



PUBLIC NOTICE

Date posted: 2/5/2025

DEQ Requests Comments on Proposed Biosolids Management Plan for the City of Enterprise

HOW TO PROVIDE PUBLIC COMMENT

Facility name: City of Enterprise Wastewater Treatment Facility

Permit type: NPDES

Comments due by: Thursday, March 13, 2025 at 5 p.m.

Send written comments to:

By mail: Permit Coordinator, Oregon DEQ
800 SE Emigrant Ave., Ste 330 Pendleton OR 97801

By email: water.permitter@deq.oregon.gov

The Oregon Department of Environmental Quality invites the public to provide written comments on the City of Enterprise's proposed Biosolids Management Plan. DEQ requires the city to maintain a biosolids management plan as a condition of their water quality permit.

Summary

This plan allows the City of Enterprise to remove biosolids from the City owned Enterprise Wastewater Treatment facility and land apply on private agricultural land in Wallowa County. The biosolids program including the beneficial use sites are described in the biosolids management plan. As a permit requirement, these plans have been updated and are on public notice. Part of the review process is an opportunity for public comment on the plan and other DEQ information. Subject to public review and comment, DEQ plans to approve the plan.

About the facility

Enterprise's Wastewater Treatment facility is a domestic wastewater treatment facility consisting of an extended aeration activated sludge process including UV effluent disinfection and sledge dewatering and storage. The facility plans to apply biosolids for beneficial reuse at application sites located both north and southwest of the City of Enterprise and are zoned for exclusive farm use.

The facility holds a National Pollution Discharge Elimination System permit from DEQ.

What happens next?

DEQ will hold a public hearing if it receives written requests for a hearing during the public comment period from at least 10 people or from an organization representing at least 10 people.

DEQ will consider and respond to all comments received and may modify the proposed permit based on comments.

For more information

Translation or other formats

[Español](#) | [한국어](#) | [繁體中文](#) | [Русский](#) | [Tiếng Việt](#) | [العربية](#)
800-452-4011 | TTY: 711 | deqinfo@deq.oregon.gov

View information about this proposed Biosolids Management Plan and Site Authorization documents [Public Notice](#) or contact Patty Isaak at 541-613-1125 or water.permitter@deq.oregon.gov with questions or to view documents in person at a DEQ office. Visit the [Your DEQ Online Help page](#) for more information on how to access public notice documents and submit comments through this platform. **Non-discrimination statement**

DEQ does not discriminate on the basis of race, color, national origin, disability, age or sex in administration of its programs or activities. Visit DEQ's [Civil Rights and Environmental Justice page](#).

BIOSOLIDS MANAGEMENT PLAN

JANUARY 2025



Prepared for the
City of Enterprise, Oregon

BIOSOLIDS MANAGEMENT PLAN

FOR

CITY OF ENTERPRISE, OREGON

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM PERMIT NO. 101659

JANUARY 2025



ANDERSON PERRY & ASSOCIATES, INC.

**La Grande, Redmond, Hermiston, and Enterprise, Oregon
Walla Walla, Washington**

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Introduction

This Biosolids Management Plan outlines the beneficial use of sewage sludge removed from the City of Enterprise, Oregon's mechanical wastewater treatment facility (WWTF). This Plan has been developed in accordance with the Oregon Department of Environmental Quality (DEQ) Biosolids Management Plan Outline. This Plan has also been developed in accordance with Oregon Administrative Rules (OAR), Chapter 340, Division 050, and supersedes all previous plans. The intent of this Plan is to guide beneficial use of WWTF biosolids for crop production.

The City owns and operates a municipal wastewater collection system, and mechanical WWTF. Wastewater processed by the treatment works is primarily of domestic origin and no formal pretreatment program is required to be implemented under the City's National Pollutant Discharge Elimination System (NPDES) Permit No. 101659. The City's current NPDES Permit was issued on June 1, 2020, and is effective through March 31, 2025.

Wastewater Treatment Facility

Liquids Processing

The City treats its wastewater using an extended aeration activated sludge process at the mechanical WWTF (see Figure 1, Location and Vicinity Maps, and Figure 2, Wastewater Treatment Facility Site Plan). The original sewer system began operation in 1915 utilizing a large septic tank. Then, in 1955, a trickling filter was constructed. In 1986, the City made improvements to the WWTF by constructing an effluent polishing and dechlorination lagoon. The next improvements in 2007 involved a major overhaul of the WWTF and replacement of the aged wastewater treatment system. The 2007 improvements included a new headworks, influent pumping facilities, treatment facilities (four aeration tanks, two clarifiers, and aerobic digesters), an ultraviolet (UV) light disinfection system, sludge dewatering, sludge storage, blower system, impure water distribution, and appurtenant piping and buildings. Currently, the City's WWTF treats and beneficially uses wastewater for irrigation on the Alpine Meadows Golf Course along with discharging to the Wallowa River in accordance with NPDES Permit No. 101659. The City discharges treated effluent to the Wallowa River just above the confluence with Trout Creek when not storing treated effluent for irrigation. During the months of April through October, in accordance with its permit, the City conveys treated effluent to a 1.2-million gallon (MG) pond at the south end of the Alpine Meadows Golf Course that stores the treated effluent until the golf course uses it for irrigation of approximately 51 acres. However, the City is allowed to discharge to the Wallowa River year-round per its NPDES Permit.

At the City's WWTF, wastewater enters through a Parshall flume for measuring influent flow. The wastewater is processed through a screen agitator for liquidizing fecal matter to assist with washing material through the screen, then wastewater is screened at the headworks with an inclined mechanical screen. Following the screen, wastewater enters the two aerated grit chambers for removal of sand and grit. A grit slurry pump sends grit to a dewatering unit where it is dewatered and deposited for landfill disposal. Influent flow leaving the grit chamber goes to an influent pump station containing three pumps that alternate pumping duties. The influent pump station pumps wastewater to the influent flow control box, located at the inlet of the treatment system. After the influent flow control box, the screened and de-gritted wastewater flows to the selector tank that is

within a larger common-walled structure containing the aeration tanks, clarifiers, and aerobic sludge digesters. The wastewater in the selector tank is mixed with return activated sludge (RAS) pumped from the clarifier. From the selector tank, the flow enters one of two treatment trains, each beginning with a first stage aerobic treatment tank. The aerobic tanks contain coarse bubble aerators for oxygenating and mixing to reduce organic material. The wastewater flow then enters the second stage of aeration tanks containing sidewall coarse bubble aerators for additional aeration and mixing. Process air is supplied via trilobe positive displacement blower systems. Flow then exits the second stage of aeration tanks through screened inlets and enters the clarifiers. The clarifiers have distribution piping to evenly provide flow throughout the clarifier from the second aeration tank. In the clarifiers, the solids are separated then removed by the RAS pumps and returned to the selector tank, while clarified water goes to the disinfection system. In the disinfection system, the clarified effluent passes through UV light reactor channels for disinfection. After disinfection, treated effluent flows through an effluent metering box and outfall box. As noted above, the treated effluent can be directed to the Wallowa River in accordance with the NPDES Permit or to the 1.2 MG pond at the Alpine Meadows Golf Course for disposal through irrigation.

Solids Processing

For the solids processing, waste activated sludge (WAS) is stabilized in the aerobic digesters. Air lift pumps transfer WAS from the first aeration tanks to the digester tanks where the solids settle to the bottom and thicken. Once stabilized in the aerobic digesters, waste digested sludge is then pumped from the digesters to the sludge dewatering component of the WWTF.

The stabilized, or digested, sludge settled in the bottom of the digesters is pumped to the sludge dewatering building. Polymer is injected from a feed system through a feed pipe to the flocculation tank where it is mixed with the digested sludge. This mixture coagulates to produce floc and is fed through a screw press for dewatering. Once the sludge is dewatered by the screw press, an auger conveys it to the sludge storage building where the sludge is stored until being transported to the landfill or an application site. All liquid (pressate) from the screw press returns to the headworks and is treated through the WWTF.

Sewage sludge is a natural byproduct of the wastewater treatment process. To balance the amount of biomass in inventory and control the biological process, biosolids are wasted from the WWTF continuously, dewatered, and stored in the sludge storage building. Historically, biosolids were collected and stored in a dumpster until the dumpster was full and transported to the landfill for disposal. Starting in early 2025, the landfill will no longer accept the biosolids, and the City will be required to land-apply biosolids for disposal. Currently, the City estimates that approximately 613 cubic yards (CY), or 77 dry tons, of biosolids are produced by the WWTF annually.

Based on the estimated biosolids production and the capacity of the sludge storage building, the frequency of land application is anticipated to be performed on a semi-annual basis (i.e., once in the spring and once in the fall), or as required. The landfill is operated by Wallowa County, who currently hauls and disposes of the biosolids in the landfill at no cost to the City. Thus, the City has not historically budgeted for transportation and land application of biosolids. The City plans to procure equipment for transportation and land application of biosolids. This will allow the City's public works department to complete the hauling and land application work, and the City will budget to cover those additional costs starting in the 2024/2025 fiscal year.

Septage Receiving Facilities

The City does not accept septage at its facility.

Pretreatment Program

At this time, the City is not required to implement an industrial wastewater pretreatment program, as there are no industrial dischargers currently utilizing the system. Pollutant monitoring requirements, as stated in the current NPDES Permit, will ensure biosolids land application occurs within federal and state limitations.

Biosolids Treatment Processes

Under 40 Code of Federal Regulations (CFR) Part 503 and OAR 340-050, pathogen reduction and vector attraction reduction for biosolids must be met prior to land application. Vector attraction reduction requirements can also be met at the time of land application if biosolids are injected below the surface of the land or incorporated into the soil within six hours after land application. Biosolids are categorized as Class A or B, depending on the mode used to determine pathogen reduction. Biosolids may also be classified as exceptional quality if they meet pollutant concentration limits in 40 CFR Part 503, one of the Class A pathogen reduction alternatives in 40 CFR 503.32(a), and one of the vector attraction reduction options in 40 CFR 503.33(b)(1) through (8). To meet regulatory requirements, pathogen reduction must be met before or at the time vector attraction reduction is achieved.

The City will certify, in writing, that Class B pathogen requirements and vector attraction reduction requirements are met. The City will also notify the DEQ in writing and obtain written approval prior to any process change that would use a pathogen reduction or vector attraction reduction method other than what is specified in this Plan.

Pathogen Reduction

Pathogen reduction requirements of 40 CFR 503 and OAR 340-050 for biosolids will be met by utilizing Alternative 1, Fecal Coliform Testing. The geometric mean of the density of fecal coliform of seven representative samples shall be less than either 2 million most probable number or 2 million colony forming units (CFUs) per gram of total solids (dry weight basis). Prior to land application, seven samples will be collected and tested to find the seven-sample geometric mean of the fecal coliform density to within a reasonable error. Provided the results have a low standard of deviation and the seven-sample mean is less than the 2 million CFUs per gram of total solids as outlined in 40 CFR 503, the biosolids will meet compliance.

Vector Attraction Reduction

Vector attraction reduction requirements of 40 CFR 503 are met by Option 3, 40 CFR 503.33(b)(3), additional digestion of aerobically digested biosolids. For Option 3, aerobically digested biosolids with 2 percent or less solids are considered to have achieved vector attraction reduction if the volatile solids are reduced by less than 15 percent in a laboratory batch test at 20° Celsius after 30 days. If Option 3 is met, this shows the biosolids have already been substantially degraded biologically prior to aerobic digestion. As such, there is low likelihood of the biosolids being a food source for microorganisms, and it is unlikely for vectors to be attracted to the biosolids. If the biosolids are unable to meet the requirements of Option 3, the biosolids will then follow Option 10

for vector attraction reduction and be incorporated into the soil within six hours after application to land or placement on the surface of the biosolids land application sites. When the appropriate Class B biosolids pathogen and vector attraction reduction parameters are met, the biosolids are considered available for spreading at the DEQ-approved biosolids land application sites.

Biosolids Storage

Wastewater Treatment Facility

The dewatered biosolids will be stored in the City's sludge storage building until being transported to the biosolids land application sites for disposal. The sludge storage building is heated and ventilated for year-round use. It is estimated that the sludge storage building is capable of storing approximately 320 CY of biosolids. The City is also in the process of constructing two drying beds for use if the sludge dewatering unit is non-operational or if additional sludge storage is needed. The proposed drying beds will consist of two drying beds with a total area of 1,200 square feet capable of processing approximately two months of sludge from the WWTF.

Staging

Annual biosolids production, which is estimated to be approximately 613 CY, or 77 dry tons, at a total solids estimate of approximately 15 percent, will be stored in the sludge storage building at the WWTF until it is time for the City to land-apply biosolids. As mentioned above, the sludge storage building can store approximately 320 CY and, therefore, cannot store a complete year of biosolids and will require removal once space is no longer available, or biosolids will be sent/transferred to the proposed drying beds. Once the biosolids are ready for land application, the biosolids will be loaded and transported from the sludge storage building to the biosolids land application sites with a combination of new equipment being procured and existing City-owned equipment. Biosolids may be staged at the biosolids land application sites on a limited time basis prior to land-applying.

Site Storage

The City will not store biosolids at the biosolids land application sites. Provided Option 3 for vector attraction reduction are met, the biosolids will be land-applied; however, the biosolids will not be incorporated into the soil. If Option 3 cannot be met, Option 10 will be utilized and all biosolids will be incorporated into the soil within a six-hour period. As noted above, the City may temporarily stage biosolids at the land application sites for a limited time while applying the biosolids.

Transportation and Land Application

The City will utilize a combination of the new equipment being procured for land application and the existing City-owned equipment such as a skid steer, dump truck, etc., for loading and hauling biosolids to the biosolids land application sites. All existing and procured equipment will be used to complete the work necessary for loading, transportation, and land application of the biosolids from the WWTF to the authorized biosolids land application sites. The City may utilize the manure spreader and/or dump trucks to haul biosolids from the WWTF to the biosolids land application sites. The City will be able to handle the volume of biosolids produced through these transportation methods.

Dewatered biosolids will be loaded from the sludge storage building for land application via the City's new or existing equipment. The City equipment will be used to surface apply biosolids at the biosolids

land application sites. The biosolids will be surface applied at the biosolids land application sites by making passes at a specific speed and operation rate to help ensure equal and consistent application over the entire site. Spreading of biosolids will be performed by the City. The application rate will be determined based on residual soil nitrogen levels, nitrogen levels present in the biosolids, and the agronomic rate for crops being grown.

If biosolids are spilled during transportation to the biosolids land application sites, immediate action will be taken to cease further spillage and to remediate the spill. Typically, a vacuum trailer or front-end loader will be used to remove the spilled biosolids and reload the biosolids into the manure spreader or truck.

Remedial Procedures

All spills into Waters of the State or spills on the ground surface that are likely to enter Waters of the State will be reported immediately to the Oregon Emergency Response System at 1-800-452-0311 and the DEQ's regional biosolids specialist as soon as possible after a spill incident.

Spill During Transportation of Biosolids

The City is responsible for cleanup of any biosolids spills that occur during transportation to the biosolids land application sites. If a spill occurs while transporting biosolids between the WWTF and the biosolids land application sites, the City will:

- Contain the spill
- If there is potential for public exposure, post the area and set up temporary fencing
- Remove spilled biosolids with a vacuum trailer, front-end loader, back-hoe, shovel, or other appropriate equipment and tools
- Cover the area with dry lime for sterilization if appropriate (not appropriate adjacent to Waters of the State)
- Apply absorbent (i.e., sand) if the biosolids were in a liquid state during transportation (Note: biosolids are anticipated to be in a dewatered state)
- Transport spilled product to a DEQ-authorized biosolids land application or disposal site

Solids Treatment Process Failure or Modification

The City's WWTF contains two treatment trains for wastewater treatment redundancy. Therefore, if a mechanical problem occurs with any portion of one of the treatment trains, the other treatment train can continue treatment. For sludge dewatering, the City is in the design phase for the proposed drying beds. The proposed drying beds will be utilized if the dewatering equipment goes offline. If a problem occurs with the biosolids removal and land application process, biosolids will remain in the storage location until the needed repairs are made.

If maintenance is needed on a treatment process component that will affect compliance with pathogen reduction or vector attraction reduction requirements, the City will notify the DEQ and obtain approval prior to the maintenance activity.

Monitoring and Reporting

Monitoring and Sampling

The City has developed and implemented a Biosolids Monitoring and Sampling Plan for disposal of biosolids. Samples collected and analyzed will be representative of the biosolids to be land-applied and consistent with the type of sampling required. Quality control measures and procedures will be implemented for microbiological tests to verify precision and accuracy. The frequency and number of samples taken will adhere to Table 1 - Frequency of Monitoring - Land Application in 40 CFR 503.16 and the 1994 *U.S. Environmental Protection Agency (EPA) Biosolids Reference Sheet*, Table 2.4-1., Number of Samples Required, for facilities with less than 1 million gallons per day design flow, and the sampling locations shall follow the process outlined below and included in Appendix A. For the sampling process, the WWTF will operate under normal conditions, and the samples will be collected and analyzed as described in the sampling locations section below and per Appendix A. Only biosolids from the sludge storage building and from the proposed drying beds, once constructed, will be removed and applied at the biosolids land application sites; therefore, the sampling will follow the Biosolids Monitoring and Sampling Plan to provide an appropriate representation of the biosolids. Sampling was performed to help prepare this Plan, and additional sampling will occur as required prior to application. The Biosolids Monitoring and Sampling Plan includes:

- Sampling locations
 - Biosolids Quality
 - Samples for biosolids quality (i.e., pollutants, total solids, and volatile solids) shall be taken at the screw press discharge.
 - Pathogen Reduction
 - Samples for pathogen reduction (i.e., Alternative 1, Fecal Coliform Testing) shall be taken from the stored biosolids inside the sludge storage building or the proposed drying beds.
 - Vector Attraction Reduction
 - Liquid samples for vector attraction reduction (i.e., Option 3, additional digestion of aerobically digested biosolids) shall be taken directly from the aerobic digesters or from a sample tap on the discharge line from the aerobic digesters.
 - The sampling locations for biosolids quality, pathogen reduction, and vector attraction reduction are based on Table 2.2, Sludge Sampling Points, in the *EPA POTW Sludge Sampling and Analysis Guidance Document* and Table 6-5, Sampling Points for Biosolids, in *A Plain English Guide to the EPA Part 503 Biosolids Rule*.
- How samples will be collected, preserved, and transported
 - Collection of Samples
 - Collection of samples will follow Section 2.3.2, Proper Sampling Practices, in the *EPA POTW Sludge Sampling and Analysis Guidance Document*. Collection equipment will be cleaned between each sample period to prevent cross-contamination.

- During collection of samples with liquid sludge, the liquid sludge shall flow for several seconds from the sample tap prior to sampling. The sampling equipment will be washed with laboratory detergent, rinsed with tap water, and then rinsed three times with distilled water to reduce contamination from the previous grab. Glass stirring rods, Teflon-coated stirring rods, or stainless steel spoons will be used to mix the sample in a stainless steel pitcher before transferring it to the sample container. For collection of dewatered sludges, grab samples will be collected in a plastic or stainless steel pail and thoroughly mixed with a scoop or spoon. Once thoroughly mixed, the grab samples will be transferred to sample containers. The grab samples will be composed of several smaller samples taken over a period of a few minutes to improve the sample quality.
- The collection of samples for biosolids quality shall be at the screw press discharge, as mentioned above. The sampling will be completed by collecting grab samples of the dewatered biosolids at the screw press discharge utilizing the collection process for dewatered sludges. The grab samples will be composited together to provide a representative sample.
- For pathogen reduction sampling for Alternative 1, Fecal Coliform Testing, seven discrete grab samples shall be collected over a two-week period preceding use or disposal from the stored biosolids inside the sludge storage building, utilizing the collection process for dewatered sludges. Along with sampling over the two-week period, samples taken from multiple locations and depths within the stored biosolids will provide a sufficiently representative sample of the biosolids and confirm regrowth has been controlled and has not occurred.
- For vector attraction reduction for Option 3, additional digestion of aerobically digested biosolids, samples shall demonstrate vector attraction reduction is being met by volatile solids being reduced by less than 15 percent after 30 days of aerobic digestion at 20° Celsius. Samples shall be a fresh, liquid representative grab sample taken directly from the aerobic digesters or from a sample tap on the discharge line from the aerobic digesters. Liquid samples will be representative as the aerobic digesters are the last process before the sludge is dewatered and then stored. Sampling will occur sufficiently close to the time of biosolids application. Discrete grab samples will be obtained utilizing the collection process for liquid sludges.
- If solids are sent to the proposed drying beds, the collection of samples will follow the *EPA POTW Sludge Sampling and Analysis Guidance Document*. Each drying bed will be divided into quarters, with a grab sample collected from the center of each quarter to form a composite grab sample representing the total drying bed.
- The size of samples from the screw press discharge, the stored biosolids in the sludge storage building, the sample tap on the discharge from the aerobic digesters, or the proposed drying beds will be small enough to conveniently transport and carefully handle in the laboratory but large enough to accurately represent the characteristics of the biosolids. The size of samples will be at least the minimum volume stated in Table 2.3,

Containers, Preservation, Holding Times, and Minimum Sample Volumes, in the *EPA POTW Sludge Sampling and Analysis Guidance Document* and in Table 6-6, Proper Conditions for Biosolids Sampling, from *A Plain English Guide to the EPA Part 504 Biosolids Rule*.

o Preservation of Samples

- The methods for preservation of samples described below are applicable to biosolids quality, pathogen reduction, and vector attraction reduction. The sample container materials, container preparation, preservation, and holding time prior to analysis will adhere to Table 2.3, Containers, Preservation, Holding Times, and Minimum Sample Volumes, in the *EPA POTW Sludge Sampling and Analysis Guidance Document* and Table 6-6, Proper Conditions for Biosolids Sampling, in *A Plain English Guide to the EPA Part 503 Biosolids Rule*.
- Sample preservation shall occur by using method-specific containers, usually made of Teflon, glass, or polyethylene and shall be wide-mouthed for sludge sampling.
- Prior to sample collection, containers shall be washed with a good quality laboratory detergent, thoroughly rinsed with tap water, and then rinsed at least three times with distilled water prior to air drying.

o Transportation of Samples

- The methods for transportation of samples described below are applicable to biosolids quality, pathogen reduction, and vector attraction reduction and will adhere to Section 2.6, Packaging and Shipping, of the *EPA POTW Sludge Sampling and Analysis Guidance Document* and *A Plain English Guide to the EPA Part 503 Biosolids Rule*.
- Samples will be packaged to protect the container and reduce the risk of leakage. Containers will be held upright and cushioned from shock, with sufficient insulation and/or artificial refrigerant to maintain a sample temperature of 39.2° Fahrenheit (4° Celsius) throughout transportation.
- The transportation/shipment time of samples will not exceed 24 hours.

• The analytical method for each analysis

- o The analytical method utilized for each analysis will follow the analytical techniques outlined in 40 CFR 136.

All monitoring and reporting will be conducted in accordance with the City's NPDES Permit and this Plan. The monitoring frequency is based on the amount of biosolids generated by the WWTF. The Biosolids Monitoring and Sampling Plan is included in Appendix A.

Recordkeeping and Reporting Procedures

The City, as the preparer and land applier of biosolids, is required to maintain records to demonstrate that federal and state biosolids requirements are met. Records will be kept on file by the City and will be available upon request by the DEQ. Monitoring and sampling records will be

retained for a period of no less than five years, unless otherwise required by the NPDES Permit or a site authorization letter. The minimum required records include the following information:

- Pollutant concentrations of each parameter stated in the NPDES Permit
- Pathogen requirements as stated in the NPDES Permit for Class B biosolids
- Description of how one of the vector attraction reduction requirements in 40 CFR 503.14 and site restrictions in 40 CFR 503.32(b)(5) are met for each biosolids land application site (note: this is for Class B bulk biosolids)
- Certification that the information submitted is accurate to determine compliance with pathogen and vector attraction reduction requirements and site restriction/management requirements
- Laboratory reports, sampling logs, and calibration logs of any field instruments

Annual Reporting

A biosolids annual report is required to be submitted to the DEQ each year by February 19, or as required by the NPDES Permit. Information required with the annual report includes:

- Daily site logs or records, including date, time, and quantity (gallons, pounds) of nitrogen per acre land-applied
- For each biosolids land application site, the crop grown, the agronomic rate, soil test data sheets, plant available nitrogen (PAN) from the soil, PAN from the biosolids, and the amount of commercial fertilizer or other sources of nitrogen applied. All sources of nitrogen will be reported in pounds of nitrogen per acre (lbs N/acre).
- Map, including scale, showing the biosolids land application sites and the location that coincides with the daily site application method (i.e., manure spreader)
- Signed copy of the certification statement shown under the Certification Statement section of this Plan

Appendix B includes a copy of the annual report form to be submitted to the DEQ every year, along with instructions on how to complete the form.

Certification Statement

The City of is capable of meeting Class B pathogen reduction and vector attraction reduction requirements. As required under 40 CFR 503.17, the City must retain a certification statement indicating whether compliance with pathogen reduction, vector attraction reduction, and certain site restrictions has been met. The certification statement must be retained for a period of five years and must be submitted with the annual report due February 19 or as required. The City will retain the following certification statement, and it will be signed by a principal executive officer or ranking elected official or their duly authorized representative (e.g., individual or position having responsibility for the overall operation of the system, such as the position of plant manager, supervisor, superintendent, or equivalent responsibility).

“I certify, under penalty of law, that the information that will be used to determine compliance with the management practices in Section 503.14, the Class B, Alternative 1, Fecal Coliform

Testing, pathogen requirements in 40 CFR 503.32(b)(2), the site restrictions in Section 503.32(b)(5), and the vector attraction reduction requirement in Section 503.33(b)(3) was prepared for the biosolids land application site(s) on which bulk sewage sludge was applied under my direction and supervision in accordance with the system designed to ensure that qualified personnel properly gather and evaluate this information. I am aware that there are significant penalties for false certification including the possibility of fine and imprisonment.”

Signature_____Date_____

The City of is also required, as the land applier, to certify that the management practices in 40 CFR 503.14 are being met. This certification includes that biosolids are being land-applied at approved agronomic loading rates as specified in DEQ-issued site authorization letters.

“I certify, under penalty of law, that the management practices in 40 CFR 503.14 have been met for the biosolids land application site(s) on which bulk biosolids are applied. This determination has been made under my direction and supervision in accordance with the system designed to ensure that qualified personnel properly gather and evaluate the information used to determine that the management practices have been met. I am aware that there are significant penalties for false certification, including the possibility of fine and imprisonment.”

Signature_____Date_____

Biosolids Characteristics

Pollutant Characteristics

Table 1 is a representative analysis for pollutant characteristics. Samples from the aerobic digester basins were collected on June 21, 2023. These data and all previous data indicate that pollutant concentrations for all regulated pollutants have been met. All test results are included in Appendix C. A comparison was performed of the pollutant concentrations from Table 3 of 40 CFR 503.13, identifying the maximum monthly average concentrations for the specified pollutants. Based on the sampling results, the collected samples met all concentration limits outlined on Table 3 of 40 CFR 503.13; therefore, no site life or annual limitations are required.

TABLE 1
ALLOWED BIOSOLIDS POLLUTION LIMITS AND CONCENTRATIONS

Pollutant	Aerobic Digester Basins Biosolids Analytical Result mg/kg (lbs/ton)	40 CFR 503.13(b)(3) Pollutant Ceiling Concentration Limits mg/kg (lbs/ton)*
Arsenic (As)	ND	75 (0.15)
Cadmium (Cd)	ND	85 (0.17)
Copper (Cu)	167 (0.334)	4,300 (8.6)
Lead (Pb)	ND	840 (1.68)
Mercury (Hg)	ND	57 (0.114)
Molybdenum (Mo)	ND	75 (0.15)
Nickel (Ni)	ND	420 (0.84)

Pollutant	Aerobic Digester Basins Biosolids Analytical Result mg/kg (lbs/ton)	40 CFR 503.13(b)(3) Pollutant Ceiling Concentration Limits mg/kg (lbs/ton)*
Selenium (Se)	ND	100 (0.2)
Zinc (Zn)	411 (0.822)	7,500 (15.0)

*Analytical results are on a dry weight basis.

mg/kg = milligrams per kilogram

lbs/ton = pounds per ton

ND = not detected

Nutrient Characteristics and Other Parameters

Table 2 is a representative biosolids analysis for nutrient characteristics and other parameters. Samples from the aerobic digester basins were collected on June 21, 2023.

TABLE 2
BIOSOLIDS NUTRIENT CHARACTERISTICS

Source Parameter/ Measurement Unit	Aerobic Digester Basins Biosolids Analytical Result		
	Wet Weight	Dry Weight	Pounds per Dry Ton
Total Solids, percent	0.764	N/A	N/A
Volatile Solids, percent	99.8	N/A	N/A
TKN, mg/kg	510.4	66,800	133.6
NO ₃ -N, mg/kg	ND	ND	ND
NH ₄ -N, mg/kg	33.8	4,430	8.86
Phosphate (P), percent	4.2	N/A	N/A

TKN = total Kjeldahl nitrogen

NO₃-N = nitrate nitrogen

NH₄-N = ammonium nitrogen

N/A = not applicable

Biosolids Utilization Program

Biosolids stored in the sludge storage building after being dewatered through the screw press will be transported and land-applied to the biosolids land application sites by the City. Biosolids will be loaded, hauled, spread, and otherwise handled using farming equipment (i.e., manure spreader).

Agronomic Application Rate and Site Crops

Class B biosolids are required to be land-applied to a site at a rate that is equal to or less than the agronomic rate for the site. An agronomic rate is the whole biosolids application rate (dry weight basis) designed to provide the annual total amount of nitrogen needed by a crop and to minimize the amount of nitrogen passing below the root zone of the crop or vegetation to groundwater. The landowner of the biosolids land application sites provided all the potential crops to be grown. The nitrogen uptake rate for each potential crop was determined and is shown in lbs N/acre on Table 3.

TABLE 3
NITROGEN UPTAKE RATES FOR POTENTIAL CROPS

Site Crop	Irrigated Nitrogen Uptake Rate (lbs N/acre)	Irrigated Yield Goals	Dryland Nitrogen Uptake Rate (lbs N/acre)	Dryland Yield Goals	Literature Source for Nitrogen Uptake Rate
Alfalfa	360	5.5 to 6 tons	60	1 ton	Pacific Northwest Extension Publication, PNW0611
Winter Wheat	195	110 to 130 bushels	85	40 to 70 bushels	Pacific Northwest Extension Publication, PNW513
Barley	160	2.5 to 3.5 tons	65	1.25 tons	OSU Cereal Grain Nutrient Management
Oats	120	2.5 to 3 tons	40	1 ton	OSU Cereal Grain Nutrient Management
Mustard/Canola	120	1,500 lbs/ 2,500 lbs	45	800 lbs/ 800 lbs	OSU Extension Publication, EM 8796
Spring Wheat	120	70 to 120 bushels	55	35 bushels	OSU Cereal Grain Nutrient Management
Timothy Hay	100	3.5 to 6 tons	50	1 to 3 tons	University of Idaho Extension Publication
Spelt	90	60 bushels	N/A	N/A	University of Wisconsin-Madison Extension Publication
Brown Flax	80	1,800 lbs	40	500 lbs	OSU Extension Publication, EM 8952-E
Cover Crop Mixture (Oats, Barley, Flax, Peas, Radish) ¹	50	Forage left standing	50	Forage left standing	
Lentils	35	0.5 to 1 ton	10	500 lbs	Alberta Pulse Growers Publication
Peas	20	1.25 to 2 tons	5	1,000 lbs	OSU Extension Publication, EM 9140

¹The application of biosolids on site(s) with the cover crop mixture planted shall have the nitrogen supplied from all sources be counted toward the agronomic rate of the crop planted following the cover crop mixture.

lbs = pounds

OSU = Oregon State University

For the purposes of this Plan, example calculations were completed to illustrate how the biosolids application rate will be determined. The biosolids application rate for one of the City of Enterprise's sites was developed based on test results of the biosolids and guidance provided by Washington State University Puyallup and OSU and the *Worksheet for Calculating Biosolids Application Rates in Agriculture, a Pacific Northwest Extension Publication, PNW511*. The example calculations and assumptions made can be found in Appendix D, Example Nutrient Uptake Calculations. Barley was used for the example calculations for nitrogen uptake. It is assumed that barley will uptake 120 lbs N/acre. There are no published data for barley nitrogen uptake; however, per OSU's Cereal Grain Nutrient Management web page, the nitrogen uptake value for barley is 80 percent of the nitrogen uptake for winter wheat. Using the value stated for winter wheat of 150 lbs N/acre in the *Nitrogen Uptake and Utilization by Pacific Northwest Crops, a Pacific Northwest Extension Publication*,

PNW513, 80 percent of the 150 lbs N/acre for winter wheat results in a 120 lbs N/acre application rate for barley (150 lbs N/acre x 80 percent = 120 lbs N/acre).

Soil testing was completed at the biosolids land application Site 1 - Parsnip Valley, shown on Figure 3, to estimate the residual nitrogen in the soil for the example calculations and provide a baseline for pollutants. The residual soil nitrogen was averaged, with the current, average residual soil nitrogen at the biosolids land application site equaling 89 lbs N/acre (see Appendix C for soil testing). The biosolids will be land-applied semi-annually during the spring and fall. Although the example calculations utilized the biosolids land application Site 1 - Parsnip Valley, shown on Figure 3, the biosolids may be land-applied to any of the biosolids land application sites, totaling approximately 859 acres when accounting for setbacks, at the agronomic rate. See Figures 3 and 4 for the biosolids land application sites.

PAN is calculated by adding inorganic nitrogen retained and organic nitrogen mineralized. Inorganic nitrogen retained is calculated by multiplying the weight of ammonium nitrogen per dry ton of biosolids by the percent retained after application. The percent retained is based on the drying method used and days to incorporation by tillage after application. The biosolids will be dewatered and not incorporated, therefore retaining approximately 20 percent of the ammonium nitrogen. The plant available inorganic nitrogen is calculated to be 1.77 pounds of nitrogen per dry ton (lbs N/dry ton) when not incorporating the biosolids. The organic nitrogen mineralized is calculated by subtracting the ammonium nitrogen from the TKN and multiplying by the percent of organic nitrogen that is plant-available in year one. The percent of organic nitrogen available in year one is approximately 35 percent based on the biosolids processing and moisture content. The amount of organic nitrogen mineralized is calculated as 43.66 lbs N/dry ton. The PAN is calculated as 45.43 lbs N/dry ton. Taking the 120 lbs N/acre needed for barley and subtracting the average residual nitrogen of 89 lbs N/acre determined by the soil testing results in 31 lbs N/acre remaining. The 31 lbs N/acre is divided by the estimated PAN to calculate an application rate of 0.68 dry ton per acre. A copy of the Example Nutrient Uptake Calculations for biosolids application at the biosolids land application Site 1 - Parsnip Valley, shown on Figure 3, with no incorporation is included in Appendix D.

Prior to application, residual soil nitrogen and biosolids testing will be performed to account for existing nitrogen and ensure the application rate does not exceed the agronomic rate of the planted crop. The residual soil nitrogen sampling shall be for $\text{NH}_4\text{-N}$ and $\text{NO}_3\text{-N}$. Sampling shall occur for each foot of soil depth (i.e., 0 to 1 foot, 1 to 2 feet, etc.) at the applicable biosolids land application site(s), with discrete samples of each foot of soil depth composited from representative subsamples. This process will result in a composite sample for each foot of soil depth from the ground surface to the rooting depth of the planted crop at the biosolids land application site.

For fall-planted crops, the sampling and testing for residual soil nitrogen shall be completed during the fall prior to planting and will be counted toward the agronomic rate for the fall-planted crop. Similarly, for spring-planted crops, the sampling and testing for residual soil nitrogen shall be completed during the spring prior to planting and will be counted toward the agronomic rate for the spring-planted crop.

Site Inventory of Existing and Potential Sites

The City does not currently land-apply Class B biosolids. The City previously had a Biosolids Management Plan with approved application sites that are no longer being utilized.

Site Selection Criteria for Application Site(s)

The City requests that a site be approved for land application. Prior to using any site(s) for land application, the City is required to receive a written site authorization letter from the DEQ. The City will look for biosolids land application site(s) within Wallowa, Union, and Baker Counties should the need for additional land arise. The following site conditions will be considered when determining the suitability of a site for land application:

- Site(s) will be located on agricultural land in Wallowa, Union, or Baker County.
- Site(s) should be on a stable geological formation not subject to flooding or excessive runoff from adjacent land.
- Minimum depth to permanent groundwater should be 4 feet, and the minimum depth to temporary groundwater should be 1 foot when application of biosolids occurs.
- Topography should be suitable for normal agricultural operations. Liquid biosolids should not be land-applied on bare soils when the slope exceeds 12 percent. Dewatered or dried biosolids may be land-applied on well vegetated slopes, up to 30 percent.
- Soil should have a minimum rooting depth of 24 inches.

Application Sites Owner/Leaseholder

The City has identified one landowner with multiple sites to allow flexibility in case crop rotations do not allow for biosolids application. However, the City will continue to look for additional biosolids land application sites in the event the identified biosolids land application site(s) change ownership, crop rotation does not allow biosolids application, or there is another reason that biosolids cannot be applied to the identified sites. Currently, the City proposes the following new parcels be approved as biosolids land application sites (see Figures 3 and 4, Biosolids Land Application Sites I and II). These sites exceed the acreage needed for biosolids disposal and provide flexibility in ensuring all site criteria are met. The landowner information for the sites to be utilized for biosolids land application is as follows:

Site 1: Parsnip Valley	Parcel Map No.: 01S44E Lot: 700 Total Parcel Acreage: 288.29 acres (ac) Field: 129.0 ac
Site 2: Stangel Pivot	Parcel Map No.: 01S44E Lot: 7000 Total Parcel Acreage: 98.81 ac Field: 67.2 ac

Site 3: Circle 137	Parcel Map No.: 01S45E Lot: 3300 Total Parcel Acreage: 316.33 ac Field: 134.8 ac
Site 4: Circle 133	Parcel Maps No.: 01S45E, 02S45E Lots: 3300, 1501 Total Parcel Acreage: 316.33 ac, 317.66 ac Field: 132.2 ac
Site 5: Ray West Pivot	Parcel Map No.: 02S44E Lot: 601 Total Parcel Acreage: 204.00 ac Field: 43.4 ac
Site 6: Circle 7	Parcel Map No.: 02S44E Lot: 601 Total Parcel Acreage: 204.00 ac Field: 5.2 ac
Site 7: Circle 20	Parcel Maps No.: 01S44E, 01S45E, 02S33E, 02S45E Lots: 7000, 3300, 601, 1501 Total Parcel Acreages: 98.81 ac, 316.33 ac, 204.00 ac, 317.66 ac Field: 19.9 ac
Site 8: Circle 16	Parcel Maps No.: 01S45E, 02S45E Lots: 3300, 1501 Total Parcel Acreage: 316.33, 317.66 ac Field: 16.9 ac
Site 9: Ray East Pivot	Parcel Map No.: 02S44E Lot: 601 Total Parcel Acreage: 204.00 ac Field: 43.4 ac
Site 10: Circle 114	Parcel Map No.: 02S45E Lot: 1501 Total Parcel Acreage: 317.66 ac Field: 115.1 ac
Site 11: Circle 118	Parcel Map No.: 02S45E Lot: 1501 Total Parcel Acreage: 317.66 ac Field: 117.6 ac
Landowner/Farmer:	Cornerstone Farms J.V. Kurt Melville/Kevin Melville 64022 Imnaha Highway Joseph, Oregon, 97846

Site Management Agreement

The signed site management agreement between the City and the landowner is included in Appendix E for reference.

Soils

Soils at the biosolids land application sites are generally mapped as Hurwal silt loam, Powwatka silt loam, Harlow-Bocker complex, and Topper silt loam (see Figures 5 and 6, Soils Map I and II). Complete official series descriptions from the National Cooperative Soil Survey completed by the Natural Resources Conservation Service are included in Appendix F.

In general, Hurwal series silt loams are deep to very deep, well-drained soils with moderately slow permeability and a depth to water table of more than 80 inches. Roots are present to 58 inches.

Powwatka series silt loams are moderately deep, well-drained soils with moderately slow permeability and a depth to water table greater than 80 inches. Roots are present to 24 inches.

Harlow-Bocker complex are shallow, well-drained soils that have slow to rapid runoff. Soils have slow permeability and a depth to water table of more than 80 inches. Roots are present down to 14 inches where there is an abrupt basalt boundary.

Topper silt loams consist of very deep, well-drained soils with moderate permeability and a depth to water table of more than 80 inches. Roots are present up to 60 inches, with the depth to bedrock greater than 60 inches.

Public Notice

The City is required to notify the public of the proposed land application activity. A public notice campaign addressing property owners and/or those residing on the properties adjacent to or near the biosolids land application sites was completed. Letters and maps were provided to notify them of the application of biosolids and provide pertinent information. The information explained what biosolids are along with the benefits and protective measures to be practiced during the application process. It also included notification of the availability of this Plan for review by the public. Copies of the public notification letters mailed to property owners adjacent to the biosolids land application sites are included in Appendix G. The public notification letters were mailed to adjacent landowners on December 26, 2024.

Site Management Practices

Site access restrictions and setbacks will be followed as outlined in the DEQ's site authorization letters. The City will ensure that access is restricted by appropriate means as necessary, such as fencing or posting signs at the biosolids land application sites. Biosolids land application will not occur in those areas designated as buffer strips and will be achieved through accurate measurement of the buffer area prior to commencing land application.

Setbacks shall be provided at the biosolids land application sites in accordance with DEQ requirements. Setbacks of 200 feet will be provided between the biosolids land application sites and any domestic water sources or wells. A 50-foot setback will be provided between the biosolids land application sites receiving Class B biosolids and any dwelling, ditch, channel, pond, waterway,

surface water, or Waters of the State. All dwellings and domestic wells located in relative proximity to the biosolids land application sites exceed the required 50-foot and 200-foot setbacks, respectively. The location of the biosolids land application sites with the required setbacks are shown on Figures 3 and 4.

Crop Management Practices

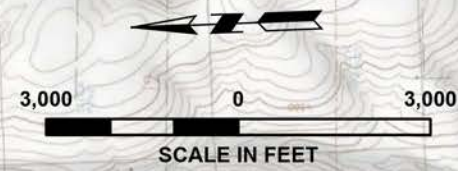
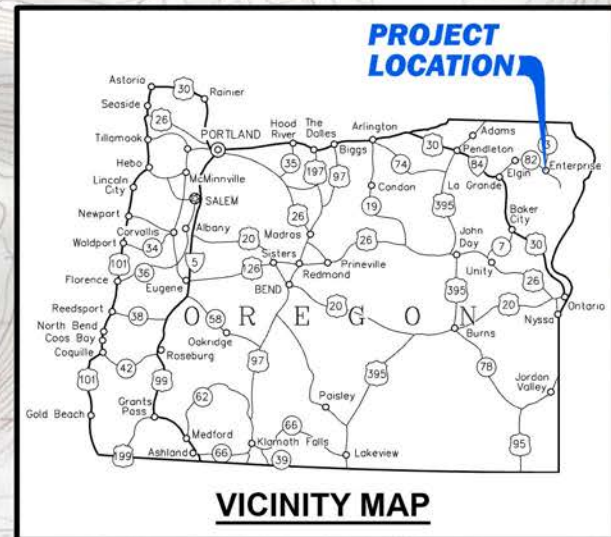
Biosolids will be applied to the biosolids land application sites for agricultural purposes. Winter wheat, spring wheat, barley, mustard/canola, flax, oats, spelt, timothy hay, alfalfa, lentils, peas, and a cover crop mixture of oats, barley, flax, peas, and radish all may be grown at the biosolids land application sites. Barley, oats, flax, timothy hay, or alfalfa will only be utilized as a feed crop for animal consumption, while winter wheat, spring wheat, lentils, and peas may be used for seed crop or human consumption depending on contracts secured by the landowner. Mustard/canola may be grown for human consumption. Spelt is cultivated solely for human consumption. The cover crop mixture of oats, barley, flax, peas, and radish may be utilized for grazing; however, all nitrogen applied through biosolids will be counted toward the following crop's nitrogen uptake rate. Soil conditions must be favorable such that runoff, leaching, or soil compaction does not occur. The timing of land application will take into consideration tilling and irrigation practices that may occur on an authorized site. Biosolids will not be applied any time that fields are frozen, snow-covered, or flooded.

The agreement with the proposed biosolids land application site owner stipulates that additional restrictions apply if food crops are grown. These restrictions are outlined on Figures 2-4 and 2-5 of *A Plain English Guide to the EPA Part 503 Biosolids Rule*, which identifies restrictions for harvesting, grazing of animals, and restrictions for public contact.

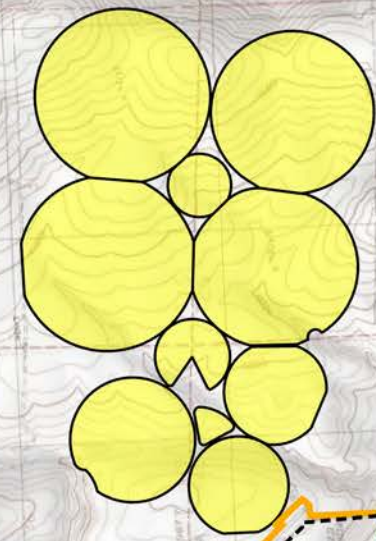
The overall management of nutrients at the biosolids land application site considers the amount of land-applied biosolids, the amount of commercial fertilizer used, and the amount of residual nutrients in the soil. When additional sources of nitrogen (e.g., commercial fertilizer) are applied to a site, then the application of biosolids should be reduced to compensate for the additional nitrogen loading.

FIGURES

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To Clarkston



To Joseph

Enterprise

EXISTING WASTEWATER TREATMENT FACILITY

LEGEND

- CITY LIMITS
- URBAN GROWTH BOUNDARY
- BIOSOLIDS LAND APPLICATION SITE

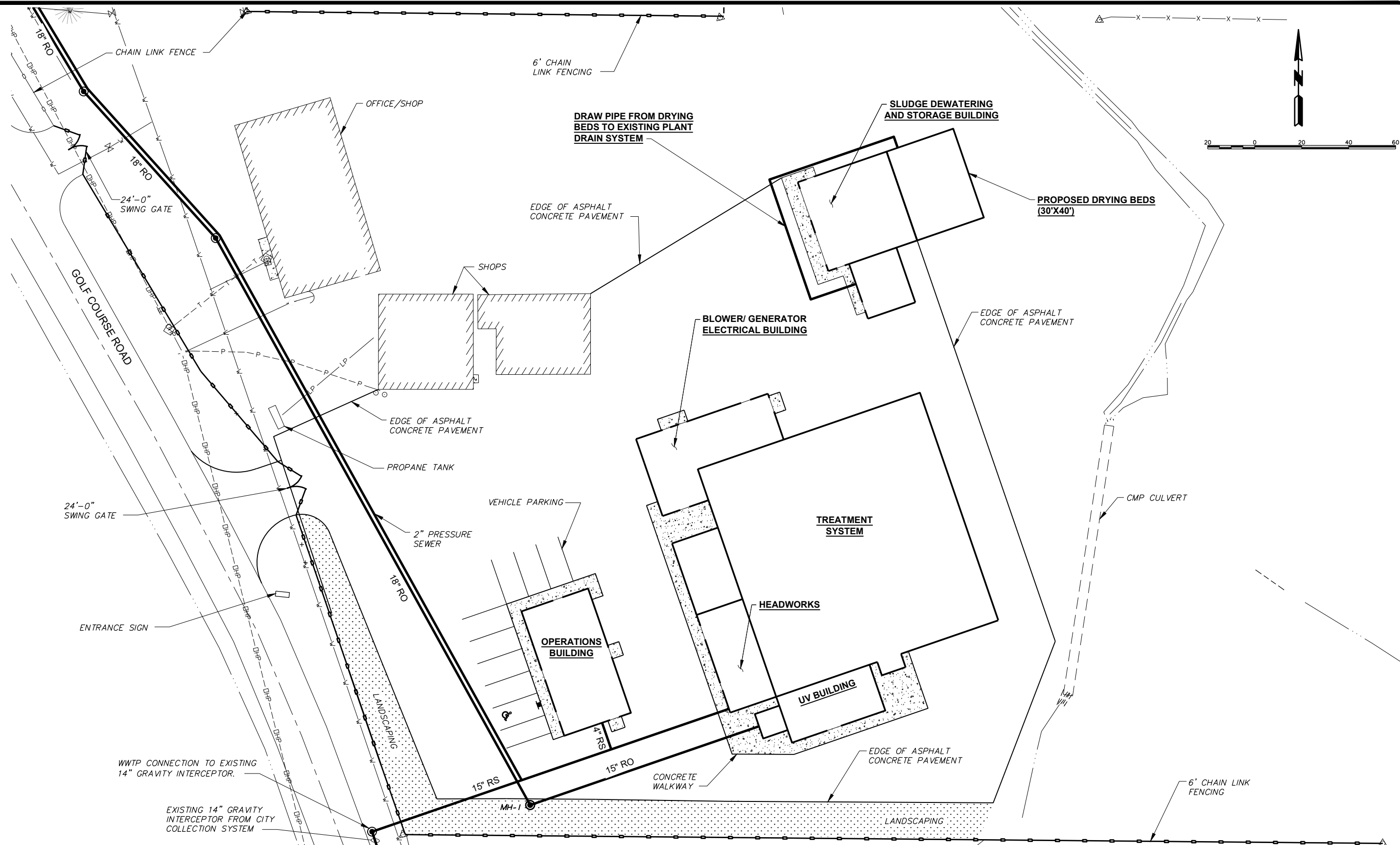
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CITY OF
ENTERPRISE, OREGON
BIOSOLIDS MANAGEMENT PLAN

LOCATION AND VICINITY MAPS

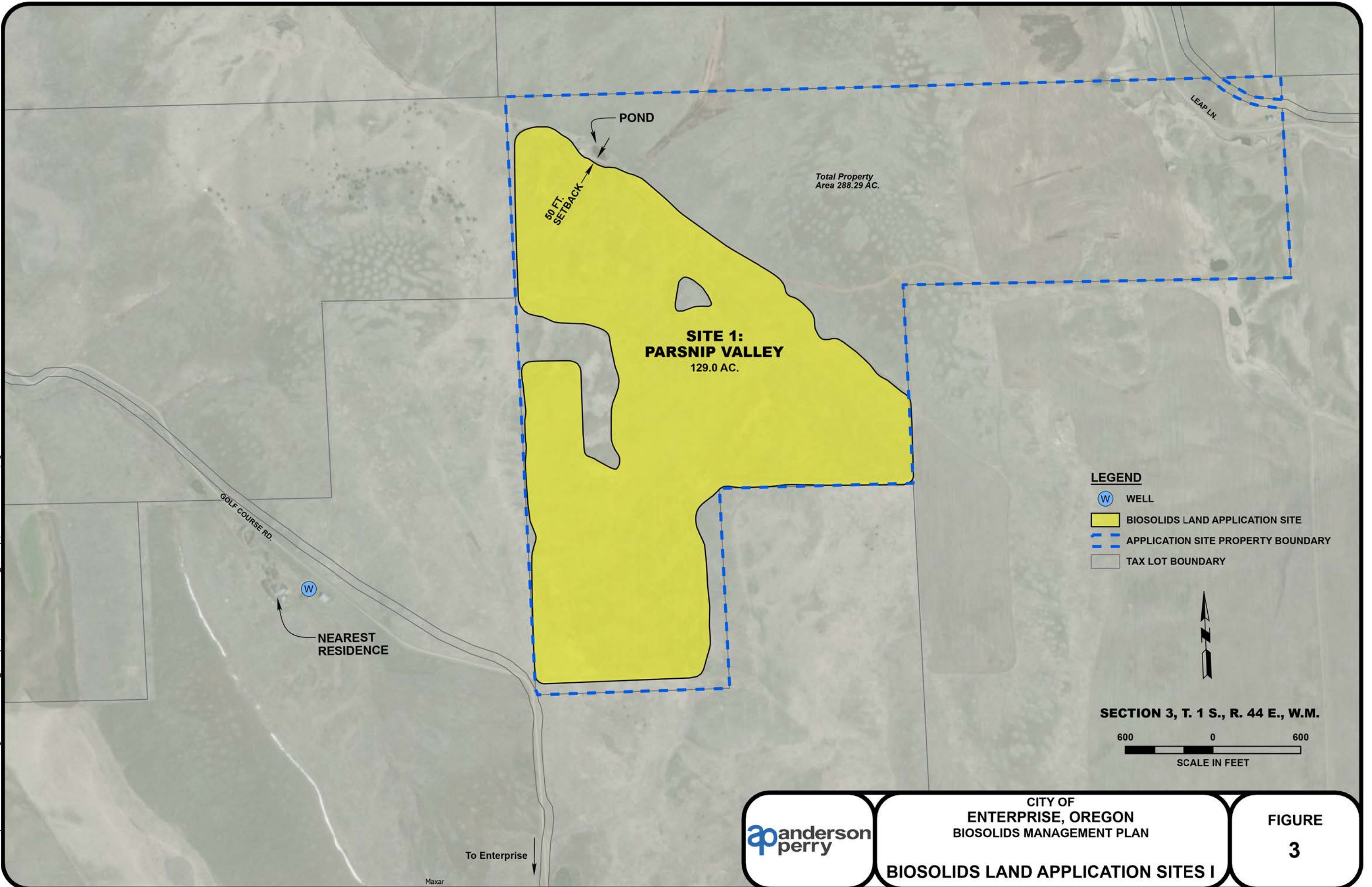
FIGURE
1

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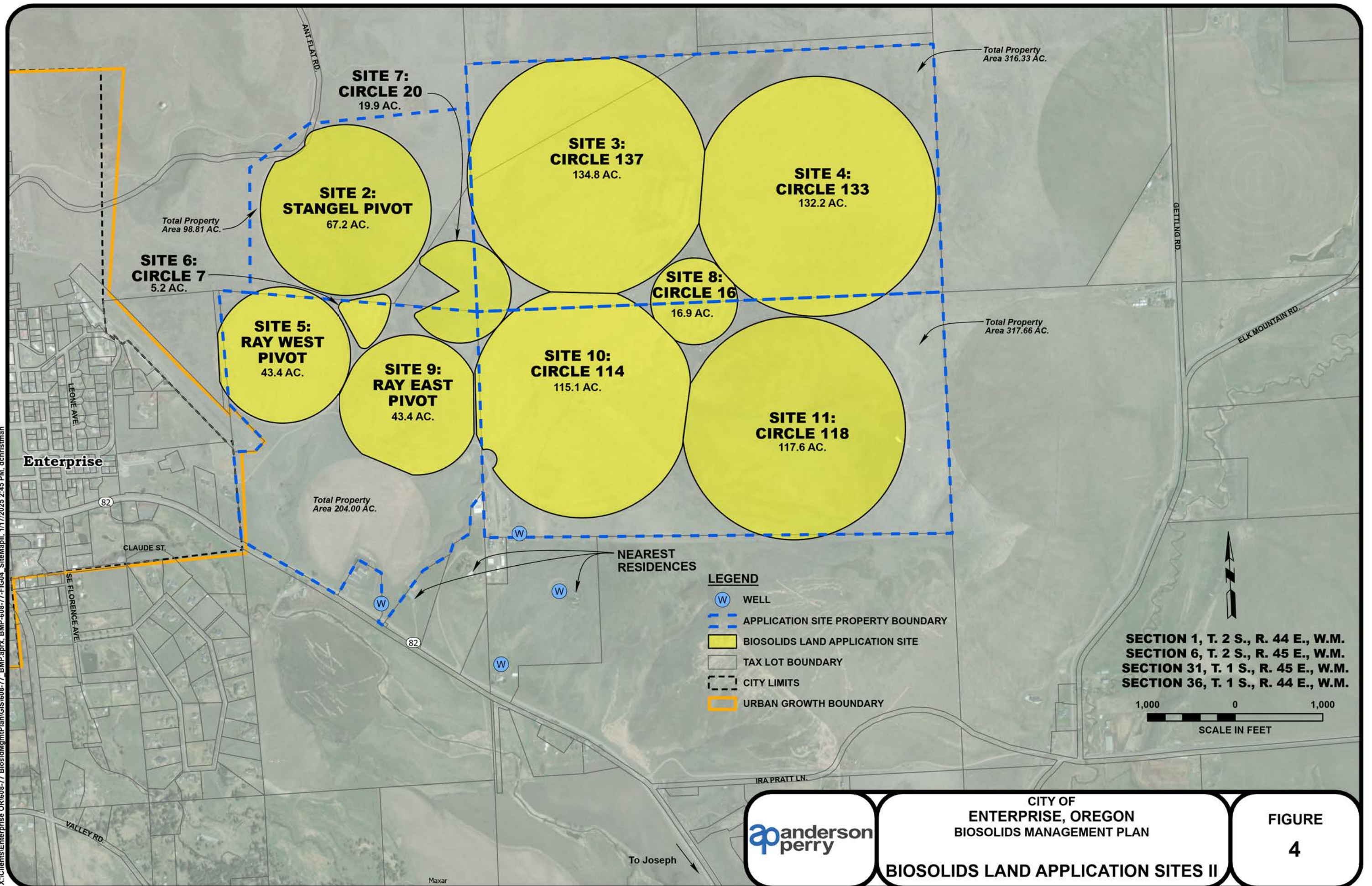


