excretion Equation*

$$N_{E-PH} = [FI_{PH} * (C_{cp} / 6.25)] * (1 - N_{RF}) \quad (3)$$

$$N_{E-T} = \sum_{x=1}^{n} [FI_x * (C_{cp-x} / 6.25)] * (1 - N_{RF}) \quad (4)$$

7.3.3 *Phosphorus Excretion Equation*

$$P_{E-PH} = (FI_{PH} * C_p) * (1 - P_{RF}) \quad (5)$$

$$P_{E-T} = \sum_{x=1}^{n} (F_x * C_p) * (1 - P_{RF}) \quad (6)$$

Note that P_{RF} varies for broilers less than and greater than 32 days of age.

7.3.4 *Potassium Excretion Equation*

$$K_{E-PH} = (FI_{PH} * C_K) * (1 - K_{RF}) \quad (7)$$

$$K_{E-T} = \sum_{x=1}^{n} (F_x * C_K) * (1 - K_{RF}) \quad (8)$$

7.4 Manure Characteristics Based Upon Typical Performance and Diets – See Tables 10a and 10b.

7.5 References

7.5.1 Applegate,T., L. Potturi, R. Angel. 2003. Model for Estimating Poultry Manure Nutrient Excretion: A Mass Balance Approach. Proceedings of the International Symposium for Animal, Agricultural, and Food Processing Wastes IX. ASAE. St. Joseph, MI. 296–302.

7.5.2 Angel, R., T. Applegate, S. Bastyr. 2003. Comparison of Two methods for Estimating Broiler Manure Nutrient Excretion: Biological Mass Balance Versus Model Based on Mass Balance Approach. Proceedings of the International Symposium for Animal, Agricultural, and Food Processing Wastes IX. ASAE. St. Joseph, MI. 303–309.

7.3.5 Table 9 – Retention Factors for Broilers, Turkeys, and Ducks.

Species	Dry Matter (DM_{RF})	Nitrogen (N_{RF})	Phosphorus (P_{RF})	Potassium (K_{RF})
Broiler if < 32 days of age	0.6884	0.602	0.493	0.182
Broiler if >= 32 days of age			0.4102	0.182
Turkey Toms and Hens	0.7479	0.588	0.4798	
Ducks	0.6937	0.657	0.4635	

8.0 Equations for As-Excreted Manure Characteristics Estimates for Poultry (Laying Hens)

8.1 Fundamental Model

Nutrient Excretion = Feed Nutrient Intake − Nutrient Retention

The laying hen model varies from other poultry specie to account for egg production. As such, the model assumes dry matter retention by the hen is equivalent to the sum of energy expenditure for maintenance, heat increment, and egg production as well as solids content within the egg, as is described below.

8.2 See 2.0 Caution

See Table 11, Definition of Input Variables – As Excreted – Poultry (Laying Hens).

8.3 Equations for Estimating Excretions

8.3.1 *Dry Matter Excretion*

$$DM_E = [FI * 0.88] - \{(FI * 0.88 * 0.85) * [1-(\{KCAL_I - [KCAL_m + KCAL_h + (KCAL_e * Egg_{prod})]\} / KCAL_i)] + (0.3319 * Egg_{wt} * Egg_{prod})\}$$

OR (1)

$$DM_E = [FI * 0.88] - \{(FI * 0.88 * 0.85) * [1-(\{KCAL_I - [140 + (53 * Egg_{prod})]\} / KCAL_i)] + (0.3319 * Egg_{wt} * Egg_{prod})\}$$

8.3.2 *Nitrogen Excretion*

$$N_E = (FI * C_{cp} / 6.25) - (0.0182 * Egg_{wt} * Egg_{prod}) \quad (2)$$

Table 10a – Estimated typical manure (urine and feces combined) characteristics as excreted based upon equations in Section 7 and assumptions in Table 10b.

Animal Type and Production Grouping	Total solids	Nitrogen	Phosphorus	Potassium	Total Manure[1]
	kg / finished animal				
Poultry - Broiler	1.3	0.053	0.016	0.031	4.9
Poultry - Turkey (male)	9.2	0.55	0.16		36
Poultry - Turkey (females)	4.4	0.26	0.074		17
Poultry – Duck	1.7	0.062	0.022		6.5
	lb / finished animal				
Poultry - Broiler	2.8	0.12	0.035	0.068	11
Poultry - Turkey (male)	20	1.2	0.36		78
Poultry - Turkey (females)	9.8	0.57	0.16		38
Poultry - Duck	3.7	0.14	0.048		14

[1] Total manure is calculated from total solids and assumed moisture of 74%.

Table 10b – Dietary and performance assumptions.

Animal Type and Production Grouping	Live Weight (kg)		Days on Feed	Feed Conversion (kg of feed per kg of gain)	Dietary Assumptions			Comments, Assumption or References
	In	Out			Dry Matter Intake (kg per phase)	Crude Protein (kg per phase)	P (kg per phase)	
Broiler	n/a	2.36	47.7	1.95	4.05 kg to 47.7 d	0.835 kg to 47.7 d	0.0288 kg to 47.7 d	Represents 95.8% of broilers marketed July 2002 (662 million birds or 1.53 billion kg live weight). Agristats, 2002 Four diet feeding program is assumed.
Turkey (male)	n/a	15.45	133	2.70	36.7 kg to 133 d	8.37 kg to 133 d	0.309 kg to 133 d	Represents 45.5 million turkey toms (Ferket 2001). Six diet feeding program is assumed.
Turkey (females)	n/a	6.82	105	2.34	17.6 kg to 105 d	3.94 kg to 105 d	0.143 kg to 105 d	Represents 59.5 million turkey hens (Ferket 2001). Six diet feeding program is assumed.
Duck	n/a	3.182	39	1.97	5.51 kg to 39 d	1.12 kg to 39 d	0.0402 kg to 39 d	Represents 13 million ducks (Applegate et al., 2003) Assumes two diet feeding program.

5.2 lbs

Assumptions: Feed is 88% dry matter.

Table 11 – Definition of Input Variables – As Excreted – Poultry (Laying Hens) – Section 8.

Variable	Description	Units
FI	Feed intake per day (wet weight). Dry matter intake assumed to be 88% of feed intake for poultry rations.	Grams / day
$KCAL_i$	Kcal intake Default: 270 kcal – Light layer strains Default: 292 kcal – Heavy layer strains	Kcal / day
$KCAL_m$	Kcal required for maintenance of body weight Default: 100 kcal	Kcal / day
$KCAL_h$	Kcal required for heat increment in thermo-neutral environment Default: 40 kcal	Kcal / day
$KCAL_e$	Kcal required for egg production of one egg Default: 53 kcal	Kcal / egg
Egg_{wt}	Egg weight Default: 60 g – Light layer strains Default: 63 g – Heavy layer strains	Grams
Egg_{prod}	Fraction of eggs that are produced each day Default: 0.80	Eggs / hen / day
C_{cp}	Concentration of crude protein of total ration	g of protein / g of feed (wet basis)
C_P	Concentration of phosphorus of total ration	g of phosphorus / g feed (wet basis)
C_{Ca}	Concentration of calcium of total ration	g of calcium / g feed (wet basis)
	Excretion outputs	
DM_E	Dry matter excretion per hen per day	g of dry matter / hen - day
N_E	Total nitrogen excretion per hen per day	g of nitrogen / hen - day
P_E	Total phosphorus excretion per hen per day	g of phosphorus / hen - day
Ca_E	Total calcium excretion per hen per day	g of phosphorus / hen - day

8.3.3 *Phosphorus Excretion*

$$P_E = (FI * C_P) - (0.0024 * Egg_{wt} * Egg_{prod}) \quad (3)$$

8.3.4 *Calcium Excretion*

$$Ca_E = (FI * C_{Ca}) - (0.00383 * Egg_{wt} * Egg_{prod}) \quad (4)$$

8.4 Assumptions: Diet contains 15% ash content and corrects diet energy retention to an ash-free, dry matter basis. Egg contains 33.19% solids, 1.82% N, 0.24% P, & 3.83% Ca. DM retention by hen is equivalent to energy expenditure for maintenance (100 kcal/hen, NRC, 1994; Lasiewski and Dawson, 1967), heat increment (40 kcal; NRC, 1994; MacLeod and Jewitt, 1988), and egg production (53 kcal/egg; NRC, 1994).

8.5 Manure Characteristics Based Upon Typical Performance and Diets – See Tables 12a and 12b.

8.6 References

8.6.1 Applegate, T., L. Potturi, R. Angel. 2003. Model for Estimating Poultry Manure Nutrient Excretion: A Mass Balance Approach.

Table 12a – Estimated typical manure (urine and feces combined) characteristics as excreted based upon equations in Section 8 and assumptions in Table 12b.

Animal Type and Production Grouping	Total solids	Nitrogen	Phosphorus	Calcium	Total Manure[1]
	kg / da–animal				
Layer	0.022	0.0016	0.00048	0.0022	0.088
	lb / da–animal				
Layer	0.049	0.0035	0.0011	0.0048	0.19

[1] Total manure is calculated from total solids and assumed moisture of 75%.

Table 12b – Dietary and performance assumptions.

Animal Type and Production Grouping	Average Live Weight (kg)	Feed Conversion (kg of feed per kg of product)	Dietary Assumptions			Comments or Written Description of Assumptions Reference [1]
			Dry Matter Intake (g per phase)	Crude Protein (g per phase)	P (g per phase)	
Layer	1.3–1.45 at start	1.994	36.64 kg from 20–80 wk	6500.4 g from 20–80 wk	249.0 g from 20–80 wk	20–80 wk production cycle. Feed is 88% dry matter 64% and 36% of industry is light (1.28 kg) and heavy (1.45) weight strains, respectively. A weekly change in diet formulation, feed consumption, and egg production was assumed from average performance.

Table 13 – Definition of Output Variables (used for all swine groups) – Section 9.

Variable	Description	Units
Nutrient Intake		
N_I	Daily nitrogen intake	g / day
N_{I-T}	Nitrogen intake per finished animal or period (e.g. lactation)	g / finished animal or g / period
P_I	Daily phosphorus intake	g / day
P_{I-T}	Phosphorus intake per finished animal or period (e.g. lactation)	g / finished animal or g / period
Nutrient Retention		
N_R	Daily nitrogen retained	g / day
N_{R-T}	Nitrogen retained per finished animal or period (e.g. lactation)	g / finished animal or g / period
WBN_F	Whole body nitrogen content at final body weight	g
WBN_I	Whole body nitrogen content at initial body weight	g
P_R	Daily phosphorus retained	g / day
P_{R-T}	Phosphorus retained per finished animal or period (e.g. lactation)	g / finished animal or g / period
Nutrient Excretion		
N_E	Daily nitrogen excretion	g / day
N_{E-T}	Total nitrogen excretion per finished animal or period (e.g. lactation)	g / finished animal or g / period
P_E	Daily phosphorus excretion	g / day
P_{E-T}	Total phosphorus excretion per finished animal or period (e.g. lactation)	g / finished animal or g / period
DM_E	Daily dry matter excretion	g / day
DM_{E-T}	Total dry matter excretion per finished animal or period (e.g. lactation)	g / finished animal or g / period

Table 14 – Input Variables—Grow-finish Pigs (20 to 120 kg) – Section 9.3.

Variable	Description	Units
Animal performance characteristics		
BW_I	Initial body weight	kg
BW_F	Final body weight (market weight)	kg
BW_{AVG}	Average of initial and final body weight	kg
DOF_G	Days on feed to finish animal (grow-finish phase)	days
DP_F	Average dressing percent (yield) at final weight. Typically from packer kill sheet.	%
$FFLP_F$	Average fat-free lean percentage at final weight. Typically from packer kill sheet.	%
Feed program characteristics		
$ADFI_G$	Average daily feed intake over finishing period (grow – finish phase). User provided or see NRC (1998)	g / d
FI_G	Feed Intake per finished animal (grow – finish phase)	g/finished animal
C_{CP}	Concentration of crude protein in total (wet) ration	%
C_P	Concentration of phosphorus in total (wet) ration	%
C_{DM}	Dry matter concentration of diet	%
DMD	Dry matter digestibility of total ration	%

Proceedings of the International Symposium for Animal, Agricultural, and Food Processing Wastes IX. ASAE. St. Joseph, MI. 296–302.