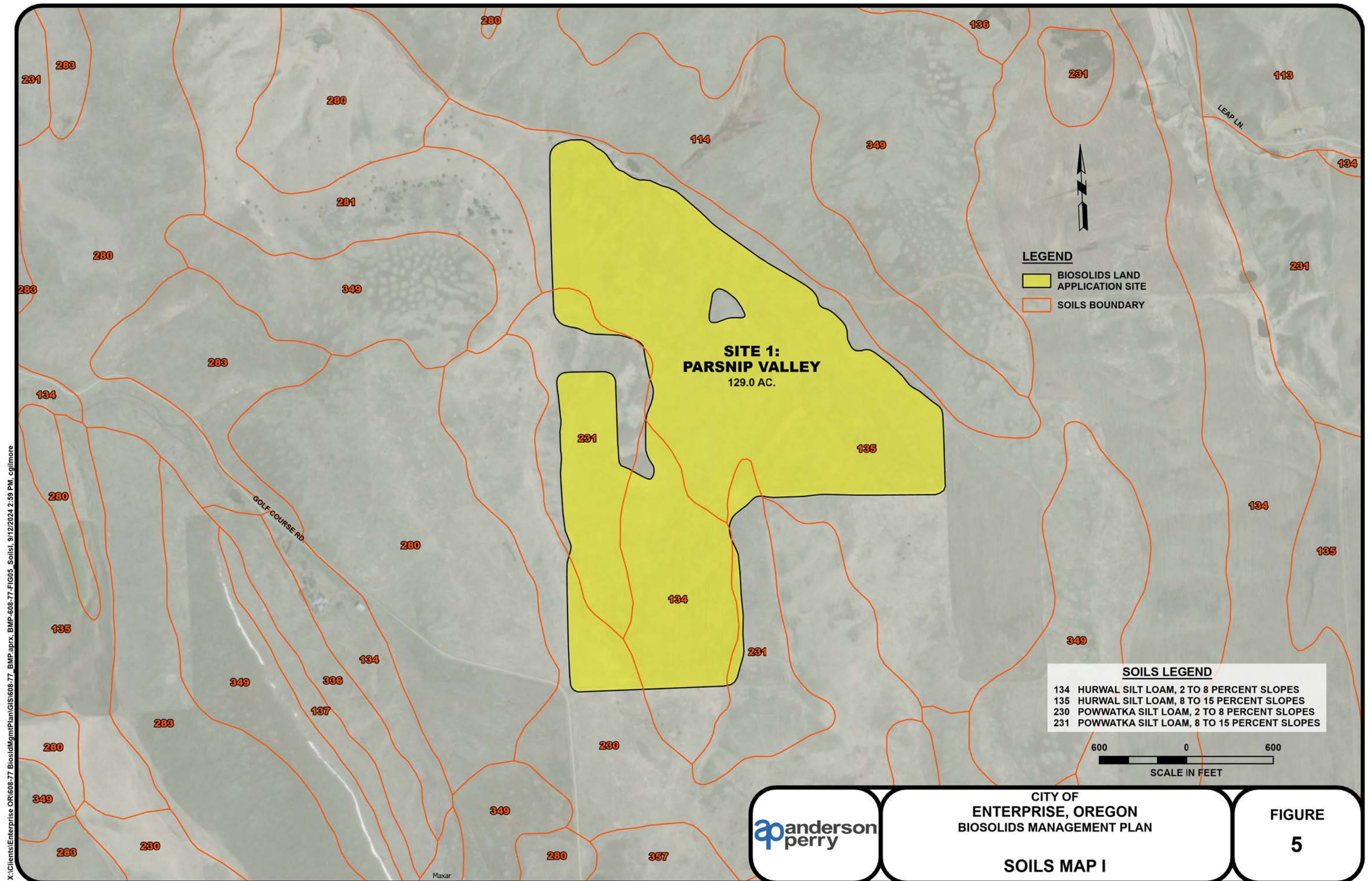
	CITY OF ENTERPRISE, OREGON BIOSOLIDS MANAGEMENT PLAN WASTEWATER TREATMENT FACILITY SITE PLAN	FIGURE 2
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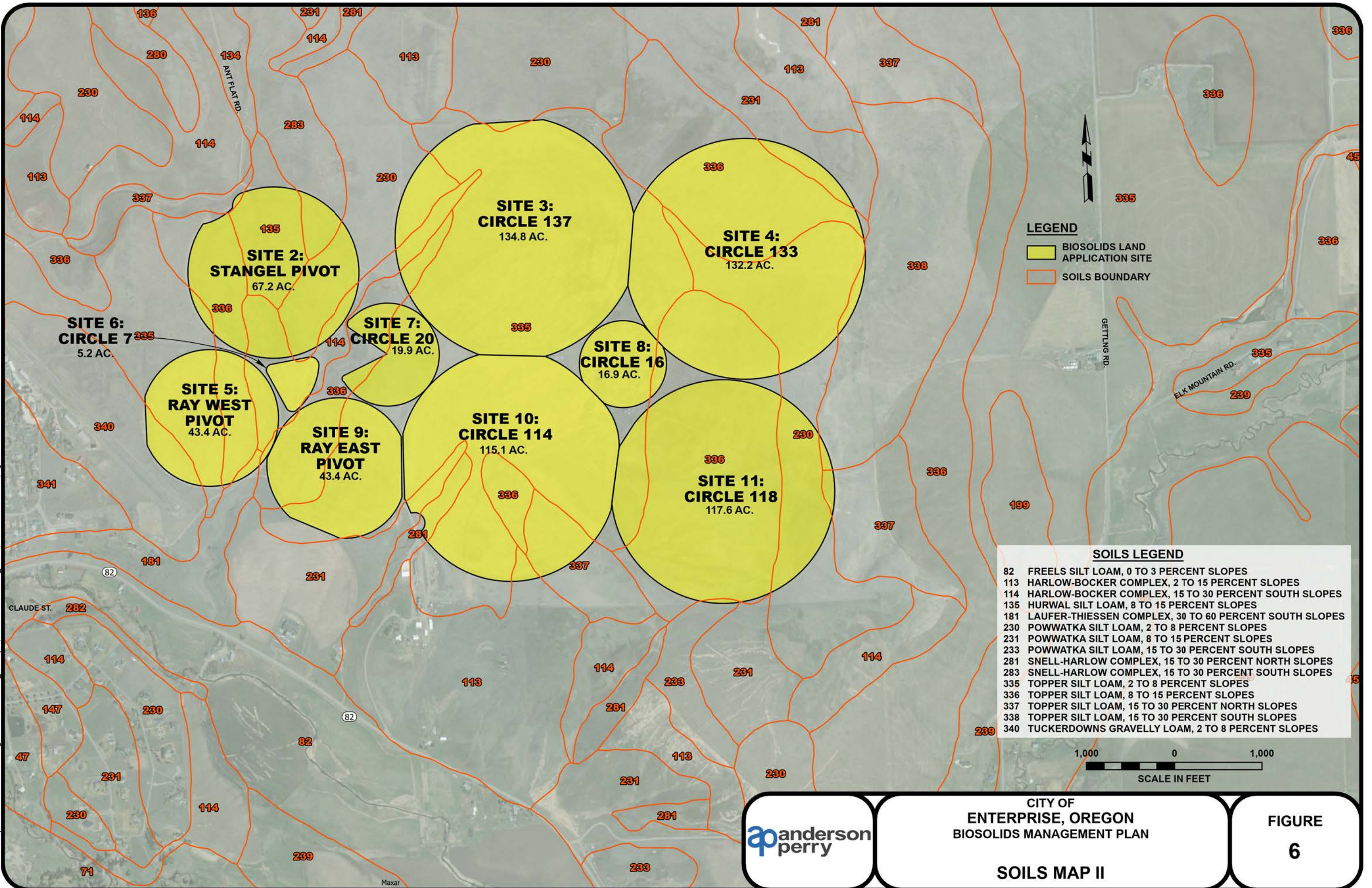


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Appendix C	Test Results
Appendix D	Example Nutrient Uptake Calculations
Appendix E	Site Management Agreement
Appendix F	Soil Survey
Appendix G	Public Notification Letters

APPENDIX A
Monitoring and Sampling Requirements
for Biosolids Land Application

**CITY OF ENTERPRISE, OREGON
BIOSOLIDS MANAGEMENT PLAN
MONITORING AND SAMPLING REQUIREMENTS FOR BIOSOLIDS LAND APPLICATION**

ITEM	MONITORING FREQUENCY	MONITORING POINT	TYPE OF MONITORING	PARAMETER ¹
Biosolids Quality (General)	Initial Report	Screw Press Discharge	Composite Grab ^{2,3}	As, Cd, Cr, Cu, Pb, Hg, Mo, Ni, Se, Zn, TKN, NO ₃ -N, NH ₄ -N, Total P, K, pH, Totals Solids, Volatile Solids
	Annually ³	Screw Press Discharge	Composite Grab ^{2,3}	As, Cd, Cr, Cu, Pb, Hg, Mo, Ni, Se, Zn, TKN, NO ₃ -N, NH ₄ -N, Total P, K, pH, Totals Solids, Volatile Solids
Pathogen Reduction (Alternative 1)	Annually ³	Compost Pile in Sludge Storage Building	Discrete Grab ^{2,3}	Fecal Coliform
Vector Attraction Reduction (Option 3)	Annually ³	Sample Tap on Discharge from Aerobic Digesters	Discrete Grab ^{2,3}	Additional Digestion for Aerobically Digested Biosolids
Soil Quality (Nutrients)	Initial Report	Proposed Application Site	Grab ²	NO ₃ -N and NH ₄ -N
	Before Application	Proposed Application Site	Grab	NO ₃ -N and NH ₄ -N
Biosolids Quantity	Daily	Loads Taken to Fields	Calculated	Biosolids Delivered to Application Site
	Daily	Land Application Site	Calculated	Pounds PAN per Acre per Field
Reporting	Daily Field Log	Application Documentation	Calculated	Quantity (Tons) Quality (Nutrients Applied) Location (Field Applied To)
	Annual Report ⁴	Application Documentation	Observed/Calculated	Crops, Acres Applied, Nitrogen Applied (lbs/ac), Application Rate (dry tons/ac), Biosolids Quality Test Data, Pathogen and Vector Attraction Reduction Monitoring/Management Records

Notes:

¹ Abbreviations are defined as follows: As = arsenic, Cd = cadmium, Cr = chromium, Cu = copper, Pb = lead, Hg = mercury, Mo = molybdenum, Ni = nickel, Se = selenium, Zn = zinc, TKN = total Kjeldahl nitrogen, NO₃-N = nitrate-nitrogen, NH₄-N = ammonium-nitrogen, P = phosphorus, K = potassium, PAN = plant-available nitrogen, lbs/ac = pounds per acre, dry tons/ac = dry tons per acre

² Sampling and testing were performed for use in the example nutrient uptake calculations in Appendix D of this Plan.

³ See the Monitoring and Sampling section of this Plan.

⁴ An annual report shall be submitted to the Oregon Department of Environmental Quality as outlined in the City's National Pollutant Discharge Elimination System Permit No. 101659.

APPENDIX B
Biosolids Annual Report Form



Wastewater Solids and Biosolids Annual Report

Part I: Wastewater solids production and disposition

Part I: Must be completed by all domestic wastewater facilities.

A. REPORTING PERIOD

1. This report is for biosolids produced during the calendar year:

B. PERMIT INFORMATION

1. Permit Type (select one): ☐ NPDES or ☐ WPCF DEQ File No.:
DEQ Permit No.: EPA Permit No.:

C. FACILITY INFORMATION

1. Legal name of facility:

Physical address

2. Street Address:

City:

State:

Zip code:

Mailing address ☐ Same as physical address.

3. Mailing Address:

City:

State:

Zip code:

Facility Type (check all that apply)

4. ☐ Major or Tier 1 facility (design flow of 1 mgd or greater, or serving a population of 10,000 or greater)
☐ Minor or Tier 2 facility (design flow less than 1 mgd or serving a population less than 10,000)
☐ Class I wastewater treatment facility (i.e., facility with a pre-treatment program)
☐ Biosolids only facility
☐ Lagoon treatment system
☐ Other, please specify:

D. CONTACT INFORMATION

Responsible official

1. Name: Title:
Email Address: Telephone:
Mailing Address:
City: State: Zip code:

Biosolids contact ☐ Same as responsible official

2. Name: Title:
Email Address: Telephone:
Mailing Address:
City: State: Zip code:

E. WASTEWATER SOLIDS RECEIVED

Please indicate if you received wastewater solids or hauled from other facilities for processing.					
Did you receive wastewater solids or hauled waste from other facilities? ☐ Yes ☐ NO <i>If you received unprocessed wastewater solids, please list sources below. All weight values should be reported in US tons. (US ton= 2,000 lbs) Attach additional pages if necessary.</i>					
1.	Name	Type	Quantity	Units (choose one)	% solids
		☐ septage ☐ sludge		☐ gallons ☐ wet tons ☐ dry tons	0.00%
		☐ septage ☐ sludge		☐ gallons ☐ wet tons ☐ dry tons	0.00%
		☐ septage ☐ sludge		☐ gallons ☐ wet tons ☐ dry tons	0.00%
		☐ septage ☐ sludge		☐ gallons ☐ wet tons ☐ dry tons	0.00%
		☐ septage ☐ sludge		☐ gallons ☐ wet tons ☐ dry tons	0.00%

F. WASTEWATER SOLIDS TREATMENT PROCESSES

Please indicate the solids treatment processes used at your facility (mark all that apply)			
1.	Thickening technology	Stabilization Technology	Dewatering technology
	☐ Gravity ☐ DAF ☐ Centrifugation ☐ Other:	☐ Aerobic digestion ☐ Anaerobic digestion ☐ Lime stabilization ☐ ATAD ☐ Composting ☐ Thermal ☐ Lagoon ☐ Other:	☐ Belt press ☐ Plate and frame press ☐ Screw press ☐ Centrifuge ☐ Vacuum filter ☐ Drying beds ☐ Heat drying ☐ Other:

$$\text{Dry tons} = \text{wet tons} \times \% \text{solids} \qquad \text{Dry tons} = \frac{(\text{gal} \times \% \text{solids} \times 8.34)}{100} \times 0.0005$$

G. WASTEWATER SOLIDS DISPOSITION

Please indicate how wastewater solids were managed at your facility. Please specify reporting units. All weight values should be reported in US tons. US ton.= 2,000 lbs					
	Disposition of wastewater solids	Quantity (choose one)			% solids
1.	☐ Treated and land applied, sold, or given-away as biosolids or biosolids-derived products	Gallons	Wet tons	Dry Tons	0.00%
2.	☐ Sent to landfill. Name:	Gallons	Wet tons	Dry Tons	0.00%
3.	☐ Sent to another permitted facility for treatment. Name:	Gallons	Wet tons	Dry Tons	0.00%
4.	☐ Long-term storage at treatment facility (e.g., lagoon, drying bed, etc.)*	Gallons	Wet tons	Dry Tons	0.00%
5.	☐ Other. Please specify:	Gallons	Wet tons	Dry Tons	0.00%

* If you operate a lagoon system and do not have accurate data on the quantity of solids in your lagoon, please check the box for long-term storage, but you may leave the quantity and other information blank.

H. LAGOON SYSTEM OPERATION and MAINTENANCE

The following section is required for facilities that operate wastewater treatment lagoons.

1. A survey of wastewater solids have been completed within the last year: ☐ Y ☐ N

2. In what year were solids last removed from the lagoon:

3. When do you estimate the next solids removal? Select only one of the following:

- ☐ Within the next calendar year
☐ Within the next 5 years
☐ Greater than 5 years from present

I. SIGNATURE OF LEGALLY AUTHORIZED REPRESENTATIVE

I certify that the information in this report is true and correct to the best of my knowledge and belief. Information and records used or referenced with this report will be maintained and made available to the Oregon Department of Environmental Quality on request.

Signature

Title

Date

Print Name:



Wastewater Solids and Biosolids Annual Report

Part II: Biosolids production and quality

Part II: Must be completed by facilities that produced Class A or Class B biosolids for land application, or sold or gave away biosolids derived products for distribution and marketing.

J. BIOSOLIDS PRODUCTION and DISPOSITION

Please specify quantity (in dry US tons) of finished biosolids stored or produced at your facility.			
		Class A	Class B
1.	Produced during reporting period		
	Total biosolids production	0	0
Please indicate how finished biosolids were managed (i.e., land applied, sold, stored, or other).			
		Class A	Class B
2.	Land applied in bulk to agricultural land		
	Land applied in bulk to forest land		
	Land applied in bulk to reclamation site		
	Land applied in bulk to a public contact site (e.g., park, roadside golf course)		
	Sold or given away as feedstock for a biosolids-derived product		
	Sold or given away in bags or other containers		
	Carried-over into next year (i.e., onsite storage)		
	Sent to landfill		
	Other, please specify:		
	Total biosolids disposition (add above lines)	0	0

K. BIOSOLIDS SAMPLING

Select your facility's minimum regulatory monitoring frequency (select only one box):							
1.	Monitoring frequency	☐ Once per year	☐ Once per quarter (four times per year)	☐ Once per 60 days (six times per year)	☐ Once per month (12 times per year)		
	Metric tons	<290	290 > 1,500	1,500 > 15,000	≥ 15,000		
	US Tons	<319	319 > 1,650	1,650 > 16,500	≥ 16,500		
Provide details on compliance sampling.							
2.	Sample type - Annual - Quarterly - 60 days - Monthly	Class	Processes (select all that apply)			Sampling date	
	Pollutants					Nutrients	
	Click Arrow	☐ A ☐ B	☐ Aerobic dig. ☐ Anaerobic dig. ☐ Compost	☐ Air-dried ☐ Heat dried ☐ Lagoon	☐ Alkaline stabil. ☐ Soil prod/blend ☐ Other		
	Click Arrow	☐ A ☐ B	☐ Aerobic dig. ☐ Anaerobic dig. ☐ Compost	☐ Air-dried ☐ Heat dried ☐ Lagoon	☐ Alkaline stabil. ☐ Soil prod/blend ☐ Other		
	Click Arrow	☐ A ☐ B	☐ Aerobic dig. ☐ Anaerobic dig. ☐ Compost	☐ Air-dried ☐ Heat dried ☐ Lagoon	☐ Alkaline stabil. ☐ Soil prod/blend ☐ Other		
	Click Arrow	☐ A ☐ B	☐ Aerobic dig. ☐ Anaerobic dig. ☐ Compost	☐ Air-dried ☐ Heat dried ☐ Lagoon	☐ Alkaline stabil. ☐ Soil prod/blend ☐ Other		
	Click Arrow	☐ A ☐ B	☐ Aerobic dig. ☐ Anaerobic dig. ☐ Compost	☐ Air-dried ☐ Heat dried ☐ Lagoon	☐ Alkaline stabil. ☐ Soil prod/blend ☐ Other		
	Click Arrow	☐ A ☐ B	☐ Aerobic dig. ☐ Anaerobic dig. ☐ Compost	☐ Air-dried ☐ Heat dried ☐ Lagoon	☐ Alkaline stabil. ☐ Soil prod/blend ☐ Other		
	Click Arrow	☐ A ☐ B	☐ Aerobic dig. ☐ Anaerobic dig. ☐ Compost	☐ Air-dried ☐ Heat dried ☐ Lagoon	☐ Alkaline stabil. ☐ Soil prod/blend ☐ Other		
	Click Arrow	☐ A ☐ B	☐ Aerobic dig. ☐ Anaerobic dig. ☐ Compost	☐ Air-dried ☐ Heat dried ☐ Lagoon	☐ Alkaline stabil. ☐ Soil prod/blend ☐ Other		
	Click Arrow	☐ A ☐ B	☐ Aerobic dig. ☐ Anaerobic dig. ☐ Compost	☐ Air-dried ☐ Heat dried ☐ Lagoon	☐ Alkaline stabil. ☐ Soil prod/blend ☐ Other		
	Click Arrow	☐ A ☐ B	☐ Aerobic dig. ☐ Anaerobic dig. ☐ Compost	☐ Air-dried ☐ Heat dried ☐ Lagoon	☐ Alkaline stabil. ☐ Soil prod/blend ☐ Other		

L. BIOSOLIDS POLLUTANT MONITORING

Report pollutant monitoring data from collected samples. Express results in mg/kg (ppm) based on dry wt. Please attach laboratory reports for results only. No lab QA/QC.

Biosolid Type: Class A ☐ Class B ☐

Sample type	Average Pollutant Concentrations								
- Annual - Quarterly - 60 days - Monthly	As (mg/kg)	Cd (mg/kg)	Cu (mg/kg)	Pb (mg/kg)	Hg (mg/kg)	Mo (mg/kg)	Ni (mg/kg)	Se (mg/kg)	Zn (mg/kg)
Click Arrow									
Click Arrow									
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Click Arrow									
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Click Arrow									
Click Arrow									
Click Arrow									
Click Arrow									
Click Arrow									
Click Arrow									
Click Arrow									
Click Arrow									
Annual Mean									
Table 1¹ Ceiling conc.	75	85	4300	840	57	75	420	100	7500
Table 3² Pollutant conc.	41	39	1500	300	17	N/A	420	100	2800

¹ 40 CFR § 503.13 Table 1 – Ceiling concentrations. Samples with pollutant concentrations that exceed the Table 1 limits are not eligible for land application and must be disposed by other means.

² 40 CFR § 503.13 Table 3 – Pollutant Concentrations. Samples with pollutant concentrations that exceed the Table 3 limits are subject to cumulative pollutant loading rates in 40 CFR § 503.13 Table 2. Annual and cumulative pollutant additions to land application sites must be submitted with the annual report.

M. BIOSOLIDS NUTRIENT MONITORING									
1.	Report nutrient monitoring data from collected samples. Express results in mg/kg (ppm) based on dry weight, except where otherwise noted. Please attach laboratory reports for results only. No lab QA/QC.								
	Biosolid Type: Class A ☐ Class B ☐								
	Sample type	Average Nutrient Concentrations							
	- Annual - Quarterly - 60 days - Monthly	TKN (mg/kg)	NO ₃ -N (mg/kg)	NH ₄ -N (mg/kg)	P (mg/kg)	K (mg/kg)	pH (S.U.)	Total solids (%)	F. coli MPN ☐ CFU ☐
	Click Arrow								
	Click Arrow								
	Click Arrow								
	Click Arrow								
	Click Arrow								
	Click Arrow								
	Click Arrow								
	Click Arrow								
	Click Arrow								
	Click Arrow								
Annual Mean									

N. BIOSOLIDS PATHOGEN REDUCTION MONITORING and RECORDS

Identify alternative(s) used to meet Class A or Class B pathogen reduction (PR): 40 CFR §503.32
Attach documentation on pathogen reduction.

	Class A Alternatives	Class B Alternatives
1.	Biosolids have been tested for (select one or both): ☐ fecal coliform ☐ salmonella ☐ Alternative 1: Thermally treated biosolids ☐ Alternative 2: Biosolids treated in a high pH-high temperature process ☐ Alternative 3: Biosolids treated in other processes that meet enteric virus and helminth ova criteria. ☐ Alternative 4: Biosolids treated in unknown processes that meet enteric virus and helminth ova criteria. ☐ Alternative 5: Use of a Process to Further Reduce Pathogens (PFRP) (select all that apply) ☐ (a) Composting ☐ (b) Heat drying ☐ (c) Heat treatment ☐ (d) Thermophilic aerobic digestion ☐ (e) Beta ray irradiation ☐ (f) Gamma ray irradiation ☐ (g) Pasteurization ☐ Alternative 6: Use of a Process equivalent to a PFRP. Identify:	☐ Alternative 1: Monitoring of fecal coliform as the geometric mean of the density of fecal coliform of seven representative samples (select option met): ☐ < 2 million Most Probable Number (MPN) per gram of solids (dry wt. basis) ☐ < 2 million Colony Forming Units (CFU) per gram of total solids (dry wt. basis) ☐ Alternative 2: Biosolids treated in one of the Processes to Significantly Reduce Pathogens (PSRP) described below: ☐ (a) Aerobic digestion ☐ (b) Air drying ☐ (c) Anaerobic digestion ☐ (d) Composting ☐ (e) Lime stabilization ☐ Alternative 3: Biosolids treated in a process that is equivalent to a PSRP. Identify:

O. BIOSOLIDS VECTOR ATTRACTION REDUCTION and RECORDS

Identify option(s) used to meet vector attraction reduction (VAR): 40 CFR §503.33
Attach documentation demonstrating compliance.

In-plant options:

1. ☐ Option 1: 38% reduction in volatile solids content. Select method used for determining volatile solids reduction:
- ☐ Full mass balance equation
 - ☐ Approximate mass balance equation
 - ☐ Van Kleeck equation
 - ☐ Volatile solids loss across all sewage sludge treatment processes
- ☐ Option 2: Bench-scale anaerobic digestion for 40 additional days at 30 °C to 37 °C.
- ☐ Option 3: Bench-scale aerobic digestion for 30 additional days at 20 °C.
- ☐ Option 4: SOUR at 20 °C. (Only for material <2% solids with no dilution.)
- ☐ Option 5: Aerobic treatment for at least 14 days over 40 °C with an average temperature of over 45 °C.
- ☐ Option 6: Alkali addition to raise pH to at least 12 at 25 °C and maintain a pH ≥ 12 for 2 hours and a pH ≥ 11.5 for 22 more hours.
- ☐ Option 7: Drying with no unstabilized (primary) solids to at least 75% solids.
- ☐ Option 8: Drying with unstabilized (primary) solids to at least 90% solids.

Site management options:

- ☐ Option 9: Injection with no biosolids present on land surface 1 hour after injection. (Class A biosolids only: Injection within 8 hours of pathogen reduction.)
- ☐ Option 10: Incorporation within 6 hours of application. (Class A biosolids only: Incorporation within 8 hours of pathogen reduction.)

If VAR was met through Option 1, a 38% reduction in volatile solids, report the average reduction percentage found.

2.	Biosolid Type	Average Volatile Solid Reduction
	Class A	0.00%
	Class B	0.00%
		0.00%
		0.00%

P. VIOLATIONS OF 40 CFR §503 or OAR CHAPTER 340 DIVISION 50

Did any violations of 40 CFR §503 or OAR Chapter 340 Division 50 occur during the reporting period?

- ☐ No.
- ☐ Yes. Provide a detailed description of the violation(s) and remedial actions taken to prevent reoccurrences in the future. If this was a spill, please include the OARS report #.

Q. SUMMARY OF PART II ATTACHMENTS

	Information DEQ requests with all annual reports:
1.	☐ Analytical laboratory reports for pollutant monitoring. <u>No lab QA/QC</u> ☐ Analytical laboratory reports for nutrient monitoring. <u>No lab QA/QC</u> ☐ Documentation to demonstrate compliance with pathogen reduction requirements. ☐ Documentation to demonstrate compliance with vector attraction reduction requirements.
	Information required if pollutants in Section L exceed Table 3 values:
2.	☐ Annual and cumulative pollutant additions to land application sites, if any pollutant concentration exceeds the Table 3 values.
	Optional and supplemental information:
3.	☐ Other information on changes to solids handling or land application site management. ☐ Other information on biosolids violations and remedial actions. ☐ Other. Please specify:

R. SIGNATURE OF LEGALLY AUTHORIZED REPRESENTATIVE

	I certify, under penalty of law, that the information that will be used to determine compliance with the pathogen requirements in 40 CFR §503.32 (identified in Section P of this report) and the vector attraction reduction requirements in 40 CFR §503.33 (identified in Section Q of this report) was prepared under my direction and supervision in accordance with the system designed to ensure that qualified personnel properly gather and evaluate this information. I am aware that there are significant penalties for false certification including the possibility of fine and imprisonment.		
	Signature	Title	Date
	Print Name:		



State of Oregon
Department of Environmental Quality
700 NE Multnomah St. Suite 600, Portland, OR 97232

DEQ use only

Wastewater Solids and Biosolids Annual Report

Part III: Biosolids land application site information

Part III: Must be completed by facilities that land applied Class B biosolids during the reporting period.
Add additional pages as needed.

S. LAND APPLICATION SITE INFORMATION

	Site ID	Owner (Last Name)	Location, PLSS (Township, Range, Section, Tax Lot)	Crop(s)	Appl. rate (lbs N/ac)	Total applied (DT/site)*	Total area applied (acres)	Was site applied to the previous year?	Soil test**
1.								☐ Yes ☐ No	☐
2.								☐ Yes ☐ No	☐
3.								☐ Yes ☐ No	☐
4.								☐ Yes ☐ No	☐
5.								☐ Yes ☐ No	☐
6.								☐ Yes ☐ No	☐
7.								☐ Yes ☐ No	☐
8.								☐ Yes ☐ No	☐
9.								☐ Yes ☐ No	☐
10.								☐ Yes ☐ No	☐
11.								☐ Yes ☐ No	☐
12.								☐ Yes ☐ No	☐
13.								☐ Yes ☐ No	☐
14.								☐ Yes ☐ No	☐
15.								☐ Yes ☐ No	☐
Attach additional pages as required to report on all sites that received class B biosolids during the reporting period.									

* Please report in units of dry US tons (US ton = 2,000 lbs)

** Please attach laboratory report showing sample results only. No lab QA/QC.

T. SUMMARY OF PART III ATTACHMENTS

1.	Information required with some annual reports:
	☐ Additional copies of Table S for additional land application. ☐ Analytical results from soil testing
2.	Example of documentation held by the permittee and available upon request:
	☐ Additional land application site information. ☐ Figures showing where biosolids were applied. ☐ Nitrogen loading calculations

U. SIGNATURE OF LEGALLY AUTHORIZED REPRESENTATIVE

	I certify, under penalty of law, that the information that will be used to determine compliance with the site restrictions in Sec. 503.32(b)(5) for each site on which Class B sewage sludge was applied was prepared under my direction and supervision in accordance with the system designed to ensure that qualified personnel properly gather and evaluate this information. I am aware that there are significant penalties for false certification including the possibility of fine and imprisonment.		
	Signature	Title	Date
	Print Name:		



Wastewater Solids and Biosolids Annual Report

Instructions

National Pollutant Discharge Elimination System (NPDES) and Water Pollution Control Facility (WPCF) permittees are required to report to the Department of Environmental Quality (DEQ) on the production, use, disposal or storage of domestic wastewater solids. DEQ requests the permit holder submit information on activities during the previous year by **February 19**. You must submit 2 copies of the report as directed below and Class I facilities must complete EPA's online NeT reporting.

The annual report is in three parts:

- **Part I: Wastewater solids production and disposition.** Required for all facilities.
- **Part II: Biosolids production and quality.** Required for facilities that produced Class A or Class B biosolids for land application, or sold or gave away biosolids derived products for distribution and marketing.
- **Part III: Biosolids land application site information.** Required for facilities that land applied Class B biosolids.

Depending on your facility's wastewater solids handling during the previous calendar year, your facility may be required to submit one, two, or all three parts of the report.

If your facility: • Is a lagoon system and has not removed solids during the previous year • Transferred solids to another wastewater facility for processing • Transferred solids to a landfill, incinerator, or energy production facility • Put solids into long-term storage Then you must submit: • Part I of the report	If your facility: • Processed wastewater solids for beneficial use on the land as a soil amendment or fertilizer • Processed and distributed wastewater solids (by sale or given away) for use as feedstock for a biosolids-derived product (e.g., compost, derived-soil, etc.) • Sold or gave away biosolids or a biosolids-derived product Then you must submit: • Part I of the report • Part II of the report	If your facility: • Land applied Class A or Class B biosolids in bulk (including application using agricultural equipment such as a manure-spreader, irrigation cannon, side-slinger, etc.) to agricultural land, forest land, reclamation site, or public contact site (e.g., park, roadside, golf course) Then you must submit: • Part I of the report • Part II of the report • Part III of the report
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Copy 1: Send a copy of the completed report to your **regional DEQ office**:

Copy 2: Send an electronic copy of the report to the **DEQ Headquarters** (heins.pat@deq.state.or.us) or **hard copy**:

ATTN: Biosolids Program Coordinator
DEQ Water Quality Division
700 NE Multnomah St. Suite 600
Portland, OR 97232

Copy 3: If you are a Class I facility, your treatment facility has a design flow of 1 MGD or more, or you serve a population of 10,000 or more, complete EPA's online NeT reporting.



Wastewater Solids and Biosolids Annual Report

Instructions for Part I: Wastewater solids production and disposition

Required for all domestic wastewater treatment facilities.

A. Reporting Period

1. The annual report is due to DEQ by February 19th and provides information on solids management activities during the previous calendar year. Enter the calendar year for which the report is being submitted.

B. Permit Information

1. Provide information on your permit:
 - a. Identify the type of permit, WPCF or NPDES. Choose only one.
 - b. DEQ File No. This information is located on the cover page of your DEQ-issued permit.
 - c. DEQ Permit No. This information is located on the cover page of your DEQ-issued permit.
 - d. EPA Permit No. Applies to NPDES permits only.

C. Facility Information

The facility information clarifies what should be included in the report and who should receive copies of the report. It expedites DEQ review of the report and ensures that you have submitted a report that complies with the conditions in your permit.

1. Provide the name of your facility.
2. Provide the physical address of the facility, including street, city, state, and zip code.
3. Provide the mailing address for the facility. If the mailing address is the same as the physical address, you may check the box "Same as physical address."
4. Identify the type of facility. Check all boxes that apply. If an important identifier has not been listed, please provide the information under "Other:" If you have checked any of the first three items *and land applied biosolids*, please report to EPA's online NeT reporting.

D. Contact Information

DEQ uses the contact information for correspondence with the facility on their wastewater solids/biosolids program.

1. Provide full contact information for the responsible official at the treatment facility. The responsible official is typically a supervisor, manager, or other person who is accountable for ensuring operations comply with the conditions in the permit. Any official correspondence on the report or the facility's compliance with requirements in the permit will be communicated to the responsible official.
2. Provide full contact information for the biosolids contact at the facility. If the biosolids contact is the same as the responsible official, check the box "Same as responsible official." Some facilities have a staff person who maintains primary responsibility for the solids handling operations. This person often has the most direct knowledge of information in the report. DEQ will contact the biosolids contact if there are questions on the technical content of the report.

E. Wastewater Solids Received

DEQ uses information on wastewater solids received to track statewide solids management. This information may also be available to provide technical assistance to communities or businesses (e.g., septage pumpers) that are seeking treatment facilities.

1. Please indicate if your facility received wastewater solids or hauled waste for from another facility (or facilities) for processing. If you received unprocessed wastewater solids or hauled waste, please identify the source of material, the type of material (septage or sludge), the quantity received and the reporting units. If you have information on the percent solids (for quantities reported in gallons or wet tons), please provide that information. If the information is unavailable, this value may be left blank. Please attach additional pages as necessary.

F. Wastewater Solids Treatment Processes

In addition to helping DEQ provide technical assistance to your program, information on wastewater solids treatment processes supports efforts to identify national and regional trends in solids management and improve beneficial reuse operations. Organizations, such as the Northwest Biosolids Management Association (NBMA) and the Water Environment Federation (WEF), often request this type of information when developing technical reports. Research organizations, such as Oregon State University, may use this information to develop best management practices for biosolids land application programs.

1. Identify the various solids treatment technologies at your facility, whether used or unused. If a technology is not listed, please check “other” and identify the type of technology used. Check as many as apply. If you operate a lagoon system, please check “Lagoon”; other boxes may be left unchecked.

G. Wastewater Solids Disposition

DEQ uses the information in this section to understand how wastewater solids are managed by wastewater treatment facilities statewide. Wastewater disposition includes reuse, disposal, storage, and transfer to other facilities. When answering these questions, please check the box for all solids management methods that were used during the reporting period. Please attach additional pages as needed.

1. Treatment to Class A or B biosolids standards for subsequent use on the land as a fertilizer or soil amendment. Please report the quantity of *untreated sludge* that was introduced for treatment. The quantity of finished biosolids produced by your facility will be reported in Part II of this report.
2. Disposal at a landfill facility. Please list the name of the facility receiving wastewater solids.
3. Transfer of solids to another wastewater facility for further treatment. Please list the name of the facility or facilities receiving wastewater solids.
4. Long-term storage at the treatment facility, including sludge lagoons, tanks, drying beds, or other storage units. *If you operate a lagoon system and do not have accurate data on the quantity of solids in your lagoon, please check the box for long-term storage, but you may leave the quantity and other information blank.*
5. Other uses or disposal of wastewater solids, such as but not limited to: transfer to a sewage sludge incinerator, feedstock for biogas generation or other energy project, or feedstock for another product or process. Please identify the other use or disposal methods.

H. Lagoon System Operation and Maintenance

The following section is required only for facilities that operate wastewater lagoons or biosolids storage lagoons. DEQ uses this information to provide technical assistance and for planning purposes. *Please respond to all three of the following:*

1. Was a survey of wastewater solids in the lagoon completed within the last year?
2. In what year were wastewater solids last removed from the lagoon?
3. When do you estimate wastewater solids will next be removed from the lagoon? Select only one of the options.

I. Signature

The report must be signed by a person legally authorized to represent your treatment facility.

DEFINITION OF LEGALLY AUTHORIZED REPRESENTATIVE

Please also provide the information requested in brackets [].

- **Corporation:** president, secretary, treasurer, vice-president, or any person who performs principal business function; or a manager of one or more facilities that is authorized in accordance to corporate procedure to sign such documents.
- **Partnership:** General partner [list of general partners, their addresses, and telephone numbers]
- **Sole Proprietorship:** Owner(s) [each owner must sign the application]
- **City, County, State, Federal, or other Public Facility:** Principal executive officer or ranking elected official
- **Limited Liability Company:** Member [articles of organization]
- **Trusts:** Acting trustee [list of trustees, their addresses, and telephone numbers]



Wastewater Solids and Biosolids Annual Report

Instructions for Part II: Biosolids production and quality

Required for all facilities that produced Class A or Class B biosolids for land application, or sold or gave away biosolids derived products for distribution and marketing.

J. Biosolids Production and Disposition

DEQ requires a summary of biosolids production and use from all facilities that produce biosolids for land application, or sell or give away biosolids derived products for distribution and marketing. The information in this section should summarize the quantity of finished biosolids produced at the facility during the reporting period as well as how those finished biosolids were managed. "Finished biosolids" refers to biosolids that have been sufficiently treated and are ready for use on the land or public distribution. Finished biosolids includes product that has been placed in storage, but does not include material that is unfit for use or distribution. (For example, a batch of biosolids compost that is curing on December 31 is not yet finished and should be reported in the next annual report.) DEQ uses this information to determine compliance with your permit as well as track trends in biosolids production and management around the state.

1. Please provide the quantity of finished biosolids that were produced or stored onsite at your facility during the reporting period. If finished biosolids were produced and stored during the *previous* reporting period, please report the quantity of material *stored at the treatment facility* that was carried-over from the previous year. Carried-over material *does not* include biosolids that are being staged or stored in the field at a land application site. Please report the quantity of biosolids in dry tons under the appropriate column for Class A or Class B biosolids. Provide the total annual biosolids production by adding together the quantity of "carried-over" biosolids and new biosolids produced during the reporting period.
2. Please indicate how finished biosolids were managed during the reporting period using the categories provided on the report (i.e., rows). Report the quantity in dry tons under the appropriate column for Class A or Class B biosolids. If finished biosolids were in onsite storage at the treatment facility on December 31, please reporting the quantity as "Carried-over into next year." If *finished biosolids* are managed in another manner, such as disposal at a landfill or transfer to another facility, please specify how the biosolids were managed and the quantity. Provide the total annual biosolids disposition (under Class A or Class B) by adding together the various biosolids management practices.

K. Biosolids Sampling

Biosolids must be sampled and monitored to demonstrate compliance with your permit. The sampled biosolids must be representative of the treatment process(es) and characterize the quantity and quality of biosolids produced. The minimum sampling frequency is based on the total quantity of biosolids produced; however, additional samples may be required to adequately characterize different treatment processes. For example, a facility that produces 250 US dry tons of biosolids must sample only once per year; however, if the facility produces biosolids by more than one process (e.g., alkaline stabilized biosolids in the winter, air-dried biosolids in the summer), additional samples may be required to meet the requirement that samples be representative. You will report both types of information in this section.

1. The minimum biosolids sampling frequency is based on the total quantity of finished biosolids produced for application to the land, including both bulk land application and biosolids produced for sale or distribution (e.g., biosolids compost sold to the public). Please select the appropriate testing frequency based on the quantity of biosolids produced at your facility during the reporting period.
2. Please provide information on the biosolids sampling that occurred during the reporting period. For each sample, please provide the following information:
 - a. Select either Class A or Class B biosolids
 - b. Identify the treatment processes that were used to produce the biosolids. More than one selection may be made for each sample type. For example, if biosolids were anaerobically digested then composted, select both "Anaerobic dig." and "Compost." This information is used to characterize how different biosolids

processes affect biosolids characteristics. Oregon State University uses this type of information when updating their biosolids publications.

- c. Please provide the date the sample(s) was taken. If sampling for pollutants and nutrients occurred on different days, different dates should be reported.

L. Biosolids Pollutant Monitoring

A report on pollutant concentrations in biosolids is required to demonstrate compliance with the pollutant limits specified in OAR 340-050-0035(2)(a). *Please attach analytical laboratory reports for pollutant monitoring.*

1. For each of the collected samples identified in the previous section, report the concentration for the nine regulated pollutants. Please report all concentrations as mg/kg on a dry weight basis. If a pollutant concentration is non-detect, please report the value using the less-than symbol followed by the reporting limit. For example <0.050 should be reported for a parameter that is non-detect where the reporting limit is 0.050 mg/kg. The 40 CFR §503.13 pollutant limits are provided as a reference. If the concentration of any pollutant exceed the Table 1 Ceiling Concentration, the biosolids may not be applied to the land and must be disposed in another manner, such as landfill or incineration. If the concentration of any pollutant exceeds the Table 3 Pollutant Concentration, the annual and cumulative pollutant additions to specific land application sites for all nine metals must be submitted with the annual report¹.

M. Biosolids Nutrient Monitoring

DEQ requires biosolids be monitored for nutrients and other chemical parameters [OAR 340-050-0035(2)(a)]. Data on nutrient concentrations, specifically nitrogen, is used to determine compliance with agronomic loading rates. *Please attach analytical laboratory reports for nutrient monitoring.*

1. For each of the collected samples identified in Section K, report the concentration for the eight nutrients and other parameters listed. Please report all concentrations as mg/kg on a dry weight basis. If a pollutant concentration is non-detect, please report the value using the less-than symbol followed by the reporting limit. For example <0.0010 should be reported for a parameter that is non-detect where the reporting limit is 0.0010.

N. Biosolids Pathogen Reduction Monitoring and Records

DEQ requires data to determine compliance with pathogen reduction [OAR 340-050-0035(6)(c)]. *Please attach supplemental data on pathogen reduction.*

1. Please identify the pathogen reduction alternatives used to produce Class A or Class B biosolids. If more than one alternative was used, multiple selections may be made. For Class A biosolids, identify whether biosolids were monitored for fecal coliform or salmonella as well as the Class A pathogen reduction alternative.

O. Biosolids Vector Attraction Reduction and Records

DEQ requires data to determine compliance with vector attraction reduction [OAR 340-050-0035(6)(c)]. *Please attach supplemental data on vector attraction reduction.*

1. Please identify the options used to achieve vector attraction reduction. If more than one option was used, multiple selections may be made.

P. Violations of 40 CFR §503 or OAR Chapter 340 Division 50

OAR 340-050-0035(6)(e) requires the permittee to provide “a detailed description of any violation of 40 CFR §503 or OAR Chapter 240, Division 50 and remedial actions to prevent the recurrence of similar violations in the future.

1. Please indicate (Y/N) if any violation of 40 CFR §503 or OAR 340-050 occurred during the reporting period. If you received a Warning Letter or other enforcement action from DEQ on your biosolids management program during the reporting period, you should answer “Yes” and provide a detailed description. Please attach additional documentation as necessary.

Q. Summary of Part II Attachments

1. DEQ requests the following information be submitted with Part II of this report:
 - a. Analytical laboratory reports for pollutant monitoring showing results. No lab QA/QC documents

¹ A report on the annual and cumulative pollutant loading rates is required for as long as the facility continues use any site that has received biosolids exceeding the Table 3 values—even if future pollutant concentrations fall below the Table 3 values.

- b. Analytical laboratory reports for nutrient monitoring showing results. No lab QA/QC documents
 - c. Documentation on demonstrate pathogen reduction
 - d. Documentation on Vector Attraction Reduction (VAR)
2. The following information is required if pollutant concentrations in land applied biosolids exceed the Table 3 concentrations in 40 CFR §503.13:
- a. Annual and cumulative pollutant addition to land application sites
3. The following information may be submitted with this report:
- a. Additional documentation on biosolids production or disposition
 - b. Additional documentation of biosolids sampling
 - c. Additional information on changes to solids handling or land application site management
 - d. Additional information on biosolids violations and remedial actions
 - e. Other information. Please identify.

R. Signature of Legally Authorized Representative

OAR 340-050-0035(3) and 40 CFR §503.17 require the biosolids preparer to maintain records with a certification statement that biosolids were prepared as required by law. The report must be signed by a person legally authorized to represent your treatment facility. See definition of Legally Authorized Representative under Section L.



Wastewater Solids and Biosolids Annual Report

Instructions for Part III: Biosolids production and quality

Required for all facilities that land applied Class B biosolids.

S. Land Application Site Information

DEQ requires information be submitted in the annual report that is adequate to demonstrate that solids were applied within agronomic loading rates and other required site management practices.

1. For each site on which biosolids were land applied during the reporting period, please provide the following information. If needed, please attach additional sheets to include all land application sites. You may provide any additional information on land application activities at the sites to demonstrate that land application was in compliance with all permit requirements.
 - a. The site ID. This should generally correspond to the site name on your DEQ site authorization approval letter.
 - b. The location of the site by the Public Land Survey System, which uses the township, range, section, and tax lot. This information should correspond to that on your DEQ site authorization approval letter.
 - c. The crop or vegetation grown on the property.
 - d. The quantity of nitrogen applied to the site as biosolids in lbs N/ac.
 - e. The total quantity of biosolids land applied in dry tons/ac.
 - f. The total area of the site receiving biosolids in acres.
 - g. Indicate if biosolids were applied to the field during the previous year.
 - h. If soil testing was done, please check the box "Soil test" and attach results to the report.

T. Summary of Part III attachments

1. If Part III of the report is completed in full and all land application sites have been reported, no additional information is required.
2. When necessary, DEQ requests the following additional information be submitted with the report:
 - a. Reporting forms for additional sites
 - b. Analytical results from soil testing
3. The following information may be submitted with this report:
 - a. Additional information necessary to demonstrate that land application occurred as required under your permit, including the land application plan and site authorization letters.
 - b. Other information, as appropriate. If other information is submitted, please identify.

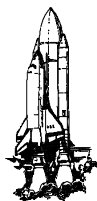
U. Signature of Legally Authorized Representative

OAR 340-050-0035(3) and 40 CFR §503.17 requires the biosolids land applied to maintain records with a certification statement that Class B biosolids were land applied as required by law. The report must be signed by a person legally authorized to represent your treatment facility. See definition of Legally Authorized Representative under Section L.

APPENDIX C

Test Results

Biosolids Testing



UMPQUA Research Company - Table Rock

419 SW 5th Street
Pendleton, Oregon 97801
(541) 863-5201 Fax: (541) 863-6199
E-mail: TRLab@URCmail.net
Internet: www.umpquaresearch.com
ORELAP ID# OR100061

ANALYSIS REPORT

URC # T3F2111

Enterprise, City of
102 E North St.
Enterprise, OR 97828

Project: Wastewater
Project #: General Testing
Client Contact: Dave Wilkie

Date Reported: 06/26/23
Date Sampled: 06/21/23 09:00
Date Received: 06/21/23 13:35
Sampled By: Dave

Sample Location: Waste Water Digester Biosolids

URC Sample #: T3F2111-01

Matrix: Sludge

Inorganics

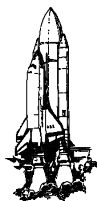
Analyte	Code	Result	Units	MRL	BML	Prepared	Analyzed	Analyst	Qualifier
SM 2540B									
Total Solids		0.756	% by Weight	0.030		06/22/23	06/26/23	DTD	B

UMPQUA Research Company/TR

Lacy McCamey For Amy Kasiska

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E-mail: TRLab@URCmail.net
Internet: www.umpquaresearch.com
ORELAP ID# OR100061

ANALYSIS REPORT

URC # T3F2111

Enterprise, City of	Project: Wastewater	Date Reported: 06/26/23
102 E North St.	Project #: General Testing	Date Sampled: 06/21/23 09:00
Enterprise, OR 97828		Date Received: 06/21/23 13:35
	Client Contact: Dave Wilkie	Sampled By: Dave

Sample Location: Waste Water Digester Biosolids

URC Sample #: T3F2111-01

Matrix: Sludge

Microbiology

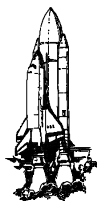
Analyte	Code	Result	Units	MRL	BML	Prepared	Analyzed	Analyst	Qualifier
SM 9221-B&E									
Fecal Coliforms		3400	MPN/g dry	26		06/22/23 14:50	06/23/23	DTD	

UMPQUA Research Company/TR

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Internet: www.umpquaresearch.com
ORELAP ID# OR100061

ANALYSIS REPORT

URC # T3F2111

Qualifiers and Definitions

B	Analyte detected in the method blank
DET	Analyte DETECTED
ND	Analyte NOT DETECTED at or above the MRL (minimum reporting limit)
NA	Not Applicable
NR	Not Reported
dry	Sample results reported on a dry weight basis
RPD	Relative Percent Difference
MRL	Minimum Reporting Limit
MDL	Minimum Detection Limit
BML	Benchmark Level
(‡)	ORELAP Accredited Analyte
(~)	Due to rounding of individual analytes, the "total" may vary slightly from the sum of the individual analyte values.

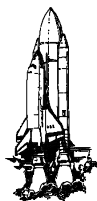
Analytes flagged with * were subcontracted to Umpqua Research Company/MC. ORELAP ID #: OR100031

UMPQUA Research Company/TR

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Internet: www.umpquaresearch.com
ORELAP ID# OR100061

ANALYSIS REPORT

URC # T3F2113

Enterprise, City of
102 E North St.
Enterprise, OR 97828

Project: Wastewater
Project #: General Testing
Client Contact: Dave Wilkie

Date Reported: 07/10/23
Date Sampled: 06/21/23 09:00
Date Received: 06/21/23 13:35
Sampled By: Dave

Sample Location: Influent

URC Sample #: T3F2113-01

Matrix: Aqueous

Inorganics

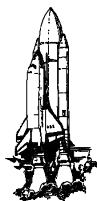
Analyte	Code	Result	Units	MRL	BML	Prepared	Analyzed	Analyst	Qualifier
SM 2540D									
TSS		162	mg/L	10.0		06/23/23	06/26/23	DTD	
SM 5210B									
5-day BOD		110	mg/L	2	20	06/22/23 17:01	06/26/23	DTD	

UMPQUA Research Company/TR

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Internet: www.umpquaresearch.com
ORELAP ID# OR100061

ANALYSIS REPORT

URC # T3F2113

Enterprise, City of
102 E North St.
Enterprise, OR 97828

Project: Wastewater
Project #: General Testing
Client Contact: Dave Wilkie

Date Reported: 07/10/23
Date Sampled: 06/21/23 09:00
Date Received: 06/21/23 13:35
Sampled By: Dave

Sample Location: Effluent

URC Sample #: T3F2113-02

Matrix: Aqueous

Inorganics

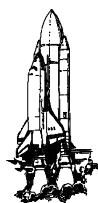
Analyte	Code	Result	Units	MRL	BML	Prepared	Analyzed	Analyst	Qualifier
SM 2540D									
TSS		1.5	mg/L	1.2		06/23/23	06/26/23	DTD	
SM 4500 NH3 B									
*Ammonia as N		ND	mg/L	0.30		06/28/23	06/28/23	JBN	
SM 5210B									
5-day BOD		3	mg/L	2	20	06/22/23 17:01	06/26/23	DTD	

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ORELAP ID# OR100061

ANALYSIS REPORT

URC # T3F2113

Enterprise, City of
102 E North St.
Enterprise, OR 97828

Project: Wastewater
Project #: General Testing
Client Contact: Dave Wilkie

Date Reported: 07/10/23
Date Sampled: 06/21/23 09:00
Date Received: 06/21/23 13:35
Sampled By: Dave

Sample Location: Digester BioSolids

URC Sample #: T3F2113-03

Matrix: Sludge

Inorganics

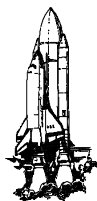
Analyte	Code	Result	Units	MRL	BML	Prepared	Analyzed	Analyst	Qualifier
SM 2540B									
*Total Solids		0.764	% by Weight	0.017		06/26/23	06/27/23	AHA	
SM 2540E									
*Volatile Solids		99.8	% by Weight (of TS)	0.017		06/26/23	06/27/23	AHA	
SM 4500 NH3 B									
*Ammonia as N		4430	mg/kg dry	981		07/07/23	07/07/23	JBN	
SM 4500-H B									
pH		7.0	pH Units			06/21/23 16:21	06/21/23	ABK	
SM 4500Norg B									
*Total Kjeldahl Nitrogen		66800	mg/kg dry	9810		06/29/23	06/30/23	JBN	
SM 4500P									
*Phosphorus-Total		4.20	% by Weight dry	0.654		07/03/23	07/03/23	JBN	
USEPA 300.0									
*Nitrite as N		ND	mg/kg dry	65.4		06/22/23 14:09	06/22/23	AHA	
*Nitrate as N		ND	mg/kg dry	262		06/22/23 14:09	06/22/23	AHA	

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Internet: www.umpquaresearch.com
ORELAP ID# OR100061

ANALYSIS REPORT

URC # T3F2113

Enterprise, City of	Project: Wastewater	Date Reported: 07/10/23
102 E North St.	Project #: General Testing	Date Sampled: 06/21/23 09:00
Enterprise, OR 97828		Date Received: 06/21/23 13:35
	Client Contact: Dave Wilkie	Sampled By: Dave

Sample Location: Digester BioSolids

URC Sample #: T3F2113-03

Matrix: Sludge

Metals

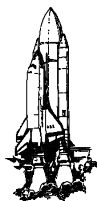
Analyte	Code	Result	Units	MRL	BML	Prepared	Analyzed	Analyst	Qualifier
EPA 6010D									
*Arsenic		ND	mg/kg dry	32.7		06/29/23	06/29/23	DST	
*Cadmium		ND	mg/kg dry	6.54		06/29/23	06/29/23	DST	
*Chromium		ND	mg/kg dry	65.4		06/29/23	06/29/23	DST	
*Copper		167	mg/kg dry	65.4		06/29/23	06/29/23	DST	
*Lead		ND	mg/kg dry	32.7		06/29/23	06/29/23	DST	
*Mercury		ND	mg/kg dry	13.1		07/05/23	07/05/23	DST	
*Molybdenum		ND	mg/kg dry	65.4		06/29/23	06/29/23	DST	
*Nickel		ND	mg/kg dry	65.4		06/29/23	06/29/23	DST	
*Potassium		0.608	% by Weight dry	0.131		06/29/23	06/29/23	DST	
*Selenium		ND	mg/kg dry	65.4		06/29/23	06/29/23	DST	
*Zinc		411	mg/kg dry	131		06/29/23	06/29/23	DST	

UMPQUA Research Company/TR

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Internet: www.umpquaresearch.com
ORELAP ID# OR100061

ANALYSIS REPORT

URC # T3F2113

Qualifiers and Definitions

QR-04	Duplicate RPD is above the control limit due to a non-homogeneous sample matrix.
DET	Analyte DETECTED
ND	Analyte NOT DETECTED at or above the MRL (minimum reporting limit)
NA	Not Applicable
NR	Not Reported
dry	Sample results reported on a dry weight basis
RPD	Relative Percent Difference
MRL	Minimum Reporting Limit
MDL	Minimum Detection Limit
BML	Benchmark Level
(‡)	ORELAP Accredited Analyte
(~)	Due to rounding of individual analytes, the "total" may vary slightly from the sum of the individual analyte values.

Analytes flagged with * were subcontracted to Umpqua Research Company/MC. ORELAP ID #: OR100031

UMPQUA Research Company/TR

Lacy McCamey For Amy Kasiska

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Soil Testing



soiltest
farm consultants, inc.

2925 Driggs Dr., Moses Lake, Wa 98837 • www.soiltestlab.com
Office: (509)765-1622 • Fax: (509)765-0314 • (800)764-1622



WALLOWA CO. GRAIN GROWERS

P.O. BOX 190

ENTERPRISE, OR 97828

Laboratory #: S23-28708

Date Received: 11/13/2023

Grower: CITY OF ENTERPRISE

Field: 1 NWN

Sampled By: KANE

Customer Account #:

Customer Sample ID:

Soil Test Results

Phosphorus	Olsen	mg/kg	13
Potassium	NH4OAc	mg/kg	485
Boron	DTPA	mg/kg	0.31
Zinc	DTPA	mg/kg	1.2
Manganese	DTPA	mg/kg	2.8
Copper	DTPA	mg/kg	0.7
Iron	DTPA	mg/kg	35
Calcium	NH4OAc	meq/100g	13.2
Magnesium	NH4OAc	meq/100g	3.5
Sodium	NH4OAc	meq/100g	0.33
Total Bases	NH4OAc	meq/100g	18.3

pH 1:1	6.0
E.C. 1:1	m.mhos/cm 0.33
Est Sat Paste E.C.	m.mhos/cm 0.86
Effervescence	None
Ammonium - N	mg/kg 26.1
Organic Matter W.B.	% 4.9
	ENR: 0

Lbs/Acre

Depth	Nitrate-N	Sulfate-S	Moisture
inches	mg/kg	lbs/acre	mg/kg
			Inches
0 - 12	28.0	90	213
Totals	28.0	90	213
Sum of Tested N:	174	lbs/acre N	

Other Tests:

Total-N (%) = 0.20

Total-C (%) = 2.0 C:N = 10.0

0 - 12 Mercury Mercury 0.10 mg/Kg

Interpretation Guide

Fertilizer recommendations for

80 BU of **WHEAT SOFT WINTER** after WHEAT SOFT WINTER
Low Medium High

Nitrogen	174	lbs/acre		70 lbs/acre of Nitrogen
Phosphorus	13	mg/kg		0 lbs/acre of P2O5
Potassium	485	mg/kg		0 lbs/acre of K2O
Sulfur	213	mg/kg		0 lbs/acre of Sulfur
Boron	0.31	mg/kg		0.5 lbs/acre of Boron
Zinc	1.2	mg/kg		0 lbs/acre of Zinc
Manganese	2.8	mg/kg		0 lbs/acre of Mn

We make every effort to provide an accurate analysis of your sample. For reasonable cause we will repeat tests, but because of factors beyond our control in sampling procedures and the inherent variability of soil, our liability is limited to the price of the tests. Recommendations are to be used as general guides and should be modified for specific field conditions and situations. Note: "u" indicates that the element was analyzed for but not detected

This is your Invoice #: S23-28708 Account #: 317300 Reviewed by: K. Bair, PhD, C List Cost: \$191.00



soiltest
farm consultants, inc.

2925 Driggs Dr., Moses Lake, Wa 98837 • www.soiltestlab.com
Office: (509)765-1622 • Fax: (509)765-0314 • (800)764-1622



WALLOWA CO. GRAIN GROWERS

P.O. BOX 190

ENTERPRISE, OR 97828

Laboratory #: S23-28709

Date Received: 11/13/2023

Grower: CITY OF ENTERPRISE

Field: 2 NWS

Sampled By: KANE

Customer Account #:

Customer Sample ID:

Soil Test Results

Phosphorus	Olsen	mg/kg	14
Potassium	NH4OAc	mg/kg	651
Boron	DTPA	mg/kg	0.36
Zinc	DTPA	mg/kg	0.9
Manganese	DTPA	mg/kg	2.4
Copper	DTPA	mg/kg	0.6
Iron	DTPA	mg/kg	32
Calcium	NH4OAc	meq/100g	16.6
Magnesium	NH4OAc	meq/100g	4.8
Sodium	NH4OAc	meq/100g	0.20
Total Bases	NH4OAc	meq/100g	23.2

pH 1:1	6.2
E.C. 1:1	m.mhos/cm 0.24
Est Sat Paste E.C.	m.mhos/cm 0.62
Effervescence	None
Ammonium - N	mg/kg 9.9
Organic Matter W.B.	% 5.1
	ENR: 0

Lbs/Acre

Depth	Nitrate-N	Sulfate-S	Moisture
inches	mg/kg	lbs/acre	mg/kg
			Inches
0 - 12	20.2	65	195
Totals	20.2	65	195
Sum of Tested N:	97	lbs/acre N	

Other Tests:

Total-N (%) = 0.177

Total-C (%) = 2.01 C:N = 11.3

0 - 12 Mercury Mercury 0.01 mg/Kg

Interpretation Guide

Fertilizer recommendations for

80 BU of **WHEAT SOFT WINTER** after WHEAT SOFT WINTER
Low Medium High

Nitrogen	97	lbs/acre		150 lbs/acre of Nitrogen
Phosphorus	14	mg/kg		0 lbs/acre of P2O5
Potassium	651	mg/kg		0 lbs/acre of K2O
Sulfur	195	mg/kg		0 lbs/acre of Sulfur
Boron	0.36	mg/kg		0.5 lbs/acre of Boron
Zinc	0.9	mg/kg		0.5 lbs/acre of Zinc
Manganese	2.4	mg/kg		0 lbs/acre of Mn

We make every effort to provide an accurate analysis of your sample. For reasonable cause we will repeat tests, but because of factors beyond our control in sampling procedures and the inherent variability of soil, our liability is limited to the price of the tests. Recommendations are to be used as general guides and should be modified for specific field conditions and situations. Note: "u" indicates that the element was analyzed for but not detected

This is your Invoice #: S23-28709 Account #: 317300 Reviewed by: K. Bair, PhD, C List Cost: \$191.00



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farm consultants, inc.

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Office: (509)765-1622 • Fax: (509)765-0314 • (800)764-1622



WALLOWA CO. GRAIN GROWERS

P.O. BOX 190

ENTERPRISE, OR 97828

Laboratory #: S23-28710

Date Received: 11/13/2023

Grower: CITY OF ENTERPRISE

Field: 3 MIDDLE W

Sampled By: KANE

Customer Account #:

Customer Sample ID:

Soil Test Results

Phosphorus	Olsen	mg/kg	14
Potassium	NH4OAc	mg/kg	767
Boron	DTPA	mg/kg	0.47
Zinc	DTPA	mg/kg	1.2
Manganese	DTPA	mg/kg	2.7
Copper	DTPA	mg/kg	0.6
Iron	DTPA	mg/kg	31
Calcium	NH4OAc	meq/100g	16.7
Magnesium	NH4OAc	meq/100g	4.1
Sodium	NH4OAc	meq/100g	0.17
Total Bases	NH4OAc	meq/100g	22.9

pH 1:1	6.3
E.C. 1:1	m.mhos/cm 0.23
Est Sat Paste E.C.	m.mhos/cm 0.60
Effervescence	None
Ammonium - N	mg/kg 10.7
Organic Matter W.B.	% 5.6
	ENR: 0

Lbs/Acre

Depth	Nitrate-N	Sulfate-S	Moisture
inches	mg/kg	lbs/acre	mg/kg
			Inches
0 - 12	26.6	85	210
Totals	26.6	85	210
Sum of Tested N:	119	lbs/acre N	

Other Tests:

Total-N (%) = 0.213

Total-C (%) = 2.28 C:N = 10.7

0 - 12 Mercury

Mercury

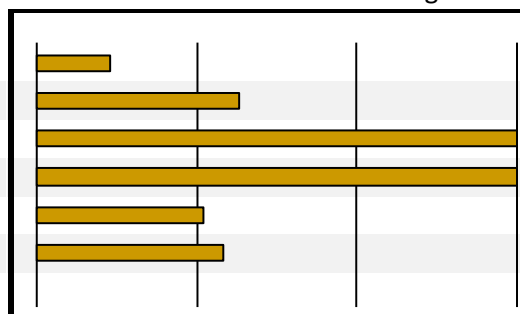
0.02 mg/Kg

Interpretation Guide

Fertilizer recommendations for

80 BU of **WHEAT SOFT WINTER** after WHEAT SOFT WINTER
Low Medium High

Nitrogen	119	lbs/acre
Phosphorus	14	mg/kg
Potassium	767	mg/kg
Sulfur	210	mg/kg
Boron	0.47	mg/kg
Zinc	1.2	mg/kg
Manganese	2.7	mg/kg



125 lbs/acre of Nitrogen
0 lbs/acre of P2O5
0 lbs/acre of K2O
0 lbs/acre of Sulfur
0 lbs/acre of Boron
0 lbs/acre of Zinc
0 lbs/acre of Mn

We make every effort to provide an accurate analysis of your sample. For reasonable cause we will repeat tests, but because of factors beyond our control in sampling procedures and the inherent variability of soil, our liability is limited to the price of the tests. Recommendations are to be used as general guides and should be modified for specific field conditions and situations. Note: "u" indicates that the element was analyzed for but not detected

This is your Invoice #: S23-28710 Account #: 317300 Reviewed by: K. Bair, PhD, C List Cost: \$191.00



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WALLOWA CO. GRAIN GROWERS

P.O. BOX 190

ENTERPRISE, OR 97828

Laboratory #: S23-28711

Date Received: 11/13/2023

Grower: CITY OF ENTERPRISE

Field: 4 MIDDLE E

Sampled By: KANE

Customer Account #:

Customer Sample ID:

Soil Test Results

Phosphorus	Olsen	mg/kg	12
Potassium	NH4OAc	mg/kg	564
Boron	DTPA	mg/kg	0.29
Zinc	DTPA	mg/kg	0.9
Manganese	DTPA	mg/kg	3.4
Copper	DTPA	mg/kg	0.5
Iron	DTPA	mg/kg	31
Calcium	NH4OAc	meq/100g	16.3
Magnesium	NH4OAc	meq/100g	4.0
Sodium	NH4OAc	meq/100g	0.32
Total Bases	NH4OAc	meq/100g	22.0

pH 1:1	6.1
E.C. 1:1	m.mhos/cm 0.35
Est Sat Paste E.C.	m.mhos/cm 0.91
Effervescence	None
Ammonium - N	mg/kg 24.8
Organic Matter W.B.	% 5.4
	ENR: 0

Depth	Nitrate-N	Sulfate-S	Moisture
inches	mg/kg	lbs/acre	mg/kg
			Inches
0 - 12	26.7	85	229
Totals	26.7	85	229
Sum of Tested N:	164	lbs/acre N	

Other Tests:

Total-N (%) = 0.202

Total-C (%) = 2.18 C:N = 10.8

0 - 12 Mercury Mercury 0.02 mg/Kg

Interpretation Guide

Fertilizer recommendations for

80 BU of **WHEAT SOFT WINTER** after WHEAT SOFT WINTER
Low Medium High

Nitrogen	164	lbs/acre	80 lbs/acre of Nitrogen
Phosphorus	12	mg/kg	15 lbs/acre of P2O5
Potassium	564	mg/kg	0 lbs/acre of K2O
Sulfur	229	mg/kg	0 lbs/acre of Sulfur
Boron	0.29	mg/kg	0.5 lbs/acre of Boron
Zinc	0.9	mg/kg	1 lbs/acre of Zinc
Manganese	3.4	mg/kg	0 lbs/acre of Mn

We make every effort to provide an accurate analysis of your sample. For reasonable cause we will repeat tests, but because of factors beyond our control in sampling procedures and the inherent variability of soil, our liability is limited to the price of the tests. Recommendations are to be used as general guides and should be modified for specific field conditions and situations. Note: "u" indicates that the element was analyzed for but not detected

This is your Invoice #: S23-28711 Account #: 317300 Reviewed by: K. Bair, PhD, C List Cost: \$191.00



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WALLOWA CO. GRAIN GROWERS

P.O. BOX 190

ENTERPRISE, OR 97828

Laboratory #: S23-28712

Date Received: 11/13/2023

Grower: CITY OF ENTERPRISE

Field: 5 SWN

Sampled By: KANE

Customer Account #:

Customer Sample ID:

Soil Test Results

Phosphorus	Olsen	mg/kg	14
Potassium	NH4OAc	mg/kg	662
Boron	DTPA	mg/kg	0.40
Zinc	DTPA	mg/kg	1.2
Manganese	DTPA	mg/kg	2.9
Copper	DTPA	mg/kg	0.6
Iron	DTPA	mg/kg	35
Calcium	NH4OAc	meq/100g	16.6
Magnesium	NH4OAc	meq/100g	4.4
Sodium	NH4OAc	meq/100g	0.20
Total Bases	NH4OAc	meq/100g	22.8

pH 1:1	6.2
E.C. 1:1	m.mhos/cm 0.29
Est Sat Paste E.C.	m.mhos/cm 0.75
Effervescence	None
Ammonium - N	mg/kg 27.5
Organic Matter W.B.	% 5.8
	ENR: 0

Lbs/Acre

Depth inches	Nitrate-N mg/kg	Sulfate-S mg/kg	Moisture inches
0 - 12	29.0	93	206
Totals	29.0	93	206
Sum of Tested N:	181	lbs/acre N	

Other Tests:

Total-N (%) = 0.232

Total-C (%) = 2.37 C:N = 10.2

0 - 12 Mercury Mercury

0.01 mg/Kg

Interpretation Guide

Fertilizer recommendations for

80 BU of **WHEAT SOFT WINTER** after WHEAT SOFT WINTER
Low Medium High

Nitrogen	181	lbs/acre	65 lbs/acre of Nitrogen
Phosphorus	14	mg/kg	0 lbs/acre of P2O5
Potassium	662	mg/kg	0 lbs/acre of K2O
Sulfur	206	mg/kg	0 lbs/acre of Sulfur
Boron	0.40	mg/kg	0.5 lbs/acre of Boron
Zinc	1.2	mg/kg	0 lbs/acre of Zinc
Manganese	2.9	mg/kg	0 lbs/acre of Mn

We make every effort to provide an accurate analysis of your sample. For reasonable cause we will repeat tests, but because of factors beyond our control in sampling procedures and the inherent variability of soil, our liability is limited to the price of the tests. Recommendations are to be used as general guides and should be modified for specific field conditions and situations. Note: "u" indicates that the element was analyzed for but not detected

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WALLOWA CO. GRAIN GROWERS

P.O. BOX 190

ENTERPRISE, OR 97828

Laboratory #: S23-28713

Date Received: 11/13/2023

Grower: CITY OF ENTERPRISE

Field: 6 SWS

Sampled By: KANE

Customer Account #:

Customer Sample ID:

Soil Test Results

Phosphorus	Olsen	mg/kg	10
Potassium	NH4OAc	mg/kg	618
Boron	DTPA	mg/kg	0.37
Zinc	DTPA	mg/kg	0.7
Manganese	DTPA	mg/kg	2.3
Copper	DTPA	mg/kg	0.6
Iron	DTPA	mg/kg	31
Calcium	NH4OAc	meq/100g	13.0
Magnesium	NH4OAc	meq/100g	3.6
Sodium	NH4OAc	meq/100g	0.22
Total Bases	NH4OAc	meq/100g	18.4

pH 1:1	6.1
E.C. 1:1	m.mhos/cm 0.26
Est Sat Paste E.C.	m.mhos/cm 0.68
Effervescence	None
Ammonium - N	mg/kg 27.6
Organic Matter W.B.	% 4.6
	ENR: 0

Lbs/Acre

Depth	Nitrate-N	Sulfate-S	Moisture
inches	mg/kg	lbs/acre	mg/kg
			Inches
0 - 12	36.4	116	205
Totals	36.4	116	205
Sum of Tested N:	204	lbs/acre N	

Other Tests:

Total-N (%) = 0.178

Total-C (%) = 1.75 C:N = 9.8

0 - 12 Mercury Mercury 0.01 mg/Kg

Interpretation Guide

Fertilizer recommendations for

80 BU of **WHEAT SOFT WINTER** after WHEAT SOFT WINTER
Low Medium High

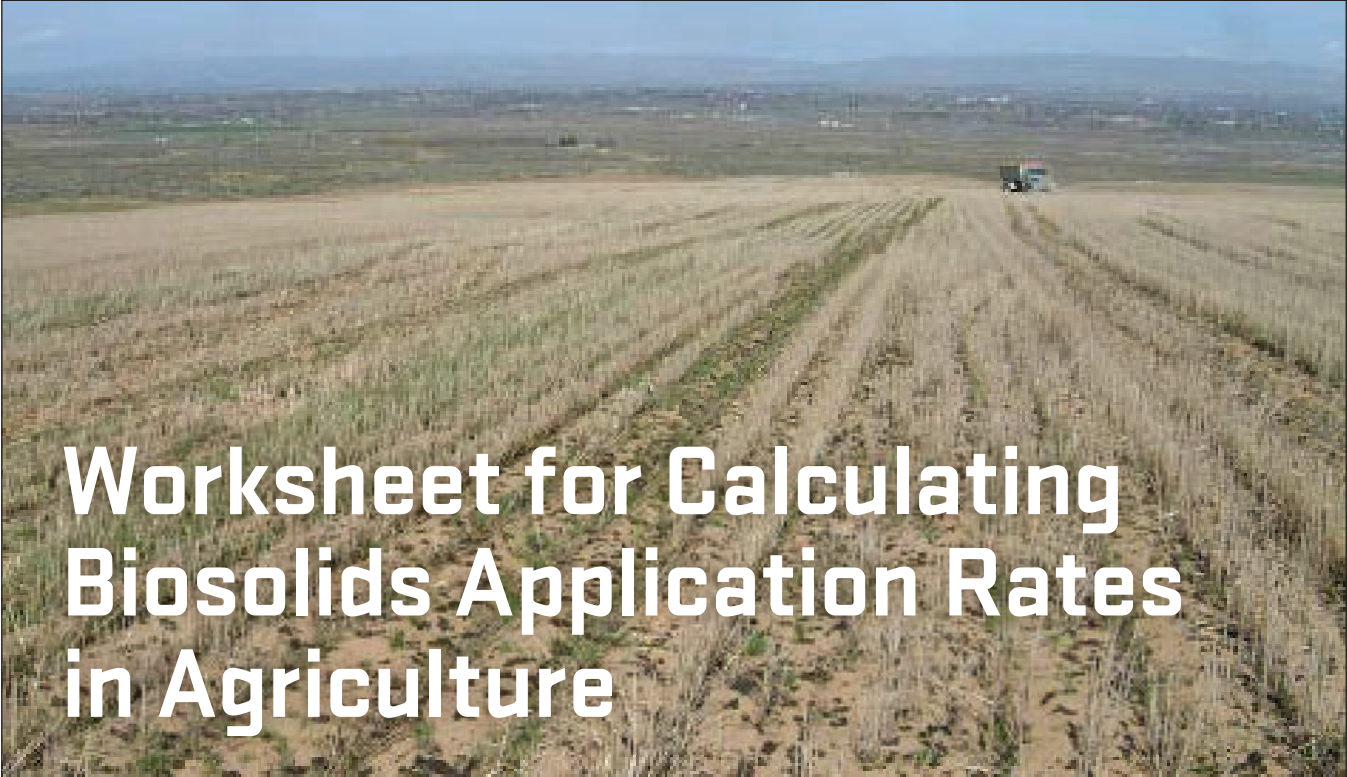
Nitrogen	204	lbs/acre	40 lbs/acre of Nitrogen
Phosphorus	10	mg/kg	30 lbs/acre of P2O5
Potassium	618	mg/kg	0 lbs/acre of K2O
Sulfur	205	mg/kg	0 lbs/acre of Sulfur
Boron	0.37	mg/kg	0.5 lbs/acre of Boron
Zinc	0.7	mg/kg	2.5 lbs/acre of Zinc
Manganese	2.3	mg/kg	0 lbs/acre of Mn

We make every effort to provide an accurate analysis of your sample. For reasonable cause we will repeat tests, but because of factors beyond our control in sampling procedures and the inherent variability of soil, our liability is limited to the price of the tests. Recommendations are to be used as general guides and should be modified for specific field conditions and situations. Note: "u" indicates that the element was analyzed for but not detected

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APPENDIX D

Example Nutrient Uptake Calculations



Worksheet for Calculating Biosolids Application Rates in Agriculture

Photo: Brian Campbell, Natural Selection Farms

Dan M. Sullivan, Deirdre Griffin LaHue, Biswanath Dari, Andy I. Bary and Craig G. Cogger

Biosolids are a product of municipal wastewater treatment. Raw sewage solids must be processed to meet U.S. Environmental Protection Agency standards before they can be called biosolids. Biosolids contain organic matter and nutrients that are beneficial for soil and crop productivity.

This publication focuses on matching the nitrogen (N) supplied by biosolids to the nitrogen needs of the crop. Regulatory agencies require agronomic rate calculations for most biosolids applications to cropland.

Overview: agronomic rate calculation

There are six steps to calculate the agronomic rate of a biosolids application:

1. Collect information on the site and crop, including crop N requirement.
2. Estimate the plant-available N needed from the biosolids application.
3. Collect biosolids N data.
4. Estimate plant-available N per dry ton of biosolids.

5. Calculate the agronomic biosolids application rate on a dry ton basis.

6. Convert the application rate to an “as is” basis.

In determining biosolids application rates, it's important to evaluate trace element concentrations in biosolids and the regulatory limits for trace element application (see Appendix A). However, in almost all cases, nitrogen controls the biosolids application rate.

A companion publication, *Fertilizing with Biosolids* (PNW 508), provides additional information about the value of biosolids as a fertilizer. The “For more information” section of this publication gives a summary of Pacific Northwest research and Extension publications on land application of municipal biosolids.

Dan M. Sullivan, Extension soil scientist and professor of nutrient management, and Biswanath Dari, agronomist and assistant professor, both of the Department of Crop and Soil Science, Oregon State University; Deirdre Griffin LaHue, sustainable soil management specialist and assistant professor, Andy I. Bary, senior scientific assistant, and Craig C. Cogger, Extension soil scientist (emeritus), all of the Department of Crop and Soil Sciences, Washington State University

WORKSHEET

For guidance on completing this worksheet, see “How to Use the Worksheet,” starting on page 5.

Step 1. Collect site information

Soil and crop information:

Line number	Your information	Example
1.1	Soil series and texture (NRCS soil survey)	Hurwal/Powwatka Silt Loams
1.2	Yield goal (units/acre/year*) estimated from grower records or by agronomist**	1.5 tons per acre
1.3	Crop rotation (grower; e.g., wheat, fallow, wheat)	perennial grass
1.4	Plant-available N needed to produce yield goal (university fertilizer/nutrient management guide; agronomist) (lb N/acre/year)	120 pounds nitrogen per acre (lbs N/acre)
		200 lb N/acre

Plant-available N provided by other sources:

Line number	Your calculation	Example	Unit	
Pre-application testing				
1.5	Nitrate-N applied in irrigation water	0	10	lb N/acre
1.6	Preplant nitrate-N in root zone (east of Cascades)***	89	—	lb N/acre
Adjustments to typical soil N mineralization				
1.7	Plowdown of cover or green manure crop***	--	—	lb N/acre
1.8	Previous biosolids applications (see Table 1, page 7)	--	30	lb N/acre
1.9	Previous manure applications	0	—	lb N/acre
Grower information				
1.10	N applied at seeding (starter fertilizer)	0	—	lb N/acre
Total				
1.11	Total plant-available N from other sources = sum of lines 1.5 through 1.10	89	40	lb N/acre

* Yield goals may be expressed in weight (tons, pounds, etc.) or in volume (bushels).

** The American Society of Agronomy certifies professional agronomists as Certified Crop Advisors (CCAs). See <https://www.certifiedcropadviser.org> for more information.

*** Do not list here if these N sources were accounted for in the nitrogen fertilizer recommendation from a university fertilizer/nutrient management guide.

Step 2. Estimate the amount of plant-available N needed from biosolids

Line number	Your calculation	Example	Unit
2.1	Plant-available N needed to produce yield goal (from line 1.4)	120	200 lb N/acre
2.2	Plant-available N from other sources (from line 1.11)	89	40 lb N/acre
2.3	Amount of plant-available N needed from biosolids = line 2.1 – line 2.2	31	160 lb N/acre

Step 3. Collect biosolids data

Application information:

Line number	Your information	Example
3.1	Moisture content of biosolids	Dewatered liquid
3.2	Biosolids processing method (see Table 3, page 10)	Aerobic digestion anaerobic
3.3	Method of application (surface or injected)	Surface surface
3.4	Number of days to incorporation of biosolids	No incorporation no incorporation
3.5	Expected application season	Spring and fall March to September

Laboratory biosolids analysis (dry weight basis):

If your biosolids analysis is on an “as is” or wet weight basis, you will need to divide your analysis by the percent total solids (line 3.10) and multiply the result by 100 to convert to a dry weight basis.

Line number	Your calculation	Example	Unit
3.6	Total Kjeldahl N (TKN)*	66,800	50,000 mg/kg
3.7	Ammonium N*	4,430	10,000 mg/kg
3.8	Nitrate N **, **	Not detected	not analyzed mg/kg
3.9	Organic N*, *** = line 3.6 – line 3.7	62,370	40,000 mg/kg
3.10	Total solids	0.76	2.5 percent

* If your analysis is in percent, multiply by 10,000 to convert to mg/kg.

** Nitrate-N analysis required for composted or aerobically digested biosolids, but not for anaerobically digested biosolids.

*** Organic N = total Kjeldahl N – ammonium N.

Step 4. Estimate plant-available N per dry ton of biosolids

Convert biosolids N analysis to lb per dry ton:

Line number	Your calculation	Example	Unit
4.1	Total Kjeldahl N (TKN)*	133.60	100
4.2	Ammonium N*	8.86	20
4.3	Nitrate N*	Not detected	not analyzed
4.4	Organic N = line 4.1 – line 4.2	124.74	80

*Multiply mg/kg (from lines 3.6 through 3.9) × 0.002. If your analyses are expressed in percent, multiply by 20 instead of 0.002.

Estimate inorganic N retained:

Line number	Your calculation	Example	Unit
4.5	Percent of ammonium-N retained after application (see Table 2, page 9)	20	55
4.6	Ammonium-N retained after application = line 4.2 × (line 4.5 ÷ 100)	1.77	11
4.7	Biosolids inorganic N retained = line 4.3 + line 4.6	1.77	11

Estimate organic N mineralized:

Line number	Your calculation	Example	Unit
4.8	Percent of organic N that is plant-available in Year 1 (see Table 3, page 10)	35	35
4.9	First year plant-available organic N = line 4.4 × (line 4.8 ÷ 100)	43.66	28

Plant-available N:

Line number	Your calculation	Example	Unit
4.10	Estimated plant-available N = available inorganic N (line 4.7) + available organic N (line 4.9)	45.43	39

Step 5. Calculate the agronomic biosolids application rate

Line number	Your calculation	Example	Unit
5.1	Amount of plant-available N needed from biosolids (from line 2.3)	31	160
5.2	Estimated plant-available N in biosolids (from line 4.10)	45.43	39
5.3	Agronomic biosolids application rate = line 5.1 ÷ line 5.2	0.68	4.1
			dry ton/acre

Step 6. Convert to “as is” biosolids basis

Desired units	Your calculation	Example
Gallons per acre =	(line 5.3 ÷ line 3.10) × 24,000	21,474
Inches per acre =	(line 5.3 ÷ line 3.10) × 0.88	0.79
Wet tons per acre =	(line 5.3 ÷ line 3.10) × 100	89.47
		164

HOW TO USE THE WORKSHEET

Step 1. Collect site information

Soil series and surface soil texture (line 1.1)

Find the location on the Natural Resources Conservation Service (NRCS) soil survey. Record the series name and surface texture of the predominant soil. NRCS soil survey data is available online at <https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm>.

Crop yield goal (line 1.2)

Field records are the best source for crop yield estimates. You can find proven yields for most grain farms from the local Farm Service Agency office. For most other cropping systems, grower records are the only source available. Be sure to note whether the yield records are on an “as is” or dry matter basis.

A site used repeatedly for biosolids application should have yield data collected each year. Use this accumulated data for determining crop nitrogen requirement.

Yield data is typically not available for grazed pastures because grazing animals consume the crop in the field. In these cases, omit the yield goal and go directly to line 1.4. Estimate plant nitrogen needs from the appropriate university fertilizer/nutrient management guide, based on the level of pasture management.

Crop rotation (line 1.3)

Consult with the grower and discuss possible crop rotations. Rotations that include root crops or other crops with long post-application waiting periods are not suitable for Class B biosolids application. A companion publication (*Fertilizing with Biosolids*, PNW 508) provides more information about USEPA standards for Class A and Class B biosolids.

Plant-available N needed to produce yield goal (line 1.4)

You can estimate plant-available N needs by referring to university fertilizer/nutrient management guides.

University fertilizer and nutrient management guides

Land grant universities (for example, Washington State University, Oregon State University, and the University of Idaho) publish fertilizer and nutrient management guides that estimate plant-available N needs. Use the guide most appropriate for the site and crop. For major crops, guides may cover irrigated or rainfed (dryland) cropping and different geographic areas. Don't use guides produced for irrigated sites when evaluating dryland sites. When appropriate guides do not exist, consult university Extension agronomists/

soil scientists or professional agronomists (Certified Crop Advisors) who have expertise working within the cropping system.

Nitrogen fertilizer application rates listed in the fertilizer/nutrient management guides are based on field trials conducted under the specified climate and cultural conditions. Growth trial results are averaged over a variety of soil types and years. Note that guide recommendations are not the same as crop uptake. This is because the guides account for N available from mineralization of soil organic matter and the efficiency of N removal by the crop.

The N rate recommended in fertilizer/nutrient management guides assumes average yields, good management practices, and removal of N from the field through crop harvest or grazing. In terms of satisfying crop N needs, plant-available N from biosolids application is considered equal to fertilizer N.

Agronomist calculations

Because of the general nature of university fertilizer and nutrient management guides, it may be worthwhile to have a professional agronomist calculate how much plant-available N is needed for a specific field. The American Society of Agronomy certifies professional agronomists as Certified Crop Advisors (CCAs). See <https://www.certifiedcropadviser.org> for more information.

Always use the same method to calculate the N requirements. You will need to document your reasons for using agronomist calculations instead of the university guide.



Photo: Andy Bary, ©Washington State University
Dewatered biosolids stockpile at field application site

Plant-available N provided by other sources (lines 1.5 to 1.11)

To make sure there isn't too much nitrogen applied to a crop, you must determine how much nitrogen comes from sources other than biosolids and soil organic matter. These sources of N are grouped into three categories in the worksheet:

- Plant-available N estimated by pre-application testing
- Adjustments to typical soil organic N mineralization (usually obtained from an agronomist)
- Information supplied by the grower

N estimated by pre-application testing (lines 1.5 to 1.6)

Irrigation water

Since the amount of nitrate-N in irrigation water varies, it should be determined by water testing. Irrigation water containing 5 mg nitrate-N per liter will contribute 1.1 pounds of nitrogen per acre-inch applied; irrigation water containing 10 mg nitrate-N per liter will contribute 2.3 pounds of N per acre-inch.

Preplant nitrate-N in the root zone (east of Cascades)

You can estimate the preplant nitrate-N in the root zone by testing the soil in early spring. Sample in 1-foot increments to a depth of at least 2 feet.

Some university fertilizer/nutrient management guides use preplant soil nitrate-N when calculating N fertilizer application rates. If you use these guides, don't count soil test nitrate-N in our worksheet—it has already been accounted for in the recommended fertilizer N rate prescribed in the university fertilizer/nutrient management guide.

In dryland cropping systems, soil testing below 3 feet is used to assess long-term N management. Accumulation of nitrate below 3 feet indicates that past N applications were not efficiently utilized by the crop. However, soil nitrate-N below 3 feet is typically not included as a credit when making a N fertilizer recommendation.

Adjustments to typical soil N mineralization (lines 1.7 to 1.9)

Nitrogen mineralization is the release of nitrogen from organic forms to plant-available inorganic forms (ammonium and nitrate). Soil organic matter supplies plant-available N through mineralization, but this is accounted for in the university fertilizer/nutrient

management guides. Sites with a history of cover crops, biosolids applications, or manure applications supply more plant-available N than do sites without a history of these inputs, and biosolids recommendations must be adjusted based on this additional supply of N.

Plowdown of cover crops

Cover crops are not removed from the field, but are recycled back into the soil. You can get an estimate of the total N contributed by estimating the biomass dry matter (lb per acre) and the nitrogen concentration (percent total) in the cover crop. Plant-available N provided by a cover crop typically ranges from 10 to 40 percent of the total N contained in aboveground cover crop biomass. Consult *Estimating Plant-Available Nitrogen Release from Cover Crops* (PNW 636) for more information.

Previous biosolids applications

Previous biosolids applications contribute to plant-available nitrogen in the years after the initial application. In the worksheet, they are considered as “N from other sources.” We estimate that 8, 3, 1, and 1 percent of the organic N *originally applied* mineralizes in Years 2, 3, 4, and 5, respectively, after application (Table 1). After Year 5, biosolids N is considered part of “stable” soil organic matter and is not included in calculations.

In using Table 1, consider the following example. Suppose:

- You applied biosolids with an average organic N content of 30,000 mg/kg

- Applications were made the previous 2 years
- The application rate was 4 dry tons per acre

Table 1 gives estimates of nitrogen credits *in terms of the organic N originally applied*. Look up 30,000 mg/kg under Year 2 and Year 3 columns in the table. The table estimates 4.8 lb plant-available N per dry ton for year 2, and 1.8 lb plant-available N for year 3 (two-year credit of 6.6 lb N per dry ton). To calculate the N credit in units of lb per acre, multiply your application rate (4 dry ton per acre) by the N credit per ton (6.6 lb N per dry ton). The N credit is 26.4 lb plant-available N per acre.

Previous manure applications

Previous manure applications contribute to plant-available nitrogen in a similar manner to previous biosolids applications. To estimate this contribution, consider field history (manure type, application rate, and date of application). The Extension publication *Fertilizing with Manure and Other Organic Amendments* (PNW 533) provides plant-available N estimates.

Information supplied by the grower (line 1.10)

N applied at seeding

Some crops need a starter fertilizer (N applied at seeding) for best growth. These fertilizers usually supply N, P, and S. Examples are 16-20-0, 10-34-0. Starters are usually applied at rates that supply 10 to 30 lb N per acre. Enter all N supplied by starter fertilizer on line 1.10 in the worksheet.

Table 1. Estimated nitrogen credits for previous biosolids applications at a site

	Years after biosolids application			
	Year 2	Year 3	Year 4 and 5	Cumulative (Years 2, 3, 4, and 5)
	Percent of organic N applied first year			
	8	3	1	13
Biosolids organic N as applied (mg/kg dry weight basis)	Plant-available N released (lb N per dry ton)			
10,000	1.6	0.6	0.2	2.6
20,000	3.2	1.2	0.4	5.2
30,000	4.8	1.8	0.6	7.8
40,000	6.4	2.4	0.8	10.4
50,000	8.0	3.0	1.0	13.0
60,000	9.6	3.6	1.2	15.6



Photo: Brian Campbell, Natural Selection Farms
Dewatered biosolids application to dryland wheat during fallow

Step 2. Estimate plant-available N needed from biosolids

Next you will estimate the amount of plant-available N the biosolids must provide. This is the difference between the total plant-available N needed to produce the yield goal and the plant-available N from other sources.

Step. 3. Collect biosolids data

To make the calculation, managers will need the following analyses:

- Total Kjeldahl N (TKN)
- Ammonium-N ($\text{NH}_4\text{-N}$)
- Nitrate-N ($\text{NO}_3\text{-N}$; composted or aerobically digested biosolids only)
- Percent total solids

If your laboratory results are on an “as is” or wet weight basis, you must convert them to a dry weight basis. To convert from an “as is” to a dry weight basis, divide your analysis by the percent solids in the biosolids and multiply the result by 100. Total Kjeldahl N includes over 95 percent of the total N in biosolids. In using the worksheet, we will assume that total Kjeldahl N equals total N.

Ammonium-N usually makes up most of the inorganic N present in biosolids. Depending on your laboratory, results for ammonium-N may be expressed as either ammonia-N ($\text{NH}_3\text{-N}$) or ammonium-N ($\text{NH}_4\text{-N}$). Make sure that the laboratory determines ammonium-N on a fresh (not dried) biosolids sample. The ammonium-N present in fresh biosolids is lost as gaseous ammonia when biosolids are dried.

There may be significant amounts of nitrate in aerobically digested biosolids or in composts. There is little nitrate in anaerobically digested biosolids; therefore, nitrate analysis is not needed for these materials.

Determine biosolids organic N by subtracting ammonium-N from total Kjeldahl N (line 3.6 minus line 3.7). Percent total solids analyses are used to calculate application rates. Biosolids applications are calculated as the dry weight of solids applied per acre (e.g., dry tons per acre).

Step 4. Estimate plant-available N per dry ton of biosolids

The estimate of plant-available N per dry ton of biosolids includes:

- Some of the ammonium-N
- All of the nitrate-N
- Some of the organic N

Inorganic N retained (lines 4.5 to 4.7)

Ammonium-N (lines 4.5 to 4.6)

Under some conditions, ammonium is readily transformed to ammonia and lost as a gas. This gaseous ammonia loss reduces the amount of plant-available N supplied by biosolids. The following section explains the factors used to estimate ammonia-N retained in plant-available form after application.

Biosolids processing

The following types of biosolids processing cause most of the ammonia-N to be lost as ammonia gas or converted to organic forms before application:

- Drying beds
- Alkaline stabilization at pH 12
- Composting

Application method

Ammonia loss occurs only with surface application. Injecting liquid biosolids eliminates most ammonia loss, since the injected liquid is not exposed to the air. Surface applications of liquid biosolids lose less ammonia than do dewatered biosolids. For liquid biosolids, the ammonia is less concentrated and is held as NH_4^+ on negatively-charged soil surfaces after the liquid contacts the soil.

Ammonia loss is fastest just after application to the field. As ammonia is lost, the remaining biosolids are acidified—that is, each molecule of NH_3 lost generates H^+ (acidity). Acidification gradually slows ammonia loss.

Biosolids that remain on the soil surface will eventually reach a pH near 7, and further ammonia losses will be small. Ammonia loss takes place very rapidly after application, with most of the loss occurring during the first two days after application.

Time to soil incorporation

Tillage to cover biosolids can reduce ammonia loss by adsorption of ammonium-N onto soil particles.

Table 2 estimates the amount of ammonium-N retained after field application. To use this table, you will need information on biosolids stabilization processes, method of application (surface or injected), and the number of days to soil incorporation.

Nitrate-N (line 4.3)

We assume 100 percent availability of biosolids nitrate-N.

Organic N mineralized (lines 4.8 to 4.9)

Biosolids organic N, which includes proteins, amino acids, and other organic N compounds, is not available to plants at the time of application. Plant-available N is released from organic N through microbial activity in soil. This process is called mineralization. It is more rapid in soils that are warm and moist, and is slower in soils that are cold or dry. Biosolids organic N mineralization rates in soil also depend on the treatment plant processes that produced the biosolids.

Use Table 3 (page 10) to estimate biosolids mineralization rates based on processing. Use the middle of the range presented, unless you have



Photo: City of Portland, Bureau of Environmental Services
Spring grass growth on dryland pasture following dewatered biosolids application (top) vs. no biosolids (bottom)

information specific to the site or biosolids that justify using higher or lower values within the range.

Step 5. Calculate the agronomic biosolids application rate

Perform this calculation using the results of the previous sections, as shown in lines 5.1 through 5.3.

Step 6. Convert agronomic biosolids application rate to “as is” basis

Use the appropriate conversion factors (given in Table 4, page 10) to convert to gallons, acre-inches, or wet tons per acre.

Table 2. Estimates of ammonium-N retained after biosolids application

	Surface-applied			Injected
	Liquid biosolids	Dewatered biosolids	Composted, air-dried, or heat-dried biosolids	All biosolids
Time to incorporation by tillage	Ammonium-N retained (percent of applied)			
Incorporated immediately	95	95	100	100
After 1 day	70	50	100	100
After 2 days	60	30	100	100
No incorporation	55	20	100	100

Table 3. First year mineralization estimates for organic N in biosolids

Processing	First-year organic N mineralization rate (percent of organic N)
Fresh*	
Anaerobic digestion, liquid or dewatered	30–40
Aerobic digestion, liquid or dewatered	30–40
Drying bed	30–40
Heat-dried	30–40
Lagoon	
Less than 6 months	30–40
6 months to 2 years	20–25
2 to 10 years	10–20
More than 10 years	5–10
Composting	0–10
Blends and soil products	†

*“Fresh” includes all biosolids that have not been stabilized by long-term storage in lagoons or composting.

†Because blends (with woody materials) and soil products that contain biosolids vary widely in composition and age depending on intended use, available N may vary widely among products. For blends, available N can be estimated through laboratory incubation studies.

Table 4. Conversion factors

1%	=	10,000 mg/kg or ppm 20 lb/ton
1 mg/kg	=	1 ppm 0.0001 % 0.002 lb/ton
1 wet ton	=	1 dry ton ÷ (percent solids × 0.01)
1 dry ton	=	1 wet ton × (percent solids × 0.01)
1 acre-inch	=	27,000 gallons

Other considerations for calculations

Small acreage sites without a reliable yield history

Some communities apply biosolids to small acreages managed by part-time farmers. In many of these cases, there is no reliable yield history for the site, and the goal of management is not to make the highest economic returns. You can be sure of maintaining agronomic use of biosolids nitrogen on these sites by applying at a rate substantially below that estimated for maximum yield.

Equipment limitations at low application rates

At some low-rainfall dryland cropping locations east of the Cascades, the agronomic rate calculated with the worksheet will be lower than can be spread with manure spreaders (usually 2 to 3 dry tons per acre). At these locations, you may be able to apply the dewatered biosolids at the equipment limit, but check with your permitting agency for local requirements.

Appendix A: Cumulative loading of trace elements

Under EPA regulations (40 CFR Part 503.13), managers must maintain records on cumulative loading of trace elements only when bulk biosolids do not meet EPA Exceptional Quality Standards for trace elements (Table 5). Contact your regulatory agency for details on record keeping if your biosolids do not meet the standards in Table 5.

Table 5. Trace elements concentration limits for land application

Element	Symbol	Concentration limit	
		Exceptional quality standard (EPA Table 3)* (mg/kg)	Ceiling limit (EPA Table 1)* (mg/kg)
Arsenic	As	41	75
Cadmium	Cd	39	85
Copper	Cu	1,500	4,300
Lead	Pb	300	840
Mercury	Hg	17	57
Molybdenum	Mo	**	75
Nickel	Ni	420	420
Selenium	Se	100	100
Zinc	Zn	2,800	7,500

Source: EPA 40 CFR Part 503

*EPA Table 3 and Table 1 refer to tables in EPA biosolids rule (40 CFR Part 503).

**Molybdenum concentration standard level is under review by the EPA.

For more information

Soil testing and soil analysis

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APPENDIX E
Site Management Agreement

AGREEMENT FOR THE LAND APPLICATION OF DOMESTIC BIOSOLIDS

This Agreement is made and entered into this 10th day of December 2024, between the City of Enterprise, Oregon, hereafter referred to as the City, and Cornerstone Farms Joint Venture, hereinafter referred to as the Owner.

RECITALS

- A. The Owner owns real properties shown on Figure 1 - Subject Properties I; and Figure 2 - Subject Properties II.
- B. The City owns and operates a municipal wastewater treatment facility (WWTF) under National Pollutant Discharge Elimination System Permit No. 101659 and desires to land apply biosolids (as defined by 40 Code of Federal Regulations 503) generated by the WWTF on the subject properties.
- C. Land application of domestic biosolids is mutually beneficial to the City and the Owner.

AGREEMENT

The City and the Owner agree to fulfill the following:

- A. The City, through its agents, agrees to:
 - a. In coordination with the Owner, make available, haul, and spread stable biosolids on subject properties at an application rate approved by the Oregon Department of Environmental Quality (DEQ). The City's obligation is subject to the availability of the biosolids;
 - b. Pick rocks and any plastic material larger than 2 inches in diameter from the spread biosolids that are inconsistent with those present on the subject properties;
 - c. Maintain daily records during biosolids application that indicate the quantity of biosolids delivered to the subject properties, the specified area where the biosolids were applied on the subject properties, application data, means of application, and any additional information required by the DEQ;
 - d. Have its biosolids tested as required by state and federal law, make certain the biosolids meet minimum requirements for land application pursuant to state and federal law, and provide the Owner and the DEQ with copies of the test results, as well as notify the Owner immediately should the biosolids fail to meet minimum standards for land application;
 - e. Use only those ingress and egress routes to and from subject properties designated by the Owner;
 - f. Conform with all state biosolids rules and guidelines governing land application of municipal biosolids and any management terms stipulated under the biosolids land application authorization letter from the DEQ;
 - g. Notify the Owner of any DEQ directives the City receives pertaining to the items covered by this Agreement; and
 - h. Obtain written authorization from the DEQ to land apply biosolids to the subject property prior to commencing biosolids land application.

- B. The Owner agrees to:
- a. Define the areas of the subject properties available for land application of biosolids;
 - b. Irrigate in accordance with the DEQ-approved Biosolids Management Plan. Irrigation of affected fields will not resume following biosolids application until the fields are planted for production. Irrigation will be managed to prevent excessive ponding on or runoff from the subject properties.
 - c. Notify the City immediately of any odor complaint, or other complaints, received by the Owner relative to the land application of biosolids upon the subject properties;
 - d. Follow DEQ regulations relative to the types of crops planted and their management;
 - e. Annually provide the City with anticipated crop type, irrigation, grazing, cutting, and other crop management practices;
 - f. Indemnify and hold the City harmless from any and all claims, suits, or causes of action brought against the City as a result of negligent surface application on the subject properties. Owner shall not be required to indemnify the City for any claims, suits, or causes of action brought against the City arising from the content of the biosolids;
 - g. Comply with the following regulatory requirements:
 - i. Public contact access is restricted for 30 days after biosolids land application. Access control is assumed based on the remoteness of the rural private land.
 - ii. Food crops with harvested parts that touch the biosolids/soil mixture and are totally above the land surface shall not be harvested until 14 months after application of biosolids.
 - iii. Food crops with harvested parts below the surface of the land shall not be harvested until 38 months after biosolids application.
 - iv. Food crops, feed crops, and fiber crops whose edible parts do not touch the surface of the soil shall not be harvested until 30 days after biosolids application.
 - v. Animals shall not be allowed to graze until 30 days after application of biosolids to the land.
 - h. Advise all purchasers, tenants, lessees, or other persons or entities of interest to the subject properties of this Agreement.
- C. Owner acknowledges that biosolids may contain some plastic or other foreign materials normally present in domestic wastewater, and Owner accepts the biosolids "as is," except as noted in this Agreement, subparagraph A.b., above.
- D. The parties agree to begin using the subject properties to apply biosolids as soon as possible after receiving DEQ approval of the Agreement, and that the Agreement shall remain in effect for three years, unless it is terminated within that time pursuant to the terms of this Agreement.
- E. All notifications to the City and the Owner shall be in writing to all parties. Notice to the City shall be provided to Jeffrey Yanke, Council President, Enterprise City Hall, 102 E. North Street, Enterprise, Oregon 97828. Notice to the Owner shall be provided to Kurt Melville/Kevin Melville, 64022 Imnaha Highway, Joseph, Oregon 97846.
- F. This Agreement shall bind the parties hereto, and it is agreed that there are no other agreements, written or oral, which add to or change the terms hereof. Any such agreements of modification shall be expressed in writing, signed by all parties, dated, and attached to this Agreement.

COMPENSATION

In consideration of the above listed agreement, the City agrees to pay Owner \$2,250 for land application for the 2024-2025 fiscal year, with the payment due by April 15th, 2025. Beginning fiscal year 2025-2026, the City agrees to pay Owner an annual payment of \$4,500, with the payment due to the Owner no later than July 30th.

TERMINATION

Either party may terminate all or any portion of this agreement by giving the other party a 180-day written Notice of Termination.

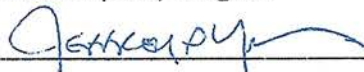
CONTINUATION OF AGREEMENT

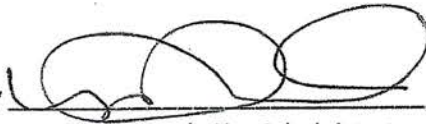
This agreement shall continue, absent Notice of Termination being provided, set forth with the terms of this agreement. Additionally, parties shall meet no later than March 31st each year.

EFFECTIVE

Effective on the date first above written.

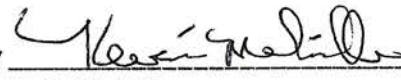
City of Enterprise, Oregon:

By 
Jeffrey Yanke, Council President

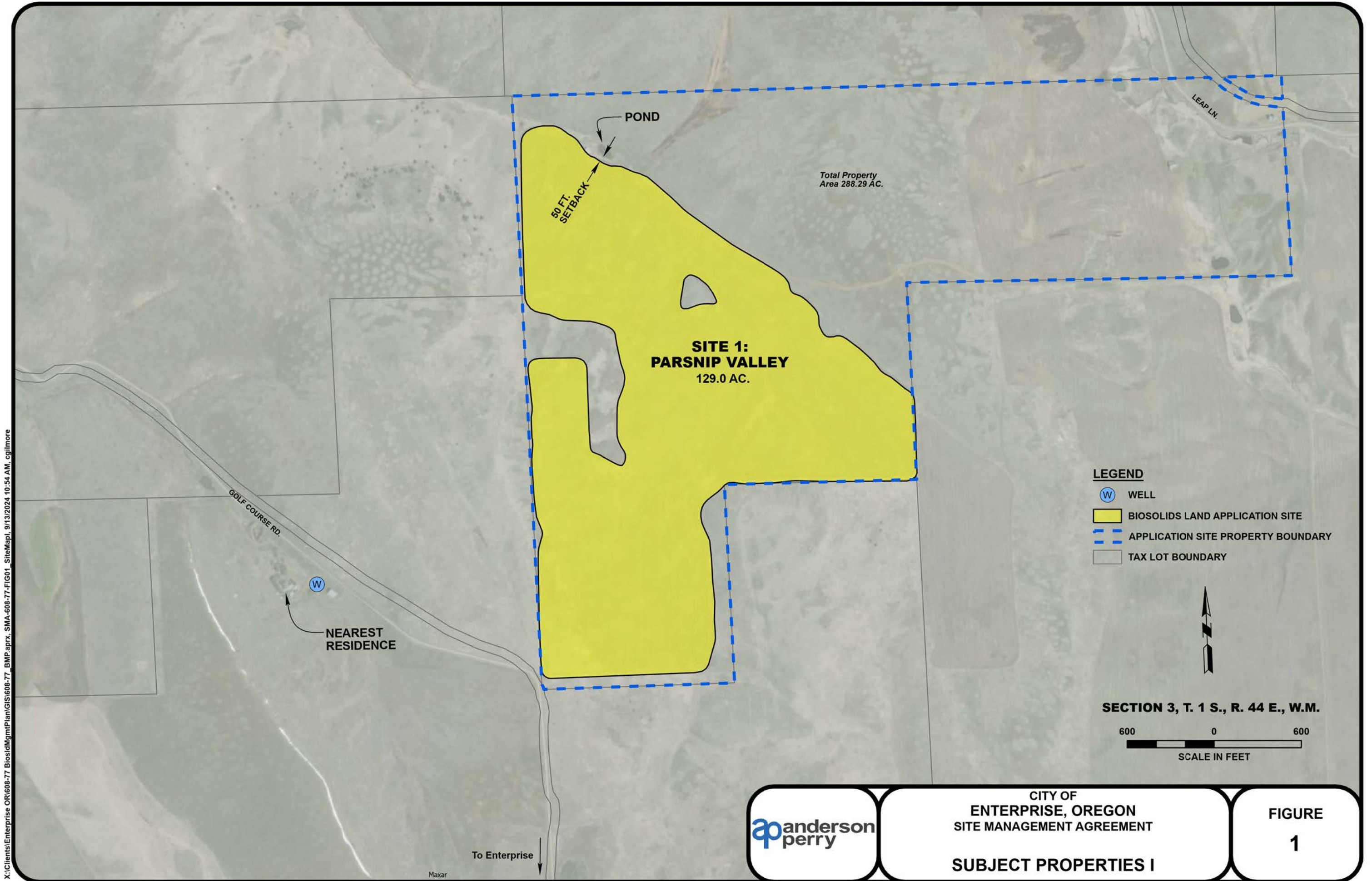
By 
Lacey McQuead, City Administrator

Owner:

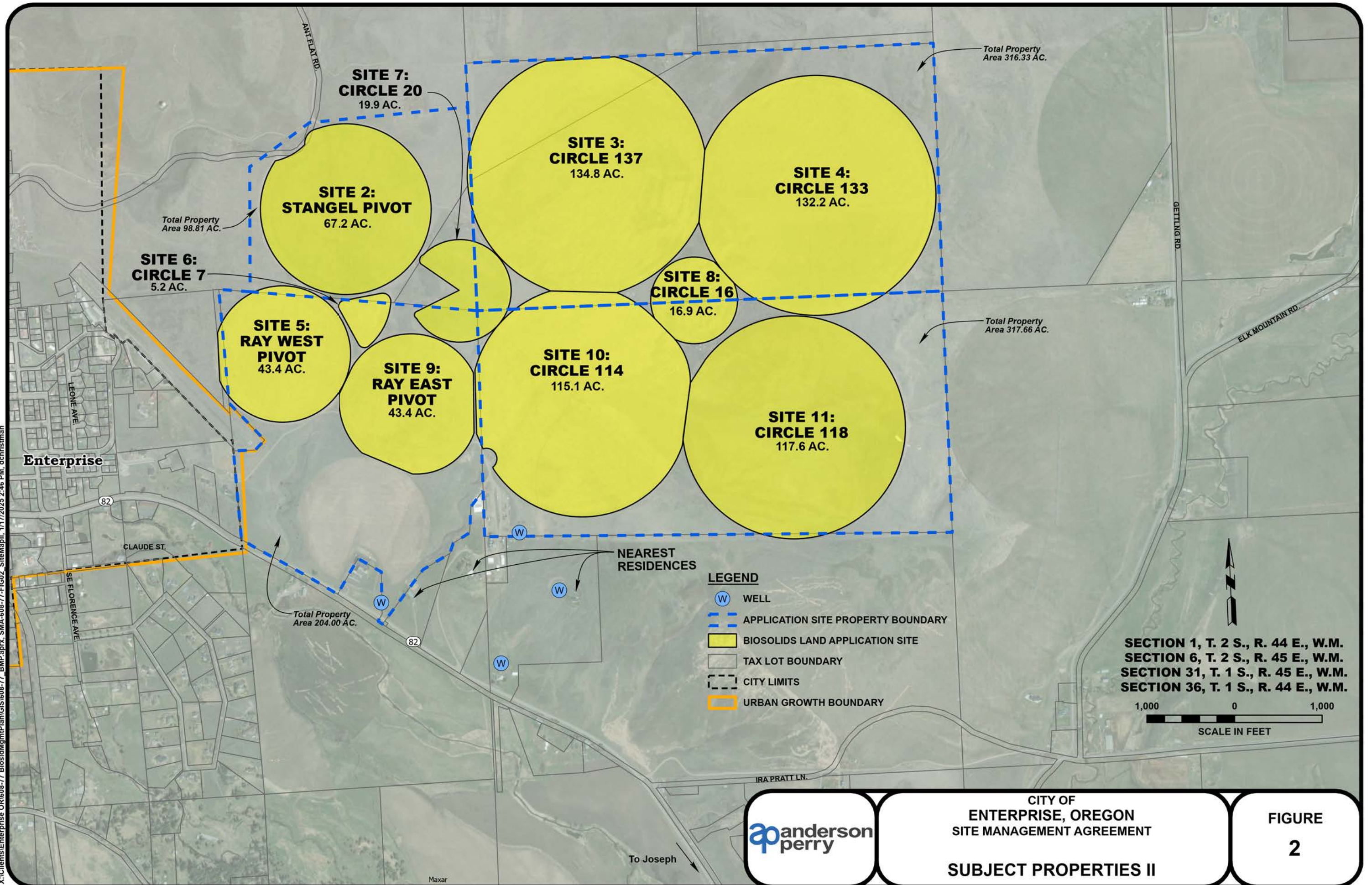
By 
Kurt Melville
Cornerstone Farms Joint Venture

By 
Kevin Melville
Cornerstone Farms Joint Venture

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APPENDIX F

Soil Survey

Established Series
Rev. HRG/RJE/KWH
06/2006

HARLOW SERIES

The Harlow series consists of shallow, well drained soils formed in loess and colluvium from basalt or argillite. Harlow soils are on canyons, structural benches, and basalt plateaus. Slopes are 2 to 90 percent. The average annual precipitation is about 26 inches and average annual temperature is about 43 degrees F.

TAXONOMIC CLASS: Clayey-skeletal, smectitic, frigid Lithic Argixerolls

TYPICAL PEDON: Harlow very stony clay loam- rangeland on a 55 percent southwest facing slope at an elevation of 4,320 feet. (Colors are for dry soils unless otherwise noted.)

A1--0 to 3 inches; dark grayish brown (10YR 4/2) very stony clay loam, very dark brown (10YR 2/2) moist; moderate fine and medium granular structure; hard, firm, moderately sticky and moderately plastic; many very fine roots; many very fine irregular pores; 30 percent gravel, 10 percent cobbles, and 5 percent stones; neutral (pH 6.7); clear wavy boundary.

A2--3 to 6 inches; dark grayish brown (10YR 4/2) very gravelly clay loam, very dark brown (10YR 2/2) moist; moderate fine and medium granular structure; hard, firm, moderately sticky and moderately plastic; many very fine roots; many irregular pores; 30 percent gravel and 10 percent cobbles; neutral (pH 7.0); clear wavy boundary. (Combined thickness of the A horizon is 4 to 8 inches)

Bt1--6 to 10 inches; brown (10YR 5/3) very cobbly clay loam, very dark grayish brown (10YR 3/2) moist; moderate fine and medium subangular blocky structure; hard, firm, moderately sticky and moderately plastic; many very fine and few medium roots; common very fine irregular pores; continuous faint stress cutans on faces of peds; 30 percent gravel and 25 percent cobbles; neutral (pH 7.0); clear wavy boundary.

Bt2--10 to 14 inches; brown (10YR 4/3) extremely cobbly clay, dark brown (10YR 3/3) moist; moderate fine and medium subangular blocky structure; very hard, firm, very sticky and very plastic; common very fine and few medium roots; common very fine irregular pores; continuous distinct stress cutans on faces of peds and few clay films in pores; 30 percent gravel and 35 percent cobbles; neutral (pH 7.2); abrupt irregular boundary. (Combined thickness of the Bt horizon is 6 to 12 inches)

R--14 inches; basalt

TYPE LOCATION: Asotin County, Washington; about 9 miles southeast of Anatone; 1,400 feet north and 2,400 feet west of southeast corner of sec. 12, T. 6 N., R. 46 E.

RANGE IN CHARACTERISTICS: Thickness of solum and depth to a lithic contact is 10 to 20 inches. The average annual soil temperature at lithic contact is about 45 degrees F. These soils are usually moist, but are dry in all parts between 4 and 12 inches for 60 to 75 consecutive days during summer and fall. The particle-size control section averages 45 to 75 percent angular basalt fragments by volume and is 35 to 50 percent clay in the fine earth fraction. The mollic epipedon is 10 to 20 inches thick and includes all of the argillic horizon.

The A1 horizon has hue of 7.5YR or 10YR, value of 3 or 4 dry, 2 or 3 moist, and chroma of 2 or 3 dry and 1 through 3 moist. It is loam, silt loam or clay loam with 18 to 35 percent clay. It has 0 to 15 percent stones, 0 to 25 percent cobbles, and 0 to 30 percent gravel.

The A2 horizon is clay loam with 27 to 35 percent clay. It has 0 to 5 percent stones, 10 to 25 percent cobbles, and 25 to 45 percent gravel.

The Bt horizon has hue of 5YR, 7.5YR or 10YR, value of 3 through 5 dry, 2 or 3 moist, and chroma of 2 or 3 dry or moist. It is clay loam or clay with 35 to 50 percent clay. It has 0 to 5 percent stones, 15 to 40 percent cobbles, and 30 to 45 percent gravel.

COMPETING SERIES: These are the [Ateron](#), [Camool](#) (T), [Canest](#)(T), [Chen](#), [Doughide](#), [Graley](#), [Itca](#), [Vennob](#) and [Wallsburg](#). Ateron soils have a mollic epipedon that does not include the argillic horizon. Canest soils are 5 to 10 inches deep to a lithic contact. Chen, Doughide, and Graley soils have aridic moisture regimes bordering on xeric. Itca soils are not mollic in the lower part of the Bt horizon and have prismatic structure. Wallsburg soils lack basalt fragments and have more than 50 percent sandstone, shale and limestone fragments in the particle-size control section. Camool soils have a surface layer 5 to 9 inches thick that meets Vitrandic subgroup criteria. Vennob soils have a mollic epipedon 7 to 10 inches thick.

GEOGRAPHIC SETTING: Harlow soils are on canyons, structural benches, and basalt plateaus. Slopes are 2 to 90 percent. These soils formed in loess and colluvium and slope alluvium from basalt or argillite. Elevation ranges from 2,800 to 6,200 feet. Summers are warm and dry and winters are cool and moist. The average annual precipitation is 13 to 40 inches. Average annual temperature is 42 to 45 degrees F. Frost-free season is 50 to 115 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the [Getaway](#), [Klicker](#), [Snell](#), [Sweitberg](#) and [Sweiting](#) soils. Getaway, Snell and Sweiting soils are on canyon walls. Klicker and Sweitberg soils are on plateaus. All of these soils are more than 20 inches deep to a lithic contact.

DRAINAGE AND PERMEABILITY: Well drained; slow to rapid runoff. Slow permeability.

USE AND VEGETATION: Used for livestock grazing and wildlife habitat. Native vegetation is mainly bluebunch wheatgrass and Idaho fescue.

DISTRIBUTION AND EXTENT: Southeastern Washington and northeastern Oregon; MLRA 9 and 43.. The series is of moderate extent.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Portland, Oregon

SERIES ESTABLISHED: Asotin County, Washington, 1982.

REMARKS: Diagnostic horizons and features recognized in this pedon are:

mollic epipedon - from the surface to 14 inches

argillic horizon - from 6 to 14 inches

lithic contact - at 14 inches.

Established Series
Rev. SCW/WEL/RWL
08/2001

HURWAL SERIES

The Hurwal series consists of deep and very deep, well drained soils formed in loess with an influence of volcanic ash in the surface. They are on hills and mountains. Slopes are 2 to 60 percent. The mean annual precipitation is about 18 inches and the mean annual temperature is about 44 degrees F.

TAXONOMIC CLASS: Fine-silty, mixed, superactive, frigid Vitrandic Argixerolls

TYPICAL PEDON: Hurwal ashy silt loam - cultivated, on a 22 percent north facing slope at an elevation of 3860 feet. (Colors are for moist soils unless otherwise noted.)