9.0 Equations for As-Excreted Manure Characteristics Estimates for Swine

9.1 Fundamental Model

Nutrient Excretion = Nutrient Feed Intake − Nutrient Retention

9.2 See 2.0 Caution

See Table 13, Definition of Output Variables (using all swine groups).

9.3 Equations for Estimating Excretions– See Table 14, Input Variables—Grow-finish Pigs (20 to 120kg).

9.3.1 *Nutrient and Solids Excretion—Grow-finish Pigs (20 to 120 kg)*

$$N_{E-T} = N_{I-T} - N_{R-T} \qquad (1)$$

$$P_{E-T} = P_{I-T} - P_{R-T} \qquad (2)$$

$$DM_{E-T} = [C_{DM} * FI_G * (100 - DMD) / 10{,}000] + [0.025 * DOF_G * (20 * BW_{AVG} + 2{,}100)] \qquad (3)$$

9.3.2 *Nutrient Intake – Grow-finish Pigs (20 to 120 kg)*

$$N_{I-T} = ADFI_G * C_{CP} * DOF_G / 625 \quad \text{OR} \quad FI_G * C_{CP} / 625 \qquad (4)$$

$$P_{I-T} = ADFI_G * C_P * DOF_G / 100 \quad \text{OR} \quad FI_G * C_P / 100 \qquad (5)$$

Table 15 – Definition of Input Variables - Weanling Pigs (5 to 20 kg) – Section 9.4.

Variable	Description	Units
	Animal performance characteristics	
BW_{I-N}	Initial body weight in nursery phase	kg
BW_{F-N}	Final body weight in nursery phase	kg
DOF_N	Days on feed to finish animal (nursery phase)	days
DP_{120}	Average dressing percent (yield) at 120 kg. Typically from packer kill sheet.	%
$FFLG_G$	Average fat-free lean gain from 20 to 120 kg. Recommended values: 350 g/day High lean growth capacity pigs 325 g/day High-moderate lean growth capacity pigs 300 g/day Moderate lean growth capacity pigs Source: National Research Council. 1998. Nutrient Requirements of Swine. National Academy Press. Washington, D. C. 189 pages.	g / d
	Feed program characteristics	
$ADFI_N$	Average daily feed intake over finishing period (nursery phase). User provided or see NRC (1998)	g / d
FI_N	Feed Intake per finished animal (nursery phase)	g / finished animal
C_{CP}	Concentration of crude protein in total (wet) ration	%
C_P	Concentration of phosphorus in total (wet) ration	%
C_{DM}	Dry matter concentration of diet	%
DMD	Dry matter digestibility of total ration	%

Table 16 – Input Variables - Gestating Sows – Section 9.5.

Variable	Description	Units
	Animal performance characteristics	
GLTG	Gestation Lean Tissue Gain Recommended value: 19.205 kg	kg
GL	Gestation period length (assumed to be 115 days)	days
SW_{Breed}	Sow body weight at breeding	kg
SW_{PF}	Sow body weight post farrowing	kg
LW_{Birth}	Litter weight at birth	kg
LITTER	Number of pigs in litter	Number of pigs
	Feed program characteristics	
$ADFI_S$	Average daily feed intake during gestation	g / d
C_{CP}	Concentration of crude protein	%
C_P	Concentration of phosphorus	%
C_{DM}	Dry matter concentration of diet	%
DMD	Dry matter digestibility of total ration	%

9.3.3 *Nutrient Retention – Grow-finish Pigs (20 to 120 kg)*[1]

$$N_{R-T} = [(BW_F * DP_F * FFLP_F) / 159.4] - \{BW_I * [DP_F - 0.05 * (BW_F - BW_I)] * [FFLP_F + 0.07 * (BW_F - BW_I)]\} / 159.4 \quad (6)$$

$$P_{R-T} = (0.2256 * N_{RT}) - [8.0 * 10^{-6} * N_{RT} * (WBN_I + WBN_F)] \quad (7)$$

$$WBN_F = (BW_F * DP_F * FFLP_F) / 159.4 \quad (8)$$

$$WBN_I = BW_I * \{DP_F - [0.05 * (BW_F - BW_I)]\} * \{FFLP_F + [0.07 * (BW_F - BW_I)]\}/159.4 \quad (9)$$

Daily excretion of solids, nitrogen and phosphorus can be estimated by dividing total excretion estimated above by days on feed for the grow-finish phase (DOF_G).

9.4 Equations for Estimating Excretions – See Table 15, Definition of Input Variables – Weanling Pigs (5 to 20kg).

[1] P retention based on relation to N (Jongbloed, 1987).

9.4.1 *Nutrient and Solids Excretion—Weanling Pigs (5 to 20 kg)*[1]

$$N_{E-T} = N_{I-T} - N_{R-T} \quad (1)$$

$$P_{E-T} = P_{I-T} - P_{R-T} \quad (2)$$

$$DM_{E-T} = C_{DM} * ADFI_N * DOF_N * (100–DMD) / 10{,}000\ ^1 \quad (3)$$

9.4.2 *Nutrient Intake – Weanling Pigs (5 to 20 kg)*

$$N_{I-T} = ADFI_N * C_{CP} * DOF_N / 625 \quad \text{OR} \quad FI_N * C_{CP} / 625 \quad (4)$$

$$P_{I-T} = ADFI_N * C_P * DOF_N / 100 \quad \text{OR} \quad FI_N * C_P / 100 \quad (5)$$

9.4.3 *Nutrient Retention – Weanling Pigs (5 to 20 kg)*[2]

$$N_{R-T} = DOF_N * FFLG_G * \{1+[0.137 * (BW_{F-N} + BW_{I-N})]\} / 125.8 \quad (6)$$

$$P_{R-T} = 4.7494 * (BW_{F-N} - BW_{I-N}) \quad (7)$$

[1] Dry matter excretion in feces only.
[2] P retention based on relation to N (Jongbloed, 1987).

Table 17 – Input Variables – Lactating Sows – Section 9.6.

Variable	Description	Units
	Animal performance characteristics	
LLTG	Lactation Lean Tissue Gain Recommended value: -4.20 kg	kg
LL	Lactation length (or time to weaning)	days
SW_{WEAN}	Sow body weight at litter weaning	kg
SW_{PF}	Sow body weight post farrowing	kg
LW_{WEAN}	Litter weight at weaning	kg
LW_{BIRTH}	Litter weight at birth	kg
	Feed program characteristics	
$ADFI_{LACT}$	Average daily feed intake during lactation	g / d
C_{CP}	Concentration of crude protein	%
C_{P}	Concentration of phosphorus	%
C_{DM}	Dry matter concentration of diet	%
DMD	Dry matter digestibility of total ration	%

Table 18a – Estimated typical manure (urine and feces combined) characteristics as excreted based upon equations in Section 9 and assumptions in Table 18b.

Animal Type and Production Grouping	Total solids	Nitrogen	P	Total solids[1]	Nitrogen	P
	kg / finished animal			lb / finished animal		
Swine - Nursery pig (12.5 kg)		0.41	0.068		0.91	0.15
154 pounds Swine - Grow-finish (70 kg)	56	4.7	0.76	120	10	1.7
	kg / day−animal			lb / day−animal		
Swine - Gestating sow-200 kg		0.032	0.009		0.071	0.020
Swine - Lactating sow-192 kg		0.085	0.025		0.19	0.055

[1]Total solids include urine and feces.

Table 18b – Dietary and performance assumptions of growing swine.[1,2]

Animal Type and Production Grouping	Live Weight (kg)		Average Daily Gain (kg/da)	Days on Feed	Feed Conversion (kg of feed per kg of gain)	Dietary Assumptions			
	In	Out				Dry Matter Intake (% of avg. body weight)	Dry Matter Digestibility	Crude Protein (g/day)	P (g/day)
Nursery pig (12.5 kg)[1,2]	5	20	0.412	36	1.50	5.0	80%	137	3.88
Grow-finish (70 kg)[1,2]	20	120	0.84	120	2.80	3.4	82%	371	10.3

[1] Feed is 88% dry matter. Corn-soybean meal-animal protein (weanling pig) or corn-soybean meal (grow-finish) diet meets the lysine requirement.
[2] N and P intake is based on NRC (1998). N and P retention are based on NRC (1998). P retention is based on Mahan and Newton (1995).

Table 18c – Dietary and performance assumptions of sows.[1,2]

Animal Type and Production Grouping	Average Live Weight (kg)	Production	Dietary Assumptions				Comments or Written Description of Assumptions Reference[1]
			Dry Matter Intake (% of average body weight)	Dry Matter Digestibility	Crude Protein (g/day)	P (g/day)	
Gestating sow-200 kg (start 175 kg, end 225 kg)[1,2] 115 day gestation period	200	12 pigs / litter	1.00	82%	259	12.4	Wt gain = 50 kg with 27 kg wt gain with litter & 23.0 kg wt gain for dam Gestation lean tissue gain = 17.6 kg
Lactating sow-192 kg (Start 198 kg, end 185 kg)[1,2] 20 day lactation period	192	10 pigs nursing	2.60	82%	967	34	Wt change = −13 kg Lactation lean tissue change = −5.3 kg

[1] Assumes corn-soy diet that is 88 % dry matter and meets the lysine requirement.
[2] N and P intake is based on NRC (1998). N retention is based on NRC (1998). P retention is based on Mahan and Newton (1995).

Table 19 – As-Removed Manure Production and Characteristics. The numbers in parenthesis are coefficients of variation.

	Moisture (% wb)	TS (% wb)	VS (% TS)	Ash (% TS)	Heat (BTU/lb wb)	TKN (% wb)	NH3-N (% wb)	P (% wb)	K (% wb)	Ca (% wb)	Na (ppm wb)	Mg (ppm wb)	Fe (ppm wb)	S (ppm wb)	Cl (ppm wb)	Zn (ppm wb)	Mn (ppm wb)	Cu (ppm wb)	Mass (Kg/hd/d)
Beef																			
Earthen	33.1	67.2	30.2	69.9	1136	1.18	0.10	0.50	1.25	1.21	3012	3650	1305	2841	7396	85	393	14	7.5
Lot	(28)	(14)	(30)	(24)	(15)	(33)	(102)	(36)	(25)	(46)	(67)	(27)	(55)	(37)	(52)	(63)	(109)	(70)	(0.58)
Poultry																			
Leghorn	65.20	40				2.13	0.85	1.00	1.10	1.49		2700							No data
pullets	(14)					(31)	(22)	(25)	(29)	(33)		(26)							
Leghorn	59.27	40				1.85	0.88	1.21	1.31	6.40		4400							0.03
hen	(14)					(30)	(39)	(34)	(28)	(41)		(32)							
Broiler	31.00	70	70			3.73	0.75	0.60	1.37	1.82									0.02
litter	(24)					(14)		(22)	(13)	(17)									
Turkey	30.00					2.18		0.33	1.23	5.00									0.11
litter																			
Dairy																			
Scraped	54	46		43		0.70		0.25	0.67	0.45	311	100	4.6		86.0	1.2	1.4	0.2	35
earthen lots	(28)	(33)				(106)		(82)	(71)	(78)	(45)	(64)	(66)			(42)		(21)	
Scraped concrete lots	72	25				0.53		0.13	0.40	0.31	32	9	1.3			0.4	0.7	0.1	40
Lagoon effluent	98	2	52			0.073	0.08	0.016	0.11	0.04	7	3	2.5		1.7	0.9	1.4	2	106
Slurry	92	8	66			0.30	0.14	0.13	0.40	0.40	905	1535	735	625		25	40	75	67
(liquid)	(1)	(16)																	
Equine																			
Solid	43.4	64.9	26.3			0.76		0.24	0.99	1.13		0.3	3614			51.7	135	12.70	32.2 (residential)
manure	(16.1)	(19.7)	(10.3)			(0.36)		(0.11)	(0.58)	(0.72)		(0.18)	(4722)			(33.66)	(60)	(6.02)	46 (commercial)
Swine																			
Finisher-Slurry, wet-dry feeders	91.00	9.00				0.70	0.50	0.21	0.24	0.25	380			400		85.0		50	3–4
Slurry	93.90	6.10				0.47	0.34	0.18	0.24	0.25	380			180		68		30	4.5
storage- Dry feeders		(86)				(43)	(43)	(83)	(36)	(98)	(24)			(55)		(53)		(56)	
Flush building	98.00	2.00				0.20	0.14	0.07	0.17	0.04	300	290		155		33.6	14.4	31.2	16
Agitated solids and water	97.80	2.20				0.10	0.05	0.06	0.06	0.08	215	300		180		44.4	15.6	19.2	
Lagoon surface water	99.6	0.40				0.06	0.04	0.02	0.07	0.01	215	55		37		3.6	1.2	2.4	
Lagoon sludge	90.0	10.0				0.26	0.07	0.25	0.07	0.04	191	132		79		22	80	90	

Table 20 – References
The numbers in the table are rounded averages gathered from across the U.S. They are best estimate interpretations based on the research data collected.