Ap--0 to 12 inches; black (10YR 2/1) ashy silt loam, dark gray (10YR 4/1) dry; weak very fine granular structure; slightly hard, friable, slightly sticky and slightly plastic; common fine roots; common irregular pores; slightly acid (pH 6.3); clear wavy boundary. (7 to 12 inches thick)

A--12 to 18 inches; very dark grayish brown (10YR 3/2) ashy silt loam, dark grayish brown (10YR 4/2) dry; weak coarse subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; common fine roots; many very fine tubular pores; many black krotovinas; neutral (pH 6.6); clear wavy boundary. (5 to 8 inches thick)

BA--18 to 27 inches; dark brown (10YR 3/3) silty clay loam, brown (10YR 4/3) dry; weak medium subangular blocky structure; slightly hard, friable, sticky and plastic; common fine roots; many very fine tubular pores; few clean, bleached coarse silt and very fine sand coatings on ped faces; many krotovinas; neutral (pH 6.7); clear wavy boundary. (0 to 12 inches thick)

Bt1--27 to 36 inches; dark yellowish brown (10YR 3/4) silty clay loam, brown (10YR 4/3) dry; moderate coarse prismatic structure parting to weak fine subangular blocky; hard, friable, sticky and plastic; common fine roots; many very fine tubular pores; common faint clay films on faces of prisms; common clean bleached coarse silt and very fine sand coatings mainly on prisms; many krotovinas; neutral (pH 6.7); clear wavy boundary.

Bt2--36 to 56 inches; dark yellowish brown (10YR 4/4) silty clay loam, yellowish brown (10YR 5/4) dry; weak coarse prismatic structure parting to moderate fine subangular blocky; hard, firm, sticky and plastic; common fine roots; many very fine tubular pores; many faint clay films on faces of prisms; common clean, bleached coarse silt and very fine sand coatings mainly on prisms; many krotovinas; neutral (pH 7.2); clear wavy boundary. (Combined thickness of the Bt horizon is 16 to 36 inches)

BC--56 to 58 inches; dark yellowish brown (10YR 4/4) silt loam, yellowish brown (10YR 5/4) dry; weak fine subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; few roots; many very fine tubular pores; common clean bleached coarse silt and very fine sand coatings on peds; 10 percent gravel; many krotovinas; slightly calcareous in places; moderately alkaline (pH 8.0); abrupt wavy boundary. (0 to 12 inches thick)

2R--58 inches; basalt.

TYPE LOCATION: Wallowa County, Oregon; about 5 miles east of Wallowa; 800 feet north and 300 feet west of the southeast corner of section 10, T. 1 N., R. 43 E.; USGS Evans topographic quadrangle (Latitude 45 degrees, 34 minutes, 38 seconds N, Longitude 117 degrees, 25 minutes, 04 seconds W)

RANGE IN CHARACTERISTICS: The soils are usually moist but are dry for 60 to 90 consecutive days following the summer solstice. The mean annual soil temperature is 44 to 47 degrees F. The solum is 40 inches or more thick. Depth to basalt bedrock is 40 to 60 inches or more. The mollic epipedon is 20 to 30 inches thick. The control section has more than 18 percent clay and less than 15 percent coarser than very fine sand.

The A horizon has value of 2 or 3 moist, 4 or 5 dry, and chroma of 1 or 2 moist and dry. It is ashy silt loam with 18 to 27 percent clay. It has 0 to 5 percent gravel, 20 to 30 percent volcanic glass and glass coated aggregate, and more than 0.4 percent acid oxalate extractable aluminum plus one-half iron. The soil reaction is slightly acid or neutral.

The Bt horizon has value of 3 or 4 moist, 4 or 5 dry, and chroma of 3 or 4 dry. It is silty clay loam or silt loam with 20 to 35 percent clay. It has 0 to 5 percent gravel. Krotovinas 2 to 8 inches in diameter are common in most profiles. The soil reaction is neutral or slightly alkaline.

The BC horizon, when present, has value of 3 or 4 moist, 5 or 6 dry and chroma of 3 or 4 moist and dry. It is silt loam or loam with 0 to 15 percent gravel and 0 to 10 percent cobbles. The soil reaction is neutral to moderately alkaline. Secondary lime occurs in some pedons. It has 0 to 5 percent CaCO₃ equivalent.

COMPETING SERIES: This is the [Powwatka](#) series. Powwatka soils are 20 to 40 inches to bedrock and have a mollic epipedon 12 to 20 inches thick.

GEOGRAPHIC SETTING: Hurwal soils are on hills and mountains. They formed in loess with an influence of volcanic ash in the surface horizons. Slope is 2 to 60 percent. Elevation is 2500 to 5900 feet. The mean annual precipitation is 13 to 24 inches. The mean annual temperature is 42 to 45 degrees F. The frost-free period is 70 to 100 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the [Harlow](#), [Parsnip](#), competing [Powwatka](#), [Snell](#), [Wallowa](#), and [Zumwalt](#) soils. Harlow soils are clayey-skeletal, shallow, and are on adjacent south slopes. Parsnip soils are 10 to 20 inches to bedrock, have a mollic epipedon 7 to 15 inches thick, and are on adjacent plateaus. Snell soils are 20 to 40 inches to bedrock, clayey-skeletal, and are on north-facing side slopes. Wallowa soils are fine-loamy, lack argillic horizons, and are the moderately deep component of patterned ground. Zumwalt soils have a fine textured control section and are on adjacent hill slopes.

DRAINAGE AND PERMEABILITY: Well drained; moderately slow permeability.

USE AND VEGETATION: These soils are used mainly for dry cropland, grain, hay and pasture, and livestock grazing. Potential native vegetation is Idaho fescue and bluebunch wheatgrass with chokecherry and snowberry on north slopes, and basin wildrye on toe slopes and swales.

DISTRIBUTION AND EXTENT: Northeastern Oregon, MLRA 9; and eastern Idaho, MLRA 13. The series is not extensive.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Portland, Oregon

SERIES ESTABLISHED: Wallowa County Area, Oregon, 1998.

REMARKS: Diagnostic horizons and features recognized in this pedon are:

Pachic epipedon - the zone from the soil surface to a depth of 27 inches (Ap, A, and BA horizons).

Vitrandic feature - the zone from the soil surface to a depth of 18 inches (Ap and A horizons) based on lab data from similar soils.

Argillic horizon - the zone from 27 to 56 inches (Bt1 and Bt2 horizons).

Particle-size control section - from 27 to 47 inches (Bt1 and upper Bt2 horizons).

ADDITIONAL DATA: Characterization data on three profiles (S64-Oreg-32-2,3,7) reported in Riverside Soil Survey Laboratory Report for soils from Wallowa County, Oregon, July 1966.

National Cooperative Soil Survey
U.S.A.



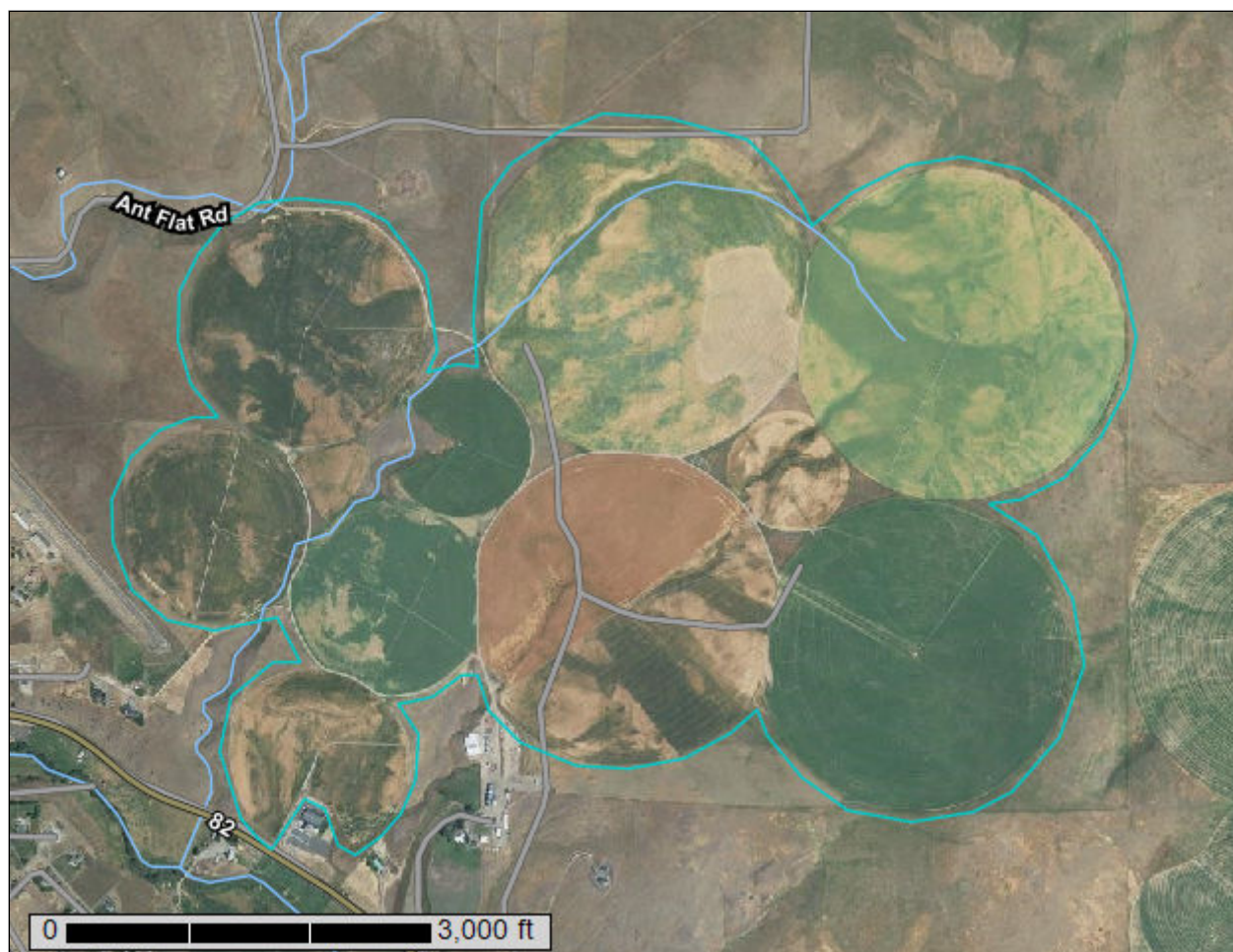
United States
Department of
Agriculture

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 **Wallowa County Area, Oregon**



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.

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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

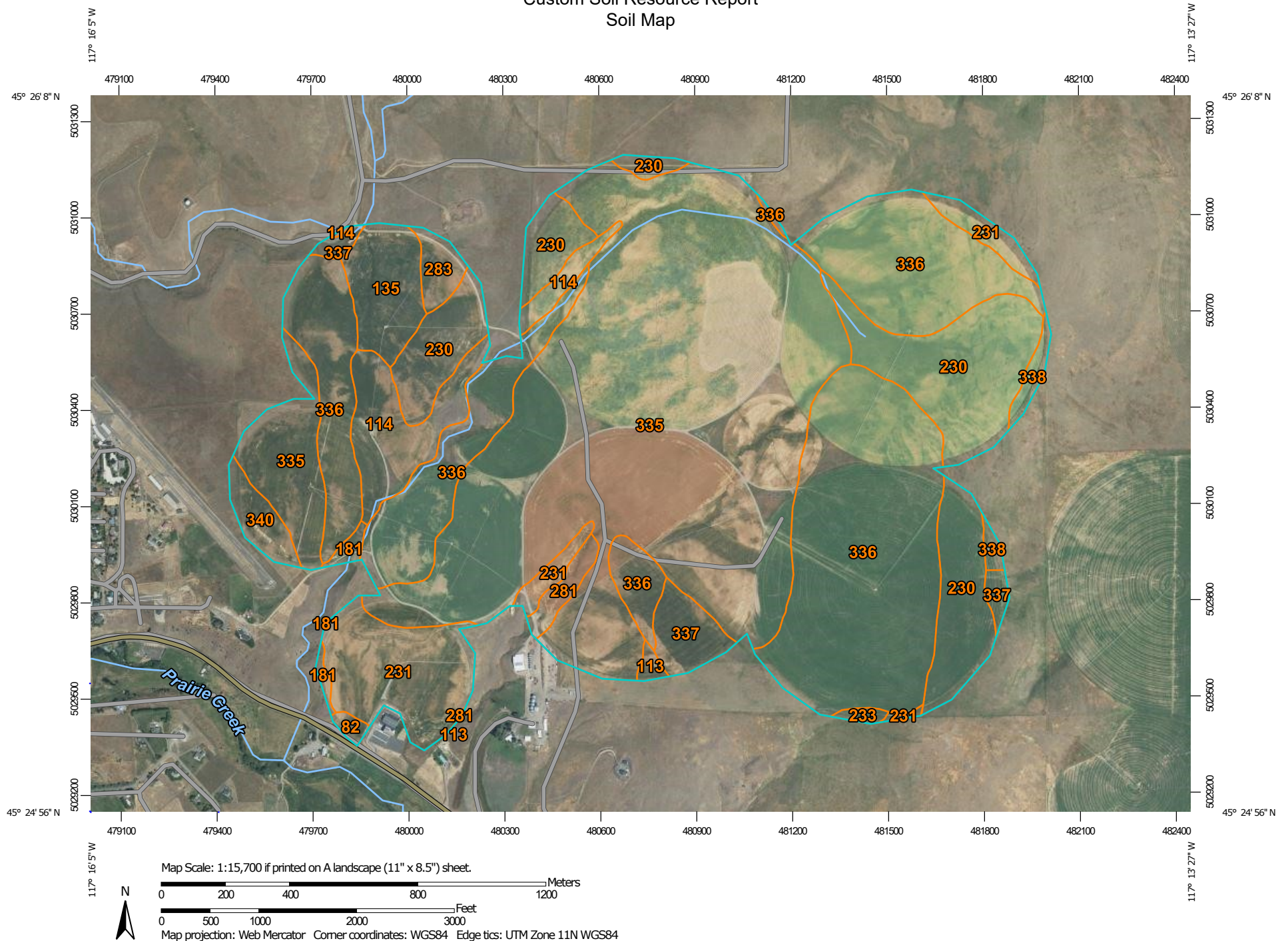
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identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

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.

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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.

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: Wallowa County Area, Oregon

Survey Area Data: Version 26, Sep 11, 2023

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

Date(s) aerial images were photographed: Aug 4, 2020—Aug 14, 2020

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

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
82	Freels silt loam, 0 to 3 percent slopes	1.7	0.2%
113	Harlow-Bocker complex, 2 to 15 percent slopes	1.7	0.2%
114	Harlow-Bocker complex, 15 to 30 percent south slopes	31.5	3.8%
135	Hurwal silt loam, 8 to 15 percent slopes	20.7	2.5%
181	Laufer-Thiessen complex, 30 to 60 percent south slopes	3.1	0.4%
230	Powwatka silt loam, 2 to 8 percent slopes	100.3	12.1%
231	Powwatka silt loam, 8 to 15 percent slopes	47.6	5.7%
233	Powwatka silt loam, 15 to 30 percent south slopes	1.5	0.2%
281	Snell-Harlow complex, 15 to 30 percent north slopes	5.5	0.7%
283	Snell-Harlow complex, 15 to 30 percent south slopes	6.6	0.8%
335	Topper silt loam, 2 to 8 percent slopes	342.3	41.2%
336	Topper silt loam, 8 to 15 percent slopes	239.2	28.8%
337	Topper silt loam, 15 to 30 percent north slopes	15.9	1.9%
338	Topper silt loam, 15 to 30 percent south slopes	5.3	0.6%
340	Tuckerdowns gravelly loam, 2 to 8 percent slopes	8.2	1.0%
Totals for Area of Interest		830.9	100.0%

Map Unit Descriptions

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

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the

characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

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

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

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

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

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

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

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

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered

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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.

Wallowa County Area, Oregon

82—Freels silt loam, 0 to 3 percent slopes

Map Unit Setting

National map unit symbol: 2v7s
Elevation: 3,400 to 4,400 feet
Mean annual precipitation: 13 to 17 inches
Mean annual air temperature: 42 to 45 degrees F
Frost-free period: 70 to 100 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Freels and similar soils: 85 percent
Minor components: 4 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Freels

Setting

Landform: Stream terraces, flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium

Typical profile

H1 - 0 to 5 inches: silt loam
H2 - 5 to 34 inches: silt loam
H3 - 34 to 51 inches: silt loam
H4 - 51 to 60 inches: silt loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high
(0.57 to 1.98 in/hr)
Depth to water table: About 36 to 60 inches
Frequency of flooding: Rare
Frequency of ponding: None
Available water supply, 0 to 60 inches: High (about 10.0 inches)

Interpretive groups

Land capability classification (irrigated): 3c
Land capability classification (nonirrigated): 3c
Hydrologic Soil Group: B
Ecological site: R010XY006OR - MOUNTAIN LOAMY BOTTOM
Hydric soil rating: No

Minor Components

Sturgill

Percent of map unit: 4 percent
Landform: Flood plains
Landform position (three-dimensional): Tread

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Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R010XY001OR - COLD WET MEADOW
Hydric soil rating: Yes

113—Harlow-Bocker complex, 2 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2tx9
Elevation: 3,400 to 5,000 feet
Mean annual precipitation: 13 to 17 inches
Mean annual air temperature: 42 to 45 degrees F
Frost-free period: 70 to 100 days
Farmland classification: Not prime farmland

Map Unit Composition

Harlow and similar soils: 60 percent
Bocker and similar soils: 25 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Harlow

Setting

Landform: Plateaus, structural benches
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loess and colluvium derived from basalt

Typical profile

A1 - 0 to 4 inches: very stony loam
A2 - 4 to 8 inches: very cobbly clay loam
Bt - 8 to 16 inches: extremely cobbly clay
2R - 16 to 26 inches: unweathered bedrock

Properties and qualities

Slope: 2 to 15 percent
Surface area covered with cobbles, stones or boulders: 1.6 percent
Depth to restrictive feature: 10 to 20 inches to lithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Very low (about 1.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s

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Hydrologic Soil Group: D

Ecological site: R009XY022OR - Cold Shallow 13+ PZ

Hydric soil rating: No

Description of Bocker

Setting

Landform: Structural benches, plateaus

Landform position (two-dimensional): Shoulder

Landform position (three-dimensional): Interfluve

Down-slope shape: Linear

Across-slope shape: Convex

Parent material: Loess and colluvium derived from basalt

Typical profile

A - 0 to 2 inches: extremely cobbly silt loam

Bw - 2 to 7 inches: very cobbly silt loam

2R - 7 to 17 inches: unweathered bedrock

Properties and qualities

Slope: 2 to 15 percent

Depth to restrictive feature: 4 to 10 inches to lithic bedrock

Drainage class: Well drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high
(0.57 to 1.98 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None

Frequency of ponding: None

Available water supply, 0 to 60 inches: Very low (about 0.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 7s

Hydrologic Soil Group: D

Ecological site: R009XY027OR - Cold Very Shallow 13+ PZ

Hydric soil rating: No

114—Harlow-Bocker complex, 15 to 30 percent south slopes

Map Unit Setting

National map unit symbol: 2txb

Elevation: 3,400 to 5,000 feet

Mean annual precipitation: 13 to 17 inches

Mean annual air temperature: 42 to 45 degrees F

Frost-free period: 70 to 100 days

Farmland classification: Not prime farmland

Map Unit Composition

Harlow and similar soils: 60 percent

Bocker and similar soils: 25 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Harlow

Setting

Landform: Hills

Landform position (two-dimensional): Backslope, footslope

Landform position (three-dimensional): Side slope, base slope

Down-slope shape: Linear

Across-slope shape: Concave

Parent material: Loess and colluvium derived from basalt

Typical profile

A1 - 0 to 4 inches: very stony loam

A2 - 4 to 8 inches: very cobbly clay loam

Bt - 8 to 16 inches: extremely cobbly clay

2R - 16 to 26 inches: unweathered bedrock

Properties and qualities

Slope: 15 to 30 percent

Surface area covered with cobbles, stones or boulders: 1.6 percent

Depth to restrictive feature: 10 to 20 inches to lithic bedrock

Drainage class: Well drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None

Frequency of ponding: None

Available water supply, 0 to 60 inches: Very low (about 1.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 7s

Hydrologic Soil Group: D

Ecological site: R009XY036OR - Cold Shallow South 13+ PZ

Hydric soil rating: No

Description of Bocker

Setting

Landform: Hills

Landform position (two-dimensional): Shoulder, backslope

Landform position (three-dimensional): Side slope

Down-slope shape: Linear

Across-slope shape: Linear

Parent material: Loess and colluvium derived from basalt

Typical profile

A - 0 to 2 inches: extremely cobbly silt loam

Bw - 2 to 7 inches: very cobbly silt loam

2R - 7 to 17 inches: unweathered bedrock

Properties and qualities

Slope: 15 to 30 percent

Depth to restrictive feature: 4 to 10 inches to lithic bedrock

Drainage class: Well drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)

Depth to water table: More than 80 inches

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Frequency of flooding: None

Frequency of ponding: None

Available water supply, 0 to 60 inches: Very low (about 0.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 7s

Hydrologic Soil Group: D

Ecological site: R009XY027OR - Cold Very Shallow 13+ PZ

Hydric soil rating: No

135—Hurwal silt loam, 8 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2ty1

Elevation: 3,400 to 5,000 feet

Mean annual precipitation: 13 to 17 inches

Mean annual air temperature: 42 to 45 degrees F

Frost-free period: 70 to 100 days

Farmland classification: Farmland of statewide importance

Map Unit Composition

Hurwal and similar soils: 90 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Hurwal

Setting

Landform: Hills

Landform position (two-dimensional): Summit, backslope

Landform position (three-dimensional): Interfluve, side slope

Down-slope shape: Linear

Across-slope shape: Linear

Parent material: Loess with an influence of volcanic ash in the surface layers

Typical profile

H1 - 0 to 12 inches: silt loam

H2 - 12 to 18 inches: silt loam

H3 - 18 to 56 inches: silty clay loam

H4 - 56 to 60 inches: silt loam

Properties and qualities

Slope: 8 to 15 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

Calcium carbonate, maximum content: 5 percent

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Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)

Available water supply, 0 to 60 inches: High (about 11.0 inches)

Interpretive groups

Land capability classification (irrigated): 4e

Land capability classification (nonirrigated): 3e

Hydrologic Soil Group: C

Ecological site: R009XY005OR - Cold Swale 13-17 PZ

Hydric soil rating: No

181—Laufer-Thiessen complex, 30 to 60 percent south slopes

Map Unit Setting

National map unit symbol: 2tzk

Elevation: 1,600 to 4,000 feet

Mean annual precipitation: 13 to 17 inches

Mean annual air temperature: 47 to 50 degrees F

Frost-free period: 100 to 120 days

Farmland classification: Not prime farmland

Map Unit Composition

Laufer and similar soils: 45 percent

Thiessen and similar soils: 40 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Laufer

Setting

Landform: Canyons

Landform position (two-dimensional): Backslope

Landform position (three-dimensional): Side slope

Down-slope shape: Linear

Across-slope shape: Convex

Parent material: Loess and colluvium derived from basalt

Typical profile

H1 - 0 to 4 inches: very stony silt loam

H2 - 4 to 8 inches: very cobbly clay loam

H3 - 8 to 16 inches: very cobbly clay

H4 - 16 to 26 inches: unweathered bedrock

Properties and qualities

Slope: 30 to 60 percent

Surface area covered with cobbles, stones or boulders: 1.6 percent

Depth to restrictive feature: 10 to 20 inches to lithic bedrock

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: Very low (about 1.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: D
Ecological site: R009XY031OR - Shallow South 14+ PZ
Hydric soil rating: No

Description of Thiessen

Setting

Landform: Canyons
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Concave
Parent material: Loess and colluvium derived from basalt

Typical profile

A - 0 to 3 inches: very cobbly silt loam
AB - 3 to 6 inches: very gravelly clay loam
Bt1 - 6 to 14 inches: very gravelly clay loam
Bt2 - 14 to 23 inches: very cobbly clay
Bt3 - 23 to 34 inches: very cobbly clay
2R - 34 to 44 inches: unweathered bedrock

Properties and qualities

Slope: 30 to 60 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Very low (about 2.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: D
Ecological site: R009XY029OR - South 14-17 PZ
Hydric soil rating: No

230—Powwatka silt loam, 2 to 8 percent slopes

Map Unit Setting

National map unit symbol: 2v1f
Elevation: 3,400 to 5,000 feet
Mean annual precipitation: 13 to 17 inches
Mean annual air temperature: 42 to 45 degrees F

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Frost-free period: 70 to 100 days

Farmland classification: Farmland of statewide importance

Map Unit Composition

Powwatka and similar soils: 85 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Powwatka

Setting

Landform: Hills

Landform position (two-dimensional): Summit

Landform position (three-dimensional): Interfluve

Down-slope shape: Linear

Across-slope shape: Linear

Parent material: Loess over basalt with minor amounts of volcanic ash in the surface layers

Typical profile

H1 - 0 to 14 inches: silt loam

H2 - 14 to 24 inches: silty clay loam

H3 - 24 to 34 inches: unweathered bedrock

Properties and qualities

Slope: 2 to 8 percent

Depth to restrictive feature: 20 to 40 inches to lithic bedrock

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 4.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 4e

Hydrologic Soil Group: C

Ecological site: R009XY017OR - Cold Loamy 13-17 PZ

Hydric soil rating: No

231—Powwatka silt loam, 8 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2v1g

Elevation: 3,400 to 5,000 feet

Mean annual precipitation: 13 to 17 inches

Mean annual air temperature: 42 to 45 degrees F

Frost-free period: 70 to 100 days

Farmland classification: Farmland of statewide importance

Map Unit Composition

Powwatka and similar soils: 85 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Powwatka

Setting

Landform: Hills

Landform position (two-dimensional): Backslope

Landform position (three-dimensional): Side slope

Down-slope shape: Linear

Across-slope shape: Linear

Parent material: Loess over basalt with minor amounts of volcanic ash in the surface layers

Typical profile

H1 - 0 to 14 inches: silt loam

H2 - 14 to 24 inches: silty clay loam

H3 - 24 to 34 inches: unweathered bedrock

Properties and qualities

Slope: 8 to 15 percent

Depth to restrictive feature: 20 to 40 inches to lithic bedrock

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 4.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 4e

Hydrologic Soil Group: C

Ecological site: R009XY017OR - Cold Loamy 13-17 PZ

Hydric soil rating: No

233—Powwatka silt loam, 15 to 30 percent south slopes

Map Unit Setting

National map unit symbol: 2v1j

Elevation: 3,400 to 5,000 feet

Mean annual precipitation: 13 to 17 inches

Mean annual air temperature: 42 to 45 degrees F

Frost-free period: 70 to 100 days

Farmland classification: Farmland of statewide importance

Map Unit Composition

Powwatka and similar soils: 85 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Powwatka

Setting

Landform: Hills

Landform position (two-dimensional): Backslope

Landform position (three-dimensional): Side slope

Down-slope shape: Linear

Across-slope shape: Linear

Parent material: Loess over basalt with minor amounts of volcanic ash in the surface layers

Typical profile

H1 - 0 to 14 inches: silt loam

H2 - 14 to 24 inches: silty clay loam

H3 - 24 to 34 inches: unweathered bedrock

Properties and qualities

Slope: 15 to 30 percent

Depth to restrictive feature: 20 to 40 inches to lithic bedrock

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 4.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 4e

Hydrologic Soil Group: C

Ecological site: R009XY034OR - Cold South 13-17 PZ

Hydric soil rating: No

281—Snell-Harlow complex, 15 to 30 percent north slopes

Map Unit Setting

National map unit symbol: 2v3b

Elevation: 2,800 to 5,000 feet

Mean annual precipitation: 13 to 30 inches

Mean annual air temperature: 42 to 45 degrees F

Frost-free period: 70 to 100 days

Farmland classification: Farmland of statewide importance

Map Unit Composition

Snell and similar soils: 60 percent

Harlow and similar soils: 25 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Snell

Setting

Landform: Plateaus, structural benches
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluvium, crest
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loess and colluvium derived from basalt

Typical profile

A1 - 0 to 4 inches: very stony loam
A2 - 4 to 9 inches: stony clay loam
Bt1 - 9 to 18 inches: very stony clay loam
Bt2 - 18 to 24 inches: extremely stony clay loam
2R - 24 to 34 inches: unweathered bedrock

Properties and qualities

Slope: 15 to 30 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
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: Very low (about 2.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: C
Ecological site: R009XY017OR - Cold Loamy 13-17 PZ
Hydric soil rating: No

Description of Harlow

Setting

Landform: Canyons
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loess and colluvium derived from basalt

Typical profile

A1 - 0 to 4 inches: very stony loam
A2 - 4 to 8 inches: very cobbly clay loam
Bt - 8 to 16 inches: extremely cobbly clay
2R - 16 to 26 inches: unweathered bedrock

Properties and qualities

Slope: 15 to 30 percent
Surface area covered with cobbles, stones or boulders: 1.6 percent
Depth to restrictive feature: 10 to 20 inches to lithic bedrock
Drainage class: Well drained

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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

Available water supply, 0 to 60 inches: Very low (about 1.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 7s

Hydrologic Soil Group: D

Ecological site: R009XY048OR - Shallow North 14+ PZ

Hydric soil rating: No

283—Snell-Harlow complex, 15 to 30 percent south slopes

Map Unit Setting

National map unit symbol: 2v3d

Elevation: 4,000 to 5,000 feet

Mean annual precipitation: 13 to 30 inches

Mean annual air temperature: 42 to 45 degrees F

Frost-free period: 70 to 100 days

Farmland classification: Farmland of statewide importance

Map Unit Composition

Snell and similar soils: 55 percent

Harlow and similar soils: 30 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Snell

Setting

Landform: Plateaus, structural benches

Landform position (two-dimensional): Summit

Landform position (three-dimensional): Interfluve, crest

Down-slope shape: Linear

Across-slope shape: Linear

Parent material: Loess and colluvium derived from basalt

Typical profile

A1 - 0 to 4 inches: very stony loam

A2 - 4 to 9 inches: stony clay loam

Bt1 - 9 to 18 inches: very stony clay loam

Bt2 - 18 to 24 inches: extremely stony clay loam

2R - 24 to 34 inches: unweathered bedrock

Properties and qualities

Slope: 15 to 30 percent

Depth to restrictive feature: 20 to 40 inches to lithic bedrock

Drainage class: Well drained

Custom Soil Resource Report

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: Very low (about 2.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 6s

Hydrologic Soil Group: C

Ecological site: R009XY017OR - Cold Loamy 13-17 PZ

Hydric soil rating: No

Description of Harlow

Setting

Landform: Canyons

Landform position (two-dimensional): Backslope

Landform position (three-dimensional): Side slope

Down-slope shape: Linear

Across-slope shape: Linear

Parent material: Loess and colluvium derived from basalt

Typical profile

A1 - 0 to 4 inches: very stony loam

A2 - 4 to 8 inches: very cobbly clay loam

Bt - 8 to 16 inches: extremely cobbly clay

2R - 16 to 26 inches: unweathered bedrock

Properties and qualities

Slope: 15 to 30 percent

Surface area covered with cobbles, stones or boulders: 1.6 percent

Depth to restrictive feature: 10 to 20 inches to lithic bedrock

Drainage class: Well drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None

Frequency of ponding: None

Available water supply, 0 to 60 inches: Very low (about 1.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 7s

Hydrologic Soil Group: D

Ecological site: R009XY048OR - Shallow North 14+ PZ

Hydric soil rating: No

335—Topper silt loam, 2 to 8 percent slopes

Map Unit Setting

National map unit symbol: 2v59
Elevation: 3,400 to 4,500 feet
Mean annual precipitation: 13 to 17 inches
Mean annual air temperature: 42 to 45 degrees F
Frost-free period: 70 to 100 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

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

Description of Topper

Setting

Landform: Hills
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Linear
Across-slope shape: Concave
Parent material: Loess with an influence of volcanic ash in the surface layers

Typical profile

H1 - 0 to 11 inches: silt loam
H2 - 11 to 25 inches: silt loam
H3 - 25 to 35 inches: silty clay loam
H4 - 35 to 60 inches: silt loam

Properties and qualities

Slope: 2 to 8 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 to high
(0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 20 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: High (about 11.2 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: B
Ecological site: R009XY017OR - Cold Loamy 13-17 PZ
Hydric soil rating: No

336—Topper silt loam, 8 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2v5b

Elevation: 3,400 to 4,500 feet

Mean annual precipitation: 13 to 17 inches

Mean annual air temperature: 42 to 45 degrees F

Frost-free period: 70 to 100 days

Farmland classification: Farmland of statewide importance

Map Unit Composition

Topper and similar soils: 85 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Topper

Setting

Landform: Hills

Landform position (two-dimensional): Backslope

Landform position (three-dimensional): Side slope

Down-slope shape: Linear

Across-slope shape: Linear

Parent material: Loess with an influence of volcanic ash in the surface layers

Typical profile

H1 - 0 to 11 inches: silt loam

H2 - 11 to 25 inches: silt loam

H3 - 25 to 35 inches: silty clay loam

H4 - 35 to 60 inches: silt loam

Properties and qualities

Slope: 8 to 15 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 to high
(0.57 to 1.98 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None

Frequency of ponding: None

Calcium carbonate, maximum content: 20 percent

Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)

Available water supply, 0 to 60 inches: High (about 11.2 inches)

Interpretive groups

Land capability classification (irrigated): 4e

Land capability classification (nonirrigated): 3e

Hydrologic Soil Group: B

Ecological site: R009XY017OR - Cold Loamy 13-17 PZ

Hydric soil rating: No

337—Topper silt loam, 15 to 30 percent north slopes

Map Unit Setting

National map unit symbol: 2v5c

Elevation: 3,400 to 4,500 feet

Mean annual precipitation: 13 to 17 inches

Mean annual air temperature: 42 to 45 degrees F

Frost-free period: 70 to 100 days

Farmland classification: Farmland of statewide importance

Map Unit Composition

Topper and similar soils: 85 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Topper

Setting

Landform: Hills

Landform position (two-dimensional): Backslope

Landform position (three-dimensional): Side slope

Down-slope shape: Linear

Across-slope shape: Linear

Parent material: Loess with an influence of volcanic ash in the surface layers

Typical profile

H1 - 0 to 11 inches: silt loam

H2 - 11 to 25 inches: silt loam

H3 - 25 to 35 inches: silty clay loam

H4 - 35 to 60 inches: silt loam

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 to high
(0.57 to 1.98 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None

Frequency of ponding: None

Calcium carbonate, maximum content: 20 percent

Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)

Available water supply, 0 to 60 inches: High (about 11.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 4e

Hydrologic Soil Group: B

Ecological site: R009XY041OR - Deep North 14-17 PZ

Hydric soil rating: No

338—Topper silt loam, 15 to 30 percent south slopes

Map Unit Setting

National map unit symbol: 2v5d

Elevation: 3,400 to 4,500 feet

Mean annual precipitation: 13 to 17 inches

Mean annual air temperature: 42 to 45 degrees F

Frost-free period: 70 to 100 days

Farmland classification: Farmland of statewide importance

Map Unit Composition

Topper and similar soils: 85 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Topper

Setting

Landform: Hills

Landform position (two-dimensional): Backslope

Landform position (three-dimensional): Side slope

Down-slope shape: Linear

Across-slope shape: Linear

Parent material: Loess with an influence of volcanic ash in the surface layers

Typical profile

H1 - 0 to 11 inches: silt loam

H2 - 11 to 25 inches: silt loam

H3 - 25 to 35 inches: silty clay loam

H4 - 35 to 60 inches: silt loam

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 to high
(0.57 to 1.98 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None

Frequency of ponding: None

Calcium carbonate, maximum content: 20 percent

Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)

Available water supply, 0 to 60 inches: High (about 11.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 4e

Hydrologic Soil Group: B

Ecological site: R009XY034OR - Cold South 13-17 PZ

Hydric soil rating: No

340—Tuckerdowns gravelly loam, 2 to 8 percent slopes

Map Unit Setting

National map unit symbol: 2v5g

Elevation: 3,700 to 4,400 feet

Mean annual precipitation: 13 to 17 inches

Mean annual air temperature: 42 to 45 degrees F

Frost-free period: 70 to 100 days

Farmland classification: Farmland of statewide importance

Map Unit Composition

Tuckerdowns and similar soils: 85 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Tuckerdowns

Setting

Landform: Terraces

Landform position (three-dimensional): Tread

Down-slope shape: Linear

Across-slope shape: Linear

Parent material: Alluvium with an influence loess in the surface layers

Typical profile

A1 - 0 to 3 inches: gravelly loam

A2 - 3 to 10 inches: gravelly loam

Bw - 10 to 17 inches: gravelly loam

Bk1 - 17 to 33 inches: very gravelly sandy clay loam

Bk2 - 33 to 60 inches: extremely gravelly sandy loam

Properties and qualities

Slope: 2 to 8 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 to high
(0.57 to 1.98 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None

Frequency of ponding: None

Calcium carbonate, maximum content: 20 percent

Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)

Available water supply, 0 to 60 inches: Low (about 5.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 3e

Hydrologic Soil Group: B

Ecological site: R009XY017OR - Cold Loamy 13-17 PZ

Hydric soil rating: No

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United States
Department of
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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 **Wallowa County Area, Oregon**



October 16, 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.

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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

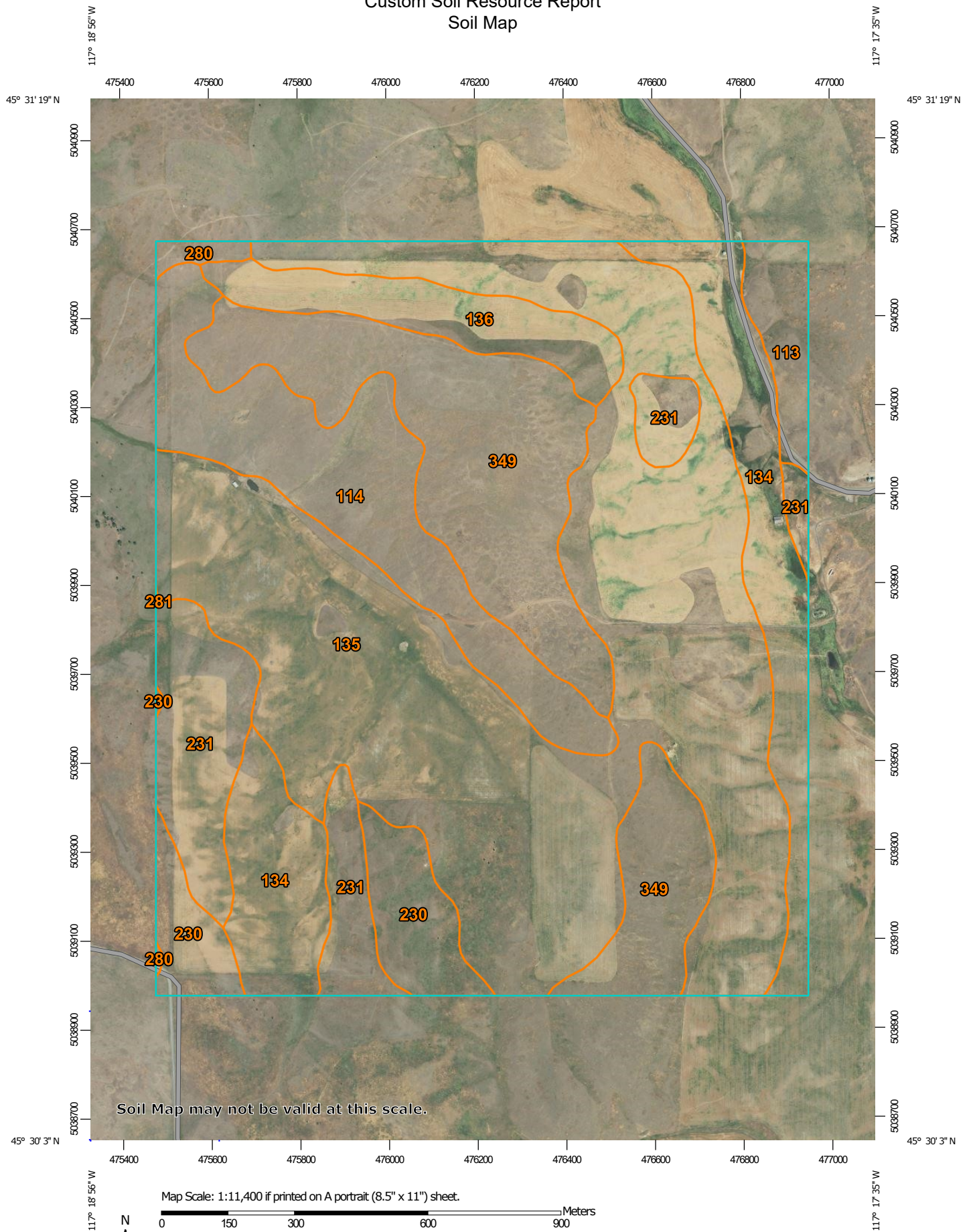
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identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

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.

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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: Wallowa County Area, Oregon
Survey Area Data: Version 26, Sep 11, 2023

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

Date(s) aerial images were photographed: Aug 4, 2020—Aug 14, 2020

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

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
113	Harlow-Bocker complex, 2 to 15 percent slopes	12.9	2.1%
114	Harlow-Bocker complex, 15 to 30 percent south slopes	61.8	10.0%
134	Hurwal silt loam, 2 to 8 percent slopes	68.1	11.0%
135	Hurwal silt loam, 8 to 15 percent slopes	267.6	43.2%
136	Hurwal silt loam, 15 to 30 percent north slopes	26.7	4.3%
230	Powwatka silt loam, 2 to 8 percent slopes	28.1	4.5%
231	Powwatka silt loam, 8 to 15 percent slopes	49.5	8.0%
280	Snell-Harlow complex, 2 to 15 percent slopes	2.9	0.5%
281	Snell-Harlow complex, 15 to 30 percent north slopes	0.1	0.0%
349	Wallowa-Bocker complex, 2 to 15 percent slopes	101.7	16.4%
Totals for Area of Interest		619.4	100.0%

Map Unit Descriptions

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

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

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties

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

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

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

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

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

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

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

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

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

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

Wallowa County Area, Oregon

113—Harlow-Bocker complex, 2 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2tx9
Elevation: 3,400 to 5,000 feet
Mean annual precipitation: 13 to 17 inches
Mean annual air temperature: 42 to 45 degrees F
Frost-free period: 70 to 100 days
Farmland classification: Not prime farmland

Map Unit Composition

Harlow and similar soils: 60 percent
Bocker and similar soils: 25 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Harlow

Setting

Landform: Plateaus, structural benches
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loess and colluvium derived from basalt

Typical profile

A1 - 0 to 4 inches: very stony loam
A2 - 4 to 8 inches: very cobbly clay loam
Bt - 8 to 16 inches: extremely cobbly clay
2R - 16 to 26 inches: unweathered bedrock

Properties and qualities

Slope: 2 to 15 percent
Surface area covered with cobbles, stones or boulders: 1.6 percent
Depth to restrictive feature: 10 to 20 inches to lithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Very low (about 1.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: D
Ecological site: R009XY022OR - Cold Shallow 13+ PZ
Hydric soil rating: No

Description of Bocker

Setting

Landform: Structural benches, plateaus

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Landform position (two-dimensional): Shoulder

Landform position (three-dimensional): Interfluve

Down-slope shape: Linear

Across-slope shape: Convex

Parent material: Loess and colluvium derived from basalt

Typical profile

A - 0 to 2 inches: extremely cobbly silt loam

Bw - 2 to 7 inches: very cobbly silt loam

2R - 7 to 17 inches: unweathered bedrock

Properties and qualities

Slope: 2 to 15 percent

Depth to restrictive feature: 4 to 10 inches to lithic bedrock

Drainage class: Well drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high
(0.57 to 1.98 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None

Frequency of ponding: None

Available water supply, 0 to 60 inches: Very low (about 0.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 7s

Hydrologic Soil Group: D

Ecological site: R009XY027OR - Cold Very Shallow 13+ PZ

Hydric soil rating: No

114—Harlow-Bocker complex, 15 to 30 percent south slopes

Map Unit Setting

National map unit symbol: 2txb

Elevation: 3,400 to 5,000 feet

Mean annual precipitation: 13 to 17 inches

Mean annual air temperature: 42 to 45 degrees F

Frost-free period: 70 to 100 days

Farmland classification: Not prime farmland

Map Unit Composition

Harlow and similar soils: 60 percent

Bocker and similar soils: 25 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Harlow

Setting

Landform: Hills

Landform position (two-dimensional): Backslope, footslope

Landform position (three-dimensional): Side slope, base slope

Down-slope shape: Linear

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Across-slope shape: Concave

Parent material: Loess and colluvium derived from basalt

Typical profile

A1 - 0 to 4 inches: very stony loam

A2 - 4 to 8 inches: very cobbly clay loam

Bt - 8 to 16 inches: extremely cobbly clay

2R - 16 to 26 inches: unweathered bedrock

Properties and qualities

Slope: 15 to 30 percent

Surface area covered with cobbles, stones or boulders: 1.6 percent

Depth to restrictive feature: 10 to 20 inches to lithic bedrock

Drainage class: Well drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None

Frequency of ponding: None

Available water supply, 0 to 60 inches: Very low (about 1.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 7s

Hydrologic Soil Group: D

Ecological site: R009XY036OR - Cold Shallow South 13+ PZ

Hydric soil rating: No

Description of Bocker

Setting

Landform: Hills

Landform position (two-dimensional): Shoulder, backslope

Landform position (three-dimensional): Side slope

Down-slope shape: Linear

Across-slope shape: Linear

Parent material: Loess and colluvium derived from basalt

Typical profile

A - 0 to 2 inches: extremely cobbly silt loam

Bw - 2 to 7 inches: very cobbly silt loam

2R - 7 to 17 inches: unweathered bedrock

Properties and qualities

Slope: 15 to 30 percent

Depth to restrictive feature: 4 to 10 inches to lithic bedrock

Drainage class: Well drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None

Frequency of ponding: None

Available water supply, 0 to 60 inches: Very low (about 0.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 7s

Hydrologic Soil Group: D

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Ecological site: R009XY027OR - Cold Very Shallow 13+ PZ

Hydric soil rating: No

134—Hurwal silt loam, 2 to 8 percent slopes

Map Unit Setting

National map unit symbol: 2ty0

Elevation: 3,400 to 5,000 feet

Mean annual precipitation: 13 to 17 inches

Mean annual air temperature: 42 to 45 degrees F

Frost-free period: 70 to 100 days

Farmland classification: Prime farmland if irrigated

Map Unit Composition

Hurwal and similar soils: 90 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Hurwal

Setting

Landform: Hills

Landform position (two-dimensional): Summit, footslope

Landform position (three-dimensional): Interfluve, base slope

Down-slope shape: Linear

Across-slope shape: Concave

Parent material: Loess with an influence of volcanic ash in the surface layers

Typical profile

H1 - 0 to 12 inches: silt loam

H2 - 12 to 18 inches: silt loam

H3 - 18 to 56 inches: silty clay loam

H4 - 56 to 60 inches: silt loam

Properties and qualities

Slope: 2 to 8 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

Calcium carbonate, maximum content: 5 percent

Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)

Available water supply, 0 to 60 inches: High (about 11.0 inches)

Interpretive groups

Land capability classification (irrigated): 3e

Land capability classification (nonirrigated): 3e

Hydrologic Soil Group: C

Ecological site: R009XY005OR - Cold Swale 13-17 PZ

Hydric soil rating: No

135—Hurwal silt loam, 8 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2ty1

Elevation: 3,400 to 5,000 feet

Mean annual precipitation: 13 to 17 inches

Mean annual air temperature: 42 to 45 degrees F

Frost-free period: 70 to 100 days

Farmland classification: Farmland of statewide importance

Map Unit Composition

Hurwal and similar soils: 90 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Hurwal

Setting

Landform: Hills

Landform position (two-dimensional): Summit, backslope

Landform position (three-dimensional): Interfluve, side slope

Down-slope shape: Linear

Across-slope shape: Linear

Parent material: Loess with an influence of volcanic ash in the surface layers

Typical profile

H1 - 0 to 12 inches: silt loam

H2 - 12 to 18 inches: silt loam

H3 - 18 to 56 inches: silty clay loam

H4 - 56 to 60 inches: silt loam

Properties and qualities

Slope: 8 to 15 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

Calcium carbonate, maximum content: 5 percent

Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)

Available water supply, 0 to 60 inches: High (about 11.0 inches)

Interpretive groups

Land capability classification (irrigated): 4e

Land capability classification (nonirrigated): 3e

Hydrologic Soil Group: C

Ecological site: R009XY005OR - Cold Swale 13-17 PZ

Hydric soil rating: No

136—Hurwal silt loam, 15 to 30 percent north slopes

Map Unit Setting

National map unit symbol: 2ty2

Elevation: 3,400 to 5,000 feet

Mean annual precipitation: 13 to 17 inches

Mean annual air temperature: 42 to 45 degrees F

Frost-free period: 70 to 100 days

Farmland classification: Farmland of statewide importance

Map Unit Composition

Hurwal, deep, and similar soils: 85 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Hurwal, Deep

Setting

Landform: Hills

Landform position (two-dimensional): Backslope

Landform position (three-dimensional): Side slope

Down-slope shape: Linear

Across-slope shape: Concave

Parent material: Loess with an influence of volcanic ash in the surface layers

Typical profile

H1 - 0 to 12 inches: silt loam

H2 - 12 to 18 inches: silt loam

H3 - 18 to 56 inches: silty clay loam

H4 - 56 to 58 inches: silt loam

H5 - 58 to 68 inches: unweathered bedrock

Properties and qualities

Slope: 15 to 30 percent

Depth to restrictive feature: 40 to 60 inches to lithic bedrock

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

Calcium carbonate, maximum content: 5 percent

Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)

Available water supply, 0 to 60 inches: High (about 10.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 4e

Hydrologic Soil Group: C

Ecological site: R009XY041OR - Deep North 14-17 PZ

Hydric soil rating: No

230—Powwatka silt loam, 2 to 8 percent slopes

Map Unit Setting

National map unit symbol: 2v1f

Elevation: 3,400 to 5,000 feet

Mean annual precipitation: 13 to 17 inches

Mean annual air temperature: 42 to 45 degrees F

Frost-free period: 70 to 100 days

Farmland classification: Farmland of statewide importance

Map Unit Composition

Powwatka and similar soils: 85 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Powwatka

Setting

Landform: Hills

Landform position (two-dimensional): Summit

Landform position (three-dimensional): Interfluve

Down-slope shape: Linear

Across-slope shape: Linear

Parent material: Loess over basalt with minor amounts of volcanic ash in the surface layers

Typical profile

H1 - 0 to 14 inches: silt loam

H2 - 14 to 24 inches: silty clay loam

H3 - 24 to 34 inches: unweathered bedrock

Properties and qualities

Slope: 2 to 8 percent

Depth to restrictive feature: 20 to 40 inches to lithic bedrock

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 4.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 4e

Hydrologic Soil Group: C

Ecological site: R009XY017OR - Cold Loamy 13-17 PZ

Hydric soil rating: No

231—Powwatka silt loam, 8 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2v1g

Elevation: 3,400 to 5,000 feet

Mean annual precipitation: 13 to 17 inches

Mean annual air temperature: 42 to 45 degrees F

Frost-free period: 70 to 100 days

Farmland classification: Farmland of statewide importance

Map Unit Composition

Powwatka and similar soils: 85 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Powwatka

Setting

Landform: Hills

Landform position (two-dimensional): Backslope

Landform position (three-dimensional): Side slope

Down-slope shape: Linear

Across-slope shape: Linear

Parent material: Loess over basalt with minor amounts of volcanic ash in the surface layers

Typical profile

H1 - 0 to 14 inches: silt loam

H2 - 14 to 24 inches: silty clay loam

H3 - 24 to 34 inches: unweathered bedrock

Properties and qualities

Slope: 8 to 15 percent

Depth to restrictive feature: 20 to 40 inches to lithic bedrock

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 4.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 4e

Hydrologic Soil Group: C

Ecological site: R009XY017OR - Cold Loamy 13-17 PZ

Hydric soil rating: No

280—Snell-Harlow complex, 2 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2v39

Elevation: 3,400 to 5,000 feet

Mean annual precipitation: 13 to 17 inches

Mean annual air temperature: 42 to 45 degrees F

Frost-free period: 70 to 100 days

Farmland classification: Farmland of statewide importance

Map Unit Composition

Snell and similar soils: 65 percent

Harlow and similar soils: 25 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Snell

Setting

Landform: Plateaus, structural benches

Landform position (two-dimensional): Summit

Landform position (three-dimensional): Interfluve, crest

Down-slope shape: Linear

Across-slope shape: Linear

Parent material: Loess and colluvium derived from basalt

Typical profile

A1 - 0 to 4 inches: very stony loam

A2 - 4 to 9 inches: stony clay loam

Bt1 - 9 to 18 inches: very stony clay loam

Bt2 - 18 to 24 inches: extremely stony clay loam

2R - 24 to 34 inches: unweathered bedrock

Properties and qualities

Slope: 2 to 15 percent

Depth to restrictive feature: 20 to 40 inches to lithic bedrock

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: Very low (about 2.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 6s

Hydrologic Soil Group: C

Ecological site: R009XY017OR - Cold Loamy 13-17 PZ

Hydric soil rating: No

Description of Harlow

Setting

Landform: Plateaus, structural benches
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loess and colluvium derived from basalt

Typical profile

A1 - 0 to 4 inches: very stony loam
A2 - 4 to 8 inches: very cobbly clay loam
Bt - 8 to 16 inches: extremely cobbly clay
2R - 16 to 26 inches: unweathered bedrock

Properties and qualities

Slope: 2 to 15 percent
Surface area covered with cobbles, stones or boulders: 1.6 percent
Depth to restrictive feature: 10 to 20 inches to lithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Very low (about 1.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: D
Ecological site: R009XY022OR - Cold Shallow 13+ PZ
Hydric soil rating: No

281—Snell-Harlow complex, 15 to 30 percent north slopes

Map Unit Setting

National map unit symbol: 2v3b
Elevation: 2,800 to 5,000 feet
Mean annual precipitation: 13 to 30 inches
Mean annual air temperature: 42 to 45 degrees F
Frost-free period: 70 to 100 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Snell and similar soils: 60 percent
Harlow and similar soils: 25 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Snell

Setting

Landform: Plateaus, structural benches
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluvium, crest
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loess and colluvium derived from basalt

Typical profile

A1 - 0 to 4 inches: very stony loam
A2 - 4 to 9 inches: stony clay loam
Bt1 - 9 to 18 inches: very stony clay loam
Bt2 - 18 to 24 inches: extremely stony clay loam
2R - 24 to 34 inches: unweathered bedrock

Properties and qualities

Slope: 15 to 30 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
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: Very low (about 2.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: C
Ecological site: R009XY017OR - Cold Loamy 13-17 PZ
Hydric soil rating: No

Description of Harlow

Setting

Landform: Canyons
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loess and colluvium derived from basalt

Typical profile

A1 - 0 to 4 inches: very stony loam
A2 - 4 to 8 inches: very cobbly clay loam
Bt - 8 to 16 inches: extremely cobbly clay
2R - 16 to 26 inches: unweathered bedrock

Properties and qualities

Slope: 15 to 30 percent
Surface area covered with cobbles, stones or boulders: 1.6 percent
Depth to restrictive feature: 10 to 20 inches to lithic bedrock
Drainage class: Well drained

Custom Soil Resource Report

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

Available water supply, 0 to 60 inches: Very low (about 1.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 7s

Hydrologic Soil Group: D

Ecological site: R009XY048OR - Shallow North 14+ PZ

Hydric soil rating: No

349—Wallowa-Bocker complex, 2 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2v5s

Elevation: 3,400 to 5,000 feet

Mean annual precipitation: 13 to 19 inches

Mean annual air temperature: 42 to 57 degrees F

Frost-free period: 70 to 100 days

Farmland classification: Farmland of statewide importance

Map Unit Composition

Wallowa and similar soils: 50 percent

Bocker and similar soils: 40 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Wallowa

Setting

Landform: Plateaus, mountain slopes

Landform position (two-dimensional): Backslope

Down-slope shape: Convex

Across-slope shape: Convex

Parent material: Loess and colluvium derived from basalt with an influence if volcanic ash

Typical profile

A - 0 to 11 inches: ashy silt loam

Bw - 11 to 29 inches: silt loam

2R - 29 to 39 inches: unweathered bedrock

Properties and qualities

Slope: 2 to 15 percent

Depth to restrictive feature: 20 to 40 inches to lithic bedrock

Drainage class: Well drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)

Depth to water table: More than 80 inches

Custom Soil Resource Report

Frequency of flooding: None

Frequency of ponding: None

Available water supply, 0 to 60 inches: Moderate (about 6.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 4e

Hydrologic Soil Group: C

Ecological site: R009XY017OR - Cold Loamy 13-17 PZ

Other vegetative classification: bluebunch wheatgrass-Sandberg bluegrass-onespike oatgrass (GB4911)

Hydric soil rating: No

Description of Bocker

Setting

Landform: Hills

Landform position (two-dimensional): Footslope

Landform position (three-dimensional): Side slope

Down-slope shape: Convex

Across-slope shape: Convex

Parent material: Loess and colluvium derived from basalt

Typical profile

A - 0 to 2 inches: extremely cobbly silt loam

Bw - 2 to 7 inches: very cobbly silt loam

2R - 7 to 17 inches: unweathered bedrock

Properties and qualities

Slope: 2 to 8 percent

Depth to restrictive feature: 4 to 10 inches to lithic bedrock

Drainage class: Well drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None

Frequency of ponding: None

Available water supply, 0 to 60 inches: Very low (about 0.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 7s

Hydrologic Soil Group: D

Ecological site: R009XY036OR - Cold Shallow South 13+ PZ

Hydric soil rating: No

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- 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>

Custom Soil Resource Report

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

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Established Series
Rev. MGL/WEL/RWL
08/2001

POWWATKA SERIES

The Powwatka series consists of moderately deep, well drained soils formed in loess with an influence of volcanic ash in the surface. They are on rolling hills and ridgetops. Slopes are 2 to 30 percent. The mean annual precipitation is about 15 inches and the mean annual temperature is about 43 degrees F.

TAXONOMIC CLASS: Fine-silty, mixed, superactive, frigid Vitrandic Argixerolls

TYPICAL PEDON: Powwatka ashy silt loam, cultivated. (Colors are for moist soil unless otherwise noted.)

Ap--0 to 8 inches; dark brown (10YR 2/2) ashy silt loam, dark gray (10YR 4/1) dry; weak very fine granular structure; slightly hard, friable, slightly sticky and slightly plastic; many very fine roots; common irregular pores; slightly acid (pH 6.4); abrupt smooth boundary.

A--8 to 14 inches; very dark grayish brown (10YR 3/2) ashy silt loam, dark grayish brown (10YR 4/2) dry; weak fine subangular blocky structure; slightly hard, friable, slightly sticky and plastic; many very fine roots; many very fine tubular pores; neutral (pH 6.6); clear wavy boundary. (Combined thickness of the A horizon is 8 to 22 inches)

Bt1--14 to 18 inches; dark brown (10YR 3/3) silty clay loam, brown (10YR 5/3) dry, weak fine prismatic structure parting to moderate fine and very fine subangular blocky; slightly hard, friable, slightly sticky and plastic; many fine roots; many very fine tubular pores; few faint clay films on ped faces; krotovinas 2 to 4 inches in diameter; neutral (pH 6.8); gradual wavy boundary.