BEEF earthen lots	**Concrete lots**		
Nebraska unpub (12 lots, 96 hd ea) NC State (n~30) Texas AM University (n~4) Oklahoma State University (n = 72) Ward lab (n = 1026) **$\sum$ = 1144**	Iowa unpublished data (N ~ 6) NC State (n ~ 27) NOTE: not enough data to publish estimates for conc. lots		
DAIRY ESTIMATES			
Scraped Earthen lots Jones (Texas, n ~ 17) TAMU (n ~ 5) Dairyland (n ~ 77) Agsource (n ~ 367) $\sum$ = 476	**Scraped Concrete lots** N.C. State data (n ~ 187) TAMU (n ~ 3) ISU (n ~ 18) KSU (n ~ 9) $\sum$ = 190	**Lagoon effluent** N.C. State data (~160) Meyer (n~ 518) NY (n~57) TAMU (n~18) $\sum$ = 753	**Liquid Slurry** N.C. State data (n ~ 400) Minn (n ~ 21) NY (n ~ 39) Kansas (n ~ 18, Stram et al.) Wisc (n ~ 746) Dairyland (n ~ 216) Agsource (n ~ 514) NRAES-31, 1989, Collins et al.) $\sum$ = 1954
SWINE			
Deep Pit Slurry ISU Jaranilla (n = 24) ISU NIR data (n = 268) (1999 & 2000 data) $\sum$ = 292	**Flush water** SE US data (Chastain)	**Lagoon Surface Water** SE US data (Chastain) Mo. Data ISU NIR data (n = 189) $\sum$ = 189+	**Agitated liquid & solids** SE US data (Chastain)
POULTRY			
Pullets Patterson	**Layer hens** Patterson ISU (Lorimor & Xin, n = 48)	**Broiler litter** ISU (Mo & Okla samples, n = 95)	**Turkey litter**

Daily excretion of solids, nitrogen and phosphorus can be estimated by dividing total excretion estimated above by days on feed for nursery phase (DOF_N).

9.5 Equations for Estimating Excretions – See Table 16, Input Variables – Gestating Sows.

9.5.1 *Nutrient and Solids Excretion – Gestating Sows*[1]

$$N_{E-T} = N_{I-T} - N_{R-T} \tag{1}$$

$$P_{E-T} = P_{I-T} - P_{R-T} \tag{2}$$

$$DM_{E-T} = C_{DM} * ADFI_S * GL * (100 - DMD) / 10{,}000$$
$$= C_{DM} * ADFI_S * 0.0115 * (100 - DMD)^1 \tag{3}$$

9.5.2 *Nutrient Intake – Gestating Sows*[1]

$$N_{I-T} = ADFI_S * C_{CP} * GL / 625 = ADFI_S * C_{CP} * 0.184 \tag{4}$$

$$P_{I-T} = ADFI_S * C_P * GL / 100 = ADFI_S * C_P * 1.15 \tag{5}$$

9.5.3 *Nitrogen Retention – Gestating Sows*[2]

$$N_{R-T} = (GLTG \times 36.8) + (LITTER \times 39.1) \tag{6}$$

[1] Dry matter excretion in feces only.
[2] Assumes gestation period length of 115 days.

$$P_{R-T} = 93.039 + \{3.9717 \times [(SW_{PF} - SW_B) - (2.277 * LITTER)]\} + (LW_{Birth} \times 5.7) + \{[(2.277 \times LITTER) - LW_{Birth}] \times 0.80\} \tag{7}$$

Note: N_{R-T} accounts for nitrogen retention in maternal weight gain and the developing litter. P_{R-T} considers phosphorus retention in maternal weight gain, developing litter and placenta tissue.

Daily excretion of solids, nitrogen and phosphorus can be estimated by dividing total excretion estimated above by gestation length (GL) in days.

9.6 Equations for Estimating Excretions – See Table 17, Input Variables – Lactating Sows.

9.6.1 *Nutrient and Solids Excretion – Lactating Sows*

$$N_{E-T} = N_{I-T} - N_{R-T} \tag{1}$$

$$P_{E-T} = P_{I-T} - P_{R-T} \tag{2}$$

$$DM_{E-T} = C_{DM} * ADFI_L * LL * (100-DMD) / 10{,}00 \tag{3}$$

9.6.2 *Nutrient Intake – Lactating Sows*

$$N_{I-T} = ADFI_{LACT} * C_{CP} * LL/625 \tag{4}$$

[1] Dry matter excretion in feces only.

$$P_{I-T} = ADFI_{LACT} * C_P * LL/100 \quad (5)$$

9.6.3 *Nutrient Retention – Lactating Sows*

$$N_{R-T} = [36.8 \times LLTG] + (LW_{WEAN} \times 32) - (LW_{BIRTH} \times 36.8) \quad (6)$$

$$P_{R-T} = [(SW_{WEAN} \times 4.84) - (SW_{PF} \times 5.28)] + [(LW_{WEAN} \times 6.4) - (LW_{BIRTH} \times 5.7)] \quad (7)$$

Daily excretion of solids, nitrogen and phosphorus can be estimated by dividing total excretion estimated above by lactation length (LL) in days.

9.7 Manure Characteristics Based Upon Typical Performance and Diets – See Tables 18a, 18b, and 18c.

9.8 References

9.8.1 Carter, S., G. Cromwell, P. Westerman, J. Park, and L. Pettey. 2003. Prediction of Nitrogen, Phosphorus, and Dry Matter Excretion by Swine Based on Diet Chemical Composition, Feed Intake, and Nutrient Retention. Proceedings of the International Symposium for Animal, Agricultural, and Food Processing Wastes IX. ASAE. St. Joseph, MI. 285–295.

10.0 As-Removed Manure Production and Characteristics

10.1 Many physical, chemical, and biological processes can alter manure characteristics from its original as-excreted form. The as-removed manure production and characteristics values reported in this table allow for common modifications to excreted manure (Section 3) resulting from water addition or removal, bedding addition, and/or treatment processes. These values represent typical values based on available data sources (see end of Section 10). The variances on the data presented in Section 10, As-Removed Manure Production and Characteristics, are significantly high, and strongly correlated to the geographic location and the type of manure management system in use. These estimates may be helpful for individual farm long-term planning prior to any samples being available and for planning estimates addressing regional issues. Whenever possible, site-specific samples or other more localized estimates should be used in lieu of national tabular estimates. **This table should not be used to develop individual year nutrient management plans for defining field specific application rates, unless absolutely no site-specific manure analysis data are available.** Where site-specific data are unavailable, this table may provide initial estimates for planning purposes until site-specific values are available.

See Tables 19 and 20.

10.2 References (continued)

10.2.1 Barker, J.C., J.P. Zublena, C.R. Campbell. 1994. Unpublished compilation of manure samples of all species and facilities. North Carolina State Univ. Raleigh, N.C.

10.2.2 Stram, T.D., J.P. Harner, D.V. Key, and J.P. Murphy. 2000. Nutrients available from dairy lagoons and sand-laden manure. Presented at Mid Central Meeting of ASAE. ASAE paper MC00-120

10.2.3 Collins, E.R., T.A. Dillaha, and H.W. Roller. 1989. Dairy manure management. NRAES-31

10.2.4 Lorimor, J.C., and H. Xin. 1999. Manure production and nutrient concentrations from high-rise layer houses. ASAE Trans. 15(4): 337-340

10.2.5 Patterson, P.H. and E.S. Lorenz. 1996. Manure nutrient production from commercial white leghorn hens. Applied Poultry Science Research report.

10.2.6 Lorimor, J.C., W. Powers, A. Sutton. 2000. Manure characteristics. MWPS18-Section 1. Midwest Plan Service. Ames, IA.

10.2.7 Lorimor, J.C., 1999. Managing manure nutrients for crop production. ISU Extension publication Pm-1811. Ames, IA.

10.2.8 Chastain, J.P. 2002. Nutrient content of swine manure as removed. Unpublished data compiled by the author.

10.2.9 Erickson, G.A., T. Klopfensteein, D. Walters, and G. Lesoing. 1998. Nutrient balance of nitrogen, organic matter, phosphorus and sulfur in the feedlot. Nebraska Beef Report, Univ. of Neb. Lincoln, NB.

10.2.10 Ward Lab. 2003 data accumulated from commercial lab. (603 samples)

10.2.11 Lorimor, J.C. 2003. Unpublished data compiled by author on earthen beef feedlots in IA.

10.2.12 Jaranilla-Sanchez, P.A., J.C. Lorimor, and J. Boeding. 2003. Manure Accumulation in a Deep Pit Finishing Building. Presented at Mid Central Meeting of ASAE. ASAE paper MC03-403.

10.2.13 Bicudo, J. 2003. Compilation of unpublished data. Numbers were based on analyses of stall waste made in KY, TX, CO, Alberta (Canada), OK, and WA.

10.2.14 Ye, W. 2003. Application of near-infrared spectroscopy for determination of nutrient contents in manure. Ph.D. dissertation, Iowa State University.

ASAE D384.1 FEB03
Manure Production and Characteristics

American Society of Agricultural Engineers

STANDARD

ASAE-The Society for engineering in agricultural, food, and biological systems
2950 Niles Rd., St. Joseph, MI 49085-9659, USA ph. 269-429-0300, fax 269-429-3852, hq@asae.org

Manure Production and Characteristics

Developed by the Engineering Practices Subcommittee of the ASAE Agricultural Sanitation and Waste Management Committee; approved by the Structures and Environment Division Standards Committee; adopted by ASAE December 1976: reconfirmed December 1981, December 1982, December 1983, December 1984, December 1985, December 1986, December 1987: revised June 1988; revised editorially and reaffirmed December 1993; revised editorially March 1995; reaffirmed December 1998, December 1999, December 2001, reaffirmed for one year February 2003.

1 Purpose and scope

1.1 Data on livestock manure production and characteristics are presented to assist in the planning, design and operation of manure collection, storage, pretreatment and utilization systems for livestock enterprises.

1.2 These data are combined from a wide base of published and unpublished information on livestock manure production and characterization. Users of this information should recognize that the mean values for each parameter are determined by an arithmetic average consisting of one data point per reference source per year. The values represent fresh (as voided) feces and urine. Actual values vary due to differences in animal diet, age, usage, productivity and management. Whenever site specific data are available or actual sample analyses can be performed, such information should be considered in lieu of the mean values presented here.

Table 1 – Fresh manure production and characteristics per 1 000 kg live animal mass per day

			Animal Type†										
Parameter	Units*		Dairy	Beef	Veal	Swine	Sheep	Goat	Horse	Layer	Broiler	Turkey	Duck
Total manure‡	kg	mean§	86	58	62	84	40	41	51	64	85	47	110
		std. deviation	17	17	24	24	11	8.6	7.2	19	13	13	**
Urine	kg	mean	26	18	**	39	15	**	10	**	**	**	**
		std. deviation	4.3	4.2	**	4.8	3.6	**	0.74	**	**	**	**
Density	kg/m^3	mean	990	1 000	1 000	990	1 000	1 000	1 000	970	1 000	1 000	**
		std. deviation	63	75	**	24	64	**	93	39	**	**	**
Total solids	kg	mean	12	8.5	5.2	11	11	13	15	16	22	12	31
		std. deviation	2.7	2.6	2.1	6.3	3.5	1.0	4.4	4.3	1.4	3.4	15
Volatile solids	kg	mean	10	7.2	2.3	8.5	9.2	**	10	12	17	9.1	19
		std. deviation	0.79	0.57	**	0.66	0.31	**	3.7	0.84	1.2	1.3	**
Biochemical oxygen demand, 5-day	kg	mean	1.6	1.6	1.7	3.1	1.2	**	1.7	3.3	**	2.1	4.5
		std. deviation	0.48	0.75	**	0.72	0.47	**	0.23	0.91	**	0.46	**
Chemical oxygen demand	kg	mean	11	7.8	5.3	8.4	11	**	**	11	16	9.3	27
		std. deviation	2.4	2.7	**	3.7	2.5	**	**	2.7	1.8	1.2	**
pH		mean	7.0	7.0	8.1	7.5	**	**	7.2	6.9	**	**	**
		std. deviation	0.45	0.34	**	0.57	**	**	**	0.56	**	**	**
Total Kjeldahl nitrogen‖	kg	mean	0.45	0.34	0.27	0.52	0.42	0.45	0.30	0.84	1.1	0.62	1.5
		std. deviation	0.096	0.073	0.045	0.21	0.11	0.12	0.063	0.22	0.24	0.13	0.54
Ammonia nitrogen	kg	mean	0.079	0.086	0.12	0.29	**	**	**	0.21	**	0.080	**
		std. deviation	0.083	0.052	0.016	0.10	**	**	**	0.18	**	0.018	**
Total phosphorus	kg	mean	0.094	0.092	0.066	0.18	0.087	0.11	0.071	0.30	0.30	0.23	0.54
		std. deviation	0.024	0.027	0.011	0.10	0.030	0.016	0.026	0.081	0.053	0.093	0.21
Orthophosphorus	kg	mean	0.061	0.030	**	0.12	0.032	**	0.019	0.092	**	**	0.25
		std. deviation	0.005 8	**	**	**	0.014	**	0.007 1	0.016	**	**	**
Potassium	kg	mean	0.29	0.21	0.28	0.29	0.32	0.31	0.25	0.30	0.40	0.24	0.71
		std. deviation	0.094	0.061	0.10	0.16	0.11	0.14	0.091	0.072	0.064	0.080	0.34
Calcium	kg	mean	0.16	0.14	0.059	0.33	0.28	**	0.29	1.3	0.41	0.63	**
		std. deviation	0.059	0.11	0.049	0.18	0.15	**	0.11	0.57	**	0.34	**
Magnesium	kg	mean	0.071	0.049	0.033	0.070	0.072	**	0.057	0.14	0.15	0.073	**
		std. deviation	0.016	0.015	0.023	0.035	0.047	**	0.016	0.042	**	0.007 1	**
Sulfur	kg	mean	0.051	0.045	**	0.076	0.055	**	0.044	0.14	0.085	**	**
		std. deviation	0.010	0.005 2	**	0.040	0.043	**	0.022	0.066	**	**	**
Sodium	kg	mean	0.052	0.030	0.086	0.067	0.078	**	0.036	0.10	0.15	0.066	**
		std. deviation	0.026	0.023	0.063	0.052	0.027	**	**	0.051	**	0.012	**
Chloride	kg	mean	0.13	**	**	0.26	0.089	**	**	0.56	**	**	**
		std. deviation	0.039	**	**	0.052	**	**	**	0.44	**	**	**
Iron	g	mean	12	7.8	0.33	16	8.1	**	16	60	**	75	**
		std. deviation	6.6	5.9	**	9.7	3.2	**	8.1	49	**	28	**
Manganese	g	mean	1.9	1.2	**	1.9	1.4	**	2.8	6.1	**	2.4	**
		std. deviation	0.75	0.51	**	0.74	1.5	**	2.1	2.2	**	0.33	**

Table 1 – Fresh manure production and characteristics per 1 000 kg live animal mass per day (continued)

Parameter	Units*		Animal Type†										
			Dairy	Beef	Veal	Swine	Sheep	Goat	Horse	Layer	Broiler	Turkey	Duck
Boron	g	mean	0.71	0.88	**	3.1	0.61	**	1.2	1.8	**	**	**
		std. deviation	0.35	0.064	**	0.95	0.30	**	0.48	1.7	**	**	**
Molybdenum	g	mean	0.074	0.042	**	0.028	0.25	**	0.083	0.30	**	**	**
		std. deviation	0.012	**	**	0.030	0.38	**	0.033	0.057	**	**	**
Zinc	g	mean	1.8	1.1	13	5.0	1.6	**	2.2	19	3.6	15	**
		std. deviation	0.65	0.43	**	2.5	1.0	**	2.1	33	**	12	**
Copper	g	mean	0.45	0.31	0.048	1.2	0.22	**	0.53	0.83	0.98	0.71	**
		std. deviation	0.14	0.12	**	0.84	0.066	**	0.39	0.84	**	0.10	**
Cadmium	g	mean	0.003 0	**	**	0.027	0.007 2	**	0.005 1	0.038	**	**	**
		std. deviation	**	**	**	0.028	**	**	**	0.032	**	**	**
Nickel	g	mean	0.28	**	**	**	**	**	0.62	0.25	**	**	**
		std. deviation	**	**	**	**	**	**	**	**	**	**	**
Lead	g	mean	**	**	**	0.084	0.084	**	**	0.74	**	**	**
		std. deviation	**	**	**	0.012	**	**	**	**	**	**	**
Total coliform bacteria	colonies#	mean	1 100	63	**	45	20	**	490	110	**	**	**
		std. deviation	2 800	59	**	33	26	**	490	100	**	**	**
Fecal coliform bacteria	colonies	mean	16	28	**	18	45	**	0.092	7.5	**	1.4	180
		std. deviation	28	27	**	12	27	**	0.029	2.0	**	**	180
Fecal streptococcus bacteria	colonies	mean	92	31	**	530	62	**	58	16	**	**	590
		std. deviation	140	45	**	290	73	**	59	7.2	**	**	**

*All values wet basis.

†Differences within species according to usage exist, but sufficient fresh manure data to list these differences was not found. Typical live animal masses for which manure values represent are: dairy, 640 kg; beef, 360 kg; veal, 91 kg; swine, 61 kg; sheep, 27 kg; goat, 64 kg; horse, 450 kg; layer, 1.8 kg; broiler, 0.9 kg; turkey, 6.8 kg; and duck, 1.4 kg.

‡Feces and urine as voided.

§Parameter means within each animal species are comprised of varying populations of data. Maximum numbers of data points for each species are: dairy, 85; beef, 50; veal, 5; swine, 58; sheep, 39; goat, 3; horse, 31; layer, 74; broiler, 14; turkey, 18; and duck, 6.

‖All nutrients and metals values are given in elemental form.

#Mean bacteria colonies per 1 000 kg animal mass multiplied by 10^{10}. Colonies per 1 000 kg animal mass divided by kg total manure per 1 000 kg animal mass multiplied by density kg/m^3 equals colonies per m^3 of manure.

**Data not found.

Table 2 – Fresh manure production and characteristics per 1,000 lb live animal mass per day

Parameter	Units*		Animal Type†										
			Dairy	Beef	Veal	Swine	Sheep	Goat	Horse	Layer	Broiler	Turkey	Duck
Total manure‡	lb	mean§	86	58	62	84	40	41	51	64	85	47	110
		std. deviation	17	17	24	24	11	8.6	7.2	19	13	13	**
Urine	lb	mean	26	18	**	39	15	**	10	**	**	**	**
		std. deviation	4.3	4.2	**	4.8	3.6	**	0.74	**	**	**	**
Density	lb/ft^3	mean	62	63	62	62	64	63	63	60	63	63	**
		std. deviation	4.0	4.7	**	1.5	4.0	**	5.8	2.4	**	**	**
Total solids	lb	mean	12	8.5	5.2	11	11	13	15	16	22	12	31
		std. deviation	2.7	2.6	2.1	6.3	3.5	1.0	4.4	4.3	1.4	3.4	15
Volatile solids	lb	mean	10	7.2	2.3	8.5	9.2	**	10	12	17	9.1	19
		std. deviation	0.79	0.57	**	0.66	0.31	**	3.7	0.84	1.2	1.3	**
Biochemical oxygen demand, 5-day	lb	mean	1.6	1.6	1.7	3.1	1.2	**	1.7	3.3	**	2.1	4.5
		std. deviation	0.48	0.75	**	0.72	0.47	**	0.23	0.91	**	0.46	**
Chemical oxygen demand	lb	mean	11	7.8	5.3	8.4	11	**	**	11	16	9.3	27
		std. deviation	2.4	2.7	**	5.3	2.5	**	**	2.7	18	1.2	**
pH		mean	7.0	7.0	8.1	7.5	**	**	7.2	6.9	**	**	**
		std. deviation	0.45	0.34	**	0.57	**	**	**	0.56	**	**	**
Total Kjeldahl nitrogen‖	lb	mean	0.45	0.34	0.27	0.52	0.42	0.45	0.30	0.84	1.1	0.62	1.5
		std. deviation	0.096	0.073	0.045	0.21	0.11	0.12	0.063	0.22	0.24	0.13	0.54
Ammonia nitrogen	lb	mean	0.079	0.086	0.12	0.29	**	**	**	0.21	**	0.080	**
		std. deviation	0.083	0.052	0.016	0.10	**	**	**	0.18	**	0.018	**
Total phosphorus	lb	mean	0.094	0.092	0.066	0.18	0.087	0.11	0.071	0.30	0.30	0.23	0.54
		std. deviation	0.024	0.027	0.011	0.10	0.030	0.016	0.026	0.081	0.053	0.093	0.21

Table 2 – Fresh manure production and characteristics per 1,000 lb live animal mass per day (continued)

			Animal Type†										
Parameter	Units*		Dairy	Beef	Veal	Swine	Sheep	Goat	Horse	Layer	Broiler	Turkey	Duck
Orthophosphorus	lb	mean	0.061	0.030	**	0.12	0.032	**	0.019	0.092	**	**	0.25
		std. deviation	0.058	**	**	**	0.014	**	0.0071	0.016	**	**	**
Potassium	lb	mean	0.29	0.21	0.28	0.29	0.32	0.31	0.25	0.30	0.40	0.24	0.71
		std. deviation	0.094	0.061	0.10	0.16	0.11	0.14	0.091	0.072	0.064	0.080	0.34
Calcium	lb	mean	0.16	0.14	0.059	0.33	0.28	**	0.29	1.3	0.41	0.63	**
		std. deviation	0.059	0.11	0.049	0.18	0.15	**	0.11	0.57	**	0.34	**
Magnesium	lb	mean	0.071	0.049	0.033	0.070	0.072	**	0.057	0.14	0.15	0.073	**
		std. deviation	0.016	0.015	0.023	0.035	0.047	**	0.016	0.042	**	0.0071	**
Sulfur	lb	mean	0.051	0.045	**	0.076	0.055	**	0.044	0.14	0.085	**	**
		std. deviation	0.010	0.0052	**	0.040	0.043	**	0.022	0.066	**	**	**
Sodium	lb	mean	0.052	0.030	0.086	0.067	0.078	**	0.036	0.10	0.15	0.066	**
		std. deviation	0.026	0.023	0.063	0.052	0.027	**	**	0.051	**	0.012	**
Chloride	lb	mean	0.13	**	**	0.26	0.089	**	**	0.56	**	**	**
		std. deviation	0.039	**	**	0.052	**	**	**	0.44	**	**	**
Iron	lb	mean	0.012	0.0078	0.00033	0.016	0.0081	**	0.016	0.060	**	0.075	**
		std. deviation	0.0066	0.0059	**	0.0097	0.0032	**	0.0081	0.049	**	0.028	**
Manganese	lb	mean	0.0019	0.0012	**	0.0019	0.0014	**	0.0028	0.0061	**	0.0024	**
		std. deviation	0.00075	0.00051	**	0.00074	0.0015	**	0.0021	0.0022	**	0.00033	**
Boron	lb	mean	0.00071	0.00088	**	0.0031	0.00061	**	0.0012	0.0018	**	**	**
		std. deviation	0.00035	0.000064	**	0.00095	0.00030	**	0.00048	0.0017	**	**	**
Molybdenum	lb	mean	0.000074	0.000042	**	0.000028	0.00025	**	0.000083	0.00030	**	**	**
		std. deviation	0.000012	**	**	0.000030	0.00038	**	0.000033	0.000057	**	**	**
Zinc	lb	mean	0.0018	0.0011	0.013	0.0050	0.0016	**	0.0022	0.019	0.0036	0.015	**
		std. deviation	0.00065	0.00043	**	0.0025	0.0010	**	0.0021	0.033	**	0.012	**
Copper	lb	mean	0.00045	0.00031	0.000048	0.0012	0.00022	**	0.00053	0.00083	0.00098	0.00071	**
		std. deviation	0.00014	0.00012	**	0.00084	0.000066	**	0.00039	0.00084	**	0.00010	**
Cadmium	lb	mean	0.0000030	**	**	0.000027	0.0000072	**	0.0000051	0.000038	**	**	**
		std. deviation	**	**	**	0.000028	**	**	**	0.000032	**	**	**
Nickel	lb	mean	0.00028	**	**	**	**	**	0.00062	0.00025	**	**	**
		std. deviation	**	**	**	**	**	**	**	**	**	**	**
Lead	lb	mean	**	**	**	0.000084	0.000084	**	**	0.00074	**	**	**
		std. deviation	**	**	**	0.000012	**	**	**	**	**	**	**
Total coliform bacteria	colonies#	mean	500	29	**	21	9.0	**	220	50	**	**	**
		std. deviation	1300	27	**	15	12	**	220	46	**	**	**
Fecal coliform bacteria	colonies	mean	7.2	13	**	8.0	20	**	0.042	3.4	**	0.62	81
		std. deviation	13	12	**	5.4	12	**	0.013	0.91	**	**	81
Fecal streptococcus	colonies	mean	42	14	**	240	28	**	26	7.4	**	**	270
bacteria		std. deviation	63	21	**	130	33	**	27	3.3	**	**	**

*All values wet basis.