Bt2--18 to 24 inches; dark brown (7.5YR 4/4) silty clay loam, brown (7.5YR 5/4) dry; weak fine prismatic structure parting to moderate fine and very fine subangular blocky; hard, friable, sticky and plastic; common very fine roots; many very fine tubular pores; few faint clay films on ped faces; krotovinas 2 to 4 inches in diameter; neutral (pH 6.8); abrupt wavy boundary. (Combined thickness of the Bt horizon is 10 to 18 inches)

2R--24 inches; fractured basalt.

TYPE LOCATION: Wallowa County, Oregon; about two miles NE of Lostine, 1,650 feet north and 400 feet east of the SW corner of section 1, T. 1 S., R. 43 E. (Latitude 45 degrees, 30 minutes, 15 seconds N, Longitude 117 degrees, 23 minutes, 36 seconds W)

RANGE IN CHARACTERISTICS: The mean annual soil temperature is 44 to 47 degrees F. The soils are usually moist, but are dry in the 4 to 12 inch control section for 60 to 90 consecutive days. The mollic epipedon is 12 to 20 inches thick and may include the upper part of the Bt horizon. The particle-size control section has more than 18 percent clay and less than 15 percent coarser than very fine sand. Depth to basalt bedrock is 20 to 40 inches.

The A horizon has value of 2 or 3 moist, 4 or 5 dry and chroma of 1 or 2 moist and dry. It is ashy silt loam or cobbly ashy silt loam with 18 to 25 percent clay. It has 0 to 30 percent cobbles and 0 to 15 percent gravel. It has 30 to 60 percent volcanic glass and glass coated aggregate and less than 0.1 percent acid oxalate extractable aluminum plus one-half iron. Soil reaction is slightly acid or neutral.

The Bt horizon has hue of 7.5YR or 10YR, value of 3 or 4 moist, 4 or 5 dry and chroma of 3 or 4 moist and dry. It is silt clay loam with 27 to 35 percent clay. The Bt2 horizon has 0 to 10 percent gravel. Soil reaction is slightly acid or neutral in the upper part and neutral or slightly alkaline in the lower part.

COMPETING SERIES: This is the [Hurwal](#) series. Hurwal soils have mollic epipedons more than 20 inches thick and are greater than 40 inches deep to bedrock.

GEOGRAPHIC SETTING: Powwatka soils are on rolling hills and ridgetops. Slope is 2 to 30 percent. The soils formed in loess with an influence of volcanic ash in the surface. Elevation is 3,400 to 5,200 feet. The climate is characterized by cold wet winters and hot dry summers. The mean annual precipitation is 13 to 17 inches. The mean annual temperature is 42 to 45 degrees F. The frost-free period is 60 to 100 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the competing [Hurwal](#), and the [Harlow](#), [Parsnip](#), and [Snell](#) series. Harlow soils are clayey-skeletal, less than 20 inches to bedrock and occur on south-facing side slopes. Hurwal soils occur in drainageways and on footslopes of north-facing side slopes. Parsnip soils are 10 to 20 inches to bedrock and occur on adjacent plateaus. Snell soils are clayey-skeletal, 20 to 40 inches to bedrock, and occur on north-facing side slopes.

DRAINAGE AND PERMEABILITY: Well drained; moderately slow permeability.

USE AND VEGETATION: The soils are used mainly for dry cropland and livestock grazing. The potential native vegetation is Idaho fescue and bluebunch wheatgrass.

DISTRIBUTION AND EXTENT: Northeastern Oregon, MLRA 9. The series is of small extent.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Portland, Oregon

SERIES ESTABLISHED: Wallowa County, Oregon, 1998.

REMARKS: Diagnostic horizons and features recognized in this pedon include:

Mollic epipedon - from the surface to 18 inches (Ap, A, and Bt1 horizons).

Argillic horizon - from 14 to 24 inches (Bt1 and Bt2 horizons).

Vitrandidic feature - from 0 to 14 inches (Ap and A horizons) based on laboratory data from the associated Parsnip soil.

Particle-size control section - from 14 to 24 inches (Bt1 and Bt2 horizons).

This series has been reclassified from Typic Argixerolls to Vitrandidic Argixerolls.

Established Series
Rev. MGL/AON/RWL
03/2001

TOPPER SERIES

The Topper series consists of very deep, well drained soils that formed in loess with an influence of volcanic ash in the surface. Topper soils are on hills. Slopes are 2 to 30 percent. The mean annual precipitation is about 16 inches and the mean annual temperature is about 43 degrees F.

TAXONOMIC CLASS: Fine-silty, mixed, superactive, frigid Vitrandic Haploxerolls

TYPICAL PEDON: Topper ashy silt loam, cultivated, at an elevation of 4,160 feet. (Colors are for moist soil unless otherwise noted.)

Ap--0 to 6 inches; very dark brown (10YR 2/2) ashy silt loam grayish brown (10YR 5/2) dry; weak fine platy structure; soft, friable, slightly sticky and slightly plastic; many very fine roots; few very fine tubular pores; neutral (pH 6.8); abrupt smooth boundary.

A--6 to 11 inches; dark brown (10YR 3/3) ashy silt loam, brown (10YR 5/3) dry; weak medium subangular blocky structure; soft, friable, slightly sticky and slightly plastic; common fine roots; common fine tubular pores; neutral (pH 6.8); abrupt irregular boundary. (Combined thickness of the A horizon is 10 to 16 inches)

C--11 to 15 inches; brown (10YR 4/3) silt loam, light gray (10YR 7/2) dry; massive; soft, very friable, nonsticky and nonplastic; few fine roots; common very fine tubular pores; slightly alkaline (pH 7.4); abrupt irregular boundary. (0 to 8 inches thick)

2Bwb--15 to 25 inches; dark brown (10YR 3/3) silt loam, brown (10YR 5/3) dry; weak coarse prismatic structure; slightly hard, friable, sticky and plastic; few fine roots; many fine tubular pores; neutral (pH 7.2); clear smooth boundary. (0 to 12 inches thick)

2Bkb1--25 to 35 inches; dark yellowish brown (10YR 4/4) silty clay loam, yellowish brown (10YR 5/4) dry; weak medium subangular blocky structure; hard, friable, sticky and plastic; few fine roots; many fine tubular pores; strongly effervescent; mycelium lime; strongly alkaline (pH 8.6); gradual boundary. (6 to 12 inches thick)

2Bkb2--35 to 60 inches; brown (10YR 5/3) silt loam, light gray (10YR 7/2) dry; massive; soft, friable, slightly sticky and slightly plastic; few fine roots; many fine tubular pores; strongly effervescent; soft segregated lime throughout; strongly alkaline (pH 8.6).

TYPE LOCATION: Wallowa County, Oregon; located about 6 miles north of Joseph; center of section 29, T. 1 S., R. 45 E. (Latitude 45 degrees, 26 minutes, 56 seconds N.; Longitude 117 degrees, 13 minutes, 04 seconds W.)

RANGE IN CHARACTERISTICS: The mean annual soil temperature is 44 to 47 degrees F. In most years the soils are usually moist but dry between 4 and 12 inches for 60 to 90 consecutive days within the 3-month period following the summer solstice. The mollic epipedon is 10 to 16 inches thick. Depth to secondary lime ranges from 20 to 40 inches with the calcic horizon having a calcium carbonate equivalent of 15 to 20 percent. The particle-size control section is 18 to 30 percent clay and less than 15 percent coarser than very fine sand. Depth to bedrock is greater than 60 inches.

The A horizon has value of 2 or 3 moist, 4 or 5 dry, and chroma of 2 or 3 moist and dry. It has 30 to 60 percent volcanic glass and glass coated aggregate and less than 0.1 percent acid oxalate extractable aluminum plus one-

half iron. It is ashy silt loam with 18 to 27 percent clay.

The C horizon, when present, has value of 3 or 4 moist, 5 to 7 dry and chroma of 2 to 4 moist and dry. It is neutral or slightly alkaline. It is silt loam with 18 to 27 percent clay.

The 2Bwb horizon has value of 3 or 4 moist, 5 or 6 dry and chroma of 3 or 4 moist and dry. It is silt loam with 18 to 27 percent clay.

The 2Bkb1 horizon has value of 3 or 4 moist, 5 or 6 dry, and chroma of 3 or 4 moist and dry. It is silt loam or silty clay loam with 18 to 30 percent clay. It is moderately to strongly calcareous with segregated or mycelium lime in the lower part.

The 2Bk2 horizon has value of 4 or 5 moist, 6 or 7 dry and chroma of 2 to 4 moist and dry. It is silt loam or loam with 18 to 27 percent clay. It has 0 to 10 percent gravel and 0 to 5 percent cobbles.

COMPETING SERIES: This is the [Hadenecreek](#) series. The Hadenecreek soils are moderately well drained, have 5 to 20 percent volcanic glass in the upper 7 to 14 inches, and have 5 to 20 percent calcium carbonate equivalent in the Bk horizon.

GEOGRAPHIC SETTING: The Topper soils are on hills and have slopes of 2 to 30 percent. The soils formed in loess and mixed loess and volcanic ash. Elevations of 3,400 to 4,500 feet. The climate is characterized by cool wet winters and hot dry summers. The mean annual precipitation of 13 to 17 inches. The mean annual temperature is 42 to 45 degrees F. The frost-free period season is 70 to 100 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the [Hurwal](#), [Parsnip](#), [Powwatka](#), and [Snell](#) series. Hurwal soils are on north-facing slopes, have argillic horizons, and lack secondary lime. Parsnip soils are on broad plateaus, have argillic horizons, and are 10 to 20 inches to bedrock. Powwatka soils are on adjacent hills, have argillic horizons, lack secondary lime, and are 20 to 40 inches to bedrock. Snell soils are on north-facing slopes, are clayey-skeletal, and lack secondary lime.

DRAINAGE AND PERMEABILITY: Well drained; moderate permeability.

USE AND VEGETATION: The soils are used mainly for small grain, alfalfa and pasture. Native vegetation is Idaho fescue with small amounts of associated forbs.

DISTRIBUTION AND EXTENT: Valleys of northeastern Oregon; MLRA 9. The series is inextensive.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Portland, Oregon

SERIES ESTABLISHED: Wallowa County, Oregon, 1998. The source of name is Topper lookout.

REMARKS: This series has been reclassified from a Calcic Haploxerolls to a Vitrandic Haploxerolls.

Diagnostic horizons and features recognized in this pedon include:

Mollic epipedon - the zone from 0 to 11 inches (Ap and A horizons)

Calcic horizon - the zone from 25 to 60 inches (2Bkb1 and 2Bkb2 horizons) with an assumed calcium carbonate equivalent of 15 to 20 percent.

Calcic subgroup feature - presence of calcic horizon beginning at 25 inches.

Vitrandic subgroup feature - the zone from 0 to 11 inches (Ap and A horizons) based on laboratory data from the associated Parsnip soil.

Particle-size control section - the zone from 10 to 40 inches.

APPENDIX G

Public Notification Letters



102 E. North St.
Enterprise, OR 97828

(541) 426-4196
Fax: (541) 426-3395
www.enterpriseoregon.org

December 19, 2024

Diana Collins
65714 Getting Road
Enterprise, Oregon 97828

RE: Proposed Application of Biosolids as Fertilizer Amendment

The City of Enterprise, Oregon, has applied to the Oregon Department of Environmental Quality (DEQ) to land apply biosolids on properties near you. The properties to receive biosolids are located in Township 2 South, Range 45 East, Section 6. Please see the attached Figure 4 showing the proposed land application sites.

Biosolids are a byproduct of domestic wastewater treatment that contains valuable nutrients. Various processes stabilize the biosolids, kill harmful bacteria, and control odors. Treated biosolids are frequently used instead of chemical fertilizers, and because many of the nutrients in the biosolids are less mobile in the soil, they are absorbed by plants and are less likely to adversely affect water resources. Additionally, the biosolids improve soil tilth and water-holding capacity and provide micronutrients not found in most chemical fertilizers.

Biosolids reuse is regulated by the U.S. Environmental Protection Agency and the DEQ to protect public health and the environment. The DEQ will inspect each proposed property and approve it prior to application. As part of the approval, the DEQ establishes buffer zones from sensitive areas such as wells, streams, roadways, residences, etc.

The City has historically taken biosolids to the landfill; however, the City is now required to land apply the biosolids. Enclosed is a brochure on biosolids recycling and a DEQ Fact Sheet. If you have any questions regarding the City's biosolids program, please contact Dave Wilkie at 541-426-3093. You may also learn more about the DEQ biosolids program on their website at: <https://www.oregon.gov/deq/wq/programs/Pages/Biosolids.aspx>

If you are not the resident or occupant of the property adjacent to this site but are the owner, please notify anyone who resides at this property of this proposed activity.

Sincerely,

Lacey McQuead, City Administrator

LM/nc

Encl.



102 E. North St.
Enterprise, OR 97828

(541) 426-4196
Fax: (541) 426-3395
www.enterpriseoregon.org

December 19, 2024

Suzette Bonneau
P.O. Box 629
Wallowa, Oregon 97885

RE: Proposed Application of Biosolids as Fertilizer Amendment

The City of Enterprise, Oregon, has applied to the Oregon Department of Environmental Quality (DEQ) to land apply biosolids on properties near you. The properties to receive biosolids are located in Township 1 South, Range 44 East, Section 3. Please see the attached Figure 3 showing the proposed land application site.

Biosolids are a byproduct of domestic wastewater treatment that contains valuable nutrients. Various processes stabilize the biosolids, kill harmful bacteria, and control odors. Treated biosolids are frequently used instead of chemical fertilizers, and because many of the nutrients in the biosolids are less mobile in the soil, they are absorbed by plants and are less likely to adversely affect water resources. Additionally, the biosolids improve soil tilth and water-holding capacity and provide micronutrients not found in most chemical fertilizers.

Biosolids reuse is regulated by the U.S. Environmental Protection Agency and the DEQ to protect public health and the environment. The DEQ will inspect each proposed property and approve it prior to application. As part of the approval, the DEQ establishes buffer zones from sensitive areas such as wells, streams, roadways, residences, etc.

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If you are not the resident or occupant of the property adjacent to this site but are the owner, please notify anyone who resides at this property of this proposed activity.

Sincerely,

Lacey McQuead, City Administrator

LM/nc

Encl.



102 E. North St.
Enterprise, OR 97828

(541) 426-4196
Fax: (541) 426-3395
www.enterpriseoregon.org

December 19, 2024

Jack and Deena Woods
63782 Eagle Road
Lostine, Oregon 97857

RE: Proposed Application of Biosolids as Fertilizer Amendment

The City of Enterprise, Oregon, has applied to the Oregon Department of Environmental Quality (DEQ) to land apply biosolids on properties near you. The properties to receive biosolids are located in Township 2 South, Range 44 East, Section 1. Please see the attached Figure 4 showing the proposed land application sites.

Biosolids are a byproduct of domestic wastewater treatment that contains valuable nutrients. Various processes stabilize the biosolids, kill harmful bacteria, and control odors. Treated biosolids are frequently used instead of chemical fertilizers, and because many of the nutrients in the biosolids are less mobile in the soil, they are absorbed by plants and are less likely to adversely affect water resources. Additionally, the biosolids improve soil tilth and water-holding capacity and provide micronutrients not found in most chemical fertilizers.

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If you are not the resident or occupant of the property adjacent to this site but are the owner, please notify anyone who resides at this property of this proposed activity.

Sincerely,

Lacey McQuead, City Administrator

LM/nc

Encl.



102 E. North St.
Enterprise, OR 97828

(541) 426-4196
Fax: (541) 426-3395
www.enterpriseoregon.org

December 19, 2024

Nicholas and Alexandra West
105 West Logan Street
Enterprise, Oregon 97828

RE: Proposed Application of Biosolids as Fertilizer Amendment

The City of Enterprise, Oregon, has applied to the Oregon Department of Environmental Quality (DEQ) to land apply biosolids on properties near you. The properties to receive biosolids are located in Township 1 South, Range 44 East, Section 3. Please see the attached Figure 3 showing the proposed land application site.

Biosolids are a byproduct of domestic wastewater treatment that contains valuable nutrients. Various processes stabilize the biosolids, kill harmful bacteria, and control odors. Treated biosolids are frequently used instead of chemical fertilizers, and because many of the nutrients in the biosolids are less mobile in the soil, they are absorbed by plants and are less likely to adversely affect water resources. Additionally, the biosolids improve soil tilth and water-holding capacity and provide micronutrients not found in most chemical fertilizers.

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If you are not the resident or occupant of the property adjacent to this site but are the owner, please notify anyone who resides at this property of this proposed activity.

Sincerely,

Lacey McQuead, City Administrator

LM/nc

Encl.



102 E. North St.
Enterprise, OR 97828

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Fax: (541) 426-3395
www.enterpriseoregon.org

December 19, 2024

Melvin and Dena Stonebrink
80995 School Flat Lane
Wallowa, Oregon 97885

RE: Proposed Application of Biosolids as Fertilizer Amendment

The City of Enterprise, Oregon, has applied to the Oregon Department of Environmental Quality (DEQ) to land apply biosolids on properties near you. The properties to receive biosolids are located in Township 1 South, Range 44 East, Section 3. Please see the attached Figure 3 showing the proposed land application site.

Biosolids are a byproduct of domestic wastewater treatment that contains valuable nutrients. Various processes stabilize the biosolids, kill harmful bacteria, and control odors. Treated biosolids are frequently used instead of chemical fertilizers, and because many of the nutrients in the biosolids are less mobile in the soil, they are absorbed by plants and are less likely to adversely affect water resources. Additionally, the biosolids improve soil tilth and water-holding capacity and provide micronutrients not found in most chemical fertilizers.

Biosolids reuse is regulated by the U.S. Environmental Protection Agency and the DEQ to protect public health and the environment. The DEQ will inspect each proposed property and approve it prior to application. As part of the approval, the DEQ establishes buffer zones from sensitive areas such as wells, streams, roadways, residences, etc.

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If you are not the resident or occupant of the property adjacent to this site but are the owner, please notify anyone who resides at this property of this proposed activity.

Sincerely,

Lacey McQuead, City Administrator

LM/nc

Encl.



102 E. North St.
Enterprise, OR 97828

(541) 426-4196
Fax: (541) 426-3395
www.enterpriseoregon.org

December 19, 2024

Stangel Industries & Machine Shop
P.O. Box 157
Enterprise, Oregon 97828

RE: Proposed Application of Biosolids as Fertilizer Amendment

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December 19, 2024

Edward Snodderly
P.O. Box 447
Enterprise, Oregon 97828

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December 19, 2024

IS 5510 Investments LLC
64022 Imnaha Highway
Joseph, Oregon 97846

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December 19, 2024

Bruce and Kathleen Hanna
541 N.E. Goldie Drive
Hillsboro, Oregon 97124

RE: Proposed Application of Biosolids as Fertilizer Amendment

The City of Enterprise, Oregon, has applied to the Oregon Department of Environmental Quality (DEQ) to land apply biosolids on properties near you. The properties to receive biosolids are located in Township 2 South, Range 45 East, Section 6. Please see the attached Figure 4 showing the proposed land application sites.

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December 19, 2024

Timothy and Audry Melville
84887 Joseph Highway
Enterprise, Oregon 97828

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December 19, 2024

Todd and Angela Nash
64541 Alder Slope Road
Enterprise, Oregon 97828

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December 19, 2024

Enterprise Christian Church
207 East Main Street
Enterprise, Oregon 97828

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Fact Sheet

Biosolids: A Beneficial Resource

Background

Biosolids are the nutrient-rich organic solids that are derived from the treatment of domestic wastewater at municipal wastewater facilities. Once biosolids have been treated to meet state and federal regulations, they can be beneficially used for land application or, in some cases, sold or given away like compost.

Recognizing the value of biosolids

Since 1978, DEQ has addressed the need to effectively manage the beneficial use of biosolids. Oregon's policy supports the land application of treated domestic wastewater biosolids, biosolids-derived products and domestic septage when managed in a manner that protects public health and maintains or improves environmental quality.

What is regulated?

The land application of biosolids, biosolids-derived products and domestic septage is a highly regulated practice. Regulatory requirements are established under Oregon Administrative Rules chapter 340, division 50. The state rules incorporate most of the federal technical biosolids regulations, including requirements for pathogen reduction, vector attraction reduction, and limits for trace pollutants. Monitoring is also required for several nutrients.

How biosolids are used

Land applying biosolids can have several benefits. The organic matter in biosolids can improve the quality and overall characteristics of cultivated soil. The additional nutrients provided by biosolids can improve plant growth. Approximately 95% of biosolids generated in Oregon are land applied on DEQ-approved sites for agricultural purposes such as hay and pasture. In 2001, biosolids from 108 domestic wastewater treatment facilities were land applied on 18,618 acres, which is about 0.11% of all Oregon land in farms. Biosolids are also used for silvicultural and horticultural activities. DEQ works with wastewater treatment facilities to ensure that management of biosolids and land application activities are adequately addressed through a National Pollutant Discharge Elimination System (NPDES) or Water Pollution Control Facility (WPCF) permit, a biosolids management plan, and site authorization letters. Good agronomic practices and site management activities ensure the protection of public health and the environment.



Land application of biosolids at an Oregon farm.

Biosolids Management Plans

Facilities are required to manage and operate their biosolids operations under a biosolids management plan. These plans are specific to each facility and are considered an extension of the facility's NPDES or WPCF permit. Together with a facility's permit and land application site authorizations, the plan provides assurance that biosolids processing and management activities are addressed in a comprehensive manner and problems with compliance are minimized. Plans must be current and on file with the permit. Each site used for land application of biosolids must be authorized by DEQ before use. Prior to authorizing a land application site, a facility must submit specific site information to DEQ for evaluation, and then DEQ will conduct a field visit. Notification to neighbors about the land application activity is also required. Any site that may be sensitive to residential housing or have runoff potential will be subject to a public comment process.

State rules also outline best management practices regarding use limitations, criteria for site selection and approval, and application.

For more information

For program information, please contact the program coordinator. For specific wastewater treatment facility and land application site information, please contact the appropriate regional specialist (list at right).

Alternative formats

Documents can be provided upon request in an alternate format for individuals with disabilities or in a language other than English for people with limited English skills. To request a document in another format or language, call DEQ in Portland at 503-229-5696, or toll-free in Oregon at 1-800-452-4011, ext. 5696; or email deqinfo@deq.state.or.us.



State of Oregon
Department of
Environmental
Quality

Biosolids Program

700 NE Multnomah St., Suite 600
Portland, OR 97232
Phone: 503-229-5696
800-452-4011
Fax: 503-229-6762
Contact: Pat Heins
www.oregon.gov/DEQ

Program Staff

Pat Heins
Program Coordinator
(503) 229-5749
Heins.pat@deq.state.or.us

Western Region, Eugene
Paul Kennedy
(503-687-7439)
kennedyv.paul@deq.state.or.us

DEQ is a leader in restoring, maintaining and enhancing the quality of Oregon's air, land and water.

Frequently Asked Questions

What are biosolids?

Biosolids are the nutrient-rich organic by-product of domestic wastewater treatment. They contain essential plant nutrients and organic matter, and can be recycled and applied as a fertilizer and soil amendment, when properly treated and managed.

What is the difference between biosolids and sludge?

The term “sludge” describes the untreated solids produced in the domestic wastewater treatment process. To make biosolids, sewage sludge is treated through carefully regulated processes (biological, chemical or physical) to kill pathogens and stabilize organic matter. This reduces offensive odors and its appeal to insects and rodents. The material only becomes biosolids once it meets federal and state standards so that it can be safely used for beneficial land application.

Why does the EPA and DEQ consider biosolids safe for land application?

Biosolids have been widely used on farms and other natural resource sites across North America for decades. Sixty percent of U.S. biosolids are applied to soils, enhancing soil health, recycling nutrients, sequestering carbon, and providing a productive use for a material that every community has to manage. (Wastewater treatment is a vital public service, and it creates solids that have to be managed.) Portland, Seattle, Los Angeles, Denver, Chicago, Boston, and hundreds of other communities recycle their biosolids to soils. Most major land grant universities have studied biosolids effects on soils and have found little risk when used according to regulations. Every U.S. state and Canadian province allows biosolids use on soils. The U.S. Environmental Protection Agency, U.S. Department of Agriculture and U.S. Food and Drug Administration all approve biosolids recycling. Thousands of research publications over 45 years and two major reviews by the National Academy of Sciences have found biosolids use on soils presents “negligible risk” when managed in accordance with federal regulations and that “there is no documented scientific evidence that the Part 503 rule (the federal biosolids regulations) has failed to protect public health.”

What are the benefits of land application of biosolids?

Land application is a cost-effective and sustainable option for managing biosolids. The Oregon Environmental Quality Commission encourages the land application of biosolids when managed in a manner which protects the public health and maintains or improves environmental quality. The Oregon Department of Environmental Quality implements this policy across the state.

Plants need a complex mixture of nutrients, soil, air and water to grow well. Biosolids enrich the soil with essential nutrients and organic matter. Biosolids typically contain about 50 percent organic matter, which improves soil tilth, allows the soil to drain and breathe better, and hold more water. This results in decreased water runoff and soil erosion, with increased water conservation. These attributes may help a farmer comply with agricultural conservation practices. Research plots and demonstration sites have shown that the quality of crops grown on biosolids-amended soils is equal or superior to those grown with commercial fertilizers.

How are biosolids regulated in Oregon?

The land application of biosolids, biosolids-derived products and domestic septage is regulated under the DEQ regulations found in Oregon Administrative Rules Chapter 340, Division 50. The state rules incorporate most of the federal biosolids regulations (Chapter 40 Code of Federal Regulations Part 503), including requirements that reduce pathogens, stabilize organic matter, and limit trace elements including arsenic, cadmium, copper, lead, mercury, molybdenum, nickel, selenium, and zinc.



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Biosolids

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Biosolids

In Oregon, monitoring is also required for several macronutrients, including potassium, nitrogen, and phosphorus. DEQ is responsible for permitting land application sites for Class B biosolids in Oregon to protect public health and the environment. For each site where biosolids are applied, DEQ issues a site authorization to the wastewater treatment facility that prescribes appropriate management practices for the site, which account for:

- Site characteristics and soil conditions
- Protection of ground and surface water and wells
- Biosolids chemical properties
- Type of biosolids (liquid, semi-solid, or solid)
- Method of biosolids application

Among other things, the site authorization establishes conditions on:

- Allowable biosolids application rate, season of application
- Public access restrictions
- Required waiting periods between biosolids application and crop harvest or grazing
- Required buffers near homes, highways, and other public areas

What risks do trace metals pose?

EPA thoroughly studied the potential risks from trace metals in biosolids and set maximum levels in biosolids to ensure protection of public health and the environment. To date, studies indicate that properly treated and managed biosolids can be land applied in an environmentally sound manner. Based on the 2017 analytical results, the concentrations of these trace metals found in biosolids produced in Oregon are well below the maximum levels identified by EPA.

Many of the regulated metals in biosolids are beneficial and necessary for healthy plant growth in correct amounts, such as copper, molybdenum, and zinc which are micronutrients for plants. The presence of these micronutrients is one reason why biosolids can be more effective than mineral fertilizers at promoting plant growth.

What about organic compounds in biosolids?

Many chemicals used in society can be found in trace amounts in wastewater. The fact is few chemicals of concern are found in biosolids. An EPA 2009 *Targeted National Sewage Sludge Survey*¹ investigated levels of several trace organic compounds in solids collected from 74 wastewater treatment plants nationally. The EPA study found some analytes were present in all samples, while others were present in none or only a few samples. EPA continues to review hazard and exposure assessments for these pollutants as data and analytical methods improve.

What about pharmaceuticals in biosolids?

Pharmaceuticals such as antibiotics, prescription drugs and personal care products, like soaps, shampoos, detergents, and perfumes contain a wide variety of chemicals. The effect of these chemicals on the environment is the focus of considerable research. Although leading scientists see little threat to the public health and the environment from these chemicals associated with biosolids, EPA is currently developing better sampling and analytical procedures for these chemicals. Once improved sampling and analytical methods are in place, EPA plans to conduct exposure and hazard assessments for these pollutants. This study will take into account toxicity data for humans and ecological receptors, solids pollutant concentrations, and the fate and transport of these chemical compounds.

The best way to reduce concentrations of pharmaceuticals in biosolids is by never flushing unwanted drugs down the toilet, and to support effective drug take back programs. Purchase soaps and cleaners that are manufactured with the environment in mind - such as those that are recognized in EPA's *Safer Choice Program*².



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¹Samples collected in 2006 & 2007 - see <https://nepis.epa.gov/Exe/ZyPDF.cgi/P1003RNO.PDF?Dockey=P1003RNO.PDF>

² See <https://www.epa.gov/saferchoice>

What about Per- and Polyfluoroalkyl substances (PFAS) in biosolids?

Perfluorooctanoic acid and perfluorooctane sulfonate have had considerable public attention in recent years, especially in New England. Concerns here in Oregon have focused on impacts near industrial facilities that used these chemicals specifically airports with foam firefighting systems. These chemicals are found in carpets, furniture, household dust and air, cooking tools, outdoor clothing, fire-fighting foams, and other products. Because these chemicals are ubiquitous in today's society and the environment there is ongoing uncertainty about their actual affects. These chemical are being phased out of use here in the U.S and Canada; as a result wastewater treatment facilities are seeing decreasing concentrations in their systems. In the 2000s perfluorooctanoic acid was found in the typical biosolids at an average concentration of 34 parts per billion (ppb) and more recent studies have found average perfluorooctanoic acid concentrations of 2.3 and 5.3 ppb in the biosolids. Research and risk assessments conducted in New England have determined that direct contact, inhalation, or ingestion of materials containing less than 500 parts per billion of perfluorooctanoic acid pose no significant risk.³ Thus, biosolids and residuals present negligible risk via these pathways.

Does the land application of biosolids pollute surface water or groundwater?

Properly managed biosolids products do not pollute surface water or groundwater. Biosolids recycling programs follow best management practices to ensure water quality is protected. In fact, documented improvements in surrounding water quality have been found in numerous biosolids application projects due to enriched soils and vigorous growth of vegetation that reduce soil erosion and stabilize contaminants that had previously contributed to stream and groundwater pollution. Biosolids are not allowed to runoff into surface water, including rivers, streams, irrigation ditches, or ponds; and, biosolids application rates and site management practices are designed to prevent the leaching of nutrients to groundwater

Are biosolids tested before land application?

Biosolids are tested by the generating facility before they are land applied. The required minimum frequency of this sampling is based on the volume of biosolids produced by the facility each year as summarized in the table below.

Dry weight – metric tons/year	Sampling Frequency
0 – < 290	Annually
>290 - <1,500	Quarterly
≥1,500 - <15,000	Bimonthly
≥15,000	Monthly

Is the soil tested at land application sites?

Facilities test the soil at land application sites to calculate the agronomic rate for that field. Facilities are required to collect soil samples at a minimum if they land apply biosolids at the agronomic rate for more than two out of three successive years. Additional or more frequent testing may be required in their biosolids management plan or site authorization letter.

What notification or signage are required for authorized sites?

There are no federal regulations requiring notification or signage for authorized biosolids sites. Oregon state regulations requires notification prior to approval of any proposed site that maybe sensitive to residential housing, runoff or groundwater. DEQ policy requests signs to be posted at the field and land application notices sent out to adjacent property owners when a facility is asking DEQ for approval to land apply on a given field. Once DEQ has approved a field with a site authorization letter, the permittee must follow the requirements established in their biosolids



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³ See <https://www.nebiosolids.org/>

Biosolids

management plan and site authorization letters which can require signs to be posted at the field at the start of land application and during land application activities. If a facility is required to post signs, most of them remove the signs after land application activities are completed so the signs do not interfere with the farming activities or get knocked down and become roadside litter.

What are biosolids agronomic rates?

The agronomic loading rate is based on a crop's ability to use nitrogen and considers the plant-available nitrogen content of the biosolids and other nitrogen sources at the site. Biosolids application at agronomic rates supplies adequate nitrogen to facilitate crop growth while protecting water quality.

For Further Information:

Oregon Department of Environmental Quality:

<https://www.oregon.gov/deq/wq/programs/Pages/Biosolids.aspx>

United States Environmental Protection Agency:

<https://www.epa.gov/biosolids>

Oregon State University:

<http://cropandsoil.oregonstate.edu/>

Washington State University:

<https://puyallup.wsu.edu/soils/biosolids/>

University of Idaho:

<https://www.uidaho.edu/extension>

University of Arizona, College of Agriculture and Life Sciences:

<http://cals.arizona.edu/pubs/consumer/az1426.pdf>

Oregon Association of Clean Water Agencies

<http://www.oracwa.org/c-biosolids.html>

Northwest Biosolids Management Association:

<http://www.nwbiosolids.org>

National Biosolids Partnership:

<http://www.biosolids.org/>

North East Biosolids and Residuals Association:

<http://www.nebiosolids.org/>

Alternative formats

Documents can be provided upon request in an alternate format for individuals with disabilities or in a language other than English for people with limited English skills. To request a document in another format or language, call DEQ in Portland at 503-229-5696, or toll-free in Oregon at 1-800-452-4011, ext. 5696; or email deqinfo@deq.state.or.us.



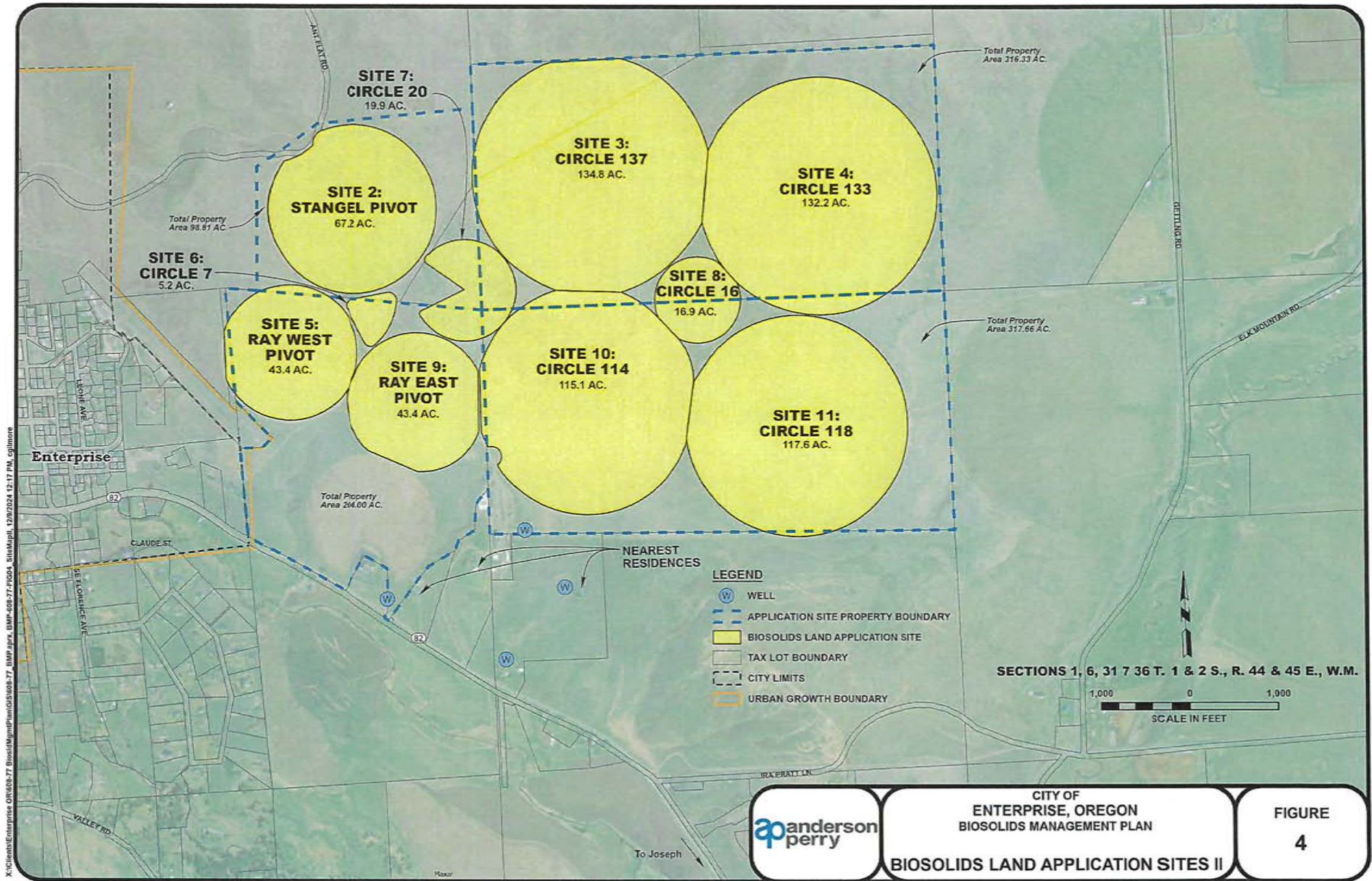
State of Oregon
Department of
Environmental
Quality

Biosolids

700 NE Multnomah St.
Suite 600
Portland, OR 97232
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800-452-4011
Fax: 503-229-5850
Contact: Pat Heins

www.oregon.gov/DEQ

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and enhancing the
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SITE AUTHORIZATION DOCUMENTATION

JANUARY 2025



Prepared for the
City of Enterprise, Oregon

CITY OF
ENTERPRISE, OREGON
SITE AUTHORIZATION DOCUMENTATION

JANUARY 2025



ANDERSON PERRY & ASSOCIATES, INC.

La Grande, Redmond, Hermiston, and Enterprise, Oregon
Walla Walla, Washington

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Introduction

This document presents the site authorization documentation required for the land application of biosolids from the City of Enterprise, Oregon's wastewater treatment facility (WWTF). This document has been developed in accordance with the Oregon Department of Environmental Quality's Biosolids Land Application Site Authorization Request Checklist.

Site Information

Geographic Area

The City of Enterprise is located approximately 64 miles from La Grande, Oregon, and approximately 6 miles northwest of Joseph, Oregon, in Wallowa County. The WWTF, located in Township 01 South, Range 44 East, Section 35, Willamette Meridian, serves a current population of approximately 2,126 people. The proposed biosolids land application sites are located both north and southwest of the City of Enterprise and are zoned for Exclusive Farm Use.

Landscape Position

The proposed biosolids land application sites are located adjacent to Golf Course Road in Section 3, Township 01 South, Range 44 East, Willamette Meridian and adjacent to the Enterprise Municipal Airport in Section 3, Township 01 South, Range 44 East, Willamette Meridian; Section 31, Township 01 South, Range 45 East, Willamette Meridian; and Section 6, Township 02 South, Range 45 East, Willamette Meridian. Figure 1 shows the location and vicinity maps with the proposed biosolids land application sites as well as the WWTF. The properties may be utilized for cultivating barley, oats, flax, timothy hay, or alfalfa as a feed crop for animal consumption. The intended use of winter wheat, spring wheat, lentils, and peas are for seed crop or human consumption depending on contracts procured by the landowner. Mustard/canola may be grown for human consumption. Spelt is cultivated solely for human consumption. A cover crop mixture of oats, barley, flax, peas, and radish may be utilized for grazing; however, all nitrogen applied through biosolids will be counted toward the following planted crop's nitrogen uptake rate.

Application Site Owner

Table 1 shows the landowner of the proposed biosolids land application sites. It also indicates the nearest residences to the biosolids land application sites. Figures 2 and 3 show the biosolids land application sites with applicable setback distances and the residences near the biosolids land application sites.

TABLE 1
APPLICATION SITES

Biosolids Land Application Site 1 - Parsnip Valley	Owner:	Cornerstone Farms J.V. Kurt Melville/Kevin Melville 64022 Imnaha Highway Joseph, Oregon 97846 541-398-0166
	Nearest Residence:	Evelyn Day P.O. Box 629 Wallowa, Oregon 97885
Biosolids Land Application Site 10 - Circle 114	Owner:	Cornerstone Farms J.V. Kurt Melville/Kevin Melville 64022 Imnaha Highway Joseph, Oregon 97846 541-398-0166
	Nearest Residence:	Timothy and Audry Melville 84887 Joseph Highway Enterprise, Oregon 97828
	Nearest Residence:	Kathleen and Bruce Hanna 541 N.E. Goldie Road Hillsboro, Oregon 97124

Site Management Agreement

The signed site management agreement between the City of Enterprise and the landowner of the biosolids land application sites is included for reference in Appendix A.

Adjacent Land Uses

Land adjacent to the biosolids land application site along Golf Course Road is used for agricultural purposes. The land adjacent to the biosolids land application sites near the Enterprise Municipal Airport are used for light commercial and airport land uses in the vicinity. The landowners adjacent to the biosolids land application sites were mailed a public notification letter regarding the proposed biosolids land application activities at the proposed sites shown on Figures 2 and 3. Copies of the public notification letters are included in Appendix B. The public notification letters were mailed to adjacent landowners on December 26, 2024.

Soil Information

The Natural Resources Conservation Service (NRCS) Soil Survey Map of Wallowa County lists the following soils at the proposed biosolids land application sites: Hurwal series, Powwatka series, Harlow-Bocker complex, and Topper silt loam. Figures 4 and 5 shows the soil survey map of the proposed biosolids land application sites. Complete official soil series descriptions from the National Cooperative Soil Survey completed by NRCS are included in Appendix C. The following paragraphs describe the major soil series indicated on the soil survey map.

Hurwal Silt Loam

Hurwal silt loam consists of deep to very deep, well-drained soils formed in loess with an influence of volcanic ash in the surface. The depth to hardpan, a root-restrictive layer, is more than 80 inches.

Water movement in the most restrictive layer is moderately high, and slopes range from 2 to 60 percent. This soil is not flooded or ponded. There is no zone of water saturation within a depth of 80 inches.

Powwatka Silt Loam

Powwatka silt loam consists of moderately deep, well-drained soils formed in loess with an influence of volcanic ash in the surface. The depth to hardpan, which is lithic bedrock, is 20 to 40 inches. Water movement in the most restrictive layer is moderately high, and slopes range from 2 to 30 percent. This soil is not flooded or ponded. There is no zone of water saturation within a depth of 80 inches.

Harlow-Bocker Complex

Harlow-Bocker complex consists of shallow, well-drained soils formed in loess and colluvium from basalt or argillite. Harlow soils are found in canyons, structural benches, and basalt plateaus. The depth to hardpan, which is lithic bedrock, is 10 to 20 inches for Harlow and 4 to 10 inches for Bocker. Water movement in the most restrictive layer for Harlow is moderately low to moderately high, and water movement is moderately high to high for Bocker in the most restrictive layer. Slopes range from 2 to 90 percent for Harlow-Bocker complex. This soil is not flooded or ponded. There is no zone of water saturation within a depth of 80 inches.

Topper Silt Loam

Topper silt loam consists of very deep, well-drained soils that formed in loess with an influence of volcanic ash in the surface. The depth to hardpan, a root-restrictive layer, is more than 80 inches. Water movement in the most restrictive layer is moderately high to high, and slopes range from 2 to 30 percent. This soil is not flooded or ponded. There is no zone of water saturation within a depth of 80 inches.

Agriculture and Crop Management Information

As mentioned above, winter wheat, mustard/canola, flax, oats, spring wheat, timothy hay, alfalfa, spelt, peas, lentils, barley, and a cover crop mixture all may be grown at the biosolids land application sites. Barley, oats, flax, timothy hay, or alfalfa may be grown as a feed crop for animal consumption, while winter wheat, spring wheat, lentils, or peas may be grown as a seed crop or human consumption depending on contracts procured by the landowner. Mustard/canola may be grown for human consumption or as a cover crop. Spelt is cultivated solely for human consumption. The cover crop mixture may be utilized for grazing.

Crop Assimilative Capacity

Class B biosolids are required to be land-applied to a site at a rate that is equal to or less than the agronomic rate for the site. An agronomic rate is the whole biosolids application rate (dry weight basis) designed to provide the annual total amount of nitrogen needed by a crop and to minimize the amount of nitrogen passing below the root zone of the crop or vegetation to groundwater. The nitrogen uptake rate for each crop to be potentially grown at the biosolids land application sites were determined and are listed on Table 2.

TABLE 2
NITROGEN UPTAKE RATES FOR POTENTIAL CROPS

Crop	Irrigated Nitrogen Uptake Rate (lbs N/acre)	Irrigated Yield Goals	Dryland Nitrogen Uptake Rate (lbs N/acre)	Dryland Yield Goals	Literature Source for Nitrogen Uptake Rate
Alfalfa	360	5.5 to 6 tons	60	1 ton	Pacific Northwest Extension Publication, PNW0611
Winter Wheat	195	110 to 130 bushels	85	40 to 70 bushels	Pacific Northwest Extension Publication, PNW513
Barley	160	2.5 to 3.5 tons	65	1.25 tons	OSU Cereal Grain Nutrient Management
Oats	120	2.5 to 3 tons	40	1 ton	OSU Cereal Grain Nutrient Management
Mustard/Canola	120	1,500 lbs/ 2,500 lbs	45	800 lbs/ 800 lbs	OSU Extension Publication, EM 8796
Spring Wheat	120	70 to 120 bushels	55	35 bushels	OSU Cereal Grain Nutrient Management
Timothy Hay	100	3.5 to 6 tons	50	1 to 3 tons	University of Idaho Extension Publication
Spelt	90	60 bushels	N/A	N/A	University of Wisconsin-Madison Extension Publication
Brown Flax	80	1,800 lbs	40	500 lbs	OSU Extension Publication, EM 8952-E
Cover Crop Mixture (Oats, Barley, Flax, Peas, Radish) ¹	50	Forage left standing	50	Forage left standing	
Lentils	35	0.5 to 1 ton	10	500 lbs	Alberta Pulse Growers Publication
Peas	20	1.25 to 2 tons	5	1,000 lbs	OSU Extension Publication, EM 9140

¹The application of biosolids on site(s) with the cover crop mixture planted shall have the nitrogen supplied from all sources be counted toward the agronomic rate of the crop planted following the cover crop mixture.

lbs = pounds

lbs N/acre = pounds of nitrogen per acre

N/A = not applicable

OSU = Oregon State University

Due to the number of potential crops and available biosolids land application sites, a single crop and site were selected to be utilized as an example. The biosolids application rate for the City of Enterprise's biosolids land application for Site 1 - Parsnip Valley shown on Figure 2 was developed based on test results of the biosolids and guidance provided by Washington State University and OSU and the *Worksheet for Calculating Biosolids Application Rates in Agriculture, a Pacific Northwest Extension Publication, PNW511*. Example calculations were made for the biosolids land application Site 1 - Parsnip Valley shown on Figure 2. For the example calculations, it was assumed

barley would be grown on the site as a dryland crop. It is assumed that barley will uptake 120 lbs N/acre. There is no published nitrogen uptake data available for barley; however, per OSU's Cereal Grain Nutrient Management web page, barley nitrogen uptake is estimated to be 80 percent of winter wheat's nitrogen uptake. The value stated for winter wheat in the *Nitrogen Uptake and Utilization by Pacific Northwest Crops, a Pacific Northwest Extension Publication, PNW 513* (see Appendix D) is 150 lbs N/acre; therefore, taking 80 percent of the 150 lbs N/acre equals 120 lbs N/acre for barley (150 lbs N/acre x 80 percent = 120 lbs N/acre).

Time of Application

Biosolids from the WWTF are planned to be land-applied semi-annually and are anticipated to be applied in the early spring, between April and May, and the late fall, between September and October following harvest.

Harvesting Methods

The crops grown at the biosolids land application sites will be harvested in accordance with standard practices applicable to the specific crop. Provided vector attraction reduction is met by Option 3, the biosolids land application sites will not be incorporated to reduce the nitrogen added to the soil.

Irrigation and Fertilizing Practices

Table 3 shows the irrigation and fertilizing practices for the biosolids land application sites.

TABLE 3
IRRIGATION AND FERTILIZING PRACTICES

Site	Irrigation	Fertilizer ²
Site 1 - Parsnip Valley	None	Supplemental Fertilizer (Commercial)
Site 2 - Stangel Pivot	Fresh Water ¹	Supplemental Fertilizer (Commercial)
Site 3 - Circle 137	Fresh Water ¹	Supplemental Fertilizer (Commercial)
Site 4 - Circle 133	Fresh Water ¹	Supplemental Fertilizer (Commercial)
Site 5 - Ray West Pivot	Fresh Water ¹	Supplemental Fertilizer (Commercial)
Site 6 - Circle 7	Fresh Water ¹	Supplemental Fertilizer (Commercial)
Site 7 - Circle 20	Fresh Water ¹	Supplemental Fertilizer (Commercial)
Site 8 - Circle 16	Fresh Water ¹	Supplemental Fertilizer (Commercial)
Site 9 - Ray East Pivot	Fresh Water ¹	Supplemental Fertilizer (Commercial)
Site 10 - Circle 114	Fresh Water ¹	Supplemental Fertilizer (Commercial)
Site 11 - Circle 118	Fresh Water ¹	Supplemental Fertilizer (Commercial)
Site 12 - Ray South Pivot	Fresh Water ¹	Supplemental Fertilizer (Commercial)

¹Fresh water supplied for irrigation is surface water from Prairie Creek.

²All biosolids land application sites receiving biosolids will only receive supplemental fertilizer as required to meet and not exceed the agronomic rate for the site. Supplemental fertilizer generally consists of UAN 32 for nitrogen, a percentage of Thio-Sul for sulfur, and dry product fertilizer such as 10-40 or 11-52 for phosphate. The ratio and amount of supplemental fertilizer utilized is determined by residuals from soil tests, farmer experience, and agronomic rates for the crop.

Biosolids and Land Application Information

Pollutant Characteristics

Table 4 is a representative biosolids analysis for pollutant characteristics. Biosolids samples from the aerobic digester basins were collected on June 21, 2023. These data and all previous data indicate that pollutant concentrations for all regulated pollutants have been met. All test results are included in Appendix E.

TABLE 4
ALLOWED BIOSOLIDS POLLUTION LIMITS AND CONCENTRATIONS

Pollutant	Aerobic Digester Basins Biosolids Analytical Result mg/kg (lbs/ton)	40 CFR 503.13(b)(1) Pollutant Ceiling Concentration Limits mg/kg (lbs/ton)*
Arsenic (As)	ND	75 (0.15)
Cadmium (Cd)	ND	85 (0.17)
Copper (Cu)	167 (0.334)	4,300 (8.6)
Lead (Pb)	ND	840 (1.68)
Mercury (Hg)	ND	57 (0.114)
Molybdenum (Mo)	ND	75 (0.15)
Nickel (Ni)	ND	420 (0.84)
Selenium (Se)	ND	100 (0.2)
Zinc (Zn)	411 (0.822)	7,500 (15.0)

**Analytical results are on a dry weight basis.*

CFR = Code of Federal Regulations

lbs/ton = pounds per ton

mg/kg = milligrams per kilogram

ND = not detected

Nutrient Characteristics and Other Parameters

Table 5 is a representative biosolids analysis for nutrient characteristics and other parameters. Biosolids samples from the aerobic digester basins were collected on June 21, 2023. The nutrient characteristics shown on Table 5 were utilized in the example calculations for the application rate.

TABLE 5
BIOSOLIDS NUTRIENT CHARACTERISTICS

Source	Aerobic Digester Basins Biosolids Analytical Result		
	Wet Weight	Dry Weight	Pounds per Dry Ton
Total Solids, percent	0.764	N/A	N/A
Volatile Solids, percent	99.8	N/A	N/A
TKN, mg/kg	510.4	66,800	133.6
NO ₃ -N, mg/kg	ND	ND	ND
NH ₄ -N, mg/kg	33.8	4,430	8.86
Phosphate (P), percent	4.2	N/A	N/A

N/A = Not Applicable

NO₃-N = nitrate nitrogen

NH₄-N = ammonium nitrogen

TKN = total Kjeldahl nitrogen

Biosolids Application Rates

The application rate at the biosolids land application sites is determined by calculating the capacity of the biosolids land application sites for nutrients and the total allowable pollutants as determined by 40 CFR 503.13. The maximum allowable application rate is then determined by the total amount of biosolids that can be applied to the sites without exceeding the limits.

For the purposes of this document, example calculations were completed to illustrate how the biosolids application rate will be determined. The biosolids application rate for one of the City of Enterprise's sites was developed based on test results of the biosolids and guidance provided by Washington State University Puyallup and OSU and the *Worksheet for Calculating Biosolids Application Rates in Agriculture, a Pacific Northwest Extension Publication, PNW511*. The example calculations and assumptions made can be found in Appendix F, Example Nutrient Uptake Calculations. Barley was used for the example calculations for nitrogen uptake. It is assumed that barley will uptake 120 lbs N/acre. There are no published data for barley nitrogen uptake; however, per OSU's Cereal Grain Nutrient Management web page, the nitrogen uptake value for barley is 80 percent of the nitrogen uptake for winter wheat. Using the value stated for winter wheat of 150 lbs N/acre in the *Nitrogen Uptake and Utilization by Pacific Northwest Crops, a Pacific Northwest Extension Publication, PNW513*, 80 percent of the 150 lbs N/acre for winter wheat results in a 120 lbs N/acre application rate for barley (150 lbs N/acre x 80 percent = 120 lbs N/acre).

Soil testing was completed at the biosolids land application Site 1 - Parsnip Valley, shown on Figure 2, to estimate the residual nitrogen in the soil for the example calculations and provide a baseline for pollutants. The residual soil nitrogen was averaged, with the current, average residual soil nitrogen at the biosolids land application site equaling 89 lbs N/acre. The biosolids will be land-applied semi-annually during the spring and fall. Although the example calculations utilized the biosolids land application Site 1 - Parsnip Valley, shown on Figure 2, the biosolids may be land-applied to any of biosolids land application sites, totaling approximately 859 acres when accounting for setbacks, at the agronomic rate. See Figures 2 and 3 for the biosolids land application sites.

Plant available nitrogen (PAN) is calculated by adding the inorganic nitrogen retained and the organic nitrogen mineralized. Inorganic nitrogen retained is calculated by multiplying the weight of

ammonium nitrogen per dry ton of biosolids by the percent retained after application and adding the weight of nitrate nitrogen per dry ton. The percent retained is based on the drying method used and the days to incorporation after application. The biosolids will be dewatered and not incorporated and, therefore, will retain approximately 20 percent of the ammonium nitrogen. The plant available inorganic nitrogen is calculated to be 1.77 pounds of nitrogen per dry ton (lbs N/dry ton). The organic nitrogen mineralized is calculated by subtracting the ammonium nitrogen from the TKN and multiplying by the percent of organic nitrogen that is plant available in year one. The percent of organic nitrogen available in year one is approximately 35 percent, based on the biosolids processing and moisture content. The amount of organic nitrogen mineralized is calculated as 43.66 lbs N/dry ton. The PAN is calculated as 45.43 lbs N/dry ton. Taking the 120 lbs N/acre needed and subtracting the average residual nitrogen of 89 lbs N/acre determined by the soil testing results in 31 lbs N/acre remaining for barley uptake. The 31 lbs N/acre is divided by the estimated PAN to calculate an application rate of 0.68 dry ton per acre. A copy of the Example Nutrient Uptake Calculations for biosolids application at the biosolids land application site shown on Figure 2 with no incorporation is included in Appendix F.

The biosolids land application sites have approximately 859 total acres available for application when accounting for setbacks. In the case of the example calculations, the biosolids land application Site 1 - Parsnip Valley, shown on Figure 2, has approximately 129 acres, and if 0.68 dry ton of biosolids is land-applied to each acre of barley, a total of approximately 88 dry tons can be applied to the biosolids land application site. The total amount of biosolids available for application on an annual basis is approximately 613 cubic yards, or 77 dry tons at a total solids estimate of 14.86 percent. Based on the example calculations, the amount of land available is sufficient if barley is cultivated. However, the agronomic rate must be calculated for the crop being grown at the time of land application along with determining the residual nitrogen in the soil.

Sampling and Monitoring Program

In 2023, in preparation for the Biosolids Management Plan, biosolids were sampled and tested from the aerobic digester basins at the WWTF. The testing provided parameters for use in the example calculations for determining the applicable land application rate. Sampling and testing of biosolids will be performed in accordance with the sampling requirements outlined on Table 1 - Frequency of Monitoring - Land Application in 40 CFR 503.16 and the 1994 U.S. EPA Biosolids Reference Sheet, Table 2.4-1., Number of Samples Required. Soil testing will be performed before the application of biosolids to account for existing nitrogen in the soil and ensure the application rate does not exceed the agronomic rate.

Pathogen/Vector Attraction Reduction Characteristics

The Class B Pathogen Reduction requirements will be met utilizing Alternative 1, Fecal Coliform Testing, which finds the geometric mean of seven samples' fecal coliform density as listed in Appendix B of 40 CFR 503. The vector attraction reduction requirements of 40 CFR 503 will be met in accordance with Option 3, 40 CFR 503.33(b)(3), additional digestion of aerobically digested biosolids. For Option 3, aerobically digested biosolids with 2 percent or less solids are considered to have achieved vector attraction reduction if the volatile solids are reduced by less than 15 percent in a laboratory batch test at 20° Celsius after 30 days. If Option 3 is met, this shows the biosolids have already been substantially degraded biologically prior to aerobic digestion. As such, there is low likelihood of the biosolids being a food source for microorganisms, and it is unlikely for vectors to be

attracted to the biosolids. If the biosolids are unable to meet the requirements of Option 3, the biosolids will then follow Option 10 for vector attraction reduction and be incorporated into the soil within six hours after application to land or placement on the surface of the biosolids land application sites.

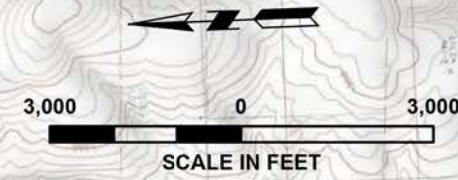
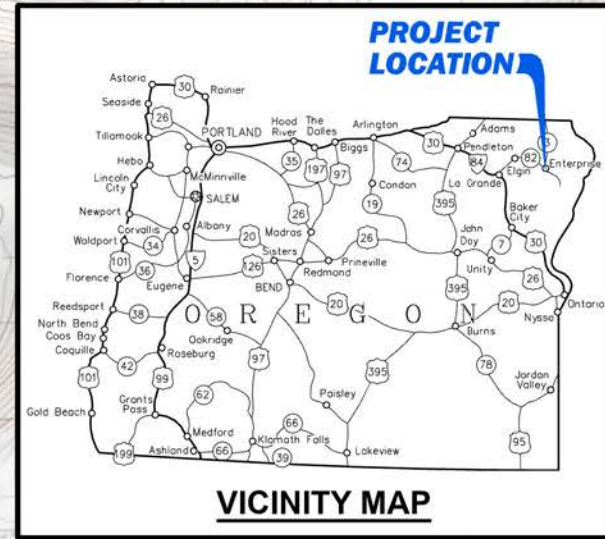
Prior to the City land-applying biosolids at the biosolids land application sites, verification that the biosolids meet compliance with pathogen reduction and vector attraction reduction requirements will be performed. The dewatered biosolids will be land applied using farming equipment (i.e., manure spreader) to evenly apply the biosolids to the surface of the biosolids land application sites at the recommended rate. The transporting and spreading of biosolids will be completed by the City.

Daily Reporting/Recordkeeping

When biosolids are applied to the biosolids land application sites, records will be kept indicating how and when the biosolids are moved and how the work is performed in accordance with the Biosolids Management Plan.

FIGURES

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To Clarkston

To Joseph



EXISTING WASTEWATER TREATMENT FACILITY

Enterprise

- LEGEND**
- CITY LIMITS
 - URBAN GROWTH BOUNDARY
 - BIOSOLIDS LAND APPLICATION SITE

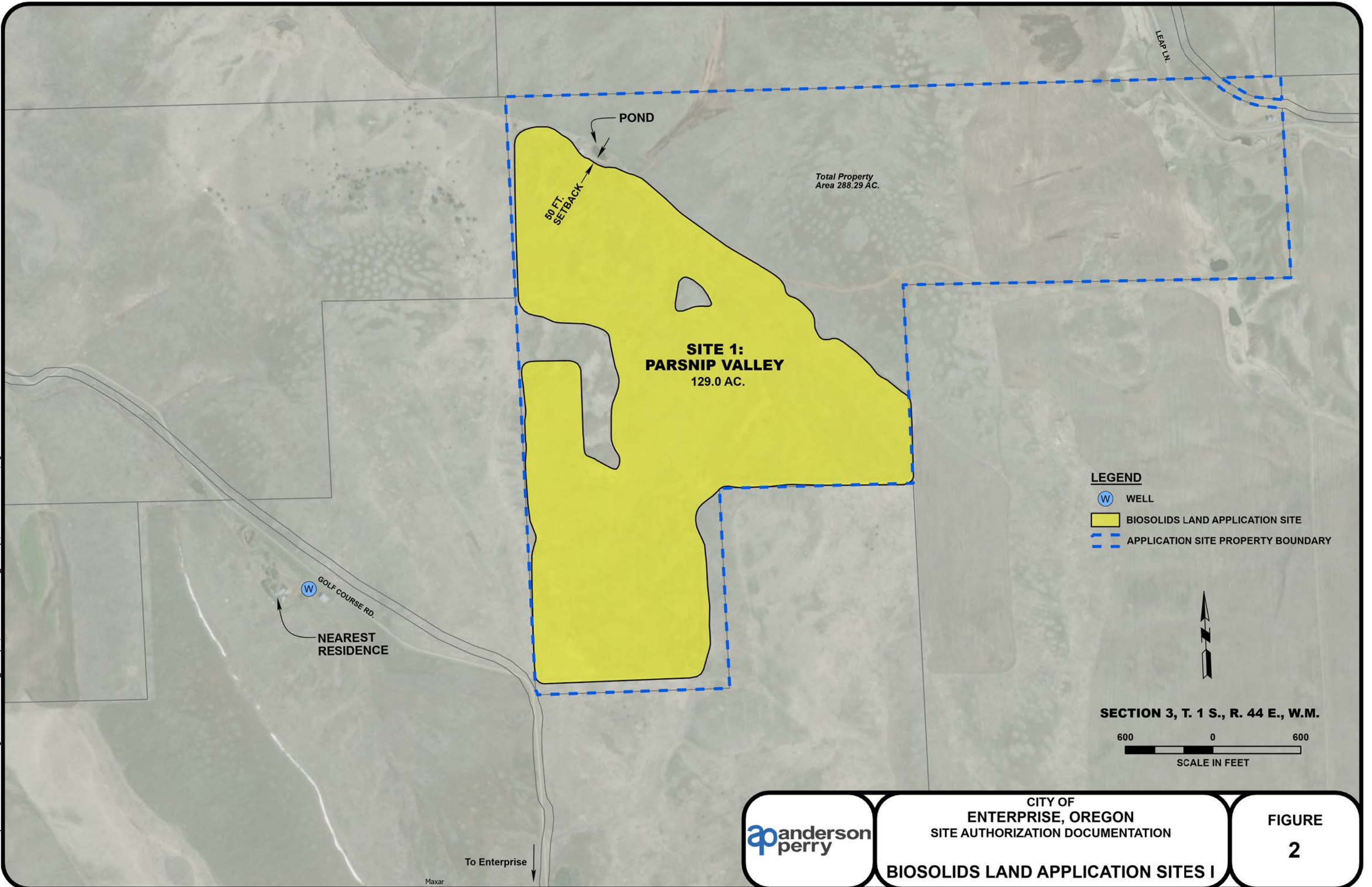
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CITY OF
ENTERPRISE, OREGON
SITE AUTHORIZATION DOCUMENTATION
LOCATION AND VICINITY MAPS

FIGURE
1

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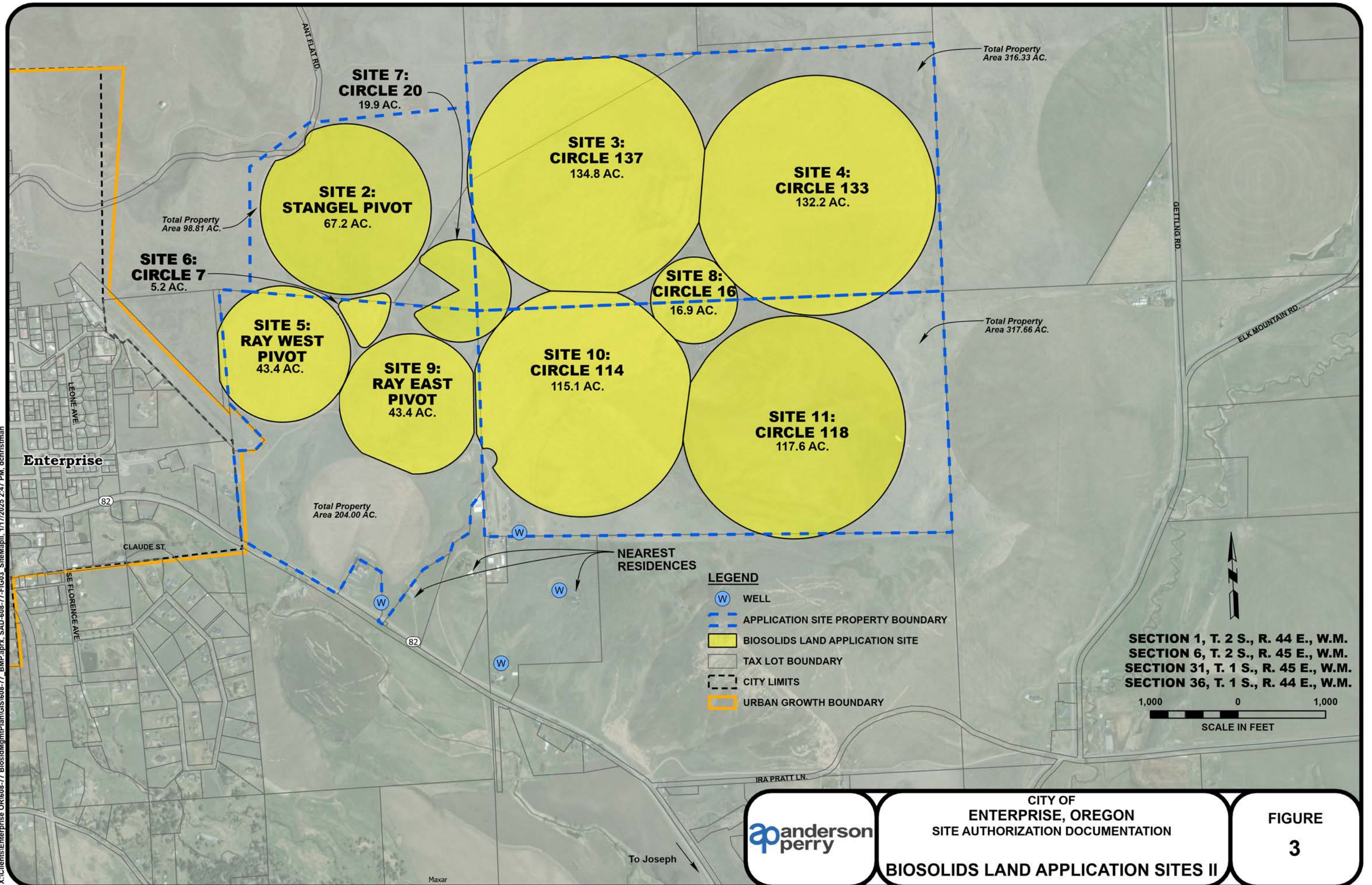


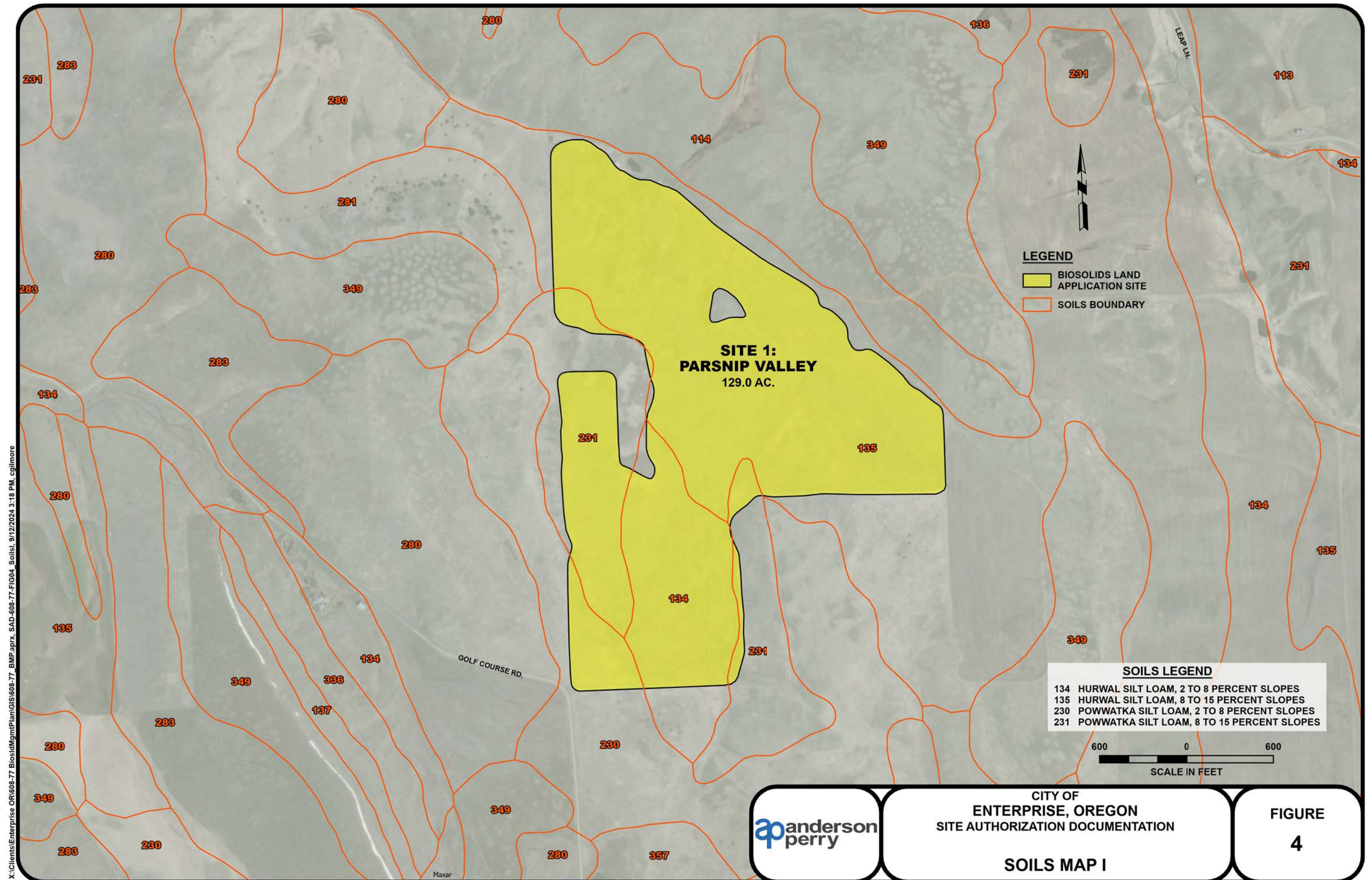
CITY OF ENTERPRISE, OREGON
SITE AUTHORIZATION DOCUMENTATION

BIOSOLIDS LAND APPLICATION SITES I

FIGURE 2

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APPENDIX A

Site Management Agreement

AGREEMENT FOR THE LAND APPLICATION OF DOMESTIC BIOSOLIDS

This Agreement is made and entered into this 10th day of December 2024, between the City of Enterprise, Oregon, hereafter referred to as the City, and Cornerstone Farms Joint Venture, hereinafter referred to as the Owner.

RECITALS

- A. The Owner owns real properties shown on Figure 1 - Subject Properties I; and Figure 2 - Subject Properties II.
- B. The City owns and operates a municipal wastewater treatment facility (WWTF) under National Pollutant Discharge Elimination System Permit No. 101659 and desires to land apply biosolids (as defined by 40 Code of Federal Regulations 503) generated by the WWTF on the subject properties.
- C. Land application of domestic biosolids is mutually beneficial to the City and the Owner.

AGREEMENT

The City and the Owner agree to fulfill the following:

- A. The City, through its agents, agrees to:
 - a. In coordination with the Owner, make available, haul, and spread stable biosolids on subject properties at an application rate approved by the Oregon Department of Environmental Quality (DEQ). The City's obligation is subject to the availability of the biosolids;
 - b. Pick rocks and any plastic material larger than 2 inches in diameter from the spread biosolids that are inconsistent with those present on the subject properties;
 - c. Maintain daily records during biosolids application that indicate the quantity of biosolids delivered to the subject properties, the specified area where the biosolids were applied on the subject properties, application data, means of application, and any additional information required by the DEQ;
 - d. Have its biosolids tested as required by state and federal law, make certain the biosolids meet minimum requirements for land application pursuant to state and federal law, and provide the Owner and the DEQ with copies of the test results, as well as notify the Owner immediately should the biosolids fail to meet minimum standards for land application;
 - e. Use only those ingress and egress routes to and from subject properties designated by the Owner;
 - f. Conform with all state biosolids rules and guidelines governing land application of municipal biosolids and any management terms stipulated under the biosolids land application authorization letter from the DEQ;
 - g. Notify the Owner of any DEQ directives the City receives pertaining to the items covered by this Agreement; and
 - h. Obtain written authorization from the DEQ to land apply biosolids to the subject property prior to commencing biosolids land application.

- B. The Owner agrees to:
- a. Define the areas of the subject properties available for land application of biosolids;
 - b. Irrigate in accordance with the DEQ-approved Biosolids Management Plan. Irrigation of affected fields will not resume following biosolids application until the fields are planted for production. Irrigation will be managed to prevent excessive ponding on or runoff from the subject properties.
 - c. Notify the City immediately of any odor complaint, or other complaints, received by the Owner relative to the land application of biosolids upon the subject properties;
 - d. Follow DEQ regulations relative to the types of crops planted and their management;
 - e. Annually provide the City with anticipated crop type, irrigation, grazing, cutting, and other crop management practices;
 - f. Indemnify and hold the City harmless from any and all claims, suits, or causes of action brought against the City as a result of negligent surface application on the subject properties. Owner shall not be required to indemnify the City for any claims, suits, or causes of action brought against the City arising from the content of the biosolids;
 - g. Comply with the following regulatory requirements:
 - i. Public contact access is restricted for 30 days after biosolids land application. Access control is assumed based on the remoteness of the rural private land.
 - ii. Food crops with harvested parts that touch the biosolids/soil mixture and are totally above the land surface shall not be harvested until 14 months after application of biosolids.
 - iii. Food crops with harvested parts below the surface of the land shall not be harvested until 38 months after biosolids application.
 - iv. Food crops, feed crops, and fiber crops whose edible parts do not touch the surface of the soil shall not be harvested until 30 days after biosolids application.
 - v. Animals shall not be allowed to graze until 30 days after application of biosolids to the land.
 - h. Advise all purchasers, tenants, lessees, or other persons or entities of interest to the subject properties of this Agreement.
- C. Owner acknowledges that biosolids may contain some plastic or other foreign materials normally present in domestic wastewater, and Owner accepts the biosolids "as is," except as noted in this Agreement, subparagraph A.b., above.
- D. The parties agree to begin using the subject properties to apply biosolids as soon as possible after receiving DEQ approval of the Agreement, and that the Agreement shall remain in effect for three years, unless it is terminated within that time pursuant to the terms of this Agreement.
- E. All notifications to the City and the Owner shall be in writing to all parties. Notice to the City shall be provided to Jeffrey Yanke, Council President, Enterprise City Hall, 102 E. North Street, Enterprise, Oregon 97828. Notice to the Owner shall be provided to Kurt Melville/Kevin Melville, 64022 Imnaha Highway, Joseph, Oregon 97846.
- F. This Agreement shall bind the parties hereto, and it is agreed that there are no other agreements, written or oral, which add to or change the terms hereof. Any such agreements of modification shall be expressed in writing, signed by all parties, dated, and attached to this Agreement.

COMPENSATION

In consideration of the above listed agreement, the City agrees to pay Owner \$2,250 for land application for the 2024-2025 fiscal year, with the payment due by April 15th, 2025. Beginning fiscal year 2025-2026, the City agrees to pay Owner an annual payment of \$4,500, with the payment due to the Owner no later than July 30th.

TERMINATION

Either party may terminate all or any portion of this agreement by giving the other party a 180-day written Notice of Termination.

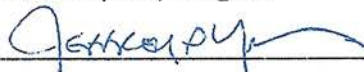
CONTINUATION OF AGREEMENT

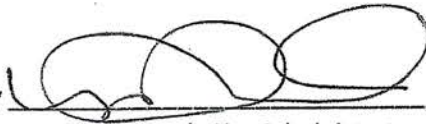
This agreement shall continue, absent Notice of Termination being provided, set forth with the terms of this agreement. Additionally, parties shall meet no later than March 31st each year.

EFFECTIVE

Effective on the date first above written.

City of Enterprise, Oregon:

By 
Jeffrey Yanke, Council President

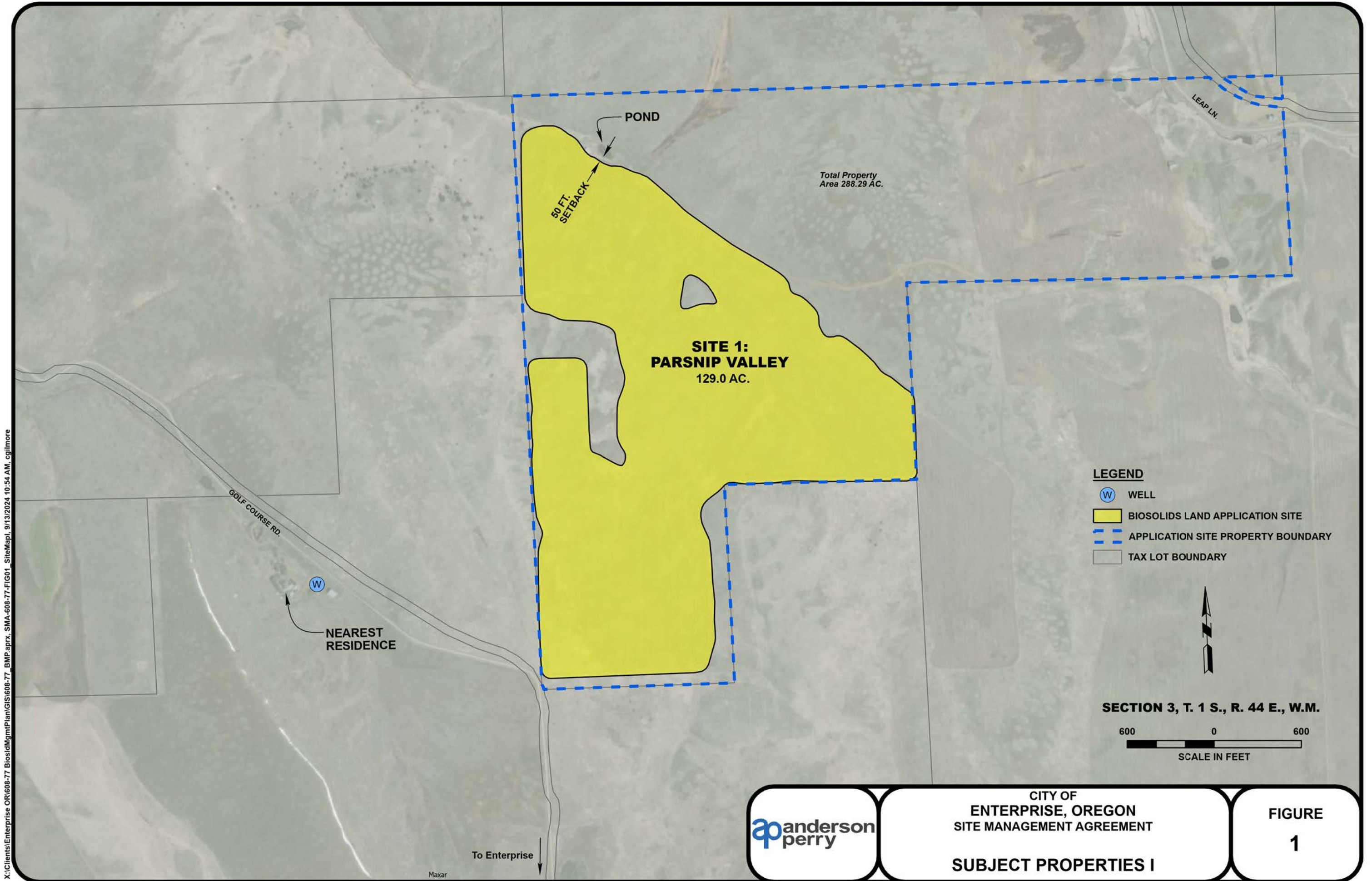
By 
Lacey McQuead, City Administrator

Owner:

By 
Kurt Melville
Cornerstone Farms Joint Venture

By 
Kevin Melville
Cornerstone Farms Joint Venture

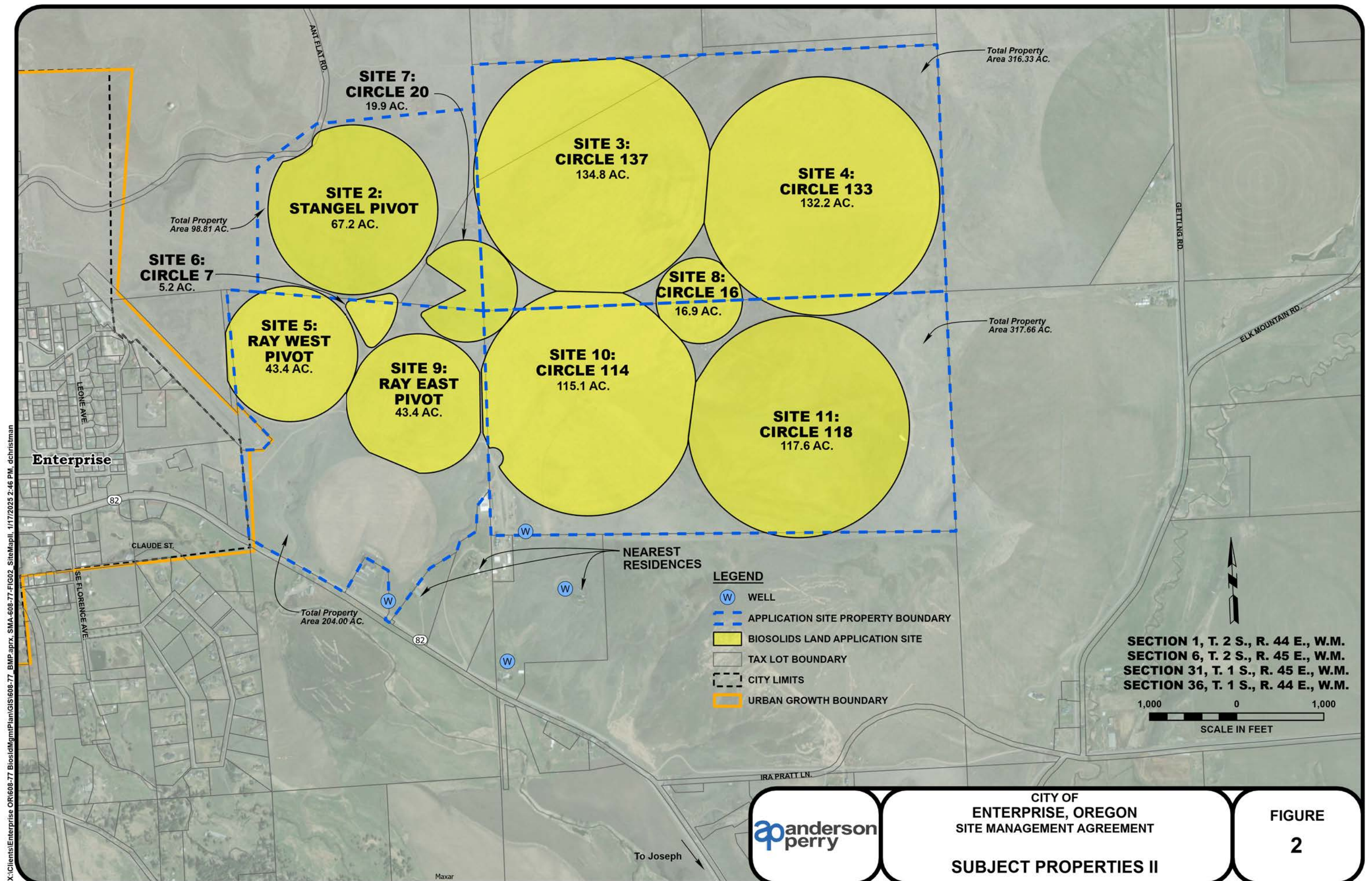
X:\Clients\Enterprise OR\608-77 BiosolidMgmtPlan\GIS\608-77 BMP.aprx, SMA-608-77-FIG01_SiteMap1. 9/13/2024 10:54 AM, cglimore



CITY OF
ENTERPRISE, OREGON
SITE MANAGEMENT AGREEMENT

SUBJECT PROPERTIES I

**FIGURE
1**



APPENDIX B

Public Notification Letters



102 E. North St.
Enterprise, OR 97828

(541) 426-4196
Fax: (541) 426-3395
www.enterpriseoregon.org

December 19, 2024

Diana Collins
65714 Getting Road
Enterprise, Oregon 97828

RE: Proposed Application of Biosolids as Fertilizer Amendment

The City of Enterprise, Oregon, has applied to the Oregon Department of Environmental Quality (DEQ) to land apply biosolids on properties near you. The properties to receive biosolids are located in Township 2 South, Range 45 East, Section 6. Please see the attached Figure 4 showing the proposed land application sites.

Biosolids are a byproduct of domestic wastewater treatment that contains valuable nutrients. Various processes stabilize the biosolids, kill harmful bacteria, and control odors. Treated biosolids are frequently used instead of chemical fertilizers, and because many of the nutrients in the biosolids are less mobile in the soil, they are absorbed by plants and are less likely to adversely affect water resources. Additionally, the biosolids improve soil tilth and water-holding capacity and provide micronutrients not found in most chemical fertilizers.

Biosolids reuse is regulated by the U.S. Environmental Protection Agency and the DEQ to protect public health and the environment. The DEQ will inspect each proposed property and approve it prior to application. As part of the approval, the DEQ establishes buffer zones from sensitive areas such as wells, streams, roadways, residences, etc.

The City has historically taken biosolids to the landfill; however, the City is now required to land apply the biosolids. Enclosed is a brochure on biosolids recycling and a DEQ Fact Sheet. If you have any questions regarding the City's biosolids program, please contact Dave Wilkie at 541-426-3093. You may also learn more about the DEQ biosolids program on their website at: <https://www.oregon.gov/deq/wq/programs/Pages/Biosolids.aspx>

If you are not the resident or occupant of the property adjacent to this site but are the owner, please notify anyone who resides at this property of this proposed activity.

Sincerely,

Lacey McQuead, City Administrator

LM/nc

Encl.



102 E. North St.
Enterprise, OR 97828

(541) 426-4196
Fax: (541) 426-3395
www.enterpriseoregon.org

December 19, 2024

Suzette Bonneau
P.O. Box 629
Wallowa, Oregon 97885

RE: Proposed Application of Biosolids as Fertilizer Amendment

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Sincerely,

Lacey McQuead, City Administrator

LM/nc

Encl.



102 E. North St.
Enterprise, OR 97828

(541) 426-4196
Fax: (541) 426-3395
www.enterpriseoregon.org

December 19, 2024

Jack and Deena Woods
63782 Eagle Road
Lostine, Oregon 97857

RE: Proposed Application of Biosolids as Fertilizer Amendment

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Sincerely,

Lacey McQuead, City Administrator

LM/nc

Encl.



102 E. North St.
Enterprise, OR 97828

(541) 426-4196
Fax: (541) 426-3395
www.enterpriseoregon.org

December 19, 2024

Nicholas and Alexandra West
105 West Logan Street
Enterprise, Oregon 97828

RE: Proposed Application of Biosolids as Fertilizer Amendment

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Sincerely,

Lacey McQuead, City Administrator

LM/nc

Encl.



102 E. North St.
Enterprise, OR 97828

(541) 426-4196
Fax: (541) 426-3395
www.enterpriseoregon.org

December 19, 2024

Melvin and Dena Stonebrink
80995 School Flat Lane
Wallowa, Oregon 97885

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Sincerely,

Lacey McQuead, City Administrator

LM/nc

Encl.



102 E. North St.
Enterprise, OR 97828

(541) 426-4196
Fax: (541) 426-3395
www.enterpriseoregon.org

December 19, 2024

Stangel Industries & Machine Shop
P.O. Box 157
Enterprise, Oregon 97828

RE: Proposed Application of Biosolids as Fertilizer Amendment

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Sincerely,

Lacey McQuead, City Administrator

LM/nc

Encl.



102 E. North St.
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December 19, 2024

Edward Snodderly
P.O. Box 447
Enterprise, Oregon 97828

RE: Proposed Application of Biosolids as Fertilizer Amendment

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Sincerely,

Lacey McQuead, City Administrator

LM/nc

Encl.



102 E. North St.
Enterprise, OR 97828

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December 19, 2024

IS 5510 Investments LLC
64022 Imnaha Highway
Joseph, Oregon 97846

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Sincerely,

Lacey McQuead, City Administrator

LM/nc

Encl.



102 E. North St.
Enterprise, OR 97828

(541) 426-4196
Fax: (541) 426-3395
www.enterpriseoregon.org

December 19, 2024

Bruce and Kathleen Hanna
541 N.E. Goldie Drive
Hillsboro, Oregon 97124

RE: Proposed Application of Biosolids as Fertilizer Amendment

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Sincerely,

Lacey McQuead, City Administrator

LM/nc

Encl.



102 E. North St.
Enterprise, OR 97828

(541) 426-4196
Fax: (541) 426-3395
www.enterpriseoregon.org

December 19, 2024

Timothy and Audry Melville
84887 Joseph Highway
Enterprise, Oregon 97828

RE: Proposed Application of Biosolids as Fertilizer Amendment

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Sincerely,

Lacey McQuead, City Administrator

LM/nc

Encl.



102 E. North St.
Enterprise, OR 97828

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December 19, 2024

Todd and Angela Nash
64541 Alder Slope Road
Enterprise, Oregon 97828

RE: Proposed Application of Biosolids as Fertilizer Amendment

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Sincerely,

Lacey McQuead, City Administrator

LM/nc

Encl.



102 E. North St.
Enterprise, OR 97828

(541) 426-4196
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December 19, 2024

Enterprise Christian Church
207 East Main Street
Enterprise, Oregon 97828

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Sincerely,

Lacey McQuead, City Administrator

LM/nc

Encl.

Fact Sheet

Biosolids: A Beneficial Resource

Background

Biosolids are the nutrient-rich organic solids that are derived from the treatment of domestic wastewater at municipal wastewater facilities. Once biosolids have been treated to meet state and federal regulations, they can be beneficially used for land application or, in some cases, sold or given away like compost.

Recognizing the value of biosolids

Since 1978, DEQ has addressed the need to effectively manage the beneficial use of biosolids. Oregon's policy supports the land application of treated domestic wastewater biosolids, biosolids-derived products and domestic septage when managed in a manner that protects public health and maintains or improves environmental quality.

What is regulated?

The land application of biosolids, biosolids-derived products and domestic septage is a highly regulated practice. Regulatory requirements are established under Oregon Administrative Rules chapter 340, division 50. The state rules incorporate most of the federal technical biosolids regulations, including requirements for pathogen reduction, vector attraction reduction, and limits for trace pollutants. Monitoring is also required for several nutrients.

How biosolids are used

Land applying biosolids can have several benefits. The organic matter in biosolids can improve the quality and overall characteristics of cultivated soil. The additional nutrients provided by biosolids can improve plant growth. Approximately 95% of biosolids generated in Oregon are land applied on DEQ-approved sites for agricultural purposes such as hay and pasture. In 2001, biosolids from 108 domestic wastewater treatment facilities were land applied on 18,618 acres, which is about 0.11% of all Oregon land in farms. Biosolids are also used for silvicultural and horticultural activities. DEQ works with wastewater treatment facilities to ensure that management of biosolids and land application activities are adequately addressed through a National Pollutant Discharge Elimination System (NPDES) or Water Pollution Control Facility (WPCF) permit, a biosolids management plan, and site authorization letters. Good agronomic practices and site management activities ensure the protection of public health and the environment.



Land application of biosolids at an Oregon farm.

Biosolids Management Plans

Facilities are required to manage and operate their biosolids operations under a biosolids management plan. These plans are specific to each facility and are considered an extension of the facility's NPDES or WPCF permit. Together with a facility's permit and land application site authorizations, the plan provides assurance that biosolids processing and management activities are addressed in a comprehensive manner and problems with compliance are minimized. Plans must be current and on file with the permit. Each site used for land application of biosolids must be authorized by DEQ before use. Prior to authorizing a land application site, a facility must submit specific site information to DEQ for evaluation, and then DEQ will conduct a field visit. Notification to neighbors about the land application activity is also required. Any site that may be sensitive to residential housing or have runoff potential will be subject to a public comment process.

State rules also outline best management practices regarding use limitations, criteria for site selection and approval, and application.

For more information

For program information, please contact the program coordinator. For specific wastewater treatment facility and land application site information, please contact the appropriate regional specialist (list at right).

Alternative formats

Documents can be provided upon request in an alternate format for individuals with disabilities or in a language other than English for people with limited English skills. To request a document in another format or language, call DEQ in Portland at 503-229-5696, or toll-free in Oregon at 1-800-452-4011, ext. 5696; or email deqinfo@deq.state.or.us.



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Frequently Asked Questions

What are biosolids?

Biosolids are the nutrient-rich organic by-product of domestic wastewater treatment. They contain essential plant nutrients and organic matter, and can be recycled and applied as a fertilizer and soil amendment, when properly treated and managed.

What is the difference between biosolids and sludge?

The term “sludge” describes the untreated solids produced in the domestic wastewater treatment process. To make biosolids, sewage sludge is treated through carefully regulated processes (biological, chemical or physical) to kill pathogens and stabilize organic matter. This reduces offensive odors and its appeal to insects and rodents. The material only becomes biosolids once it meets federal and state standards so that it can be safely used for beneficial land application.

Why does the EPA and DEQ consider biosolids safe for land application?

Biosolids have been widely used on farms and other natural resource sites across North America for decades. Sixty percent of U.S. biosolids are applied to soils, enhancing soil health, recycling nutrients, sequestering carbon, and providing a productive use for a material that every community has to manage. (Wastewater treatment is a vital public service, and it creates solids that have to be managed.) Portland, Seattle, Los Angeles, Denver, Chicago, Boston, and hundreds of other communities recycle their biosolids to soils. Most major land grant universities have studied biosolids effects on soils and have found little risk when used according to regulations. Every U.S. state and Canadian province allows biosolids use on soils. The U.S. Environmental Protection Agency, U.S. Department of Agriculture and U.S. Food and Drug Administration all approve biosolids recycling. Thousands of research publications over 45 years and two major reviews by the National Academy of Sciences have found biosolids use on soils presents “negligible risk” when managed in accordance with federal regulations and that “there is no documented scientific evidence that the Part 503 rule (the federal biosolids regulations) has failed to protect public health.”

What are the benefits of land application of biosolids?

Land application is a cost-effective and sustainable option for managing biosolids. The Oregon Environmental Quality Commission encourages the land application of biosolids when managed in a manner which protects the public health and maintains or improves environmental quality. The Oregon Department of Environmental Quality implements this policy across the state.

Plants need a complex mixture of nutrients, soil, air and water to grow well. Biosolids enrich the soil with essential nutrients and organic matter. Biosolids typically contain about 50 percent organic matter, which improves soil tilth, allows the soil to drain and breathe better, and hold more water. This results in decreased water runoff and soil erosion, with increased water conservation. These attributes may help a farmer comply with agricultural conservation practices. Research plots and demonstration sites have shown that the quality of crops grown on biosolids-amended soils is equal or superior to those grown with commercial fertilizers.

How are biosolids regulated in Oregon?

The land application of biosolids, biosolids-derived products and domestic septage is regulated under the DEQ regulations found in Oregon Administrative Rules Chapter 340, Division 50. The state rules incorporate most of the federal biosolids regulations (Chapter 40 Code of Federal Regulations Part 503), including requirements that reduce pathogens, stabilize organic matter, and limit trace elements including arsenic, cadmium, copper, lead, mercury, molybdenum, nickel, selenium, and zinc.



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Biosolids

In Oregon, monitoring is also required for several macronutrients, including potassium, nitrogen, and phosphorus. DEQ is responsible for permitting land application sites for Class B biosolids in Oregon to protect public health and the environment. For each site where biosolids are applied, DEQ issues a site authorization to the wastewater treatment facility that prescribes appropriate management practices for the site, which account for:

- Site characteristics and soil conditions
- Protection of ground and surface water and wells
- Biosolids chemical properties
- Type of biosolids (liquid, semi-solid, or solid)
- Method of biosolids application

Among other things, the site authorization establishes conditions on:

- Allowable biosolids application rate, season of application
- Public access restrictions
- Required waiting periods between biosolids application and crop harvest or grazing
- Required buffers near homes, highways, and other public areas

What risks do trace metals pose?

EPA thoroughly studied the potential risks from trace metals in biosolids and set maximum levels in biosolids to ensure protection of public health and the environment. To date, studies indicate that properly treated and managed biosolids can be land applied in an environmentally sound manner. Based on the 2017 analytical results, the concentrations of these trace metals found in biosolids produced in Oregon are well below the maximum levels identified by EPA.

Many of the regulated metals in biosolids are beneficial and necessary for healthy plant growth in correct amounts, such as copper, molybdenum, and zinc which are micronutrients for plants. The presence of these micronutrients is one reason why biosolids can be more effective than mineral fertilizers at promoting plant growth.

What about organic compounds in biosolids?

Many chemicals used in society can be found in trace amounts in wastewater. The fact is few chemicals of concern are found in biosolids. An EPA 2009 *Targeted National Sewage Sludge Survey*¹ investigated levels of several trace organic compounds in solids collected from 74 wastewater treatment plants nationally. The EPA study found some analytes were present in all samples, while others were present in none or only a few samples. EPA continues to review hazard and exposure assessments for these pollutants as data and analytical methods improve.

What about pharmaceuticals in biosolids?

Pharmaceuticals such as antibiotics, prescription drugs and personal care products, like soaps, shampoos, detergents, and perfumes contain a wide variety of chemicals. The effect of these chemicals on the environment is the focus of considerable research. Although leading scientists see little threat to the public health and the environment from these chemicals associated with biosolids, EPA is currently developing better sampling and analytical procedures for these chemicals. Once improved sampling and analytical methods are in place, EPA plans to conduct exposure and hazard assessments for these pollutants. This study will take into account toxicity data for humans and ecological receptors, solids pollutant concentrations, and the fate and transport of these chemical compounds.

The best way to reduce concentrations of pharmaceuticals in biosolids is by never flushing unwanted drugs down the toilet, and to support effective drug take back programs. Purchase soaps and cleaners that are manufactured with the environment in mind - such as those that are recognized in EPA's *Safer Choice Program*².



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¹Samples collected in 2006 & 2007 - see <https://nepis.epa.gov/Exe/ZyPDF.cgi/P1003RNO.PDF?Dockey=P1003RNO.PDF>

² See <https://www.epa.gov/saferchoice>

Biosolids

What about Per- and Polyfluoroalkyl substances (PFAS) in biosolids?

Perfluorooctanoic acid and perfluorooctane sulfonate have had considerable public attention in recent years, especially in New England. Concerns here in Oregon have focused on impacts near industrial facilities that used these chemicals specifically airports with foam firefighting systems. These chemicals are found in carpets, furniture, household dust and air, cooking tools, outdoor clothing, fire-fighting foams, and other products. Because these chemicals are ubiquitous in today's society and the environment there is ongoing uncertainty about their actual affects. These chemical are being phased out of use here in the U.S and Canada; as a result wastewater treatment facilities are seeing decreasing concentrations in their systems. In the 2000s perfluorooctanoic acid was found in the typical biosolids at an average concentration of 34 parts per billion (ppb) and more recent studies have found average perfluorooctanoic acid concentrations of 2.3 and 5.3 ppb in the biosolids. Research and risk assessments conducted in New England have determined that direct contact, inhalation, or ingestion of materials containing less than 500 parts per billion of perfluorooctanoic acid pose no significant risk.³ Thus, biosolids and residuals present negligible risk via these pathways.

Does the land application of biosolids pollute surface water or groundwater?

Properly managed biosolids products do not pollute surface water or groundwater. Biosolids recycling programs follow best management practices to ensure water quality is protected. In fact, documented improvements in surrounding water quality have been found in numerous biosolids application projects due to enriched soils and vigorous growth of vegetation that reduce soil erosion and stabilize contaminants that had previously contributed to stream and groundwater pollution. Biosolids are not allowed to runoff into surface water, including rivers, streams, irrigation ditches, or ponds; and, biosolids application rates and site management practices are designed to prevent the leaching of nutrients to groundwater

Are biosolids tested before land application?

Biosolids are tested by the generating facility before they are land applied. The required minimum frequency of this sampling is based on the volume of biosolids produced by the facility each year as summarized in the table below.

Dry weight – metric tons/year	Sampling Frequency
0 – < 290	Annually
>290 - <1,500	Quarterly
≥1,500 - <15,000	Bimonthly
≥15,000	Monthly

Is the soil tested at land application sites?

Facilities test the soil at land application sites to calculate the agronomic rate for that field. Facilities are required to collect soil samples at a minimum if they land apply biosolids at the agronomic rate for more than two out of three successive years. Additional or more frequent testing may be required in their biosolids management plan or site authorization letter.

What notification or signage are required for authorized sites?

There are no federal regulations requiring notification or signage for authorized biosolids sites. Oregon state regulations requires notification prior to approval of any proposed site that maybe sensitive to residential housing, runoff or groundwater. DEQ policy requests signs to be posted at the field and land application notices sent out to adjacent property owners when a facility is asking DEQ for approval to land apply on a given field. Once DEQ has approved a field with a site authorization letter, the permittee must follow the requirements established in their biosolids



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³ See <https://www.nebiosolids.org/>

Biosolids

management plan and site authorization letters which can require signs to be posted at the field at the start of land application and during land application activities. If a facility is required to post signs, most of them remove the signs after land application activities are completed so the signs do not interfere with the farming activities or get knocked down and become roadside litter.

What are biosolids agronomic rates?

The agronomic loading rate is based on a crop's ability to use nitrogen and considers the plant-available nitrogen content of the biosolids and other nitrogen sources at the site. Biosolids application at agronomic rates supplies adequate nitrogen to facilitate crop growth while protecting water quality.

For Further Information:

Oregon Department of Environmental Quality:

<https://www.oregon.gov/deq/wq/programs/Pages/Biosolids.aspx>

United States Environmental Protection Agency:

<https://www.epa.gov/biosolids>

Oregon State University:

<http://cropandsoil.oregonstate.edu/>

Washington State University:

<https://puyallup.wsu.edu/soils/biosolids/>

University of Idaho:

<https://www.uidaho.edu/extension>

University of Arizona, College of Agriculture and Life Sciences:

<http://cals.arizona.edu/pubs/consumer/az1426.pdf>

Oregon Association of Clean Water Agencies

<http://www.oracwa.org/c-biosolids.html>

Northwest Biosolids Management Association:

<http://www.nwbiosolids.org>

National Biosolids Partnership:

<http://www.biosolids.org/>

North East Biosolids and Residuals Association:

<http://www.nebiosolids.org/>

Alternative formats

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APPENDIX C

Soil Survey

Established Series
Rev. HRG/RJE/KWH
06/2006

HARLOW SERIES

The Harlow series consists of shallow, well drained soils formed in loess and colluvium from basalt or argillite. Harlow soils are on canyons, structural benches, and basalt plateaus. Slopes are 2 to 90 percent. The average annual precipitation is about 26 inches and average annual temperature is about 43 degrees F.

TAXONOMIC CLASS: Clayey-skeletal, smectitic, frigid Lithic Argixerolls

TYPICAL PEDON: Harlow very stony clay loam- rangeland on a 55 percent southwest facing slope at an elevation of 4,320 feet. (Colors are for dry soils unless otherwise noted.)

A1--0 to 3 inches; dark grayish brown (10YR 4/2) very stony clay loam, very dark brown (10YR 2/2) moist; moderate fine and medium granular structure; hard, firm, moderately sticky and moderately plastic; many very fine roots; many very fine irregular pores; 30 percent gravel, 10 percent cobbles, and 5 percent stones; neutral (pH 6.7); clear wavy boundary.

A2--3 to 6 inches; dark grayish brown (10YR 4/2) very gravelly clay loam, very dark brown (10YR 2/2) moist; moderate fine and medium granular structure; hard, firm, moderately sticky and moderately plastic; many very fine roots; many irregular pores; 30 percent gravel and 10 percent cobbles; neutral (pH 7.0); clear wavy boundary. (Combined thickness of the A horizon is 4 to 8 inches)

Bt1--6 to 10 inches; brown (10YR 5/3) very cobbly clay loam, very dark grayish brown (10YR 3/2) moist; moderate fine and medium subangular blocky structure; hard, firm, moderately sticky and moderately plastic; many very fine and few medium roots; common very fine irregular pores; continuous faint stress cutans on faces of peds; 30 percent gravel and 25 percent cobbles; neutral (pH 7.0); clear wavy boundary.

Bt2--10 to 14 inches; brown (10YR 4/3) extremely cobbly clay, dark brown (10YR 3/3) moist; moderate fine and medium subangular blocky structure; very hard, firm, very sticky and very plastic; common very fine and few medium roots; common very fine irregular pores; continuous distinct stress cutans on faces of peds and few clay films in pores; 30 percent gravel and 35 percent cobbles; neutral (pH 7.2); abrupt irregular boundary. (Combined thickness of the Bt horizon is 6 to 12 inches)

R--14 inches; basalt

TYPE LOCATION: Asotin County, Washington; about 9 miles southeast of Anatone; 1,400 feet north and 2,400 feet west of southeast corner of sec. 12, T. 6 N., R. 46 E.

RANGE IN CHARACTERISTICS: Thickness of solum and depth to a lithic contact is 10 to 20 inches. The average annual soil temperature at lithic contact is about 45 degrees F. These soils are usually moist, but are dry in all parts between 4 and 12 inches for 60 to 75 consecutive days during summer and fall. The particle-size control section averages 45 to 75 percent angular basalt fragments by volume and is 35 to 50 percent clay in the fine earth fraction. The mollic epipedon is 10 to 20 inches thick and includes all of the argillic horizon.

The A1 horizon has hue of 7.5YR or 10YR, value of 3 or 4 dry, 2 or 3 moist, and chroma of 2 or 3 dry and 1 through 3 moist. It is loam, silt loam or clay loam with 18 to 35 percent clay. It has 0 to 15 percent stones, 0 to 25 percent cobbles, and 0 to 30 percent gravel.

The A2 horizon is clay loam with 27 to 35 percent clay. It has 0 to 5 percent stones, 10 to 25 percent cobbles, and 25 to 45 percent gravel.

The Bt horizon has hue of 5YR, 7.5YR or 10YR, value of 3 through 5 dry, 2 or 3 moist, and chroma of 2 or 3 dry or moist. It is clay loam or clay with 35 to 50 percent clay. It has 0 to 5 percent stones, 15 to 40 percent cobbles, and 30 to 45 percent gravel.

COMPETING SERIES: These are the [Ateron](#), [Camool](#) (T), [Canest](#)(T), [Chen](#), [Doughide](#), [Graley](#), [Itca](#), [Vennob](#) and [Wallsburg](#). Ateron soils have a mollic epipedon that does not include the argillic horizon. Canest soils are 5 to 10 inches deep to a lithic contact. Chen, Doughide, and Graley soils have aridic moisture regimes bordering on xeric. Itca soils are not mollic in the lower part of the Bt horizon and have prismatic structure. Wallsburg soils lack basalt fragments and have more than 50 percent sandstone, shale and limestone fragments in the particle-size control section. Camool soils have a surface layer 5 to 9 inches thick that meets Vitrandic subgroup criteria. Vennob soils have a mollic epipedon 7 to 10 inches thick.

GEOGRAPHIC SETTING: Harlow soils are on canyons, structural benches, and basalt plateaus. Slopes are 2 to 90 percent. These soils formed in loess and colluvium and slope alluvium from basalt or argillite. Elevation ranges from 2,800 to 6,200 feet. Summers are warm and dry and winters are cool and moist. The average annual precipitation is 13 to 40 inches. Average annual temperature is 42 to 45 degrees F. Frost-free season is 50 to 115 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the [Getaway](#), [Klicker](#), [Snell](#), [Sweitberg](#) and [Sweiting](#) soils. Getaway, Snell and Sweiting soils are on canyon walls. Klicker and Sweitberg soils are on plateaus. All of these soils are more than 20 inches deep to a lithic contact.

DRAINAGE AND PERMEABILITY: Well drained; slow to rapid runoff. Slow permeability.

USE AND VEGETATION: Used for livestock grazing and wildlife habitat. Native vegetation is mainly bluebunch wheatgrass and Idaho fescue.

DISTRIBUTION AND EXTENT: Southeastern Washington and northeastern Oregon; MLRA 9 and 43.. The series is of moderate extent.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Portland, Oregon

SERIES ESTABLISHED: Asotin County, Washington, 1982.

REMARKS: Diagnostic horizons and features recognized in this pedon are:

mollic epipedon - from the surface to 14 inches

argillic horizon - from 6 to 14 inches

lithic contact - at 14 inches.

Established Series
Rev. SCW/WEL/RWL
08/2001

HURWAL SERIES

The Hurwal series consists of deep and very deep, well drained soils formed in loess with an influence of volcanic ash in the surface. They are on hills and mountains. Slopes are 2 to 60 percent. The mean annual precipitation is about 18 inches and the mean annual temperature is about 44 degrees F.

TAXONOMIC CLASS: Fine-silty, mixed, superactive, frigid Vitrandic Argixerolls

TYPICAL PEDON: Hurwal ashy silt loam - cultivated, on a 22 percent north facing slope at an elevation of 3860 feet. (Colors are for moist soils unless otherwise noted.)

Ap--0 to 12 inches; black (10YR 2/1) ashy silt loam, dark gray (10YR 4/1) dry; weak very fine granular structure; slightly hard, friable, slightly sticky and slightly plastic; common fine roots; common irregular pores; slightly acid (pH 6.3); clear wavy boundary. (7 to 12 inches thick)

A--12 to 18 inches; very dark grayish brown (10YR 3/2) ashy silt loam, dark grayish brown (10YR 4/2) dry; weak coarse subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; common fine roots; many very fine tubular pores; many black krotovinas; neutral (pH 6.6); clear wavy boundary. (5 to 8 inches thick)

BA--18 to 27 inches; dark brown (10YR 3/3) silty clay loam, brown (10YR 4/3) dry; weak medium subangular blocky structure; slightly hard, friable, sticky and plastic; common fine roots; many very fine tubular pores; few clean, bleached coarse silt and very fine sand coatings on ped faces; many krotovinas; neutral (pH 6.7); clear wavy boundary. (0 to 12 inches thick)

Bt1--27 to 36 inches; dark yellowish brown (10YR 3/4) silty clay loam, brown (10YR 4/3) dry; moderate coarse prismatic structure parting to weak fine subangular blocky; hard, friable, sticky and plastic; common fine roots; many very fine tubular pores; common faint clay films on faces of prisms; common clean bleached coarse silt and very fine sand coatings mainly on prisms; many krotovinas; neutral (pH 6.7); clear wavy boundary.

Bt2--36 to 56 inches; dark yellowish brown (10YR 4/4) silty clay loam, yellowish brown (10YR 5/4) dry; weak coarse prismatic structure parting to moderate fine subangular blocky; hard, firm, sticky and plastic; common fine roots; many very fine tubular pores; many faint clay films on faces of prisms; common clean, bleached coarse silt and very fine sand coatings mainly on prisms; many krotovinas; neutral (pH 7.2); clear wavy boundary. (Combined thickness of the Bt horizon is 16 to 36 inches)

BC--56 to 58 inches; dark yellowish brown (10YR 4/4) silt loam, yellowish brown (10YR 5/4) dry; weak fine subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; few roots; many very fine tubular pores; common clean bleached coarse silt and very fine sand coatings on peds; 10 percent gravel; many krotovinas; slightly calcareous in places; moderately alkaline (pH 8.0); abrupt wavy boundary. (0 to 12 inches thick)

2R--58 inches; basalt.

TYPE LOCATION: Wallowa County, Oregon; about 5 miles east of Wallowa; 800 feet north and 300 feet west of the southeast corner of section 10, T. 1 N., R. 43 E.; USGS Evans topographic quadrangle (Latitude 45 degrees, 34 minutes, 38 seconds N, Longitude 117 degrees, 25 minutes, 04 seconds W)

RANGE IN CHARACTERISTICS: The soils are usually moist but are dry for 60 to 90 consecutive days following the summer solstice. The mean annual soil temperature is 44 to 47 degrees F. The solum is 40 inches or more thick. Depth to basalt bedrock is 40 to 60 inches or more. The mollic epipedon is 20 to 30 inches thick. The control section has more than 18 percent clay and less than 15 percent coarser than very fine sand.

The A horizon has value of 2 or 3 moist, 4 or 5 dry, and chroma of 1 or 2 moist and dry. It is ashy silt loam with 18 to 27 percent clay. It has 0 to 5 percent gravel, 20 to 30 percent volcanic glass and glass coated aggregate, and more than 0.4 percent acid oxalate extractable aluminum plus one-half iron. The soil reaction is slightly acid or neutral.

The Bt horizon has value of 3 or 4 moist, 4 or 5 dry, and chroma of 3 or 4 dry. It is silty clay loam or silt loam with 20 to 35 percent clay. It has 0 to 5 percent gravel. Krotovinas 2 to 8 inches in diameter are common in most profiles. The soil reaction is neutral or slightly alkaline.

The BC horizon, when present, has value of 3 or 4 moist, 5 or 6 dry and chroma of 3 or 4 moist and dry. It is silt loam or loam with 0 to 15 percent gravel and 0 to 10 percent cobbles. The soil reaction is neutral to moderately alkaline. Secondary lime occurs in some pedons. It has 0 to 5 percent CaCO₃ equivalent.

COMPETING SERIES: This is the [Powwatka](#) series. Powwatka soils are 20 to 40 inches to bedrock and have a mollic epipedon 12 to 20 inches thick.

GEOGRAPHIC SETTING: Hurwal soils are on hills and mountains. They formed in loess with an influence of volcanic ash in the surface horizons. Slope is 2 to 60 percent. Elevation is 2500 to 5900 feet. The mean annual precipitation is 13 to 24 inches. The mean annual temperature is 42 to 45 degrees F. The frost-free period is 70 to 100 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the [Harlow](#), [Parsnip](#), competing [Powwatka](#), [Snell](#), [Wallowa](#), and [Zumwalt](#) soils. Harlow soils are clayey-skeletal, shallow, and are on adjacent south slopes. Parsnip soils are 10 to 20 inches to bedrock, have a mollic epipedon 7 to 15 inches thick, and are on adjacent plateaus. Snell soils are 20 to 40 inches to bedrock, clayey-skeletal, and are on north-facing side slopes. Wallowa soils are fine-loamy, lack argillic horizons, and are the moderately deep component of patterned ground. Zumwalt soils have a fine textured control section and are on adjacent hill slopes.

DRAINAGE AND PERMEABILITY: Well drained; moderately slow permeability.

USE AND VEGETATION: These soils are used mainly for dry cropland, grain, hay and pasture, and livestock grazing. Potential native vegetation is Idaho fescue and bluebunch wheatgrass with chokecherry and snowberry on north slopes, and basin wildrye on toe slopes and swales.

DISTRIBUTION AND EXTENT: Northeastern Oregon, MLRA 9; and eastern Idaho, MLRA 13. The series is not extensive.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Portland, Oregon

SERIES ESTABLISHED: Wallowa County Area, Oregon, 1998.

REMARKS: Diagnostic horizons and features recognized in this pedon are:

Pachic epipedon - the zone from the soil surface to a depth of 27 inches (Ap, A, and BA horizons).

Vitrandic feature - the zone from the soil surface to a depth of 18 inches (Ap and A horizons) based on lab data from similar soils.

Argillic horizon - the zone from 27 to 56 inches (Bt1 and Bt2 horizons).

Particle-size control section - from 27 to 47 inches (Bt1 and upper Bt2 horizons).

ADDITIONAL DATA: Characterization data on three profiles (S64-Oreg-32-2,3,7) reported in Riverside Soil Survey Laboratory Report for soils from Wallowa County, Oregon, July 1966.

National Cooperative Soil Survey
U.S.A.