†Differences within species according to usage exist, but sufficient fresh manure data to list these differences was not found. Typical live animal masses for which manure values represent are: dairy, 1400 lb; beef, 800 lb; veal, 200 lb; swine, 135 lb; sheep, 60 lb; goat, 140 lb; horse, 1000 lb; layer, 4 lb; broiler, 2 lb; turkey, 15 lb; and duck, 3 lb.

‡Feces and urine as voided.

§Parameter means within each animal species are comprised of varying populations of data. Maximum numbers of data points for each species are: dairy, 85; beef, 50; veal, 5; swine, 58; sheep, 39; goat, 3; horse, 31; layer, 74; broiler, 14; turkey, 18; and duck, 6.

||All nutrients and metals values are given in elemental form.

#Mean bacteria colonies per 1,000 lb animal mass multiplied by 10^{10}. Colonies per 1,000 lb animal mass divided by lb total manure per 1,000 lb animal mass multiplied by density (lb/ft^3) equals colonies per ft^3 of manure.

**Data not found.

Attachment 6
National Air Quality Site Assessment Report - Broilers

DELLAVALLE LABORATORY INC

1910 W. McKinley Avenue, Suite 110 ● Fresno, California 93728-1298
Phone (559) 233-6129 ● (800) 228-9896 ● Fax (559) 268-8174
Website: dellavallelab.com

Broiler Chickens | National Air Quality Site Assessment Tool

Abalone Creek Ranch

*This report was compiled at **5/30/2023 4:10:06 PM** and will be available for one month at this location:* ***http://naqsat.tamu.edu/broiler-chickens/?key=d6af74f1***.

Effectiveness Results:

	Odor	Particulate Matter	Ammonia	Hydrogen sulfide	Methane	Volatile organic compounds (VOCs)	Nitrous Oxide (N_2O)
Animals and Housing				N/A	N/A	N/A	N/A
Feed and Water		N/A		N/A	N/A	N/A	N/A
Collection and Transfer				N/A	N/A	N/A	N/A
Manure Storage							
Land Application		covered pasture					N/A
Mortalities		N/A					N/A
On-farm Roads				N/A	N/A		N/A

Animals and Housing

Note to User: Many farms may use more than one of the listed choices below. In order to allow the use of NAQSAT as a "What If" tool only one of the choices can be selected at a time. The user can click on "Get Results" for that selection and see how changing the answer will affect their results. **See user's manual for more information.** If only a general overview is desired, identifying the predominant practice will accomplish that result.

For broilers, what is your average market weight per year?

○ Unknown

- ○ 2.0 to 3.5
- ○ 3.5 to 4.5
- ● 4.5 to 5.2

  What is your average feed conversion for the year (lbs feed to lbs gain)?

  - ○ < 1.4
  - ○ 1.4 to 1.6
  - ● 1.6 to 1.8
  - ○ 1.8 to 2.0
  - ○ > 2.0

- ○ 5.2 to 6.0
- ○ 6.0 to 7.0
- ○ > 7.0

Housing type:

- ○ Curtain
- ○ Tunnel
- ● Natural (Outside access)

  Do you see bare ground?

  - ○ Yes
  - ● No

Feed and Water

Do you have control or input into diet formulation?

- ○ Yes
- ● No

Do you make your own feed or process your feed onsite?

- ○ Yes
- ● No

How is water supplied to your animals in the natural (outside access) facility?

- ● Nipple drinkers
- ○ Trough, cups, bowls, or bells

How often are all waterers checked then repaired for leaks?

- ○ Daily
- ● At least weekly
- ○ Weekly or less frequently

How often are your waterers flushed?

- ● End of flock or between flocks
- ○ More than once per flock

○ Less than once per flock

Collection and Transfer

Note to User: Many farms may use more than one of the listed choices below. In order to allow the use of NAQSAT as a "What If" tool only one of the choices can be selected at a time. The user can click on "Get Results" for that selection and see how changing the answer will affect their results. **See user's manual for more information.** If only a general overview is desired, identifying the predominant practice will accomplish that result.

How often does a complete clean-out occur?

○ More than once per year
◉ Yearly
○ Less than once per year

Are more than 1 flock are on the same litter?

○ Yes
◉ No

What method is used to transfer the majority of manure from storage to the field?

○ Open spreader or truck
◉ Does not apply

Manure Storage

Note to User: Many farms may use more than one of the listed choices below. In order to allow the use of NAQSAT as a "What If" tool only one of the choices can be selected at a time. The user can click on "Get Results" for that selection and see how changing the answer will affect their results. **See user's manual for more information.** If only a general overview is desired, identifying the predominant practice will accomplish that result.

Do any of these processes occur onsite? (Check all that apply)

☑ Storage/stockpile

How often is seepage noticed?

◉ Rarely
○ Commonly

Does water pond around the base of compost piles (from rainfall events or leachate) for greater than 24 hours?

◉ Ponding or standing water is not present more than 24 hr after a rainfall event
○ Ponding or standing water is present more than 24 hr after a rainfall event

How often are maggots noticed?

- [x] Rarely
- [ ] Commonly

How often are flies noticed?

- [x] Rarely
- [ ] Commonly

- [x] Composting

How often is seepage noticed?

- [x] Rarely
- [ ] Commonly

Does water pond around the base of compost piles (from rainfall events or leachate) for greater than 24 hours?

- [x] Ponding or standing water is not present more than 24 hr after a rainfall event
- [ ] Ponding or standing water is present more than 24 hr after a rainfall event

What is average of the highest two consecutive weekly temperature readings of your compost pile?

- [ ] I don't know
- [ ] < 120F
- [ ] 120F to 140F
- [x] > 140F

How often are maggots or flies noticed?

- [x] Rarely
- [ ] Commonly

- [ ] Pelletizing
- [ ] Gasification
- [ ] Incineration/burn

Land Application

Where does manure go?

- [ ] Moved offsite (sold or given away) directly from the housing
- [ ] Composted or stockpiled, then sold or given away
- [x] Land applied

What form of manure is land applied? (Check all that apply)

- [x] Solid

How long are solids piled, or staged, on the field prior to application?

- [ ] < 3 days
- [ ] >= 3 days
- [x] Directly land applied; not piled or staged

Are the majority of your solids composted prior to land application?

- [ ] Yes

- [x] No

When are solids incorporated?

- [x] At time of application
- [ ] < 24 hours after application
- [ ] 24 hours to 3 days following application
- [ ] More than 3 days after application or not incorporated

- [ ] Liquid

Mortalities

How long before carcasses are picked up or put into the disposal system?

- [x] Daily
- [ ] Less frequently

How is mortality handled? (Check all that apply)

- [ ] Managed offsite (such as rendered or landfilled, or offsite composting)
- [x] Buried onsite

Is cover added to the burial pit or pile every time mortality is added?

- [x] Yes
- [ ] No

Is a temporary cover adequately sealed?

- [ ] Always
- [ ] Never
- [x] Most of the time

- [x] Composted onsite

How often is seepage noticed?

- [x] Rarely
- [ ] Commonly

Does water pond around the base of compost piles (from rainfall events or leachate) for greater than 24 hours?

- [x] Ponding or standing water is not present more than 24 hr after a rainfall event
- [ ] Ponding or standing water is present more than 24 hr after a rainfall event

Are you following a specific compost recipe?

- [ ] Yes
- [x] No

What is average of the highest two consecutive weekly temperature readings of your compost pile?

- [ ] I don't know
- [ ] < 120F
- [ ] 120F to 140F
- [x] > 140F

How often are maggots or flies noticed?

- (x) Rarely
- ( ) Commonly

How often are uncovered carcass parts visible or noticed?

- (x) Rarely
- ( ) Commonly

How often is compost cover added?

- (x) Immediately after each carcass addition
- ( ) At least once daily
- ( ) Less frequently than each carcass addition

- [ ] Contained (in-vessel) incinerated onsite

On-farm Roads

Are unpaved roads used for any of the following activities? (check all that apply)

- [ ] Routine service traffic (feed delivery, milk truck, renderer)
- [x] Less frequent service traffic (manure handling)
- [ ] General transportation (veterinarians, maintenance, nutritionists, managers, employees, farm tours)
- [ ] Does not apply

Unpaved roads are surfaced with: (Check all that apply)

- [ ] Caliche/limestone
- [x] Unimproved dirt road
- [x] Washed gravel
- [ ] Gravel

Which is the predominant road-surface treatment used?

- ( ) Petroleum products, resins, emulsions as per manufacturer recommendations
- ( ) Salts or hygroscopic materials (e. g., magnesium chloride)
- (x) Fresh water
- ( ) Holding pond wastewater
- ( ) None

Are speed limits strictly enforced, or is speed controlled by passive means (e. g., speed bumps)?

- ( ) Speed limits are not present or are not enforced by management
- (x) Speed limits are enforced by management
- ( ) Speed is controlled by speed bumps or other passive means

Do you restrict public access to private roads?

- (x) Yes
- ( ) No

Are most roads lined with windbreaks or shelterbelts?

- [ ] No
- [x] Some or all roads are lined with vegetation

Attachment 7
Monthly Manure Tracking Report

DELLAVALLE™
LABORATORY INC

1910 W. McKinley Avenue, Suite 110 ● Fresno, California 93728-1298
Phone (559) 233-6129 ● (800) 228-9896 ● Fax (559) 268-8174
Website: dellavallelab.com

Abalone Creek Ranch Monthly Manure Tracking

Monthly Manure Record____________________________
Month

Stockpile

Date stockpiled____________________________________

Area stockpiled____________________________________

Amount stockpiled_________________________________

Total existing amount stockpiled (cubic-ft)_____________

Notes____
____
____

Land Application

Date and Time_____________________________________

Air Temperature (ºF)_______________________________

Method of application______________________________

Field ID____

Acres completed___________________________________

Soil

- o Field Capacity
- o Dry
- o Saturated
- o Muddy

Wind Speed

- o Calm (0-2 mph)
- o Light (2-5 mph)
- o Breezy (5-15 mph)
- o Windy (15+)

Notes____
____
____

Attachment 8
National Air Quality Site Assessment Report - Horses

DELLAVALLE LABORATORY INC

1910 W. McKinley Avenue, Suite 110 ● Fresno, California 93728-1298
Phone (559) 233-6129 ● (800) 228-9896 ● Fax (559) 268-8174
Website: dellavallelab.com

Horse | National Air Quality Site Assessment Tool

Abalone Creek Ranch

*This report was compiled at **5/31/2023 6:42:38 AM** and will be available for one month at this location: **http://naqsat.tamu.edu/dairy/?key=04552f6e**.*

Effectiveness Results:

	Odor	Particulate Matter	Ammonia	Hydrogen sulfide	Methane	Volatile organic compounds (VOCs)	Nitrous Oxide (N_2O)
Animals and Housing				N/A	N/A	N/A	
Feed and Water		N/A					N/A
Collection and Transfer							N/A
Manure Storage							
Land Application		covered pasture					N/A
Mortalities		N/A	rendered				N/A
On-farm Roads				N/A	N/A		N/A

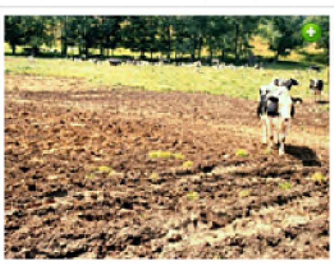
Animals and Housing

Note to User: Many farms may use more than one of the listed choices below. In order to allow the use of NAQSAT as a "What If" tool only one of the choices can be selected at a time. The user can click on "Get Results" for that selection and see how changing the answer will affect their results. **See user's manual for more information.** If only a general overview is desired, identifying the predominant practice will accomplish that result.

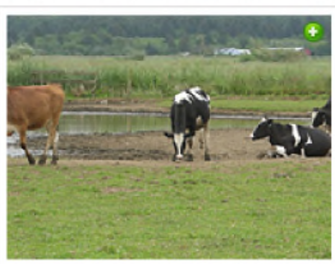
Housing type: Select the photo that best represents your facility for each set of photos revealed below.

- [ ] Pen/Dry lot
- [x] Pasture

Water, feed and shade areas: *(Click on an image below; your selection will highlight in green.)*



Heavily trampled, wet, little vegetation



Trampled and soft, some vegetation remaining

Minimal hoof damage, hard surface, significant vegetation

Complete grass cover, no bare areas

- [ ] Box stall
- [ ] Riding arena

Feed and Water

How is water supplied to your animals in the facility?

- ( ) Cups, bowls, or bells
- (•) Stock tank or circulating tank
- ( ) Overflow waterers (seasonal and run continuously)

How often are all waterers checked then repaired for leaks?

- ( ) Daily
- (•) At least weekly
- ( ) Weekly or less frequently

Are rations (roughage and supplement) formulated for animal age, size and activity?

- (•) Yes
- ( ) No

Is water sulfur concentration considered when rations are formulated?

- (•) Yes
- ( ) No

How are legume roughages offered?

- (•) Free choice
- ( ) Limited

Collection and Transfer

Note to User: Many farms may use more than one of the listed choices below. In order to allow the use of NAQSAT as a "What If" tool only one of the choices can be selected at a time. The user can click on "Get Results" for that selection and see how changing the answer will affect their results. **See user's manual for more information.** If only a general overview is desired, identifying the predominant practice will accomplish that result.

How often does a complete clean-out occur?

- ( ) More than once per year
- (•) Yearly
- ( ) Less than once per year

What method is used to transfer the majority of manure from storage to the field?

- (•) Open spreader or truck

If a truck or spreader is used to transport manure to fields, is it covered (whether the truck leaves the farm and goes on a public road or not)?

- (•) Yes
- ( ) No

( ) Does not apply

Is the manure spilled at the loading station/area?

- ( ) Yes
- (•) No

Manure Storage

Note to User: Many farms may use more than one of the listed choices below. In order to allow the use of NAQSAT as a "What If" tool only one of the choices can be selected at a time. The user can click on "Get Results" for that selection and see how changing the answer will affect their results. **See user's manual for more information.** If only a general overview is desired, identifying the predominant practice will accomplish that result.

Do you haul manure daily?

- ( ) Yes
- (•) No

What percent of your farm's manure is stored as a liquid or slurry (does not stack) in your predominant housing type?

Please slide to change value:

1%

Do any of these processes occur onsite? (Check all that apply)

[x] Storage/stockpile

How often is seepage noticed?

- (•) Rarely
- ( ) Commonly

Does water pond around the base of compost piles (from rainfall events or leachate) for greater than 24 hours?

- (•) Ponding or standing water is not present more than 24 hr after a rainfall event
- ( ) Ponding or standing water is present more than 24 hr after a rainfall event

How often are maggots noticed?

- (•) Rarely
- ( ) Commonly

How often are flies noticed?

- (•) Rarely
- ( ) Commonly

[x] Composting

How often is seepage noticed?

- (•) Rarely
- ( ) Commonly

Does water pond around the base of compost piles (from rainfall events or leachate) for greater than 24 hours?

- (•) Ponding or standing water is not present more than 24 hr after a rainfall event

- ○ Ponding or standing water is present more than 24 hr after a rainfall event

Are you following a specific recipe?

- ● Yes

  What is your recipe?

  - ● 3:1 or greater carbon source (stalks, sawdust, straw, etc):manure
  - ○ < 3:1 carbon source (stalks, sawdust, straw, etc):manure

- ○ No

What is average of the highest two consecutive weekly temperature readings of your compost pile?

- ○ I don't know
- ○ < 120F
- ● 120F to 140F
- ○ > 140F

How often is compost cover added?

- ● With each manure addition
- ○ At least once daily
- ○ Less frequently than each manure addition

How often are maggots noticed?

- ● Rarely
- ○ Commonly

How often are flies noticed?

- ● Rarely
- ○ Commonly

- ☐ Pelletizing
- ☐ Gasification
- ☐ Incineration/burn

For each stage of manure storage you have, click the "Add Stage" button below and complete the questions for each stage. For example, if you have a 3-stage manure storage system, you will need to complete the first stage below, and then add 2 stages (click the "Add stage" button twice).

Stage 1

Does your manure contain greater or less than 5 lb of nitrogen per 1000 gallons (600 mg/kg) or less than 4% solids?

- ○ Less than 5 lbs/1000 gallons or 600 mg/kg and be less than 4% total solids
- ● Greater than 5 lb N / 1000 gal and greater than 4% total solids

  Regarding your manure storage structure, describe the material for any cover that you may have on it.

  - ○ Natural crust
  - ○ Permeable cover (such as straw, stalks, geotextile material)
  - ○ Impermeable cover (such as plastic)
  - ● Building (for slatted or deep pit buildings)
  - ○ No cover

- ○ I don't know

Land Application

Where does manure go?

- ☑ Moved offsite (sold or given away) directly from the housing
- ☐ Composted or stockpiled, then sold or given away
- ☑ Land applied

What form of manure is land applied? (Check all that apply)

- [x] Solid

  How long are solids piled, or staged, on the field prior to application?

  - ( ) < 3 days
  - ( ) >= 3 days
  - (•) Directly land applied; not piled or staged

  Are the majority of your solids composted prior to land application?

  - (•) Yes
  - ( ) No

- [ ] Liquid

Mortalities

Other than during freezing weather, how long before carcasses are picked up or put into the disposal system?

- (•) Within 24 hours of death
- ( ) Within a week of death
- ( ) Less frequently

How is mortality handled? (Check all that apply)

- [x] Managed offsite (such as rendered or landfilled, or offsite composting)
- [ ] Buried onsite
- [ ] Composted onsite
- [ ] Contained (in-vessel) incinerated onsite

On-farm Roads

Are unpaved roads used for any of the following activities? (check all that apply)

- [ ] Routine service traffic (feed delivery, milk truck, renderer)
- [x] Less frequent service traffic (manure handling)
- [ ] General transportation (veterinarians, maintenance, nutritionists, managers, employees, farm tours)
- [ ] Does not apply

Unpaved roads are surfaced with: (Check all that apply)

- [ ] Caliche/limestone
- [x] Unimproved dirt road
- [x] Washed gravel
- [ ] Gravel

Which is the predominant road-surface treatment used?

- ( ) Petroleum products, resins, emulsions as per manufacturer recommendations
- ( ) Salts or hygroscopic materials (e. g., magnesium chloride)
- (•) Fresh water
- ( ) Holding pond wastewater
- ( ) None

Are speed limits strictly enforced, or is speed controlled by passive means (e. g., speed bumps)?

- ( ) Speed limits are not present or are not enforced by management
- (•) Speed limits are enforced by management
- ( ) Speed is controlled by speed bumps or other passive means

Do you restrict public access to private roads?

- [x] Yes
- [ ] No

Are most roads lined with windbreaks or shelterbelts?

- [ ] No
- [x] Some or all roads are lined with vegetation

Attachment 9
NRCS Pasture Conditions Scorecard

DELLAVALLE™
LABORATORY INC

1910 W. McKinley Avenue, Suite 110 ● Fresno, California 93728-1298
Phone (559) 233-6129 ● (800) 228-9896 ● Fax (559) 268-8174
Website: dellavallelab.com

Pasture Condition Score Sheet

Operator:		**Date:**	
Evaluator:		**Pasture ID:**	
Soil(s), ESD(s) and or FSG(s):		**Livestock type:**	
Current Season's Precipitation (check one)	Above Normal ◻ Normal ◻	Below Normal ◻	
Seasonal Temperature Trend (check one)	Above Normal ◻ Normal ◻	Below Normal ◻	

Evaluate the site and rate each indicator based upon your observations. Scores for each indicator may range from 1 to 5. Sum the indicator scores to determine overall pasture condition score.

Indicator	1 Point	2 Points	3 Points	4 Points	5 Points	Score Points
Percent Desirable Plants* (Dry Weight; for Livestock Type)	Desirable species <20% of stand.	Desirable species 20 – 40% of stand.	Desirable species 41 – 60% of stand.	Desirable species 61 – 80% of stand.	Desirable species exceed 80% of stand.	
Percent Legume by Dry Weight	<5% **OR** >50% bloating legumes.	5-10% legumes **OR** >40% bloating legume.	11-20% legumes.	21-30% legumes.	31-40% legumes. No grass loss; grass may be increasing.	
Live (includes dormant) Plant Cover	Less than 40% is live leaf canopy. Remaining is either dead standing material, or bare ground.	40-65% is live leaf canopy. Remaining is either dead standing material, or bare ground.	66-80% live leaf canopy. Remaining is either dead standing material, or bare ground.	81-95% live leaf canopy. Remaining is either dead standing material, or bare ground.	More than 95% live (non-dormant) leaf canopy. Remaining is either dead standing material, or bare ground.	
Plant Diversity by Dry Weight (*See footnote at bottom of page)	**Diversity:** Very low	**Diversity**: Low	**Diversity:** Moderate	**Diversity:** High	**Diversity:** Very high	
	<50% desirable species **OR** 1 dominant desirable species in 1 functional group **OR** No dominant desirable species and all minor species in each functional group totaling <15%	2 dominant desirable species in 1 functional group **OR** 2 functional groups each represented by minor species totaling ≥15%	3 dominant desirable species in 1 functional group **OR** 2-3 dominant desirable species in 2 functional groups **OR** 3 functional groups each represented by minor species totaling ≥15%	4 dominant desirable species in 2 functional groups **OR** 3 dominant desirable species in 3 functional groups **OR** 3 dominant desirable species in 2 functional groups **AND** 1 additional functional group represented by minor species totaling ≥15%	4 dominant desirable species in 3 functional groups **OR** 4 dominant desirable species in 2 functional groups **AND** 1 additional functional group represented by minor species totaling ≥15%	
Plant Residue and Litter as Soil Cover (*Pull back canopy*)	Bare soil is very easily seen;	Openings of bare soil can be seen fairly easily;	Small openings of bare soil can be seen, but minimal;	No bare soil is easily seen;	No bare soil is seen;	
	There is <20% cover on the soil surface or it is excessive, and slow to break down.	Soil cover is 21-40%.	Soil cover is 41-60%.	Soil cover is 61-80%.	Soil cover is >80% with good biological activity and decomposition of older residue.	
Grazing Utilization and Severity	Pasture is overgrazed throughout.	Pasture consists primarily of overgrazed and/or refused areas (former dung areas, older plants, undesired plants).	Pastures show uneven grazing throughout with heavier grazing near water or feeding areas, or distinct zone grazing.	Pasture grazed evenly throughout with minimal overgrazing with some under grazed small areas and heavier use near water sources.	Pasture grazed evenly throughout with no overgrazing.	

*Use NRCS plant list for livestock species. Functional groups are as appropriate for your state (cool-season grasses, legumes, warm-season grasses, non-leguminous forbs). Any time there are more undesirables than desirables, it will be 1 point. Desirable species must total more than 50% of the total biomass. Dominant species are ≥15%. Functional groups must be ≥15% of stand to be counted.