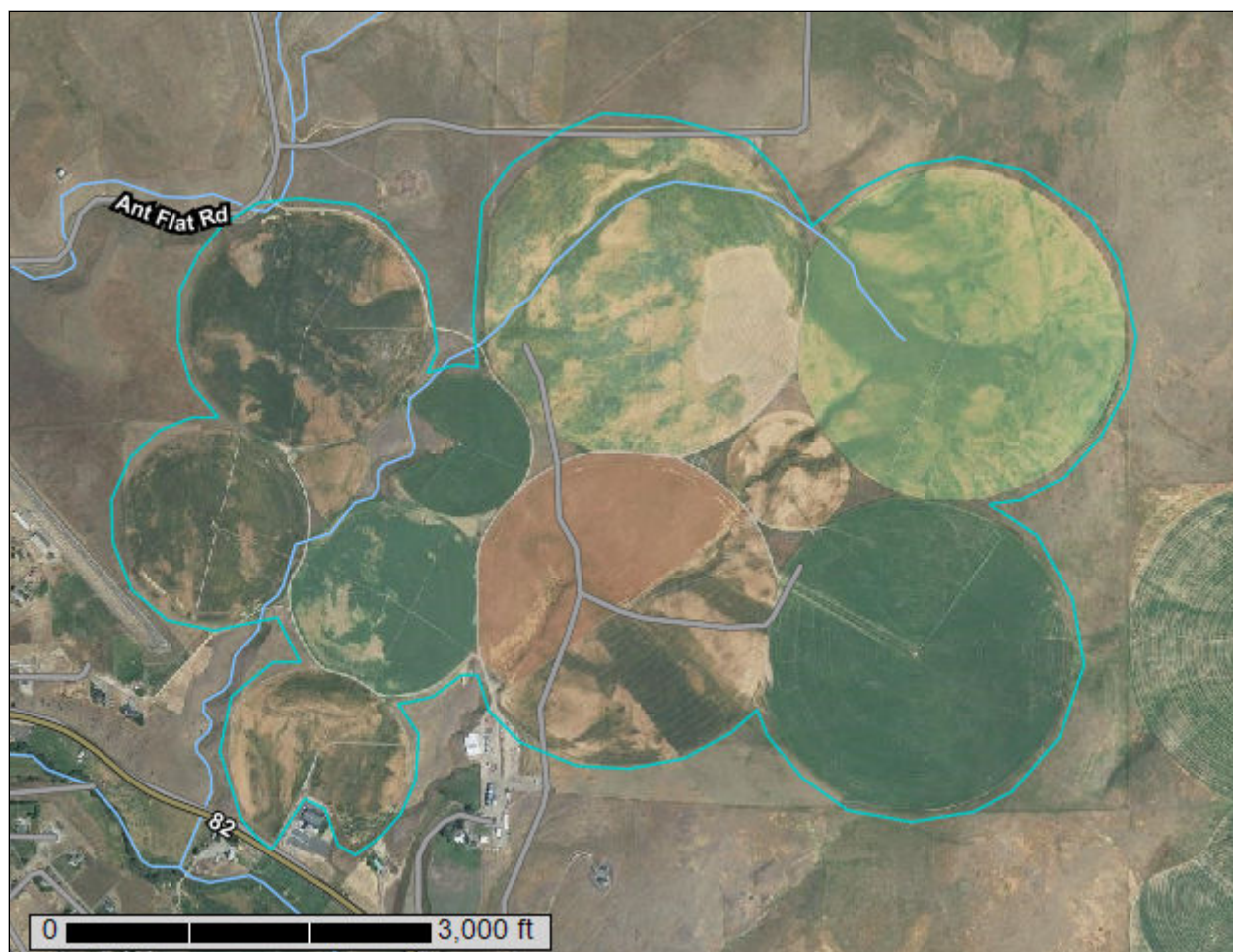
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Federal agencies, State
agencies including the
Agricultural Experiment
Stations, and local
participants

Custom Soil Resource Report for **Wallowa County Area, Oregon**



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.

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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

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identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

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

Map Scale: 1:15,700 if printed on A landscape (11" x 8.5") sheet.

0 200 400 800 1200 Meters

0 500 1000 2000 3000 Feet

Map projection: Web Mercator Corner coordinates: WGS84 Edge ticks: UTM Zone 11N WGS84

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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.

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: Wallowa County Area, Oregon

Survey Area Data: Version 26, Sep 11, 2023

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

Date(s) aerial images were photographed: Aug 4, 2020—Aug 14, 2020

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

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
82	Freels silt loam, 0 to 3 percent slopes	1.7	0.2%
113	Harlow-Bocker complex, 2 to 15 percent slopes	1.7	0.2%
114	Harlow-Bocker complex, 15 to 30 percent south slopes	31.5	3.8%
135	Hurwal silt loam, 8 to 15 percent slopes	20.7	2.5%
181	Laufer-Thiessen complex, 30 to 60 percent south slopes	3.1	0.4%
230	Powwatka silt loam, 2 to 8 percent slopes	100.3	12.1%
231	Powwatka silt loam, 8 to 15 percent slopes	47.6	5.7%
233	Powwatka silt loam, 15 to 30 percent south slopes	1.5	0.2%
281	Snell-Harlow complex, 15 to 30 percent north slopes	5.5	0.7%
283	Snell-Harlow complex, 15 to 30 percent south slopes	6.6	0.8%
335	Topper silt loam, 2 to 8 percent slopes	342.3	41.2%
336	Topper silt loam, 8 to 15 percent slopes	239.2	28.8%
337	Topper silt loam, 15 to 30 percent north slopes	15.9	1.9%
338	Topper silt loam, 15 to 30 percent south slopes	5.3	0.6%
340	Tuckerdowns gravelly loam, 2 to 8 percent slopes	8.2	1.0%
Totals for Area of Interest		830.9	100.0%

Map Unit Descriptions

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

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the

characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

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

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

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

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

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

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

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

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered

practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

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

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

Wallowa County Area, Oregon

82—Freels silt loam, 0 to 3 percent slopes

Map Unit Setting

National map unit symbol: 2v7s
Elevation: 3,400 to 4,400 feet
Mean annual precipitation: 13 to 17 inches
Mean annual air temperature: 42 to 45 degrees F
Frost-free period: 70 to 100 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Freels and similar soils: 85 percent
Minor components: 4 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Freels

Setting

Landform: Stream terraces, flood plains
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium

Typical profile

H1 - 0 to 5 inches: silt loam
H2 - 5 to 34 inches: silt loam
H3 - 34 to 51 inches: silt loam
H4 - 51 to 60 inches: silt loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high
(0.57 to 1.98 in/hr)
Depth to water table: About 36 to 60 inches
Frequency of flooding: Rare
Frequency of ponding: None
Available water supply, 0 to 60 inches: High (about 10.0 inches)

Interpretive groups

Land capability classification (irrigated): 3c
Land capability classification (nonirrigated): 3c
Hydrologic Soil Group: B
Ecological site: R010XY006OR - MOUNTAIN LOAMY BOTTOM
Hydric soil rating: No

Minor Components

Sturgill

Percent of map unit: 4 percent
Landform: Flood plains
Landform position (three-dimensional): Tread

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Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R010XY001OR - COLD WET MEADOW
Hydric soil rating: Yes

113—Harlow-Bocker complex, 2 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2tx9
Elevation: 3,400 to 5,000 feet
Mean annual precipitation: 13 to 17 inches
Mean annual air temperature: 42 to 45 degrees F
Frost-free period: 70 to 100 days
Farmland classification: Not prime farmland

Map Unit Composition

Harlow and similar soils: 60 percent
Bocker and similar soils: 25 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Harlow

Setting

Landform: Plateaus, structural benches
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loess and colluvium derived from basalt

Typical profile

A1 - 0 to 4 inches: very stony loam
A2 - 4 to 8 inches: very cobbly clay loam
Bt - 8 to 16 inches: extremely cobbly clay
2R - 16 to 26 inches: unweathered bedrock

Properties and qualities

Slope: 2 to 15 percent
Surface area covered with cobbles, stones or boulders: 1.6 percent
Depth to restrictive feature: 10 to 20 inches to lithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Very low (about 1.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s

Custom Soil Resource Report

Hydrologic Soil Group: D

Ecological site: R009XY022OR - Cold Shallow 13+ PZ

Hydric soil rating: No

Description of Bocker

Setting

Landform: Structural benches, plateaus

Landform position (two-dimensional): Shoulder

Landform position (three-dimensional): Interfluve

Down-slope shape: Linear

Across-slope shape: Convex

Parent material: Loess and colluvium derived from basalt

Typical profile

A - 0 to 2 inches: extremely cobbly silt loam

Bw - 2 to 7 inches: very cobbly silt loam

2R - 7 to 17 inches: unweathered bedrock

Properties and qualities

Slope: 2 to 15 percent

Depth to restrictive feature: 4 to 10 inches to lithic bedrock

Drainage class: Well drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high
(0.57 to 1.98 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None

Frequency of ponding: None

Available water supply, 0 to 60 inches: Very low (about 0.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 7s

Hydrologic Soil Group: D

Ecological site: R009XY027OR - Cold Very Shallow 13+ PZ

Hydric soil rating: No

114—Harlow-Bocker complex, 15 to 30 percent south slopes

Map Unit Setting

National map unit symbol: 2txb

Elevation: 3,400 to 5,000 feet

Mean annual precipitation: 13 to 17 inches

Mean annual air temperature: 42 to 45 degrees F

Frost-free period: 70 to 100 days

Farmland classification: Not prime farmland

Map Unit Composition

Harlow and similar soils: 60 percent

Bocker and similar soils: 25 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Harlow

Setting

Landform: Hills

Landform position (two-dimensional): Backslope, footslope

Landform position (three-dimensional): Side slope, base slope

Down-slope shape: Linear

Across-slope shape: Concave

Parent material: Loess and colluvium derived from basalt

Typical profile

A1 - 0 to 4 inches: very stony loam

A2 - 4 to 8 inches: very cobbly clay loam

Bt - 8 to 16 inches: extremely cobbly clay

2R - 16 to 26 inches: unweathered bedrock

Properties and qualities

Slope: 15 to 30 percent

Surface area covered with cobbles, stones or boulders: 1.6 percent

Depth to restrictive feature: 10 to 20 inches to lithic bedrock

Drainage class: Well drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None

Frequency of ponding: None

Available water supply, 0 to 60 inches: Very low (about 1.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 7s

Hydrologic Soil Group: D

Ecological site: R009XY036OR - Cold Shallow South 13+ PZ

Hydric soil rating: No

Description of Bocker

Setting

Landform: Hills

Landform position (two-dimensional): Shoulder, backslope

Landform position (three-dimensional): Side slope

Down-slope shape: Linear

Across-slope shape: Linear

Parent material: Loess and colluvium derived from basalt

Typical profile

A - 0 to 2 inches: extremely cobbly silt loam

Bw - 2 to 7 inches: very cobbly silt loam

2R - 7 to 17 inches: unweathered bedrock

Properties and qualities

Slope: 15 to 30 percent

Depth to restrictive feature: 4 to 10 inches to lithic bedrock

Drainage class: Well drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)

Depth to water table: More than 80 inches

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Frequency of flooding: None

Frequency of ponding: None

Available water supply, 0 to 60 inches: Very low (about 0.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 7s

Hydrologic Soil Group: D

Ecological site: R009XY027OR - Cold Very Shallow 13+ PZ

Hydric soil rating: No

135—Hurwal silt loam, 8 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2ty1

Elevation: 3,400 to 5,000 feet

Mean annual precipitation: 13 to 17 inches

Mean annual air temperature: 42 to 45 degrees F

Frost-free period: 70 to 100 days

Farmland classification: Farmland of statewide importance

Map Unit Composition

Hurwal and similar soils: 90 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Hurwal

Setting

Landform: Hills

Landform position (two-dimensional): Summit, backslope

Landform position (three-dimensional): Interfluve, side slope

Down-slope shape: Linear

Across-slope shape: Linear

Parent material: Loess with an influence of volcanic ash in the surface layers

Typical profile

H1 - 0 to 12 inches: silt loam

H2 - 12 to 18 inches: silt loam

H3 - 18 to 56 inches: silty clay loam

H4 - 56 to 60 inches: silt loam

Properties and qualities

Slope: 8 to 15 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

Calcium carbonate, maximum content: 5 percent

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Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)

Available water supply, 0 to 60 inches: High (about 11.0 inches)

Interpretive groups

Land capability classification (irrigated): 4e

Land capability classification (nonirrigated): 3e

Hydrologic Soil Group: C

Ecological site: R009XY005OR - Cold Swale 13-17 PZ

Hydric soil rating: No

181—Laufer-Thiessen complex, 30 to 60 percent south slopes

Map Unit Setting

National map unit symbol: 2tzk

Elevation: 1,600 to 4,000 feet

Mean annual precipitation: 13 to 17 inches

Mean annual air temperature: 47 to 50 degrees F

Frost-free period: 100 to 120 days

Farmland classification: Not prime farmland

Map Unit Composition

Laufer and similar soils: 45 percent

Thiessen and similar soils: 40 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Laufer

Setting

Landform: Canyons

Landform position (two-dimensional): Backslope

Landform position (three-dimensional): Side slope

Down-slope shape: Linear

Across-slope shape: Convex

Parent material: Loess and colluvium derived from basalt

Typical profile

H1 - 0 to 4 inches: very stony silt loam

H2 - 4 to 8 inches: very cobbly clay loam

H3 - 8 to 16 inches: very cobbly clay

H4 - 16 to 26 inches: unweathered bedrock

Properties and qualities

Slope: 30 to 60 percent

Surface area covered with cobbles, stones or boulders: 1.6 percent

Depth to restrictive feature: 10 to 20 inches to lithic bedrock

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: Very low (about 1.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: D
Ecological site: R009XY031OR - Shallow South 14+ PZ
Hydric soil rating: No

Description of Thiessen

Setting

Landform: Canyons
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Concave
Parent material: Loess and colluvium derived from basalt

Typical profile

A - 0 to 3 inches: very cobbly silt loam
AB - 3 to 6 inches: very gravelly clay loam
Bt1 - 6 to 14 inches: very gravelly clay loam
Bt2 - 14 to 23 inches: very cobbly clay
Bt3 - 23 to 34 inches: very cobbly clay
2R - 34 to 44 inches: unweathered bedrock

Properties and qualities

Slope: 30 to 60 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Very low (about 2.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: D
Ecological site: R009XY029OR - South 14-17 PZ
Hydric soil rating: No

230—Powwatka silt loam, 2 to 8 percent slopes

Map Unit Setting

National map unit symbol: 2v1f
Elevation: 3,400 to 5,000 feet
Mean annual precipitation: 13 to 17 inches
Mean annual air temperature: 42 to 45 degrees F

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Frost-free period: 70 to 100 days

Farmland classification: Farmland of statewide importance

Map Unit Composition

Powwatka and similar soils: 85 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Powwatka

Setting

Landform: Hills

Landform position (two-dimensional): Summit

Landform position (three-dimensional): Interfluve

Down-slope shape: Linear

Across-slope shape: Linear

Parent material: Loess over basalt with minor amounts of volcanic ash in the surface layers

Typical profile

H1 - 0 to 14 inches: silt loam

H2 - 14 to 24 inches: silty clay loam

H3 - 24 to 34 inches: unweathered bedrock

Properties and qualities

Slope: 2 to 8 percent

Depth to restrictive feature: 20 to 40 inches to lithic bedrock

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 4.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 4e

Hydrologic Soil Group: C

Ecological site: R009XY017OR - Cold Loamy 13-17 PZ

Hydric soil rating: No

231—Powwatka silt loam, 8 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2v1g

Elevation: 3,400 to 5,000 feet

Mean annual precipitation: 13 to 17 inches

Mean annual air temperature: 42 to 45 degrees F

Frost-free period: 70 to 100 days

Farmland classification: Farmland of statewide importance

Map Unit Composition

Powwatka and similar soils: 85 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Powwatka

Setting

Landform: Hills

Landform position (two-dimensional): Backslope

Landform position (three-dimensional): Side slope

Down-slope shape: Linear

Across-slope shape: Linear

Parent material: Loess over basalt with minor amounts of volcanic ash in the surface layers

Typical profile

H1 - 0 to 14 inches: silt loam

H2 - 14 to 24 inches: silty clay loam

H3 - 24 to 34 inches: unweathered bedrock

Properties and qualities

Slope: 8 to 15 percent

Depth to restrictive feature: 20 to 40 inches to lithic bedrock

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 4.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 4e

Hydrologic Soil Group: C

Ecological site: R009XY017OR - Cold Loamy 13-17 PZ

Hydric soil rating: No

233—Powwatka silt loam, 15 to 30 percent south slopes

Map Unit Setting

National map unit symbol: 2v1j

Elevation: 3,400 to 5,000 feet

Mean annual precipitation: 13 to 17 inches

Mean annual air temperature: 42 to 45 degrees F

Frost-free period: 70 to 100 days

Farmland classification: Farmland of statewide importance

Map Unit Composition

Powwatka and similar soils: 85 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Powwatka

Setting

Landform: Hills

Landform position (two-dimensional): Backslope

Landform position (three-dimensional): Side slope

Down-slope shape: Linear

Across-slope shape: Linear

Parent material: Loess over basalt with minor amounts of volcanic ash in the surface layers

Typical profile

H1 - 0 to 14 inches: silt loam

H2 - 14 to 24 inches: silty clay loam

H3 - 24 to 34 inches: unweathered bedrock

Properties and qualities

Slope: 15 to 30 percent

Depth to restrictive feature: 20 to 40 inches to lithic bedrock

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 4.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 4e

Hydrologic Soil Group: C

Ecological site: R009XY034OR - Cold South 13-17 PZ

Hydric soil rating: No

281—Snell-Harlow complex, 15 to 30 percent north slopes

Map Unit Setting

National map unit symbol: 2v3b

Elevation: 2,800 to 5,000 feet

Mean annual precipitation: 13 to 30 inches

Mean annual air temperature: 42 to 45 degrees F

Frost-free period: 70 to 100 days

Farmland classification: Farmland of statewide importance

Map Unit Composition

Snell and similar soils: 60 percent

Harlow and similar soils: 25 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Snell

Setting

Landform: Plateaus, structural benches
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluvium, crest
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loess and colluvium derived from basalt

Typical profile

A1 - 0 to 4 inches: very stony loam
A2 - 4 to 9 inches: stony clay loam
Bt1 - 9 to 18 inches: very stony clay loam
Bt2 - 18 to 24 inches: extremely stony clay loam
2R - 24 to 34 inches: unweathered bedrock

Properties and qualities

Slope: 15 to 30 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
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: Very low (about 2.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: C
Ecological site: R009XY017OR - Cold Loamy 13-17 PZ
Hydric soil rating: No

Description of Harlow

Setting

Landform: Canyons
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loess and colluvium derived from basalt

Typical profile

A1 - 0 to 4 inches: very stony loam
A2 - 4 to 8 inches: very cobbly clay loam
Bt - 8 to 16 inches: extremely cobbly clay
2R - 16 to 26 inches: unweathered bedrock

Properties and qualities

Slope: 15 to 30 percent
Surface area covered with cobbles, stones or boulders: 1.6 percent
Depth to restrictive feature: 10 to 20 inches to lithic bedrock
Drainage class: Well drained

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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

Available water supply, 0 to 60 inches: Very low (about 1.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 7s

Hydrologic Soil Group: D

Ecological site: R009XY048OR - Shallow North 14+ PZ

Hydric soil rating: No

283—Snell-Harlow complex, 15 to 30 percent south slopes

Map Unit Setting

National map unit symbol: 2v3d

Elevation: 4,000 to 5,000 feet

Mean annual precipitation: 13 to 30 inches

Mean annual air temperature: 42 to 45 degrees F

Frost-free period: 70 to 100 days

Farmland classification: Farmland of statewide importance

Map Unit Composition

Snell and similar soils: 55 percent

Harlow and similar soils: 30 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Snell

Setting

Landform: Plateaus, structural benches

Landform position (two-dimensional): Summit

Landform position (three-dimensional): Interfluve, crest

Down-slope shape: Linear

Across-slope shape: Linear

Parent material: Loess and colluvium derived from basalt

Typical profile

A1 - 0 to 4 inches: very stony loam

A2 - 4 to 9 inches: stony clay loam

Bt1 - 9 to 18 inches: very stony clay loam

Bt2 - 18 to 24 inches: extremely stony clay loam

2R - 24 to 34 inches: unweathered bedrock

Properties and qualities

Slope: 15 to 30 percent

Depth to restrictive feature: 20 to 40 inches to lithic bedrock

Drainage class: Well drained

Custom Soil Resource Report

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: Very low (about 2.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 6s

Hydrologic Soil Group: C

Ecological site: R009XY017OR - Cold Loamy 13-17 PZ

Hydric soil rating: No

Description of Harlow

Setting

Landform: Canyons

Landform position (two-dimensional): Backslope

Landform position (three-dimensional): Side slope

Down-slope shape: Linear

Across-slope shape: Linear

Parent material: Loess and colluvium derived from basalt

Typical profile

A1 - 0 to 4 inches: very stony loam

A2 - 4 to 8 inches: very cobbly clay loam

Bt - 8 to 16 inches: extremely cobbly clay

2R - 16 to 26 inches: unweathered bedrock

Properties and qualities

Slope: 15 to 30 percent

Surface area covered with cobbles, stones or boulders: 1.6 percent

Depth to restrictive feature: 10 to 20 inches to lithic bedrock

Drainage class: Well drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None

Frequency of ponding: None

Available water supply, 0 to 60 inches: Very low (about 1.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 7s

Hydrologic Soil Group: D

Ecological site: R009XY048OR - Shallow North 14+ PZ

Hydric soil rating: No

335—Topper silt loam, 2 to 8 percent slopes

Map Unit Setting

National map unit symbol: 2v59
Elevation: 3,400 to 4,500 feet
Mean annual precipitation: 13 to 17 inches
Mean annual air temperature: 42 to 45 degrees F
Frost-free period: 70 to 100 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

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

Description of Topper

Setting

Landform: Hills
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Linear
Across-slope shape: Concave
Parent material: Loess with an influence of volcanic ash in the surface layers

Typical profile

H1 - 0 to 11 inches: silt loam
H2 - 11 to 25 inches: silt loam
H3 - 25 to 35 inches: silty clay loam
H4 - 35 to 60 inches: silt loam

Properties and qualities

Slope: 2 to 8 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 to high
(0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 20 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: High (about 11.2 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: B
Ecological site: R009XY017OR - Cold Loamy 13-17 PZ
Hydric soil rating: No

336—Topper silt loam, 8 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2v5b

Elevation: 3,400 to 4,500 feet

Mean annual precipitation: 13 to 17 inches

Mean annual air temperature: 42 to 45 degrees F

Frost-free period: 70 to 100 days

Farmland classification: Farmland of statewide importance

Map Unit Composition

Topper and similar soils: 85 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Topper

Setting

Landform: Hills

Landform position (two-dimensional): Backslope

Landform position (three-dimensional): Side slope

Down-slope shape: Linear

Across-slope shape: Linear

Parent material: Loess with an influence of volcanic ash in the surface layers

Typical profile

H1 - 0 to 11 inches: silt loam

H2 - 11 to 25 inches: silt loam

H3 - 25 to 35 inches: silty clay loam

H4 - 35 to 60 inches: silt loam

Properties and qualities

Slope: 8 to 15 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 to high
(0.57 to 1.98 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None

Frequency of ponding: None

Calcium carbonate, maximum content: 20 percent

Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)

Available water supply, 0 to 60 inches: High (about 11.2 inches)

Interpretive groups

Land capability classification (irrigated): 4e

Land capability classification (nonirrigated): 3e

Hydrologic Soil Group: B

Ecological site: R009XY017OR - Cold Loamy 13-17 PZ

Hydric soil rating: No

337—Topper silt loam, 15 to 30 percent north slopes

Map Unit Setting

National map unit symbol: 2v5c

Elevation: 3,400 to 4,500 feet

Mean annual precipitation: 13 to 17 inches

Mean annual air temperature: 42 to 45 degrees F

Frost-free period: 70 to 100 days

Farmland classification: Farmland of statewide importance

Map Unit Composition

Topper and similar soils: 85 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Topper

Setting

Landform: Hills

Landform position (two-dimensional): Backslope

Landform position (three-dimensional): Side slope

Down-slope shape: Linear

Across-slope shape: Linear

Parent material: Loess with an influence of volcanic ash in the surface layers

Typical profile

H1 - 0 to 11 inches: silt loam

H2 - 11 to 25 inches: silt loam

H3 - 25 to 35 inches: silty clay loam

H4 - 35 to 60 inches: silt loam

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 to high
(0.57 to 1.98 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None

Frequency of ponding: None

Calcium carbonate, maximum content: 20 percent

Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)

Available water supply, 0 to 60 inches: High (about 11.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 4e

Hydrologic Soil Group: B

Ecological site: R009XY041OR - Deep North 14-17 PZ

Hydric soil rating: No

338—Topper silt loam, 15 to 30 percent south slopes

Map Unit Setting

National map unit symbol: 2v5d

Elevation: 3,400 to 4,500 feet

Mean annual precipitation: 13 to 17 inches

Mean annual air temperature: 42 to 45 degrees F

Frost-free period: 70 to 100 days

Farmland classification: Farmland of statewide importance

Map Unit Composition

Topper and similar soils: 85 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Topper

Setting

Landform: Hills

Landform position (two-dimensional): Backslope

Landform position (three-dimensional): Side slope

Down-slope shape: Linear

Across-slope shape: Linear

Parent material: Loess with an influence of volcanic ash in the surface layers

Typical profile

H1 - 0 to 11 inches: silt loam

H2 - 11 to 25 inches: silt loam

H3 - 25 to 35 inches: silty clay loam

H4 - 35 to 60 inches: silt loam

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 to high
(0.57 to 1.98 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None

Frequency of ponding: None

Calcium carbonate, maximum content: 20 percent

Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)

Available water supply, 0 to 60 inches: High (about 11.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 4e

Hydrologic Soil Group: B

Ecological site: R009XY034OR - Cold South 13-17 PZ

Hydric soil rating: No

340—Tuckerdowns gravelly loam, 2 to 8 percent slopes

Map Unit Setting

National map unit symbol: 2v5g

Elevation: 3,700 to 4,400 feet

Mean annual precipitation: 13 to 17 inches

Mean annual air temperature: 42 to 45 degrees F

Frost-free period: 70 to 100 days

Farmland classification: Farmland of statewide importance

Map Unit Composition

Tuckerdowns and similar soils: 85 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Tuckerdowns

Setting

Landform: Terraces

Landform position (three-dimensional): Tread

Down-slope shape: Linear

Across-slope shape: Linear

Parent material: Alluvium with an influence loess in the surface layers

Typical profile

A1 - 0 to 3 inches: gravelly loam

A2 - 3 to 10 inches: gravelly loam

Bw - 10 to 17 inches: gravelly loam

Bk1 - 17 to 33 inches: very gravelly sandy clay loam

Bk2 - 33 to 60 inches: extremely gravelly sandy loam

Properties and qualities

Slope: 2 to 8 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 to high
(0.57 to 1.98 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None

Frequency of ponding: None

Calcium carbonate, maximum content: 20 percent

Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)

Available water supply, 0 to 60 inches: Low (about 5.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 3e

Hydrologic Soil Group: B

Ecological site: R009XY017OR - Cold Loamy 13-17 PZ

Hydric soil rating: No

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United States
Department of
Agriculture

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Natural
Resources
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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 **Wallowa County Area, Oregon**



October 16, 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.

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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

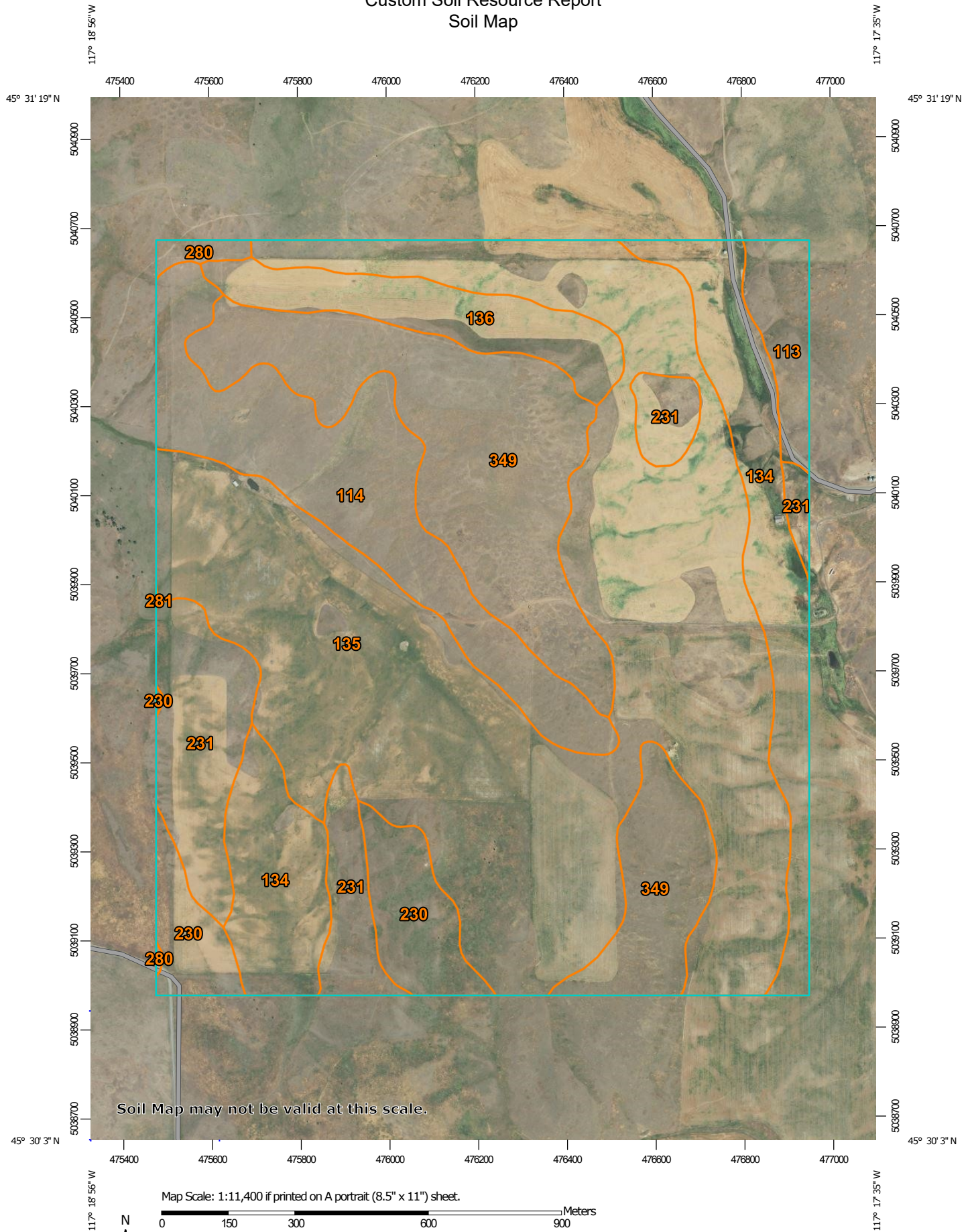
Custom Soil Resource Report

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



Map Scale: 1:11,400 if printed on A portrait (8.5" x 11") sheet.



Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 11N WGS84

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: Wallowa County Area, Oregon
Survey Area Data: Version 26, Sep 11, 2023

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

Date(s) aerial images were photographed: Aug 4, 2020—Aug 14, 2020

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

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
113	Harlow-Bocker complex, 2 to 15 percent slopes	12.9	2.1%
114	Harlow-Bocker complex, 15 to 30 percent south slopes	61.8	10.0%
134	Hurwal silt loam, 2 to 8 percent slopes	68.1	11.0%
135	Hurwal silt loam, 8 to 15 percent slopes	267.6	43.2%
136	Hurwal silt loam, 15 to 30 percent north slopes	26.7	4.3%
230	Powwatka silt loam, 2 to 8 percent slopes	28.1	4.5%
231	Powwatka silt loam, 8 to 15 percent slopes	49.5	8.0%
280	Snell-Harlow complex, 2 to 15 percent slopes	2.9	0.5%
281	Snell-Harlow complex, 15 to 30 percent north slopes	0.1	0.0%
349	Wallowa-Bocker complex, 2 to 15 percent slopes	101.7	16.4%
Totals for Area of Interest		619.4	100.0%

Map Unit Descriptions

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

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

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties

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

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

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

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

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

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

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

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

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

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

Wallowa County Area, Oregon

113—Harlow-Bocker complex, 2 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2tx9
Elevation: 3,400 to 5,000 feet
Mean annual precipitation: 13 to 17 inches
Mean annual air temperature: 42 to 45 degrees F
Frost-free period: 70 to 100 days
Farmland classification: Not prime farmland

Map Unit Composition

Harlow and similar soils: 60 percent
Bocker and similar soils: 25 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Harlow

Setting

Landform: Plateaus, structural benches
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loess and colluvium derived from basalt

Typical profile

A1 - 0 to 4 inches: very stony loam
A2 - 4 to 8 inches: very cobbly clay loam
Bt - 8 to 16 inches: extremely cobbly clay
2R - 16 to 26 inches: unweathered bedrock

Properties and qualities

Slope: 2 to 15 percent
Surface area covered with cobbles, stones or boulders: 1.6 percent
Depth to restrictive feature: 10 to 20 inches to lithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Very low (about 1.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: D
Ecological site: R009XY022OR - Cold Shallow 13+ PZ
Hydric soil rating: No

Description of Bocker

Setting

Landform: Structural benches, plateaus

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Landform position (two-dimensional): Shoulder

Landform position (three-dimensional): Interfluve

Down-slope shape: Linear

Across-slope shape: Convex

Parent material: Loess and colluvium derived from basalt

Typical profile

A - 0 to 2 inches: extremely cobbly silt loam

Bw - 2 to 7 inches: very cobbly silt loam

2R - 7 to 17 inches: unweathered bedrock

Properties and qualities

Slope: 2 to 15 percent

Depth to restrictive feature: 4 to 10 inches to lithic bedrock

Drainage class: Well drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high
(0.57 to 1.98 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None

Frequency of ponding: None

Available water supply, 0 to 60 inches: Very low (about 0.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 7s

Hydrologic Soil Group: D

Ecological site: R009XY027OR - Cold Very Shallow 13+ PZ

Hydric soil rating: No

114—Harlow-Bocker complex, 15 to 30 percent south slopes

Map Unit Setting

National map unit symbol: 2txb

Elevation: 3,400 to 5,000 feet

Mean annual precipitation: 13 to 17 inches

Mean annual air temperature: 42 to 45 degrees F

Frost-free period: 70 to 100 days

Farmland classification: Not prime farmland

Map Unit Composition

Harlow and similar soils: 60 percent

Bocker and similar soils: 25 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Harlow

Setting

Landform: Hills

Landform position (two-dimensional): Backslope, footslope

Landform position (three-dimensional): Side slope, base slope

Down-slope shape: Linear

Custom Soil Resource Report

Across-slope shape: Concave

Parent material: Loess and colluvium derived from basalt

Typical profile

A1 - 0 to 4 inches: very stony loam

A2 - 4 to 8 inches: very cobbly clay loam

Bt - 8 to 16 inches: extremely cobbly clay

2R - 16 to 26 inches: unweathered bedrock

Properties and qualities

Slope: 15 to 30 percent

Surface area covered with cobbles, stones or boulders: 1.6 percent

Depth to restrictive feature: 10 to 20 inches to lithic bedrock

Drainage class: Well drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None

Frequency of ponding: None

Available water supply, 0 to 60 inches: Very low (about 1.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 7s

Hydrologic Soil Group: D

Ecological site: R009XY036OR - Cold Shallow South 13+ PZ

Hydric soil rating: No

Description of Bocker

Setting

Landform: Hills

Landform position (two-dimensional): Shoulder, backslope

Landform position (three-dimensional): Side slope

Down-slope shape: Linear

Across-slope shape: Linear

Parent material: Loess and colluvium derived from basalt

Typical profile

A - 0 to 2 inches: extremely cobbly silt loam

Bw - 2 to 7 inches: very cobbly silt loam

2R - 7 to 17 inches: unweathered bedrock

Properties and qualities

Slope: 15 to 30 percent

Depth to restrictive feature: 4 to 10 inches to lithic bedrock

Drainage class: Well drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None

Frequency of ponding: None

Available water supply, 0 to 60 inches: Very low (about 0.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 7s

Hydrologic Soil Group: D

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Ecological site: R009XY027OR - Cold Very Shallow 13+ PZ

Hydric soil rating: No

134—Hurwal silt loam, 2 to 8 percent slopes

Map Unit Setting

National map unit symbol: 2ty0

Elevation: 3,400 to 5,000 feet

Mean annual precipitation: 13 to 17 inches

Mean annual air temperature: 42 to 45 degrees F

Frost-free period: 70 to 100 days

Farmland classification: Prime farmland if irrigated

Map Unit Composition

Hurwal and similar soils: 90 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Hurwal

Setting

Landform: Hills

Landform position (two-dimensional): Summit, footslope

Landform position (three-dimensional): Interfluve, base slope

Down-slope shape: Linear

Across-slope shape: Concave

Parent material: Loess with an influence of volcanic ash in the surface layers

Typical profile

H1 - 0 to 12 inches: silt loam

H2 - 12 to 18 inches: silt loam

H3 - 18 to 56 inches: silty clay loam

H4 - 56 to 60 inches: silt loam

Properties and qualities

Slope: 2 to 8 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

Calcium carbonate, maximum content: 5 percent

Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)

Available water supply, 0 to 60 inches: High (about 11.0 inches)

Interpretive groups

Land capability classification (irrigated): 3e

Land capability classification (nonirrigated): 3e

Hydrologic Soil Group: C

Ecological site: R009XY005OR - Cold Swale 13-17 PZ

Hydric soil rating: No

135—Hurwal silt loam, 8 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2ty1

Elevation: 3,400 to 5,000 feet

Mean annual precipitation: 13 to 17 inches

Mean annual air temperature: 42 to 45 degrees F

Frost-free period: 70 to 100 days

Farmland classification: Farmland of statewide importance

Map Unit Composition

Hurwal and similar soils: 90 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Hurwal

Setting

Landform: Hills

Landform position (two-dimensional): Summit, backslope

Landform position (three-dimensional): Interfluve, side slope

Down-slope shape: Linear

Across-slope shape: Linear

Parent material: Loess with an influence of volcanic ash in the surface layers

Typical profile

H1 - 0 to 12 inches: silt loam

H2 - 12 to 18 inches: silt loam

H3 - 18 to 56 inches: silty clay loam

H4 - 56 to 60 inches: silt loam

Properties and qualities

Slope: 8 to 15 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

Calcium carbonate, maximum content: 5 percent

Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)

Available water supply, 0 to 60 inches: High (about 11.0 inches)

Interpretive groups

Land capability classification (irrigated): 4e

Land capability classification (nonirrigated): 3e

Hydrologic Soil Group: C

Ecological site: R009XY005OR - Cold Swale 13-17 PZ

Hydric soil rating: No

136—Hurwal silt loam, 15 to 30 percent north slopes

Map Unit Setting

National map unit symbol: 2ty2

Elevation: 3,400 to 5,000 feet

Mean annual precipitation: 13 to 17 inches

Mean annual air temperature: 42 to 45 degrees F

Frost-free period: 70 to 100 days

Farmland classification: Farmland of statewide importance

Map Unit Composition

Hurwal, deep, and similar soils: 85 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Hurwal, Deep

Setting

Landform: Hills

Landform position (two-dimensional): Backslope

Landform position (three-dimensional): Side slope

Down-slope shape: Linear

Across-slope shape: Concave

Parent material: Loess with an influence of volcanic ash in the surface layers

Typical profile

H1 - 0 to 12 inches: silt loam

H2 - 12 to 18 inches: silt loam

H3 - 18 to 56 inches: silty clay loam

H4 - 56 to 58 inches: silt loam

H5 - 58 to 68 inches: unweathered bedrock

Properties and qualities

Slope: 15 to 30 percent

Depth to restrictive feature: 40 to 60 inches to lithic bedrock

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

Calcium carbonate, maximum content: 5 percent

Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)

Available water supply, 0 to 60 inches: High (about 10.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 4e

Hydrologic Soil Group: C

Ecological site: R009XY041OR - Deep North 14-17 PZ

Hydric soil rating: No

230—Powwatka silt loam, 2 to 8 percent slopes

Map Unit Setting

National map unit symbol: 2v1f

Elevation: 3,400 to 5,000 feet

Mean annual precipitation: 13 to 17 inches

Mean annual air temperature: 42 to 45 degrees F

Frost-free period: 70 to 100 days

Farmland classification: Farmland of statewide importance

Map Unit Composition

Powwatka and similar soils: 85 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Powwatka

Setting

Landform: Hills

Landform position (two-dimensional): Summit

Landform position (three-dimensional): Interfluve

Down-slope shape: Linear

Across-slope shape: Linear

Parent material: Loess over basalt with minor amounts of volcanic ash in the surface layers

Typical profile

H1 - 0 to 14 inches: silt loam

H2 - 14 to 24 inches: silty clay loam

H3 - 24 to 34 inches: unweathered bedrock

Properties and qualities

Slope: 2 to 8 percent

Depth to restrictive feature: 20 to 40 inches to lithic bedrock

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 4.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 4e

Hydrologic Soil Group: C

Ecological site: R009XY017OR - Cold Loamy 13-17 PZ

Hydric soil rating: No

231—Powwatka silt loam, 8 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2v1g

Elevation: 3,400 to 5,000 feet

Mean annual precipitation: 13 to 17 inches

Mean annual air temperature: 42 to 45 degrees F

Frost-free period: 70 to 100 days

Farmland classification: Farmland of statewide importance

Map Unit Composition

Powwatka and similar soils: 85 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Powwatka

Setting

Landform: Hills

Landform position (two-dimensional): Backslope

Landform position (three-dimensional): Side slope

Down-slope shape: Linear

Across-slope shape: Linear

Parent material: Loess over basalt with minor amounts of volcanic ash in the surface layers

Typical profile

H1 - 0 to 14 inches: silt loam

H2 - 14 to 24 inches: silty clay loam

H3 - 24 to 34 inches: unweathered bedrock

Properties and qualities

Slope: 8 to 15 percent

Depth to restrictive feature: 20 to 40 inches to lithic bedrock

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 4.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 4e

Hydrologic Soil Group: C

Ecological site: R009XY017OR - Cold Loamy 13-17 PZ

Hydric soil rating: No

280—Snell-Harlow complex, 2 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2v39

Elevation: 3,400 to 5,000 feet

Mean annual precipitation: 13 to 17 inches

Mean annual air temperature: 42 to 45 degrees F

Frost-free period: 70 to 100 days

Farmland classification: Farmland of statewide importance

Map Unit Composition

Snell and similar soils: 65 percent

Harlow and similar soils: 25 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Snell

Setting

Landform: Plateaus, structural benches

Landform position (two-dimensional): Summit

Landform position (three-dimensional): Interfluve, crest

Down-slope shape: Linear

Across-slope shape: Linear

Parent material: Loess and colluvium derived from basalt

Typical profile

A1 - 0 to 4 inches: very stony loam

A2 - 4 to 9 inches: stony clay loam

Bt1 - 9 to 18 inches: very stony clay loam

Bt2 - 18 to 24 inches: extremely stony clay loam

2R - 24 to 34 inches: unweathered bedrock

Properties and qualities

Slope: 2 to 15 percent

Depth to restrictive feature: 20 to 40 inches to lithic bedrock

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: Very low (about 2.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 6s

Hydrologic Soil Group: C

Ecological site: R009XY017OR - Cold Loamy 13-17 PZ

Hydric soil rating: No

Description of Harlow

Setting

Landform: Plateaus, structural benches
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loess and colluvium derived from basalt

Typical profile

A1 - 0 to 4 inches: very stony loam
A2 - 4 to 8 inches: very cobbly clay loam
Bt - 8 to 16 inches: extremely cobbly clay
2R - 16 to 26 inches: unweathered bedrock

Properties and qualities

Slope: 2 to 15 percent
Surface area covered with cobbles, stones or boulders: 1.6 percent
Depth to restrictive feature: 10 to 20 inches to lithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Very low (about 1.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: D
Ecological site: R009XY022OR - Cold Shallow 13+ PZ
Hydric soil rating: No

281—Snell-Harlow complex, 15 to 30 percent north slopes

Map Unit Setting

National map unit symbol: 2v3b
Elevation: 2,800 to 5,000 feet
Mean annual precipitation: 13 to 30 inches
Mean annual air temperature: 42 to 45 degrees F
Frost-free period: 70 to 100 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Snell and similar soils: 60 percent
Harlow and similar soils: 25 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Snell

Setting

Landform: Plateaus, structural benches
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluvium, crest
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loess and colluvium derived from basalt

Typical profile

A1 - 0 to 4 inches: very stony loam
A2 - 4 to 9 inches: stony clay loam
Bt1 - 9 to 18 inches: very stony clay loam
Bt2 - 18 to 24 inches: extremely stony clay loam
2R - 24 to 34 inches: unweathered bedrock

Properties and qualities

Slope: 15 to 30 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
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: Very low (about 2.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: C
Ecological site: R009XY017OR - Cold Loamy 13-17 PZ
Hydric soil rating: No

Description of Harlow

Setting

Landform: Canyons
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loess and colluvium derived from basalt

Typical profile

A1 - 0 to 4 inches: very stony loam
A2 - 4 to 8 inches: very cobbly clay loam
Bt - 8 to 16 inches: extremely cobbly clay
2R - 16 to 26 inches: unweathered bedrock

Properties and qualities

Slope: 15 to 30 percent
Surface area covered with cobbles, stones or boulders: 1.6 percent
Depth to restrictive feature: 10 to 20 inches to lithic bedrock
Drainage class: Well drained

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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

Available water supply, 0 to 60 inches: Very low (about 1.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 7s

Hydrologic Soil Group: D

Ecological site: R009XY048OR - Shallow North 14+ PZ

Hydric soil rating: No

349—Wallowa-Bocker complex, 2 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2v5s

Elevation: 3,400 to 5,000 feet

Mean annual precipitation: 13 to 19 inches

Mean annual air temperature: 42 to 57 degrees F

Frost-free period: 70 to 100 days

Farmland classification: Farmland of statewide importance

Map Unit Composition

Wallowa and similar soils: 50 percent

Bocker and similar soils: 40 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Wallowa

Setting

Landform: Plateaus, mountain slopes

Landform position (two-dimensional): Backslope

Down-slope shape: Convex

Across-slope shape: Convex

Parent material: Loess and colluvium derived from basalt with an influence if volcanic ash

Typical profile

A - 0 to 11 inches: ashy silt loam

Bw - 11 to 29 inches: silt loam

2R - 29 to 39 inches: unweathered bedrock

Properties and qualities

Slope: 2 to 15 percent

Depth to restrictive feature: 20 to 40 inches to lithic bedrock

Drainage class: Well drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)

Depth to water table: More than 80 inches

Custom Soil Resource Report

Frequency of flooding: None

Frequency of ponding: None

Available water supply, 0 to 60 inches: Moderate (about 6.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 4e

Hydrologic Soil Group: C

Ecological site: R009XY017OR - Cold Loamy 13-17 PZ

Other vegetative classification: bluebunch wheatgrass-Sandberg bluegrass-
onespike oatgrass (GB4911)

Hydric soil rating: No

Description of Bocker

Setting

Landform: Hills

Landform position (two-dimensional): Footslope

Landform position (three-dimensional): Side slope

Down-slope shape: Convex

Across-slope shape: Convex

Parent material: Loess and colluvium derived from basalt

Typical profile

A - 0 to 2 inches: extremely cobbly silt loam

Bw - 2 to 7 inches: very cobbly silt loam

2R - 7 to 17 inches: unweathered bedrock

Properties and qualities

Slope: 2 to 8 percent

Depth to restrictive feature: 4 to 10 inches to lithic bedrock

Drainage class: Well drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high
(0.57 to 1.98 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None

Frequency of ponding: None

Available water supply, 0 to 60 inches: Very low (about 0.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 7s

Hydrologic Soil Group: D

Ecological site: R009XY036OR - Cold Shallow South 13+ PZ

Hydric soil rating: No

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Established Series
Rev. MGL/WEL/RWL
08/2001

POWWATKA SERIES

The Powwatka series consists of moderately deep, well drained soils formed in loess with an influence of volcanic ash in the surface. They are on rolling hills and ridgetops. Slopes are 2 to 30 percent. The mean annual precipitation is about 15 inches and the mean annual temperature is about 43 degrees F.

TAXONOMIC CLASS: Fine-silty, mixed, superactive, frigid Vitrandic Argixerolls

TYPICAL PEDON: Powwatka ashy silt loam, cultivated. (Colors are for moist soil unless otherwise noted.)

Ap--0 to 8 inches; dark brown (10YR 2/2) ashy silt loam, dark gray (10YR 4/1) dry; weak very fine granular structure; slightly hard, friable, slightly sticky and slightly plastic; many very fine roots; common irregular pores; slightly acid (pH 6.4); abrupt smooth boundary.

A--8 to 14 inches; very dark grayish brown (10YR 3/2) ashy silt loam, dark grayish brown (10YR 4/2) dry; weak fine subangular blocky structure; slightly hard, friable, slightly sticky and plastic; many very fine roots; many very fine tubular pores; neutral (pH 6.6); clear wavy boundary. (Combined thickness of the A horizon is 8 to 22 inches)

Bt1--14 to 18 inches; dark brown (10YR 3/3) silty clay loam, brown (10YR 5/3) dry, weak fine prismatic structure parting to moderate fine and very fine subangular blocky; slightly hard, friable, slightly sticky and plastic; many fine roots; many very fine tubular pores; few faint clay films on ped faces; krotovinas 2 to 4 inches in diameter; neutral (pH 6.8); gradual wavy boundary.

Bt2--18 to 24 inches; dark brown (7.5YR 4/4) silty clay loam, brown (7.5YR 5/4) dry; weak fine prismatic structure parting to moderate fine and very fine subangular blocky; hard, friable, sticky and plastic; common very fine roots; many very fine tubular pores; few faint clay films on ped faces; krotovinas 2 to 4 inches in diameter; neutral (pH 6.8); abrupt wavy boundary. (Combined thickness of the Bt horizon is 10 to 18 inches)

2R--24 inches; fractured basalt.

TYPE LOCATION: Wallowa County, Oregon; about two miles NE of Lostine, 1,650 feet north and 400 feet east of the SW corner of section 1, T. 1 S., R. 43 E. (Latitude 45 degrees, 30 minutes, 15 seconds N, Longitude 117 degrees, 23 minutes, 36 seconds W)

RANGE IN CHARACTERISTICS: The mean annual soil temperature is 44 to 47 degrees F. The soils are usually moist, but are dry in the 4 to 12 inch control section for 60 to 90 consecutive days. The mollic epipedon is 12 to 20 inches thick and may include the upper part of the Bt horizon. The particle-size control section has more than 18 percent clay and less than 15 percent coarser than very fine sand. Depth to basalt bedrock is 20 to 40 inches.

The A horizon has value of 2 or 3 moist, 4 or 5 dry and chroma of 1 or 2 moist and dry. It is ashy silt loam or cobbly ashy silt loam with 18 to 25 percent clay. It has 0 to 30 percent cobbles and 0 to 15 percent gravel. It has 30 to 60 percent volcanic glass and glass coated aggregate and less than 0.1 percent acid oxalate extractable aluminum plus one-half iron. Soil reaction is slightly acid or neutral.

The Bt horizon has hue of 7.5YR or 10YR, value of 3 or 4 moist, 4 or 5 dry and chroma of 3 or 4 moist and dry. It is silt clay loam with 27 to 35 percent clay. The Bt2 horizon has 0 to 10 percent gravel. Soil reaction is slightly acid or neutral in the upper part and neutral or slightly alkaline in the lower part.

COMPETING SERIES: This is the [Hurwal](#) series. Hurwal soils have mollic epipedons more than 20 inches thick and are greater than 40 inches deep to bedrock.

GEOGRAPHIC SETTING: Powwatka soils are on rolling hills and ridgetops. Slope is 2 to 30 percent. The soils formed in loess with an influence of volcanic ash in the surface. Elevation is 3,400 to 5,200 feet. The climate is characterized by cold wet winters and hot dry summers. The mean annual precipitation is 13 to 17 inches. The mean annual temperature is 42 to 45 degrees F. The frost-free period is 60 to 100 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the competing [Hurwal](#), and the [Harlow](#), [Parsnip](#), and [Snell](#) series. Harlow soils are clayey-skeletal, less than 20 inches to bedrock and occur on south-facing side slopes. Hurwal soils occur in drainageways and on footslopes of north-facing side slopes. Parsnip soils are 10 to 20 inches to bedrock and occur on adjacent plateaus. Snell soils are clayey-skeletal, 20 to 40 inches to bedrock, and occur on north-facing side slopes.

DRAINAGE AND PERMEABILITY: Well drained; moderately slow permeability.

USE AND VEGETATION: The soils are used mainly for dry cropland and livestock grazing. The potential native vegetation is Idaho fescue and bluebunch wheatgrass.

DISTRIBUTION AND EXTENT: Northeastern Oregon, MLRA 9. The series is of small extent.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Portland, Oregon

SERIES ESTABLISHED: Wallowa County, Oregon, 1998.

REMARKS: Diagnostic horizons and features recognized in this pedon include:

Mollic epipedon - from the surface to 18 inches (Ap, A, and Bt1 horizons).

Argillic horizon - from 14 to 24 inches (Bt1 and Bt2 horizons).

Vitrandidic feature - from 0 to 14 inches (Ap and A horizons) based on laboratory data from the associated Parsnip soil.

Particle-size control section - from 14 to 24 inches (Bt1 and Bt2 horizons).

This series has been reclassified from Typic Argixerolls to Vitrandidic Argixerolls.

Established Series
Rev. MGL/AON/RWL
03/2001

TOPPER SERIES

The Topper series consists of very deep, well drained soils that formed in loess with an influence of volcanic ash in the surface. Topper soils are on hills. Slopes are 2 to 30 percent. The mean annual precipitation is about 16 inches and the mean annual temperature is about 43 degrees F.

TAXONOMIC CLASS: Fine-silty, mixed, superactive, frigid Vitrandic Haploxerolls

TYPICAL PEDON: Topper ashy silt loam, cultivated, at an elevation of 4,160 feet. (Colors are for moist soil unless otherwise noted.)

Ap--0 to 6 inches; very dark brown (10YR 2/2) ashy silt loam grayish brown (10YR 5/2) dry; weak fine platy structure; soft, friable, slightly sticky and slightly plastic; many very fine roots; few very fine tubular pores; neutral (pH 6.8); abrupt smooth boundary.

A--6 to 11 inches; dark brown (10YR 3/3) ashy silt loam, brown (10YR 5/3) dry; weak medium subangular blocky structure; soft, friable, slightly sticky and slightly plastic; common fine roots; common fine tubular pores; neutral (pH 6.8); abrupt irregular boundary. (Combined thickness of the A horizon is 10 to 16 inches)

C--11 to 15 inches; brown (10YR 4/3) silt loam, light gray (10YR 7/2) dry; massive; soft, very friable, nonsticky and nonplastic; few fine roots; common very fine tubular pores; slightly alkaline (pH 7.4); abrupt irregular boundary. (0 to 8 inches thick)

2Bwb--15 to 25 inches; dark brown (10YR 3/3) silt loam, brown (10YR 5/3) dry; weak coarse prismatic structure; slightly hard, friable, sticky and plastic; few fine roots; many fine tubular pores; neutral (pH 7.2); clear smooth boundary. (0 to 12 inches thick)

2Bkb1--25 to 35 inches; dark yellowish brown (10YR 4/4) silty clay loam, yellowish brown (10YR 5/4) dry; weak medium subangular blocky structure; hard, friable, sticky and plastic; few fine roots; many fine tubular pores; strongly effervescent; mycelium lime; strongly alkaline (pH 8.6); gradual boundary. (6 to 12 inches thick)

2Bkb2--35 to 60 inches; brown (10YR 5/3) silt loam, light gray (10YR 7/2) dry; massive; soft, friable, slightly sticky and slightly plastic; few fine roots; many fine tubular pores; strongly effervescent; soft segregated lime throughout; strongly alkaline (pH 8.6).

TYPE LOCATION: Wallowa County, Oregon; located about 6 miles north of Joseph; center of section 29, T. 1 S., R. 45 E. (Latitude 45 degrees, 26 minutes, 56 seconds N.; Longitude 117 degrees, 13 minutes, 04 seconds W.)

RANGE IN CHARACTERISTICS: The mean annual soil temperature is 44 to 47 degrees F. In most years the soils are usually moist but dry between 4 and 12 inches for 60 to 90 consecutive days within the 3-month period following the summer solstice. The mollic epipedon is 10 to 16 inches thick. Depth to secondary lime ranges from 20 to 40 inches with the calcic horizon having a calcium carbonate equivalent of 15 to 20 percent. The particle-size control section is 18 to 30 percent clay and less than 15 percent coarser than very fine sand. Depth to bedrock is greater than 60 inches.

The A horizon has value of 2 or 3 moist, 4 or 5 dry, and chroma of 2 or 3 moist and dry. It has 30 to 60 percent volcanic glass and glass coated aggregate and less than 0.1 percent acid oxalate extractable aluminum plus one-

half iron. It is ashy silt loam with 18 to 27 percent clay.

The C horizon, when present, has value of 3 or 4 moist, 5 to 7 dry and chroma of 2 to 4 moist and dry. It is neutral or slightly alkaline. It is silt loam with 18 to 27 percent clay.

The 2Bwb horizon has value of 3 or 4 moist, 5 or 6 dry and chroma of 3 or 4 moist and dry. It is silt loam with 18 to 27 percent clay.

The 2Bkb1 horizon has value of 3 or 4 moist, 5 or 6 dry, and chroma of 3 or 4 moist and dry. It is silt loam or silty clay loam with 18 to 30 percent clay. It is moderately to strongly calcareous with segregated or mycelium lime in the lower part.

The 2Bk2 horizon has value of 4 or 5 moist, 6 or 7 dry and chroma of 2 to 4 moist and dry. It is silt loam or loam with 18 to 27 percent clay. It has 0 to 10 percent gravel and 0 to 5 percent cobbles.

COMPETING SERIES: This is the [Hadenecreek](#) series. The Hadenecreek soils are moderately well drained, have 5 to 20 percent volcanic glass in the upper 7 to 14 inches, and have 5 to 20 percent calcium carbonate equivalent in the Bk horizon.

GEOGRAPHIC SETTING: The Topper soils are on hills and have slopes of 2 to 30 percent. The soils formed in loess and mixed loess and volcanic ash. Elevations of 3,400 to 4,500 feet. The climate is characterized by cool wet winters and hot dry summers. The mean annual precipitation of 13 to 17 inches. The mean annual temperature is 42 to 45 degrees F. The frost-free period season is 70 to 100 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the [Hurwal](#), [Parsnip](#), [Powwatka](#), and [Snell](#) series. Hurwal soils are on north-facing slopes, have argillic horizons, and lack secondary lime. Parsnip soils are on broad plateaus, have argillic horizons, and are 10 to 20 inches to bedrock. Powwatka soils are on adjacent hills, have argillic horizons, lack secondary lime, and are 20 to 40 inches to bedrock. Snell soils are on north-facing slopes, are clayey-skeletal, and lack secondary lime.

DRAINAGE AND PERMEABILITY: Well drained; moderate permeability.

USE AND VEGETATION: The soils are used mainly for small grain, alfalfa and pasture. Native vegetation is Idaho fescue with small amounts of associated forbs.

DISTRIBUTION AND EXTENT: Valleys of northeastern Oregon; MLRA 9. The series is inextensive.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Portland, Oregon

SERIES ESTABLISHED: Wallowa County, Oregon, 1998. The source of name is Topper lookout.

REMARKS: This series has been reclassified from a Calcic Haploxerolls to a Vitrandic Haploxerolls.

Diagnostic horizons and features recognized in this pedon include:

Mollic epipedon - the zone from 0 to 11 inches (Ap and A horizons)

Calcic horizon - the zone from 25 to 60 inches (2Bkb1 and 2Bkb2 horizons) with an assumed calcium carbonate equivalent of 15 to 20 percent.

Calcic subgroup feature - presence of calcic horizon beginning at 25 inches.

Vitrandic subgroup feature - the zone from 0 to 11 inches (Ap and A horizons) based on laboratory data from the associated Parsnip soil.