Indicator	1 Point	2 Points	3 Points	4 Points	5 Points	Points
Livestock Concentration Areas (If field <1 acre, see ** footnote)	Livestock concentration areas are within 100 feet of, or are a direct conveyance to surface water, and cover more than 0.1 acre, including trails.	Livestock concentration areas are within 100 feet of, or are a direct conveyance to surface water, and cover less than 0.1 acre, including trails.	Livestock concentration areas are farther than 100 feet from and are not a direct conveyance to surface water, and cover more than 0.1 acre, including trails.	Livestock concentration areas are farther than 100 feet and are not a direct conveyance to surface water, and cover less than 0.1 acre, including trails.	Livestock concentration areas, including trails, not present.	
Soil Compaction and Soil Regenerative Features (***See footnote at bottom of page)	**Compaction:** Dense or thick platy layer very distinct;	**Compaction:** Dense or moderate platy layer noticeable;	**Compaction:** Thin dense or platy layer still present;	**Compaction:** Minor dense or platy layer; good aggregates common (crumbly soil);	**Compaction:** No dense or platy layers; crumbly soil throughout;	
	Roots: Dominantly horizontal; most shallow/sparse;	**Roots:** Numerous horizontal; moderate amount shallow/sparse;	**Roots:** Some horizontal with increasing downward;	**Roots:** Few horizontal, more downward through the soil profile;	**Roots:** Abundant growth primarily downward through the soil profile;	
	Color: Surface horizon same as subsoil;		**Color:** Surface horizon moderately darker than subsoil;		**Color:** Surface horizon dramatically darker than subsoil;	
	Soil Life: Few or no signs.	**Soil Life:** Signs scattered in surface layer.	**Soil Life:** Signs scattered throughout.	**Soil Life:** Signs numerous throughout.	**Soil Life:** Signs abundant throughout.	
Plant Vigor	No plant recovery after grazing/harvest. Pale, yellow or brown, or severe stunting of desirable forage.	Some recovery. Yellowish green forage, or moderately or slight stunting of desirable forage.	Adequate recovery of desirable forage. Yellowish and dark green areas due to manure and urine patches.	Good recovery of desirable forage. Light green and dark green forage present.	Rapid recovery of desirable forage. All healthy green forage.	
Erosion (Circle all that apply; the overall indicator score will be the lowest rating indicated)	**Sheet and Rill:** Plant density is insufficient to stop runoff, with poor infiltration. Erosion easily visible throughout pasture;	**Sheet and Rill:** Plant density slows runoff. Erosion present and easily seen on steeper terrain;	**Sheet and Rill:** Plant density good and runoff moderate. If present, erosion concentrated on heavily used areas;	**Sheet and Rill:** Plant density high, runoff low, good infiltration. May have evidence of past erosion if present;	**Sheet and Rill:** Plant density high, no runoff, good infiltration. No evidence of present or past erosion;	
	Wind: Severe scoured areas and deposition throughout;	**Wind:** Scoured areas common, deposition effecting plants;	**Wind:** Occasional scoured areas, litter windrolled;	**Wind:** Minimal soil exposed, some detatched vegetation windrolled, minor plant damage;	**Wind:** No exposed soil;	
	Streambank and/or Shoreline: Banks bare, major sloughing, no bank vegetation;	**Streambank and/or Shoreline:** More than half the bank vegetation trampled; sloughing.	**Streambank and/or Shoreline:** Less than half the bank vegetation trampled; eroding at crossing/entrances.	**Streambank and/or Shoreline:** Eroding at crossings, entrances; all the bank vegetation is intact and banks are stable.	**Streambank and/or Shoreline:** Vegetation intact and stable, hardened crossings and alternative water sources used;	
	Gully: Very large mass movement, caving sides.	**Gully:** Advancing upslope, increasing fingering extensions.	**Gully:** Not all active but extensions present.	**Gully:** Stable with vegetative cover.	**Gully:** None, drainage ways vegetative.	

** If field size is less than 1 ac. Use 10% of field size in place of 0.1 acre. ***Use a shovel. Root and Compaction subindicators are primary and should be considered first. Soil color and soil life are secondary subindicators which can be considered where applicable.

Overall Pasture Condition Score	Individual Indicator Score	Management Change Suggested
45 to 50	5	No changes in management needed at this time.
35 to 45	4	Minor changes would enhance, do most beneficial first.
25 to 35	3	Improvements would benefit productivity and/or environment.
15 to 25	2	Needs immediate management changes, high return likely.
10 to 15	1	Major effort required in time, management and expense.

Overall Pasture Condition Score =

Comments/Notes:

Desirable species are listed in handout - Fieldguide for California Rangelands. Bloating legumes are alfalfa and white clover. Diversity is off of the fieldguide. Soil life is healthy plants, fungus, earthworms, etc.

Attachment 10
NRCS Plant List for Livestock Species in Central Coast CA

DELLAVALLE™
LABORATORY INC

1910 W. McKinley Avenue, Suite 110 ● Fresno, California 93728-1298
Phone (559) 233-6129 ● (800) 228-9896 ● Fax (559) 268-8174
Website: dellavallelab.com

NRCS Plant List

Scientific Name	Common Name	Type	Function
Agropyron cristatum	crested wheatgrass	Perennial	CSGrass
Bromus inermis	smooth brome	Perennial	CSGrass
Dactylis glomerata	Orchardgrass	Perennial	CSGrass
Elymus glaucus	blue wildrye	Perennial	CSGrass
Agropyron cristatum	Crested Wheatgrass	Perennial	Graminoid
Festuca idahoensis	Idaho Fescue	Perennial	Graminoid
Leymus triticoides	Creeping wildrye	Perennial	Graminoid
Lolium multiflorum	ryegrass, Annual	Annual	CSGrass
Nassella viridula	Green Needlegrass	Perennial	Graminoid
Schedonorus arundinaceus	tall fescue	Perennial	CSGrass
Thinopyrum ponticum	tall wheatgrass	Perennial	CSGrass
Erodium cicutarium	Stork's bill	Annual	Forb
Medicago polymorpha	Bur clover	Annual	Legume
Trifolium incarnatum	clover, crimson	Annual	Legume
Trifolium pratense	clover, red	Perennial	Legume
Trifolium subterraneum	clover, Subterranean	Annual	Legume
Trifolium repens	clover, white	Perennial	Legume
Trifolium subterraneum	subterranean clover	Annual	Legume
Vicia sativa	vetch, common	Annual	Legume

Attachment 11
Field Guide to Common California Rangeland Plants

DELLAVALLE™
LABORATORY INC

1910 W. McKinley Avenue, Suite 110 ● Fresno, California 93728-1298
Phone (559) 233-6129 ● (800) 228-9896 ● Fax (559) 268-8174
Website: dellavallelab.com

Field Guide to Common California Rangeland Plants				
Scientific Name	**Common Name**	**Season**	**Time of Year for Flowering**	**IMAGE**
Bromus hordeaceus	Soft Chess, Soft Brome	cool season grass	April-July	
Bromus diandrus	Ripgut Brome	cool season grass	March-June	
Erodium circutarium	Stork's Bill	winter annual broadleav e	February-July	
Avena fatua	Wild Oat	cool season grass	March-June	

Medicago polymorpha	California Burclover	winter annual broadleave	March-June	
Trifolium repens	White Clover	winter annual broadleave	March-December	
Festuca arundinacea	Annual Fescue	cool season grass	May-June	
Lolium multiflorum	Annual Ryegrass	cool season grass	April-September	

Poa annua	Annual Bluegrass	cool season grass	December-July	
Vicia sativa	Common Vetch	winter annual broadleave	April-July	
Dactylis glomerata	Dryland Orchardgrass	cool season grass	May-August	
Elymus glaucus	Blue Wildrye	cool season grass	June-August	

Agropyron cristatum	Crested Wheatfgrass	cool season grass	May-June	
Festuca idahoensis	Idaho Fescue	cool season grass	April to July	
Achnatherum occidentale	Western Needlegrass	cool season grass	May-June	
Achnatherum occidentale	Tall Wheatgrass	cool season grass	July-August	

Attachment 12
Information About Crops (MMP)

DELLAVALLE™
LABORATORY INC

1910 W. McKinley Avenue, Suite 110 ● Fresno, California 93728-1298
Phone (559) 233-6129 ● (800) 228-9896 ● Fax (559) 268-8174
Website: dellavallelab.com

Information About Crops

State: California ***Init. File Rev:*** 5/26/2022

Crop	*Yield Units*	*N Removed Lb/Unit*	*P_2O_5 Removed Lb/Unit*	*K_2O Removed Lb/Unit*	*Source Of Fertilizer Recommendations*
Alfalfa, hay	Ton	60	12.4	50	Western Fertilizer Handbook & Roland Meyer (UCCE) & Inter-agency CNMP Development Committee (2002)
Barley, grain	Ton	64	24	64	Western Fertilizer Handbook & Roland Meyer (UCCE) & Inter-agency CNMP Development Committee (2002)
Barley,silage, boot stage	Ton	16	6	14	Western Fertilizer Handbook & Roland Meyer (UCCE) & Inter-agency CNMP Development Committee (2002)
Barley,silage,dough stage	Ton	10	3.7	10	Western Fertilizer Handbook & Roland Meyer (UCCE) & Inter-agency CNMP Development Committee (2002)
Bermudagrass, hay	Ton	35	10.5	50	Western Fertilizer Handbook & Roland Meyer (UCCE) & Inter-agency CNMP Development Committee (2002)
Clover-grass, hay	Ton	38	11.5	50	Western Fertilizer Handbook & Roland Meyer (UCCE) & Inter-agency CNMP Development Committee (2002)
Corn, grain	Ton	48	20	48	Western Fertilizer Handbook & Roland Meyer (UCCE) & Inter-agency CNMP Development Committee (2002)
Corn, silage	Ton	8	3.5	8	Western Fertilizer Handbook & Roland Meyer (UCCE) & Inter-agency CNMP Development Committee (2002)
Cotton, lint	Bale	80	25	50	Western Fertilizer Handbook & Roland Meyer (UCCE) & Inter-agency CNMP Development Committee (2002)
Oats, grain	Ton	100	37	100	Western Fertilizer Handbook & Roland Meyer (UCCE) & Inter-agency CNMP Development Committee (2002)
Oats, hay	Ton	40	15	40	Western Fertilizer Handbook & Roland Meyer (UCCE) & Inter-agency CNMP Development Committee (2002)
Oats, silage, soft dough	Ton	10	3.7	10	Western Fertilizer Handbook & Roland Meyer (UCCE) & Inter-agency CNMP Development Committee (2002)
Orchardgrass, hay	Ton	35	10.5	50	Western Fertilizer Handbook & Roland Meyer (UCCE) & Inter-agency CNMP Development Committee (2002)
Ryegrass, hay	Ton	32	10.5	50	Western Fertilizer Handbook & Roland Meyer (UCCE) & Inter-agency CNMP Development Committee (2002)
Safflower	Ton	100	25	75	Western Fertilizer Handbook & Roland Meyer (UCCE) & Inter-agency CNMP Development Committee (2002)
Sorghum	Ton	50	20	48	Western Fertilizer Handbook & Roland Meyer (UCCE) & Inter-agency CNMP Development Committee (2002)
Sudan, hay	Ton	32	10	40	Western Fertilizer Handbook & Roland Meyer (UCCE) & Inter-agency CNMP Development Committee (2002)
Sudan, silage	Ton	11	4	15	Western Fertilizer Handbook & Roland Meyer (UCCE) & Inter-agency CNMP Development Committee (2002)
Sugar beets	Ton	8.5	2	18	Western Fertilizer Handbook & Roland Meyer (UCCE) & Inter-agency CNMP Development Committee (2002)
Tall fescue, hay	Ton	32	10.5	50	Western Fertilizer Handbook & Roland Meyer (UCCE) & Inter-agency CNMP Development Committee (2002)
Timothy, hay	Ton	35	10.5	50	Western Fertilizer Handbook & Roland Meyer (UCCE) & Inter-agency CNMP Development Committee (2002)
Triticale, boot stage	Ton	15	6.1	14	Western Fertilizer Handbook & Roland Meyer (UCCE) & Inter-agency CNMP Development Committee (2002)
Triticale, soft dough	Ton	10	3.8	9	Western Fertilizer Handbook & Roland Meyer (UCCE) & Inter-agency CNMP Development Committee (2002)
Wheat, grain	Ton	58	25	60	Western Fertilizer Handbook & Roland Meyer (UCCE) & Inter-agency CNMP Development Committee (2002)
Wheat, hay	Ton	40	15	40	Western Fertilizer Handbook & Roland Meyer (UCCE) & Inter-agency CNMP Development Committee (2002)
Wheat, silage, boot stage	Ton	16	6.4	15	Western Fertilizer Handbook & Roland Meyer (UCCE) & Inter-agency CNMP Development Committee (2002)
Wheat, silage, soft dough	Ton	11	4	10	Western Fertilizer Handbook & Roland Meyer (UCCE) & Inter-agency CNMP Development Committee (2002)

Attachment 13
Nutrient and Manure Management Tables

DELLAVALLE™
LABORATORY INC

1910 W. McKinley Avenue, Suite 110 ● Fresno, California 93728-1298
Phone (559) 233-6129 ● (800) 228-9896 ● Fax (559) 268-8174
Website: dellavallelab.com

Nutrient & Manure Management Tables

MINNESOTA DEPARTMENT OF AGRICULTURE

UNIVERSITY OF MINNESOTA EXTENSION

Table 1. Annual Manure Production and Nutrient Excretion from Livestock

Animal Type	Manure Production per 1,000 lb. of Animal Weight		Excreted Nutrients in Manure per 1,000 lb. of Animal Weight		
	Solid tons/year	Liquid gal./year	N lb./year	P2O5 lb./year	K2O lb./year
BEEF CATTLE					
Calf	19.5	4,591	162	73	130
Finishing	9.0	2,141	131	39	83
Cow	16.8	3,982	128	66	106
DAIRY CATTLE					
Calf	14.6	3,358	146	24	122
Heifer	11.0	2,536	112	39	112
Lactating	20.3	4,876	263	135	146
Dry Cow	9.3	2,241	110	40	88
Veal	4.8	1,153	44	29	73
SWINE					
Nursery	13.9	3,358	292	146	146
Finishing	9.0	2,166	219	73	97
Gestating Sow	4.1	998	61	37	49
Lactating Sow	8.5	2,025	165	107	127
Boar	3.8	900	49	37	37
POULTRY					
Layer	9.1	2,068	316	97	146
Broiler	17.3	4,198	383	256	183
Turkey (F)	8.6	2,044	285	186	124
Turkey (M)	6.8	1,606	203	135	88
Duck	20.1	4,836	392	310	237
HORSE					
Pleasure	9.9	2,394	66	22	22
"Racer"	10.1	2,446	110	55	84
SHEEP					
Feeder	7.5	1,825	146	73	146

Adapted From: Manure Characteristics, MWPS-18 Section 1, Midwest Plan Service, 2004 Second Edition

Table 2. Nitrogen Losses From Animal Manure as Affected by Method of Handling and Storage

Manure Storage and Handling method	Manure Type	% Storage Nitrogen Loss
Daily scrape and haul	Solid (tons)	25
Manure pack	Solid (tons)	30
Open lot	Solid (tons)	50
Litter	Solid (tons)	35
Above ground tank	Liquid (gallons)	20
Below ground covered pit	Liquid (gallons)	20
Below ground open pit	Liquid (gallons)	25
Under-floor dry storage	Solid (tons)	25
Under-floor liquid storage	Liquid (gallons)	20
Earthen storage	Liquid (gallons)	30
Lagoon	Liquid (gallons)	75

Adapted From: Animal Manure as a Plant Nutrient Source, ID-101, Cooperative Extension Service, Purdue University, 2001

Table 3. Nutrient Content of Stored Manure

Animal Type	Liquid Manure (lb./1000 gallons)			Solid Manure (lb./Tons)		
	N	P2O5	K20	N	P2O5	K20
BEEF						
Cows	20	16	24	7	4	7
Finishing Cattle	29	18	26	11	7	11
DAIRY						
Cows	31	15	19	10	3	6
Heifers	32	14	28	10	3	7
SWINE						
Farrowing	15	12	11	14	6	4
Nursery	25	19	22	13	8	4
Gestation	25	25	24	9	7	5
Finishing	58	44	40	16	9	5
POULTRY						
Broilers	63	40	29	46	53	36
Layers	57	52	33	34	51	26
Tom Turkeys	53	40	29	40	50	30
Hen Turkeys	60	38	32	40	50	30
HORSE				14	4	14
SHEEP				18	11	26

Manure Management in Minnesota, FO-3553-C, University of Minnesota Extension, 2012 Manure Characteristics, MWPS-18 Section 1, Midwest Plan Service, 2004

Table 4. Nitrogen Availability and Loss as Affected by Method of Manure Application and Animal Species

Year Available (1)	% of Total Nitrogen Available Per Year				
	Broadcast Incorporation Time (2)			Injection	
	> 96 hrs	12-96 hrs.	<12 hrs.	Sweep	Knife
BEEF					
Year 1	25	45	60	60	50
Year 2	25	25	25	25	25
Lost	*40*	*20*	*5*	*5*	*10*
DAIRY					
Year 1	20	40	55	55	50
Year 2	25	25	25	25	25
Lost	*40*	*20*	*10*	*5*	*10*
SWINE					
Year 1	35	55	75	80	70
Year 2	15	15	15	15	15
Lost	*50*	*30*	*10*	*5*	*15*
POULTRY					
Year 1	45	55	70	NA	NA
Year 2	25	25	25	NA	NA
Lost	*30*	*20*	*5*		

From: Manure Management in Minnesota, FO-3553-C, University of Minnesota Extension Service, 2007

(1) *Third year available N is not listed but can be computed by adding 1st and 2nd year and lost percentages and subtracting this sum from 100.*

(2) *Timing categories refer to the length of time between manure application and incorporation.*

Calibrating Your Manure Spreader

1. Determine manure weight (solid manure) or manure volume (liquid manure) per spreader load (*Use measured manure weight or 90% of the manufacturer's listed volume for liquid).*
2. Calculate rate based on loads applied per field of known size **OR** calculate rate based on acres covered per load (*Length x Width of Spread (ft.^{2})/43,560*).

Table 5. Average Nutrient Removal Rates for Crops in the Northcentral Region

Crop	Crop Nutrient Removal (lb. per unit)			
	Yield Units	N	P2O5	K2O
Alfalfa	ton (air dry)	51	12	49
Alsike clover	ton (air dry)	41	11	54
Barley (grain)	bushel	0.99	0.4	0.32
Barley (grain & straw)	bushel	1.39	0.56	1.52
Birdsfoot trefoil	ton (air dry)	45	11	42
Canola	bushel	1.9	1.2	2
Corn (grain)	bushel	0.9	0.38	0.27
Corn silage	ton (as fed)	9.7	3.1	7.3
Beans, dry	bushel	3	0.79	0.92
Bromegrass	ton	32	10	46
Orchardgrass	ton	36	13	54
Oats (grain)	bushel	0.77	0.28	0.19
Oats (straw)	ton	12	6.3	37
Potatoes (tuber)	cwt	0.32	0.12	0.55
Red clover	ton	45	12	42
Rye (grain)	bushel	1.4	0.46	0.31
Rye (straw)	ton	12	3	22
Soybeans	bushel	3.8	0.84	1.3
Sugar beets	ton	3.7	2.2	7.3
Sunflowers	cwt	2.7	0.97	0.9
Wheat (grain)	bushel	1.5	0.6	0.34
Wheat (straw)	ton	14	3.3	24

Source: International Plant Nutrition Institute (IPNI) Sept. 2005 http://nanc.ipni.net/articles/NANC0005-EN

Table 6. Common Fertilizer Analyses

Example to calculate fertilizer price per pound:
Urea (46-0-0) = $600/ton
(2000 lb. X .46% N) = 920 lb. N/ton
$600 / 920 lb.= $0.65/lb.

Fertilizer	Analysis
N	
Anhydrous Ammonia	82-0-0
Ammonium Nitrate	34-0-0
Urea	46-0-0
UAN Solution (*Urea Ammonium Nitrate*)	28 to 32-0-0
Ammonium Sulfate	21-0-0-24(S)
P	
Triple Superphosphate (TSP)	0-44 to 0-46
Diammonium Phosphate (DAP)	18-46-0
Monoammonium Phosphate (MAP)	11-52-0
Ammonium Polyphosphate Liquid (APP)	10-34-0
Ammonium Polyphosphate Dry (APP)	15-62-0
K	
Potassium Chloride (*Muriate of Potash*)	0-0-60
Potassium Sulfate	0-0-50-18(S)
Potassium-Magnesium Sulfate (*Sul-fo-mag*)	0-0-22-22(S)-11(Mg)
Potassium Nitrate	13-0-44

Table 7. Nitrogen Rate Guidelines for Corn (When Using a Manure Source)

Previous Crop[1]	Soil / Field Productivity Potential	
	Highly Productive Soils	Medium Productive Soils[2]
	------------ lb. N/A ------------	
CORN	130 - 180	130
SOYBEAN	100 - 140	100

[1]For previous crops other than corn or soybeans use the corn following corn rate guideline and subtract any previous crop N credits in Table 8.

[2]Soil and environmental conditions that limit crop production such as erosion, poor soil drainage, restriction to root growth, short growing season, and marginal growing season rainfall, among others, would qualify a site as having medium productivity potential.

Table 8. Legume Nitrogen Credits

For Corn, Wheat, and Barley grown the 1st and 2nd year after a legume crop

Legume (*Previous Crop*)	Corn		Wheat & Barley	
	1st year	2nd year	1st year	2nd year
Soybeans	40	0	20	0
Edible beans	20	0	10	0
Field peas	20	0	10	0
Red Clover	75	35	35	20
Harvested sweet clover	20	0	10	0
Harvested alfalfa or nonharvested sweet clover (plants/ft 2)				
4 or more	150	75	75	35
2-3	100	50	50	25
1 or less	40	0	0	0

Table 9. Nitrogen Sources Per Pound Conversions

Anhydrous Ammonia (82-0-0)		Urea (46-0-0)		UAN (28-0-0)	
Price per ton	N Price per. lb	Price per ton	N Price per. lb	Price per ton	N Price per. lb
400	$0.25	350	$0.38	200	$0.36
450	$0.28	385	$0.42	225	$0.40
500	$0.30	420	$0.46	250	$0.45
550	$0.34	455	$0.49	275	$0.49
600	$0.37	490	$0.53	300	$0.54
650	$0.40	525	$0.57	325	$0.58
700	$0.43	560	$0.61	350	$0.63
750	$0.46	595	$0.65	375	$0.67
800	$0.49	630	$0.68	400	$0.71
850	$0.52	665	$0.72	425	$0.76
900	$0.55	700	$0.76	450	$0.80
950	$0.58	735	$0.80	475	$0.85
1,000	$0.61	770	$0.84	500	$0.89
1,050	$0.64	805	$0.88	525	$0.94
1,100	$0.67	840	$0.91	550	$0.98
1,150	$0.70	875	$0.95	600	$1.07
1,200	$0.73	910	$0.99	650	$1.16

Table 10. Conversion Factors

1 acre = 43,560 sq. ft
1 cubic ft. = 7.48 gallons
1 gallon of water = 8.33 lb.
1 ton = 2000 lb.
SOIL TESTING CONVERSIONS
Plow Layer (6-7 in) = ppm X 2 = lb./acre
Top 12 inches = ppm X 4 = lb./acre
Top 24 inches = ppm X 8 = lb./acre
P2O5 X 0.44 = P
P X 2.29 = P2O5
K2O X 0.83 = K
K X 1.20 = K20
FERTILIZER CONVERSIONS
1 gal. of UAN (28%) = 10.66 lb.
1 gal. (10-34-0) = 11.65 lb.
1 gal. (7-21-7) = 11.0 lb.
1 gal. (9-18-9) = 11.11 lb.

Manure Management Related Websites

Certified Manure Testing Laboratories: http://www2.mda.state.mn.us/webapp/lis/manurelabs.jsp
University of Minnesota Manure Management: http://www.manure.umn.edu/
Minnesota Department of Ag Manure Management: http://www.mda.state.mn.us/protecting/conservation/practices/manuremgmt.aspx
Minnesota NRCS Manure Management: http://www.mn.nrcs.usda.gov/technical/ecs/nutrient/manure/manure.htm
Nitrogen Best Management Practices (BMPs): http://www.mda.state.mn.us/nitrogenbmps
Nitrogen Rate Calculator: http://extension.agron.iastate.edu/soilfertility/nrate.aspx
Minnesota Pollution Control Agency: http://www.pca.state.mn.us/index.php/topics/feedlots/feedlot-nutrient-and-manure-management.html?menuid=&redirect=1

Printing made possible through a grant from Conservation Marketplace Midwest

Nov. 2012

End of Report

This page intentionally left blank