Particle-size control section - the zone from 10 to 40 inches.

APPENDIX D
Nitrogen Uptake Publications for
Potential Crops

Southern Idaho Fertilizer Guide



Irrigated Alfalfa



Jeffrey Stark, Brad Brown and Glenn Shewmaker

The following fertilizer recommendations are based on university and USDA-ARS research that relates crop yield response to nutrient application rates at different soil test values. The recommendations are designed to produce above average yields if other environmental or cultural factors are not limiting. Good crop management is assumed.

The suggested fertilizer rates also assume that soil samples are properly collected, processed, and analyzed, and that they represent the areas to be fertilized. Many fields have appreciable variation in residual soil fertility and potential productivity. Areas within fields that differ appreciably should be sampled and fertilized separately if they are large enough to allow nutrient application rates to be conveniently adjusted and if the differential application would be cost effective.

Precision ag technology and variable rate applicators currently provide options for differentially fertilizing field areas. For information on mapping soil nutrient concentrations and variably applying fertilizer, contact an extension soil fertility specialist, your local county extension educator, or reputable fertilizer dealers/consultants.

Soil Sampling

Representative soil samples are essential. Each soil sample submitted to a soil test laboratory should consist of a composite of at least 20 individual cores from within the area of interest. Collect separate samples from the 0- to 12-inch and 12- to 24-inch depths. Skip areas that represent only a small portion of the field such as gravelly areas, saline or sodic areas, wet spots, and turn rows.

Do not store moist samples under warm conditions because microbial activity can change the extractable

N in the sample. Samples that are not air-dried should be sent to the laboratory as quickly as possible.

Fertilizer Recommendations

Nutrient requirements for alfalfa are relatively high compared to many other crops commonly grown in Idaho. Each ton of alfalfa hay removes about 60 lb nitrogen (N) per acre, 50 lb potassium (K) per acre, 30 lb calcium (Ca) per acre, 8 lb phosphorus (P) per acre, and about 6 lb per acre of both sulfur (S) and magnesium (Mg). Requirements for phosphorus and potassium fertilizers are much higher than for S, manganese (Mn), zinc (Zn), iron (Fe), and boron (B).

Nitrogen

Essentially all N required by established alfalfa is provided by the symbiotic relationship with N-fixing Rhizobium bacteria and N mineralized from soil organic matter. Topdressed N usually does not improve yield, quality, or vigor of established stands. However, applications of 20 to 40 lb N per acre may be helpful during stand establishment prior to nodulation of the roots. Applied N would most likely be needed following small grain production in which the residue is returned to the soil. Application of larger amounts may inhibit nodulation, decrease symbiotic N fixation, and encourage grass weeds, thereby reducing alfalfa growth or quality when harvested. Alfalfa receiving appreciable amounts of animal manures, dairy effluent, or other organic N sources will also have reduced N fixation. The probability of an N response is usually greatest on coarse-textured soils with low organic matter content.

Nitrogen fertilizer may be required for maximum alfalfa production and quality if the roots are poorly nodulated. Poor nodulation as well as poor Rhizobial activity and N-fixing capacity can result from a number of factors, including lack of proper seed



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CIS 1102

inoculation at planting, diseases, insects, water deficits, nutrient deficiencies or toxicities, or other soil physical or chemical conditions that reduce the effectiveness of the Rhizobium inoculant. Poor inoculation results from not using inoculant, using inoculant that has lost its viability (expired shelf life), or using Rhizobium inoculant strains that are not effective. Poor inoculation, nodulation, or Rhizobial effectiveness is indicated when alfalfa protein is low (less than 18%) when cut at the early bloom stage. Healthy Rhizobium nodules should be pink when cut open if they are effectively fixing atmospheric N.

If nodulation or Rhizobial effectiveness is limited by pests, water deficits, or soil conditions such as salinity, sodicity, nutrient deficiencies, or soil compaction, then attempts should be made to correct the problem through appropriate management practices. For more information on proper inoculation of alfalfa, refer to CIS 838 *Inoculation of Legumes in Idaho*.

Alfalfa is sometimes used to scavenge nutrients from soils receiving excessive animal manure or other biological waste applications. An alfalfa crop yielding 6 tons per acre can remove up to 360 lb of N per acre. However, excessive nitrogen uptake can increase the forage nitrate toxicity hazard for dairy and beef cattle. In addition, animal manure applications can promote grass and weed growth, which in turn can also increase the potential for nitrate toxicity if the population of the noxious weed Kochia increases.

Producers sometimes plant a companion crop when establishing alfalfa in order to increase the productivity of the first cutting. However, this practice is not recommended because the alfalfa stand typically is reduced by competition from the companion crop. If growers plant alfalfa with a companion crop, both crops compete for the available N. Under these conditions, N rates of 30 to 40 lb per acre are suggested if available soil N does not exceed 60 to 80 lb per acre.

Phosphorus

Adequate P availability is important for maintaining plant health, winterhardiness, and optimum root, stem, and leaf growth. Since phosphorus is relatively immobile in soil, P fertilizer should be incorporated into the soil prior to planting to raise soil P concentrations to optimum levels for early plant growth. The phosphorus recommendations presented in Table 1 are based on the soil test P concentration and free

lime content in the top foot of soil, and the yield potential. Significant amounts of free lime in the soil will make less phosphorus available to plants as it precipitates soil solution P.

Table 1. Recommended P fertilization rates for irrigated alfalfa based on soil test P and free lime content.

Soil test P ¹ (0 to 12 inch)	Free Lime Content (%)			
	0	4	8	12
ppm P	-----P ₂ O ₅ (lb/acre)-----			
0	300	340	380	420
3	250	290	330	370
6	200	240	280	320
9	150	190	230	270
12	100	140	180	220
15	50	90	130	170
18	0	40	80	120
21	0	0	30	70

¹NaHCO₃ extraction

NOTE: Add 10 lb P₂O₅ per acre for each 1 ton per acre increase in yield goal above 6 tons per acre.

Topdressed P applications can also be effective but should be made following harvest in the fall or in the spring before regrowth in order to maximize soil contact. Knifing ammonium polyphosphate (10-34-0) into the soil or applying surface bands in the fall or spring are also effective P fertilization methods for alfalfa.

As the stand ages and plant density decreases, the ability of the alfalfa root system to take up P diminishes due to decreased soil P concentrations and root activity. Under these conditions, smaller P rates applied more frequently may increase P uptake efficiency.

Effective sources of P for alfalfa include monoammonium phosphate (11-52-0), triple superphosphate (0-45-0), ammonium polyphosphate (10-34-0), and phosphoric acid. Fertilizer P can be broadcast as 11-52-0 or applied through the irrigation system as 10-34-0 with equal effectiveness. Phosphorus sources should be selected on the basis of cost, local availability, and equipment requirements.

Potassium

Alfalfa has a high K requirement. A crop of 8 tons per acre will remove about 480 lb of K₂O per acre. Most Idaho soils and surface irrigation waters are naturally high in K. However, K deficiencies can develop in intensively cropped fields, particularly those fields cropped to alfalfa for many years. Sandy soils are generally more prone to developing K deficiencies than silt loam or clay soils and therefore have a higher probability of responding to K fertilization.

Potassium movement in soils is limited, although it is more mobile than P. Like phosphorus, potassium fertilizer recommendations are based on calibrated relationships between soil test concentrations in the top foot of soil and yield response (Table 2). Soil test K should generally be in the range of 160 to 200 ppm for optimum alfalfa yield. Potassium fertilizer should also be incorporated during seedbed preparation prior to establishment, or broadcast in the fall or early spring on established stands. Potassium chloride (0-0-60), potassium sulfate (0-0-52), K-Mag, and various liquid K fertilizers are all effective K sources for alfalfa.

Table 2. Recommended K fertilization rates for irrigated alfalfa based on soil test K concentrations and yield goal.

Soil test K ¹ (0 to 12 inch)	Yield goal (tons/acre)			
	6	7	8	9
ppm	K application rate (lb K ₂ O/acre)			
0	240	300	360	420
40	180	240	300	360
80	120	180	240	300
120	60	120	180	240
160	0	60	120	180
200	0	0	60	120
240	0	0	0	60

¹NaHCO₃ extraction

Potassium applications exceeding 300 lb K₂O per acre should be split between fall and spring to avoid salt damage. Excessive K applications should be avoided since alfalfa will remove substantially more K than it needs for maximum yield. Excessive K concentrations in alfalfa can contribute to milk fever in dairy cattle.

Sulfur

Sulfur is a key contributor to alfalfa yield and quality. Sulfur requirements for alfalfa vary with soil texture, leaching losses, soil test SO₄-S concentration, and S content of the irrigation water. About 30 to 40 lb of SO₄-S should be applied before planting to soils containing less than 10ppm SO₄-S in the top foot of soil. This amount should provide adequate soil S for several years, provided the SO₄-S is not leached from the rooting depth. The SO₄-S form is mobile and can be leached to lower soil profile depths. For established alfalfa, sampling to a depth of two feet will provide a more accurate indication of S availability to alfalfa roots beyond the first foot.

Areas irrigated with water from the Snake River or streams fed by return flow should have adequate S for alfalfa production. High rainfall areas, mountain valleys, and foothills are more likely to have S deficiencies, particularly on course-textured soils with low organic matter content.

Sulfur fertilizer sources should be carefully selected because elemental S must be converted to SO₄-S by soil microorganisms before plant roots can take it up. Conversion of elemental S to SO₄-S may take several months in warm, moist soil. Consequently, elemental S fertilizers usually cannot supply adequate levels of S to alfalfa in the year that it is applied. However, elemental S fertilizers can supply considerable S during the year following application. Sulfate-sulfur sources such as gypsum (calcium sulfate), ammonium sulfate (21-0-0), or potassium sulfate (0-0-52-18) are recommended to correct S deficiencies during the year of application.

Secondary Nutrients and Micronutrients

Calcium and magnesium deficiencies in alfalfa are rare in the irrigated areas of southern Idaho. Most soils in the Snake River plain have adequate amounts of Ca and Mg for alfalfa production, although low soil Mg concentrations are sometimes encountered on very sandy soils that have been heavily fertilized with K for long periods. Under these conditions, applications of MgSO₄ or K-Mag at 20 to 40 lb of Mg per acre may provide a benefit.

Micronutrient applications should be based on recent soil test results (Table 3). Boron deficiencies can usually be corrected by applying 2 to 3 lb of B per acre for the duration of the crop. However, on very sandy soils, or high rainfall areas where soils are subject to excessive leaching of B, annual applications of 1/2 to 1 lb of B per acre may be more

effective. Commonly used forms of B include boric acid, Borax, and sodium borate.

Zinc, Mn, and Fe deficiencies can be corrected by applying 5 to 10 lb per acre of the required nutrient using Zn, Mn, or Fe sulfates or other soluble forms. Molybdenum availability is generally adequate in the alkaline soils that are prevalent in the irrigated areas of southern Idaho.

Table 3. Adequate soil test micronutrient concentrations for alfalfa.

Nutrient	Adequate concentration (ppm) ¹
Boron	> 0.5
Zinc	> 1.0
Manganese	> 1.0
Iron	> 5.0

¹DTPA extractable zinc, manganese, and iron

Table 4. Sufficiency ranges for alfalfa stem tissue sampled at early bloom.

Nutrient	Sufficiency range
	-----%-----
Nitrogen	3.00-5.00
Phosphorus	0.25-0.75
Potassium	2.50-4.00
Calcium	0.50-3.00
Magnesium	0.30-1.00
Sulfur	0.25-0.50
	----ppm---
Boron	30-80
Zinc	20-70
Manganese	30-100
Iron	30-150
Copper	5-25
Molybdenum	1-5

Tissue Testing

Plant tissue testing provides an effective means of evaluating the nutrient status of an established alfalfa stand. Samples should be collected from about 20 to 30 plants at early bloom in representative areas of the field that are free from water stress or obvious pest problems. The top six inches of the stem should be sampled and sent immediately to a soil testing lab for analysis. Sufficiency ranges for the various nutrients are presented in Table 4. Nutrient concentrations below these ranges indicate a need for supplemental fertilization.

When nutrient deficiencies are identified during the growing season, the deficiencies can often be corrected by injecting water-soluble fertilizers through the sprinkler system. Liquid forms of N, P, K, S, and micronutrients are commonly available in Idaho and should be selected on the basis of cost relative to dry fertilizers and ease of application. If alfalfa is furrow irrigated, foliar sprays can be used to correct micronutrient deficiencies but avoid foliar applications of N, P, K, and S at high rates that can cause foliar burning.

For Further Reading

You may order this and other publications about fertilizers and crops in southern Idaho from the University of Idaho Cooperative Extension offices in your county or Ag Publications, P.O. Box 442240, University of Idaho, Moscow, ID 83844-2240, phone (208) 885-7982, fax (208) 885-7982, email agpub@uidaho.edu, or <http://info.ag.uidaho.edu> on the internet.

CIS 838 Inoculation of Legumes in Idaho, \$0.35

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Nutrient Management Guide for Dryland and Irrigated Alfalfa in the Inland Northwest

A PACIFIC NORTHWEST EXTENSION PUBLICATION • PNW0611



Washington State University • Oregon State University • University of Idaho

Nutrient Management Guide for Dryland and Irrigated Alfalfa in the Inland Northwest

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Nutrient management is necessary to produce high-yielding, high-quality alfalfa economically, while at the same time preserving soil, air, and water quality. As the term implies, nutrient management includes activities such as sampling to monitor soil and plant tissue nutrient levels, adjusting nutrient application rates based on soil and tissue test results, and varying the placement, timing, and source of nutrients to optimize plant availability and uptake.

The information presented here is applicable to alfalfa grown throughout Idaho and east of the Cascade mountain range in Oregon and Washington. Different climates, soils, and topography result in considerable variation in alfalfa yields across a region, an individual farm, and even within a field on the same farm. Due to this inherent variability, a one-size-fits-all recommendation for the management of any one nutrient is of little value. Nutrient management choices should be based on individual grower practices, realistic yield expectations, and current soil and tissue test information.

This document summarizes locally-based guidelines for managing major nutrients in alfalfa, emphasizes how producers can tailor recommendations to their production system, and identifies opportunities where information such as soil and tissue test results can help

refine and improve nutrient management practices to optimize alfalfa yield, quality, and economic returns. The recommendations are based on existing Extension bulletins, recent research data, field experiences, and estimates of nutrient removal and efficiency.

Nutrient removal by alfalfa

Growing alfalfa removes large quantities of nutrients from soil (Table 1). In fact, high-yielding stands of alfalfa hay remove as much or more nutrients than any other intensive forage managed for hay or silage. Growers have historically relied on phosphorus and potassium as the main nutrients added for optimal alfalfa production. Areas with a long history of alfalfa and other intensive crops have commonly mined soil nutrient reserves. This, coupled with modern, higher-yielding varieties and production systems, means that many alfalfa fields now require supplementation with multiple nutrients.

Soil pH and alfalfa

Optimum alfalfa yields occur when soil pH is near 7.0; however, alfalfa can tolerate soil in the pH range 6.0–8.2 and still produce high yields. Northern Idaho and western Oregon and Washington, where rainfall is high, have lower soil pH than more arid regions of the inland

Table 1. Average tissue nutrient contents and their removal in alfalfa hay production.

Nutrient	Nutrient concentration in early bloom hay (dry matter basis) ¹	Nutrients removed per ton of early bloom alfalfa hay (analysis from previous column, 88% dry matter)	Range of nutrients removed per ton of hay at 88% dry matter ²
Nitrogen (N)	19.9% crude protein (3% N)	56 lb N	50–70 lb N
Phosphorus (P)	0.2% P	8 lb P ₂ O ₅ ³	8–16 lb P ₂ O ₅
Potassium (K)	2.6% K	54 lb K ₂ O ⁴	48–72 lb K ₂ O
Sulfur (S)	0.3% S	5 lb S	4–6 lb S
Calcium (Ca)	1.6% Ca	30 lb Ca	28–35 lb Ca
Magnesium (Mg)	0.3% Mg	6 lb Mg	5–8 lb Mg
Boron (B)	—	—	0.05 lb B
Zinc (Zn)	30 ppm ⁵ Zn	0.05 lb Zn	0.05 lb Zn
Copper (Cu)	12.7 ppm ⁵ Cu	0.02 lb Cu	0.02 lb Cu
Molybdenum (Mo)	0.29 ppm ⁵ Mo	0.0005 lb Mo	0.0005 lb Mo

¹Adapted from National Research Council 2000, pp. 134–135.

²Variations in nutrient removal that may occur with different soil residual nutrient values.

³To convert P (phosphorus) to P₂O₅ (oxide form), divide by 0.44.

⁴To convert K (potassium) to K₂O (oxide form), divide by 0.83.

⁵parts per million



Figure 1. Symptoms of phosphorus deficiency in alfalfa include short plants, thin and weedy stands, and small, dark, or blue-green leaves. The overview photo is of a severely phosphorus-deficient stand of alfalfa. The left insert photo is of a phosphorus-deficient stand, while the right insert photo is of a phosphorus-fertilized stand.

Pacific Northwest. Soil pH below 6.0 limits nitrogen fixation and alfalfa yield. In these low pH areas, lime may be needed to increase soil pH. A soil test to determine alfalfa lime requirements (SMP buffer test) will indicate the lime application rates needed for low pH soils. For more information on this test, contact a soil testing lab (Daniels 2005) and see Oregon State University (Hart 1990) and University of Idaho (Mahler 1994) Extension bulletins on lime materials.

Many inland Pacific Northwest soils have become acidic (pH less than 7.0) due to long-term use of ammonium-based nitrogen fertilizer. Often these acidified soils have higher pH subsoil. When this situation exists, deep tillage can mix the topsoil and subsoil and delay the need for lime application.

Nitrogen (N)

Fortunately, alfalfa obtains most of the nitrogen it needs from the atmosphere through a symbiotic association with rhizobia (*Sinorhizobium meliloti*) bacteria that inhabit nodules in the alfalfa root system. Successful conversion of atmospheric nitrogen to a form usable by alfalfa (“fixation”) depends on the presence of rhizobia in soil or inoculated seed, suitable soil pH (discussed above), and nutrient availability—particularly molybdenum, copper, and cobalt (discussed later).

Rhizobia require a source of energy (carbohydrate) from alfalfa. This comes at some cost to the plant, so alfalfa preferentially uses ammonium- and nitrate-nitrogen in the soil, if available, rather than fixing its own nitrogen. Nitrogen fixation is, however, a very cost-effective way to obtain nitrogen. Given the high nitrogen content of alfalfa (Table 1), fertilizing stands with nitrogen is seldom economical. For long-term production, correcting the underlying problem that is limiting fixation or shifting to non-legume (grass) production is normally more economical than fertilizing alfalfa with nitrogen.

Alfalfa is deep-rooted and drought-tolerant, making it well-suited for nitrogen uptake. The crop is commonly used to dispose of waste

nitrogen from a variety of industries. At 50–70 lb per ton of hay, alfalfa removes more nitrogen than almost any other crop. When nitrogen is supplied via wastewater or manure, alfalfa preferentially absorbs nitrogen from the soil rather than fixing it from the atmosphere. A reasonable nitrogen application rate for disposal situations is 80% of the nitrogen removed by the hay crop. Fertilizing alfalfa with nitrogen may increase nitrate in the hay, so monitoring is helpful to curtail this problem if necessary.

Phosphorus (P)

Phosphorus is an important nutrient in alfalfa production with mild to moderate deficiencies commonly delaying maturity and limiting hay yield. Visual symptoms (Figure 1) can be difficult to recognize since they also resemble drought stress and certain diseases. Also, visual symptoms may not be apparent until deficiencies become severe enough to significantly reduce yield and allow grassy weeds to encroach on the stand.

Soil testing is a reliable way to diagnose phosphorus deficiency before it causes major yield reductions. Samples should be collected in late fall or early spring when alfalfa is dormant. Soil samples collected in-season will have lower test levels as a result of active absorption by growing plants and the relatively slow release of plant-available phosphorus from soil minerals. Tissue testing can also be used to diagnose phosphorus deficiencies during the growing season. Guidelines for phosphorus and other important alfalfa nutrient concentrations are summarized in Table 2. Soil or tissue testing for phosphorus should be done annually in irrigated systems and every 2–3 years in dryland systems to monitor nutrient levels.

Phosphorus recommendations based on soil test results are summarized in Table 3. For new stands, apply the amount of P_2O_5 specified in Table 2 plus enough additional P_2O_5 for 2 years of production based on expected yields and estimated crop removal (Table 1). Phosphorus movement in soil is very limited, so extra phosphorus applied during or prior to stand establishment will be available in future years.

Soil Testing for Alfalfa

It is difficult to generalize about the location and occurrence of specific nutrient deficiencies. Soils are inherently variable due to geologic processes and historic crop yields and nutrient applications. Some irrigation water sources also add nutrients to soil. For these reasons, soil testing is necessary to determine which nutrients are needed and in what amounts. Soil testing also provides important information on soil pH, salinity, and other conditions that may influence alfalfa growth. Common sampling depths for alfalfa are the surface 0–6 inches for lime requirements and 0–12 inches for most nutrients and soil pH. See the reference section at the end of this guide for information on where to send soil samples for analysis (Daniels 2005).

If a field will be fertilized as one unit, collect a minimum of 20 soil cores from representative locations throughout the field and combine these for the sample. This composite sampling technique provides a field average measure of soil properties. (If you are concerned about unusual or unrepresentative areas, collect cores from these separately and clearly distinguish via labeling.)

An alternative sampling approach is to divide a field into management units based on knowledge of variability in soil properties and yield potential. However, this approach is only warranted if you have the ability to manage units within a field separately. For example, you could separate a field into 2–3 management units based on slope, drainage, and/or soil type. Sample each management unit separately by collecting cores from several locations within the unit. Fertilize each unit according to the soil test results.

Additional information on soil sampling strategies can be found in publications listed at the end of this guide (Staben et al. 2003, Summers and Putnam 2008).

When possible, incorporate fertilizer into the surface 3–5 inches of soil with light tillage prior to establishing a new stand so that phosphorus will still be available to the plant when the soil surface dries.

Table 2. Interpretations of tissue tests for nutrient concentrations in alfalfa sampled at first bloom^{1,2}.

Nutrient	Critical concentration for sufficiency	Concentration including excess
Nitrogen (N)	3–4% 4–5%	
Phosphorus (P)	0.20–0.25% 0.25–0.35%	
Potassium (K)	2.0–2.5% 2.5–3.5%	above 3% ³ above 4%
Sulfur (S)	0.20–0.25% 0.25–0.30%	
Boron (B)	20 ppm 20–40 ppm	above 200 ⁴ above 200
Manganese (Mn)	15 ppm 30–50 ppm	125–250
Iron (Fe)	40 ppm 40–100 ppm	
Zinc (Zn)	12 ppm 20–70 ppm	
Copper (Cu)	5 ppm 5–25 ppm	
Molybdenum (Mo)	0.8 ppm ⁵ 1–5 ppm ⁵	above 10 ⁶ above 10

¹Correct insufficiencies in a manner similar to correcting low soil test results for these nutrients.

²The first concentration listed per nutrient corresponds to the whole plant top, while the second corresponds to the top 1/3 of the plant.

³Excess potassium may aggravate milk fever in “close-up” cows, hyperkalemic periodic paralysis in genetically susceptible horses, and winter tetany in beef cows.

⁴Tissue concentrations of boron above this level indicate plant toxicity, which may reduce yield.

⁵When a molybdenum tissue test indicates deficiency, this nutrient can be applied as a seed treatment at a maximum rate of 1 oz/acre or broadcast at 1–2 oz/acre.

⁶High molybdenum may cause secondary copper deficiency in ruminants. The ratio of copper to molybdenum should be above 2.

Supplemental applications of phosphorus made to established stands should be based on soil and/or tissue tests. Broadcast applications of dry phosphorus fertilizers are most effective when made in the fall or early spring to allow time for the phosphorus to dissolve before active growth begins. In furrow-irrigated systems, fall application of phosphorus is more important if dry forms are used since winter moisture is necessary to dissolve fertilizer pellets stranded on the beds. Fluid phosphorus forms are preferred for in-season applications to actively growing stands.

Tissue Testing for Alfalfa

Tissue testing is an effective way to directly monitor the nutrient status of alfalfa and diagnose nutrient-related problems. For certain elements like molybdenum where no soil test is available, tissue testing is the only way to accurately determine whether the nutrient is present in sufficient quantities that yield quality alfalfa.

Diagnosis of a nutrient deficiency with tissue testing may necessitate subsequent soil testing since insufficient databases exist from which to develop fertilizer recommendations based on tissue tests alone. One good source to check for tissue test-based fertilizer recommendation information is Summers and Putnam 2008.

Both growth stage and plant parts are important when sampling alfalfa tissue (Table 2). Gather sample tissues by removing the appropriate plant part at first bloom in 10 locations throughout a field, and then combine. Keep tissue samples cool and transport them to a testing lab as soon as possible (Daniels 2005). When you get the results, compare the tissue nutrient levels to the critical values given in Table 2 to determine if your alfalfa's nutrient concentrations are sufficient.

Another way to diagnose nutrient deficiencies in your alfalfa is to collect paired tissue samples where one composite sample is from a good section of a field and another, separate composite is from a problem area. Clearly label each composite and send to a lab. Compare the findings for the problem area with the critical levels in Table 2 as well as what the lab found for both the good and problem areas to identify major differences.

Fluids can be applied through an irrigation system (fertigation), in surface bands spaced 12 inches or less apart with stream nozzles, or sprayed uniformly on fields using a fan nozzle.

Several high analysis (high P_2O_5 concentration) sources of phosphorus fertilizer are available, including dry triple superphosphate (0-45-0; 45% P_2O_5 by weight), monoammonium

phosphate (11-52-0; 52% P_2O_5 by weight), diammonium phosphate (18-46-0; 46% P_2O_5 by weight), fluid ammonium polyphosphate (10-34-0 or 11-37-0, 34 or 37% P_2O_5 concentrations on a weight basis), and phosphoric acids (various P_2O_5 concentrations). High analysis forms are typically the least expensive fertilizers per unit of phosphorus. Other, lower analysis phosphorus fertilizers are available such as 16-20-0-13S (20% P_2O_5), but the extra cost for nitrogen in the material is often not warranted and the sulfur concentration is too high to make this a practical phosphorus fertilizer source. Numerous comparisons indicate that when topdressed at the same rate of P_2O_5 , the fertilizer sources mentioned above are equally effective. Therefore, it is most economical to select a phosphorus source based on local availability, ease of application, and cost per unit of P_2O_5 . Rock phosphate is insoluble and is not recommended as a source of phosphorus for alfalfa.

Potassium (K)

After phosphorus, potassium is often the second most limiting nutrient in alfalfa production. Moderate potassium deficiencies can limit yields and reduce stand life. Visual symptoms (Figure 2) are easy to recognize but may not become apparent until deficiencies are severe enough to significantly reduce yield and shorten stand life.

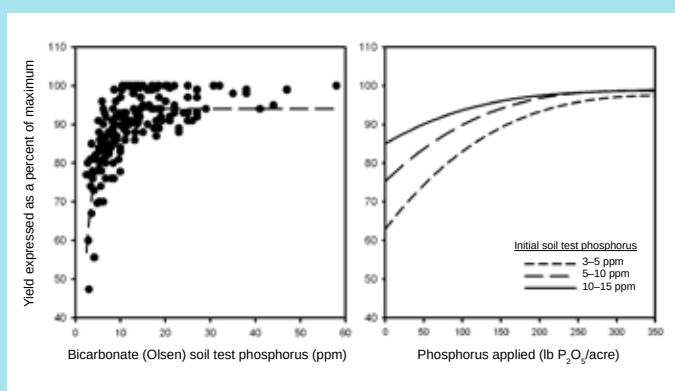


Figure 2. Potassium deficiency in alfalfa is represented by necrotic spots on the outer margins of young leaves and thin, declining stands.

Predicting Alfalfa Responses to Phosphorus Fertilizer

Soil test interpretations and fertilizer recommendations are based in part on the probability of obtaining a yield response to fertilizer application as well as the magnitude of that yield response. The probability and magnitude of a response are generally higher when initial soil test values are lower; however, both depend on many other factors that influence yield, including water availability, stand quality, and pest pressures.

The graph below and to the left illustrates an example of relative alfalfa yields at soil test phosphorus levels using the Olsen (sodium bicarbonate) extraction procedure. Relative yield is used here in order to combine data from a large number of studies and identify trends. According to the lefthand graph, yield approaches 95% of the maximum for most locations when the Olsen soil test for phosphorus results in 15 ppm. The graph below and to the right shows an example of relative alfalfa yield responses to phosphorus fertilizer application when the initial soil test is very low (3–5 ppm), low (5–10 ppm), or moderate (10–15 ppm). As expected, the yield response is greatest and the most fertilizer phosphorus is required to reach maximum yield when the initial soil test indicates phosphorus is very low.



Data from Koenig et al. 1999

The phosphorus fertilizer recommendations summarized in Table 3 are based on initial soil test values and yield potentials for irrigated and dryland production situations. There is some uncertainty in developing these recommendations since individual soil types vary in their ability to supply phosphorus and yield is influenced annually by more factors than just the soil test level. However, attempts to further refine fertilizer recommendations are not justified given the uncertainty and variability in yield responses to soil test phosphorus levels and fertilizer rates. Growers are encouraged to use the recommendations in this document as a guide as well as monitor their alfalfa yields and soil and plant tissue concentrations to evaluate the success of their fertilizer programs.

Alfalfa removes large quantities of potassium from soil (Table 1). In areas with a long history of alfalfa production, soil potassium reserves are commonly depleted. Soil testing is a reliable way to diagnose potassium deficiency before it causes significant yield reductions. The standard sampling depth for potassium is 0–12 inches. Samples should be collected in late fall or early spring when alfalfa is dormant. Soil samples collected in-season will have lower test levels as a result of active absorption by growing plants and the relatively slow release of plant-available

potassium from soil minerals. Tissue sampling can be used to diagnose potassium deficiencies in-season. In areas with a history of potassium deficiency, soil or tissue sampling for potassium should be done annually to monitor nutrient levels.

Potassium recommendations based on soil test results are summarized in Table 4. Alfalfa will absorb more potassium than it needs for optimum yields. This tendency for “luxury consumption” may result in the harvest of

Table 3. Soil test-based phosphorus fertilizer recommendations for irrigated and dryland alfalfa.*Table 3a. Per acre recommendations based on P soil testing.*

Soil test for phosphorus ¹		P ₂ O ₅ ² recommendation	
Olsen (bicarbonate) method	Morgan (acetate) method	Irrigated	Dryland
—mg/kg of soil or ppm—		—lb P ₂ O ₅ /acre ³ —	
0–5 ⁴	0–3 ⁴	150–200	50–75
5–10	3–4	100–150	25–50
10–15	4–5	50–100	0–25
15–20	5–6	0–50	0
above 20	above 6	0	0

Table 3b. Per ton recommendations based on yield expectations and P soil testing.

Soil test for phosphorus ¹		P ₂ O ₅ ² recommendation	
Olsen (bicarbonate) method	Morgan (acetate) method	Irrigated	Dryland
—mg/kg of soil or ppm—		—lb P ₂ O ₅ /acre ³ —	
0–5 ⁴	0–3 ⁴	20–30	15–20
5–10	3–4	15–20	10–15
10–15	4–5	8–15	0–10
15–20	5–6	0–8	0
above 20	above 6	0	0

¹Soil testing for phosphorus is based on a 0–12-inch sample depth. Olsen is the preferred extract method. While some labs use Morgan, it is the least reliable extract method and should be avoided. Interpretations are given here only because some testing labs still use the Morgan procedure. In southern Idaho, soil lime content is also included in the interpretation of an Olsen soil test for phosphorus (Stark et al. 2002).

²Fertilizer labels are expressed in % P₂O₅. To convert P₂O₅ to P, multiply by 0.44.

³Recommendations in Table 3a assume a 6–8 ton/acre yield for irrigated and a 2–3 ton/acre yield for dryland alfalfa.

⁴Low soil test levels severely limit yield. Test soil and apply phosphate annually until levels are adequate.

Table 4. Soil test-based potassium fertilizer recommendations for irrigated and dryland alfalfa.*Table 4a. Per acre recommendations based on K soil testing³.*

Soil test for potassium		K ₂ O recommendation ²	
Olsen (sodium bicarbonate), Morgan (acetate), or equivalent exchangeable method ¹		Irrigated	Dryland
—mg/kg of soil or ppm—		—lb K ₂ O/acre ³ —	
0–50 ⁴		200–300 ⁵	50–100
50–100		100–200	0–50
100–150		50–100	0
150–200		0–50	0
above 200		0	0

Table 4b. Per ton recommendations based on yield expectations and K soil testing.

Soil test for potassium		K ₂ O recommendation ²	
Olsen (sodium bicarbonate), Morgan (acetate), or equivalent exchangeable method ¹		Irrigated	Dryland
—mg/kg of soil or ppm—		—lb K ₂ O/acre ³ —	
0–50 ⁴		30–40 ⁵	20–30
50–100		15–25	0–20
100–150		10–15	0
150–200		0–5	0
above 200		0	0

¹Soil testing for potassium is based on a 0–12-inch sample depth. These 2 extract methods are commonly used for potassium. Both are accurate across a range of soil conditions and the results and interpretations are identical.

²Fertilizer labels are expressed in % K₂O. To convert K₂O to K, multiply K₂O by 0.83.

³Recommendations in Table 4a assume a 6–8 ton/acre yield for irrigated and a 2–3 ton/acre yield for dryland alfalfa.

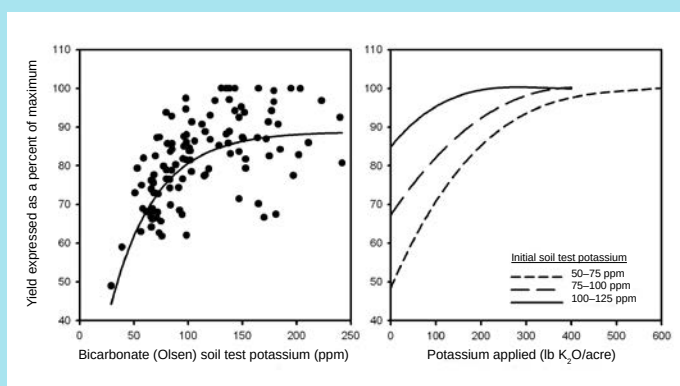
⁴Low soil test levels severely limit yield. Test soil and apply potash annually until levels are adequate.

⁵Split K₂O applications by applying 50% in early spring and 50% after the second cutting.

Predicting Alfalfa Responses to Potassium Fertilizer

Similar to phosphorus, potassium fertilizer recommendations at a given soil test level are based in part on the probability of obtaining a yield response and the magnitude of that response. The graph below and to the left illustrates an example of relative alfalfa yield at a soil test potassium level using Olsen (sodium bicarbonate) or acetate extract procedures. Again, relative yield is used in order to combine data from a large number of studies and identify trends. The relationship is not as clear as for phosphorus. Yield approaches 90% of the maximum for most locations when soil test potassium is 150 ppm.

The graph below and to the right shows an example of relative alfalfa yield responses to potassium fertilizer application when an initial soil test result is very low (50–75 ppm), low (75–100 ppm), or moderate (100–125 ppm). As with phosphorus, the lower the level of potassium an initial soil test indicates, the greater the yield response will be but more fertilizer potassium required to reach maximum yield.



Data from Koenig et al. 2001

high potassium hay and accelerated removal of potassium from soil. For this reason, large applications to meet multiple years of potassium needs are not recommended; annual applications above 200 lb K₂O/acre should be split between early spring and mid-season dates.

Several high analysis sources of potassium fertilizer are available, including dry potassium chloride (0-0-60; 60% K₂O by weight), potassium sulfate (0-0-50-18S; 50% K₂O by weight), and potassium-magnesium sulfate (0-0-22-18S, 22% K₂O by weight). Fluid forms of potassium fertilizer also exist, but these contain less potassium per pound and are commonly more expensive than dry sources. High analysis (high K₂O concentration) forms are typically the least expensive fertilizers per unit of potassium. As with phosphorus, multiple comparisons indicate that when

applied at the same rate of K₂O, the materials mentioned above are equally effective.

Therefore, it is most economical to select a potassium source based on local availability, ease of application, and cost per unit of K₂O. Irrigation water may also contain potassium; to estimate, analyze a sample of irrigation water and multiply the parts per million of potassium by 3.28 to convert to pounds of K₂O per acre-foot of water.

Sulfur (S)

Sulfur deficiency in alfalfa is common in areas with high rainfall, as well as sandy soils and when irrigation water with low sulfur concentrations is used. The effects of sulfur deficiency (Figure 3) resemble those of nitrogen deficiency, except that sulfur deficiency symptoms appear on the newest foliage first. A



Figure 3. Symptoms of sulfur deficiency in alfalfa include short plants, thin stands, and light green color. The main photo shows a sulfur Z-strip applied to a sulfur-deficient field of alfalfa. The inset photo illustrates alfalfa that is sulfur-deficient (right) and sulfur-fertilized (left).

deficiency in sulfur for alfalfa results in reduced yield, crude protein content, and feed value.

The soil test for sulfur is somewhat unreliable due to the mobility of the plant-available form of sulfur (sulfate) and inability of the soil test to estimate sulfur release from soil organic matter. Most soil tests report sulfur in the sulfate ($\text{SO}_4\text{-S}$) form. Interpretations of sulfate-sulfur soil test values are summarized in Table 5. Tissue testing can also be used to monitor the sulfur status of alfalfa. Irrigation water from return flows and certain groundwater wells may contain substantial sulfur, so analysis of these sources may be warranted. To estimate this contribution, multiply parts per million sulfate-sulfur ($\text{SO}_4\text{-S}$) in irrigation water by 2.72 to convert to pounds of sulfur per acre-foot of water applied.

Common sources of dry sulfur fertilizer include ammonium sulfate (21-0-0-24S; 24% sulfur), potassium sulfate (0-0-50-18S; 18% sulfur), potassium-magnesium sulfate (0-0-22-18S, 18% S), gypsum (0-0-0-17S, 17% sulfur), and elemental sulfur (0-0-0-90S; 90% sulfur). Fluids such as potassium thiosulfate (0-0-25-17S, 17% S), potassium polysulfide (0-0-22-23S, 23% S), ammonium thiosulfate (12-0-0-26S, 26% S), and ammonium polysulfide (20-0-0-40S, 40% S) are also available. Many of these fluids can be mixed with irrigation water and applied in-season. Undiluted fluid forms of sulfur will

burn tissue if applied to actively growing alfalfa, but are generally safe when applied to dormant alfalfa.

Micronutrients

Zinc, molybdenum, and boron deficiencies occur relatively frequently in alfalfa. Zinc deficiency is more common in high pH soils. Molybdenum and boron deficiencies are more common in high rainfall areas with low pH soils. Soil or tissue testing can be used as a guide to zinc and boron deficiencies, although the boron test has not proven reliable. Copper and manganese deficiencies are very rare in alfalfa. Micronutrient soil (Table 6) or tissue testing can be used to determine if copper fertilization is necessary. Manganese deficiency should be diagnosed with a tissue test. There is no soil test for molybdenum, so it is best to rely on tissue testing to diagnose a deficiency. A very small amount of cobalt is needed for nitrogen fixation; however, there is no evidence that cobalt deficiency is a problem and no soil tests or critical tissue values for alfalfa are available.

Sources of zinc, iron, copper, and manganese include metal salts and oxides (e.g., zinc sulfate or zinc oxide) and chelated forms. Chelated forms are more available to alfalfa than salts or oxides and can generally be applied at lower rates to correct deficiencies. However, chelated forms cost more than salts or oxides. Sodium

Table 5. Soil test-based sulfur fertilizer recommendations for irrigated and dryland alfalfa.*Table 5a. Per acre recommendations based on S soil testing.*

Soil test for sulfur in the sulfate form (SO ₄ -S) ¹		Sulfur recommendation	
		Irrigated	Dryland
mg/kg of soil or ppm	—lb/acre—	—lb sulfate or sulfide-sulfur/acre ^{2,3} —	
0–5	0–20	25–35	10–20
5–10	20–40	15–25	0–10
10–15	40–60	10–15	0
above 15	above 60	0	0

Table 5b. Per ton recommendations based on yield expectations and S soil testing.

Soil test for sulfur in the sulfate form (SO ₄ -S) ¹		Sulfur recommendation	
		Irrigated	Dryland
mg/kg of soil or ppm	—lb/acre—	lb sulfate or sulfide-sulfur/ton of expected yield ²	
0–5	0–20	3–5	2–4
5–10	20–40	2–3	0–2
10–15	40–60	0–2	0
above 15	above 60	0	0

¹Soil testing for sulfur is based on a 0–12-inch sample depth. Various extract methods are used for sulfur, but the results and interpretations are identical. All soil test sulfur methods are subject to limitations described in the sulfur section of the text.

²Sulfate- and sulfide-sulfur forms are rapidly available to the plant and should be used to correct a deficiency. Combining these recommendations with 50–100 lb of elemental sulfur (0-0-0-90 S, a slow release form) will provide sufficient sulfur for the current year of production plus an additional 10–20 tons of hay production over the next 2–3 years.

³These recommendations assume 6–8 ton/acre yield for irrigated and a 2–3 ton/acre yield for dryland alfalfa.

Table 6. Micronutrient soil test concentrations, interpretations, and recommendations for alfalfa¹.

Micronutrient	Low	Marginal	Adequate
	soil test concentration in mg/kg or ppm ²		
Zinc	below 0.8	0.8–1.0	above 1.0
Copper	below 0.2	—	above 0.2
Manganese	Rely on tissue testing to diagnose a deficiency.		
Molybdenum	Rely on tissue testing to diagnose a deficiency.		
Boron (coarse-textured soils) ³	below 0.2	0.3–0.4	0.5–1.0
Boron (fine-textured soils) ⁴	below 0.3	0.4–0.8	0.9–1.5
Recommendation	Apply 10 lb of zinc and 2 lb of copper or boron.	Apply 5 lb of zinc and 1 lb of copper or boron.	NA

¹Soil test levels are based on a 0–12-inch sample depth.

²The soil test extraction method for zinc and copper is abbreviated DTPA (Diethylene triamine pentaacetic acid). Boron is extracted with hot water.

³sand, loamy sand, sandy loam

⁴loam, silt loam, clay loam, clay

or calcium salts of boron and molybdenum are highly soluble and available to plants.

Additional considerations

Fertigation

Application of liquid fertilizers via irrigation is an efficient and convenient way to supply nutrients to alfalfa, including during the growing season. Liquid sources of phosphorus, potassium, sulfur, and micronutrients are available. It is important to carefully compare the cost and convenience of using liquid sources vs. dry fertilizer materials. Also understand that some fluid fertilizer sources can precipitate in irrigation lines and plug orifices, while others are corrosive. Seek advice from your fertilizer and irrigation system dealers on injecting specific chemicals into your system.

Manure and alfalfa

Livestock manures contain large quantities of phosphorus and potassium, and smaller amounts of all other nutrients alfalfa requires.

When applied to grain or other crops in a rotation, manure is an efficient way to build soil nutrient levels before reestablishing alfalfa. Manure can also be applied to dormant alfalfa, but may increase weed problems in established alfalfa stands by supplying weed seeds and high rates of nitrogen that stimulate grassy weed growth.

Potassium and animal health

The high potassium content of alfalfa hay is related to milk fever in dairy cows and hyperkalemic periodic paralysis in genetically susceptible horses. Potassium levels in hay can be moderated by limiting potassium fertilizer to anticipated crop use and available soil potassium as determined by soil testing. Not surprisingly, alfalfa harvested from fields known to have low soil test potassium will be lower in potassium content than hay harvested from fields with adequate soil potassium. Delaying alfalfa harvest until early to mid-bloom also reduces hay potassium content. Rain that occurs while the crop is still in the windrow causes potassium to leach from hay.

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Willamette Valley Field Crops

[Home](#) » [Cereal Grain](#)

Cereal Grain Nutrient Management

Nutrient Management In Cereal Grain Crops

Nutrient management is important for wheat production before planting and in late winter. Soil pH, phosphorus, potassium, calcium, and magnesium need to be adequate before planting. A common problem with direct seed or no-till wheat production is low soil pH in the top 2-3 inches of soil. [Stratified soil samples](#) should be taken before direct seeding. Nitrogen typically is the nutrient most limiting to wheat production. The amount of spring N to apply can be determined from a soil test when a sample is collected in late January. If consecutive crops of wheat are planted, soil pH, phosphorus, chloride, and nitrogen source changes substantially from first year wheat.

Compared to winter wheat, less nitrogen is required for barley, oats or spring wheat compared to winter wheat. For barley, use approximately 80% of the winter wheat nitrogen rate. For oats use approximately 60% of the winter wheat rate and for spring wheat, apply between 50 and 60 % of the winter wheat nitrogen rate.

CLICK ON THE FOLLOWING LINKS TO VIEW RELATED OSU EXTENSION PUBLICATIONS:

[Applying Lime to Raise Soil pH for Crop Production \(Western Oregon\), EM 9057](#)

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Monitoring Soil Nutrients Using a Management Unit Approach

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Flax

D.T. Ehrensing

History

Flax (*Linum usitatissimum* L.) is an ancient crop grown for seed and oil and for the strong fiber produced in its stems. The plant was domesticated approximately 7,000 years ago. The ancient Egyptians produced fabrics from flax including linen, which they used to wrap their dead for embalming.

Flax was introduced to North America by the earliest European settlers and has been produced in the U.S. and Canada since then. It was grown as early as 1617 in Quebec and moved across the continent with settlers in the 1800s. Flax was always one of the first crops settlers planted as they broke prairie sod throughout the upper Midwest, Great Plains, and Canadian Prairies.

Although it was once grown throughout the United States, the majority of domestic oilseed flax is currently produced in the Dakotas and Minnesota, primarily because it is a crop that matures rapidly under cool, short-season growing conditions. Large-scale production of oilseed flax still occurs in the Canadian Prairies.



Oilseed flax in bloom.

Fiber flax has been produced commercially for centuries in northern and eastern Europe, but the highest quality fiber is produced in cool coastal areas. Fiber flax was brought to Oregon in 1843, and the Willamette Valley was a major producer of high-quality flax fiber from the late 1800s until about 1960. Mechanical harvesters and improved processing machinery developed by the USDA in Corvallis in the 1940s ushered in the age of efficient mechanization for fiber flax.

Following World War II, European fiber flax growers rapidly adopted the machinery developed in the United States.

The advent of synthetic fibers in the late 1950s as well as development of easier-to-grow and more profitable crops like grass seed hastened the decline of the Oregon fiber flax industry. Belgium, France (Normandy), and the Netherlands are the primary fiber flax producing countries today.

Description

Flax is an annual herbaceous plant that can be grown as a winter annual in mild climates. Flax plants grow from 12 to 48 inches high. The flowers have five petals and form a five-celled boll that can contain up to 10 seeds. Flowering continues until plant growth stops.

Distinct varieties have been developed for oilseed and fiber flax. Oilseed flax varieties tend to be short, highly branched plants bred to maximize the number of flowers per unit area. Fiber flax varieties are tall, unbranched plants that are grown at very high density to maximize fiber production.

Although flax generally is planted as a spring crop, a few winter-hardy varieties have been developed that allow fall planting in many areas. Winter varieties tend to be intermediate between oilseed and fiber types, and may offer the opportunity to produce high oilseed yields and better quality fiber than traditional oilseed varieties.



Flax flowers.

Uses

Oilseed flax

Currently, oilseed flax is more economically important than fiber flax. Most world flax production is for linseed or flaxseed oil, flaxseed meal, and flax straw. Flax seeds are an excellent source of oil, containing from 40 to 45 percent oil.

The fatty acid profile typically found in linseed oil is shown in Table 1 (page 3). The distinguishing characteristic of linseed oil is the high linolenic acid (18:3) content (> 50%). The fatty acid composition of sunflower is shown for comparison.

Linseed oil was the only class of flaxseed oil until 1990, when low linolenic-acid flax cultivars were developed. Low linolenic-acid flax cultivars are called linola or solin flax.



Oilseed Crops

Table 1. The fatty acid content of linseed, low linolenic acid flaxseed (linola or solin), and sunflower oil.

	16:0 ^a	18:0	18:1	18:2	18:3
Oil source	----- % -----				
Linseed	5.3	3.1	16.2	14.7	59.6
Solin flax	9.5	4.6	15.6	65.3	2.1
Sunflower	6.0	4.0	16.5	72.4	0.0

^a Fatty acid profiles show the percentage of each fatty acid component in a vegetable oil. The first number in the notation at the top of each column in the profile (e.g., 18:3) indicates the number of carbon atoms in the fatty acid. The number after the colon indicates the number of double bonds in the fatty acid. Although fatty acid profiles vary somewhat from sample to sample, they are generally used to characterize vegetable oils from particular species or varieties of plants.

Industrial uses

Because it contains high levels of linolenic acid, linseed oil is highly reactive and oxidatively unstable. As a result, linseed oil goes rancid (oxidizes) more rapidly than most other seed oils. Many of the industrial uses of linseed oil, however, rely on the chemical properties of linolenic acid. Linseed oil is a drying oil, which rapidly changes to a hard, tough, elastic substance when exposed in a thin film to air. It is used in paints, resins, varnishes, printing inks, and linoleum. Linoleum is a mixture of solidified linseed oil mixed with gums and cork dust or wood flour. Although it fell out of favor for many years, linoleum production has increased recently because it is considered a “green” building material.

Historically, the straw residue from oilseed flax was considered a waste product, and most oilseed flax straw is still burned in the field. But, fiber from oilseed flax straw makes strong, high quality paper (U.S. currency, tea bags, bible paper). In Canada, oilseed flax straw is gathered to central locations, processed through a hammer mill to remove most of the woody stem core, and baled for shipment to paper mills.

Recent research has led to renewed interest in industrial uses for flax straw and fiber.

- Flax straw is a carbon-neutral fuel that burns cleanly and has the same heating value as soft coal.
- Because paper fibers lose strength each time they are recycled, adding small amounts of flax fiber to paper pulp greatly increases the strength of recycled paper.
- The automotive and aerospace industries are using flax fiber to replace fiberglass in a wide range of fiber-reinforced composites, due to its high performance and light weight. Flax fiber also takes much less energy to produce than fiberglass and is biodegradable.
- Demand for flax fiber in composites is currently growing by 50 percent per year in Europe, and American manufacturers are investigating industrial uses of flax.



Nutritional uses

Although normally thought of as an industrial oil, linseed oil is a rich source of essential fatty acids and is the richest natural source of linolenic acid, an omega-3 fatty acid that may reduce the risk of heart disease. Increasing interest in healthy lifestyles and diets has created growing markets for both conventional and organically grown flax seed and flaxseed products.

Linola or solin flax oil, due to its low 18:3 content, is more oxidatively stable than linseed oil. The fatty acid composition and chemical, physical, and storage properties of solin oil are close to those of sunflower and other important edible oils.

Flaxseed meal is a good source of dietary protein. Most flaxseed meal is fed to animals. Whole flax seeds are used in cereals, breads, and other baked foods. Flax seed is also an excellent source of soluble and insoluble dietary fiber: the dietary fiber content of flax seeds is 25 percent. Eating foods rich in soluble fibers can reduce blood serum cholesterol.

Fiber flax

Fiber flax cultivars produce long fiber (line fiber, in the trade) and short fiber (tow). Long fiber is spun and woven to produce very high-quality linen fabric. Linen is used to make fine clothing, sheets, tablecloths, and other household goods. Linen yarn is used to make the very finest lace.

Short fiber generally is blended with cotton or wool and spun into yarn to make a wide variety of apparel, upholstery, and carpet fabric. The recent development of wrinkle-free linen/cotton blends has been particularly popular because they feel cool in hot, humid climates and need no ironing.

The by-products of fiber flax processing are shives and seeds. Shives are the woody core of the flax stem separated from the fibers. In Oregon flax mills, shives were burned to heat the water. Since the 1950s, shives have been used to make strong, lightweight particleboard panels in Europe. Shives are also extremely absorbent and can be used as animal bedding or to absorb liquid spills.



Fiber flax stems after high-density planting.

Adaptation

Climate

Oilseed flax is widely adapted to a broad range of soil and environmental conditions. Cool temperatures after flowering tend to increase oil (particularly linolenic acid) content. As a result, flax oil yield and quality are generally better in higher latitudes.



Oilseed Crops

Fiber flax also will grow in many environments; however, cool weather conditions during crop development are essential to produce high-quality fiber. The best quality flax fiber generally comes from temperate regions (near 45° latitude) with a strong coastal climatic influence.

Soil

Flax generally does best on well-drained soils with good water-holding capacity, such as silt-loams and clay loams. Flax does not tolerate poorly drained soils well. Surface crusting on heavy soils can retard germination and interfere with good crop establishment. Do not plant flax on sandy soils unless plenty of moisture is available.

Cultural practices

Most flax varieties are spring planted. Flax is cold-hardy to about 25°F, and frost damage has rarely been a problem with spring seeding.

Because flax will germinate and grow under relatively cool conditions, winter flax can be planted later in the fall than other oilseed crops. In dry fall planting conditions, this may be a significant advantage over crops like canola that are more sensitive to planting date.

Fiber flax typically is sown from mid-February through mid-April in Oregon.

Seedbed preparation

Under conventional tillage, flax should be sown in a firm, moist seedbed. A clean, firm, smooth seedbed is vital for flax production, especially fiber flax.

With the development of effective herbicide programs, direct seeding has become viable for oilseed flax. In Canada, direct seeding improves both yield and water use efficiency in flax production compared to conventional tillage.

Seeding rate

Seeding rates and optimum stand densities for oilseed and fiber flax differ greatly. Oilseed flax typically is planted at a rate of 30 to 40 lb of seed per acre. The optimum stand density for oilseed flax is about 30 plants per square foot.



Flax seed.



Fiber flax seed normally is planted at 100 to 150 lb/acre, depending on seed size and germination rate. The optimum stand densities for fiber flax are 175 to 200 plants per square foot. Fiber flax seeding rates are commonly adjusted to take into account 1,000-seed weight and germination rate of each seed lot.

Seeding depth

Plant flax seed shallow, in the range of ½ to 1½ inches deep.

Row spacing

Use conventional grain drills to plant oilseed flax in rows 6 to 8 inches apart. Use press wheels or some other mechanism to firm the soil over the seed behind the planter.

To increase plant density, plant fiber flax using a unique planter and technique known as underground broadcasting. V-shaped planter shoes are pulled through the soil just below the soil surface while spreader plates randomly distribute the seed underground. The result is bands of uniformly distributed seed placed at uniform depth and at high seed density.

Variety selection

Most oilseed flax varieties that are readily available in the United States were developed at North Dakota State University or in Canada. Performance information for many varieties is available at <http://www.ag.ndsu.edu/pubs/plantsci/smgrains/a1049-10.htm>. Agronomic descriptions of North Dakota State University varieties are available at <http://www.ag.ndsu.nodak.edu/aginfo/seedstock/varieties/VA-FLAX.htm>.

Solin oilseed flax varieties were developed in Canada. They are not currently available in the United States.

Many excellent fiber flax varieties were developed in Oregon in the mid-1900s, but modern European fiber flax varieties have much higher fiber content (approximately 30 percent vs. 15 percent). They also are more disease- and lodging-resistant than earlier varieties.

Fertilizer

Nitrogen

Oilseed flax responds well to moderate nitrogen application. Excess nitrogen application stimulates vegetative growth and increases disease susceptibility and lodging. Eighty pounds of N per acre is the maximum amount normally applied. Most recommendations subtract available



soil-test nitrate-N and N available from previous crops from the base rate of 80 lb N/acre to arrive at an application rate.

Fiber flax has a moderate to low requirement for nitrogen and is prone to lodging at high nitrogen rates. Once lodged, fiber flax is extremely difficult to harvest. Traditional fiber varieties such as 'Cascade' were grown with a maximum of 40 lb/acre of available nitrogen. Newer European varieties use 70 to 75 lb/acre of available nitrogen, and growers rarely apply more than 50 lb/acre of nitrogen.

Phosphorus and potassium

Phosphorus and potassium applications are not generally made for flax except in cases of extreme soil deficiency.

Zinc

Flax is sensitive to zinc deficiency, and applications of zinc sulfate are common in Europe. Zinc-deficient plants are chlorotic, and the primary terminal bud may die. Liming prior to planting a flax crop appears to increase problems with zinc deficiency. No zinc deficiency symptoms in fiber flax have been reported in Oregon.

Weed control

Oilseed flax is a relatively poor competitor with weeds, especially when planted on wider row spacing. There is a wide variety of herbicides that can provide effective control of both grass and broadleaf weeds; however, many are registered for use only in Canada.

Although high-density fiber flax is quite competitive, weed control is very important during its early development. Several herbicides currently registered for use on oilseed flax in the U.S. can also be used in fiber flax production. MCPA causes rapid curling to the tips of the flax stems, but the plants will recover within a few days.

Pest management

Diseases

The most serious fungal diseases of flax are Fusarium wilt (*Fusarium oxysporum* f. sp. *lini*), flax rust (*Melampsora lini*), and pasmo (*Septoria linicola*). While these were extremely serious diseases in the past, careful use of crop rotation and the development of varieties resistant to Fusarium and rust have greatly reduced the impact of plant diseases in flax production.

Treat flax seed with fungicides to help control seedling diseases.

Insects

Insect pests are rarely a problem in flax production. The most widely cited insect pests of flax are cutworms, wireworms, aphids, grasshoppers, aster leafhopper, tarnished plant bug, and beet webworm. Most can be



controlled or reduced using cultural practices, insecticides, and crop rotation.

Harvest

Oilseed flax

Modern oilseed flax varieties have very little seed shattering and can be harvested by direct combining or by swathing and field drying before threshing with a combine. Swathing is commonly used in Canada to ensure uniform drying of fields with uneven maturity or weed control problems. To enhance drying when swathing flax, leave 4 to 6 inches of stubble to keep the windrow off the ground. Mature oilseed flax straw is readily cut with a sickle bar; however, immature flax is very difficult to cut and can rapidly dull a sickle bar.

Flax seed moisture must be 10 percent or less before storing seed.

Fiber flax

Fiber flax is harvested by pulling rather than cutting. Specialized machinery uses rubber belts that pull and then lay the crop down in windrows with the stems oriented perpendicular to the swath.

Depending on variety and weather conditions, flax is ready for pulling 85 to 100 days after planting. Pull the crop when about $\frac{2}{3}$ of the leaves have fallen and the stems are $\frac{1}{2}$ to $\frac{2}{3}$ yellowed. At this point, the seeds are still somewhat immature, but fiber quality is highest.

Following pulling, fiber flax must be retted to allow clean separation of the fiber from the stems. Retting is the microbial breakdown of pectins that bind the fiber bundles together within the flax stems, allowing easy mechanical separation of the fibers. Retting requires adequate moisture and temperatures high enough for microbial activity. The key to producing high-quality fiber is to halt the retting process before the continued breakdown of cellulose weakens the fibers.

Most of the fiber flax produced today is field retted. Previously, both European and Oregon flax was retted by submerging flax bundles in tanks of water over several days or weeks. Since World War II, most European production has moved toward field retting to save cost and avoid problems of water pollution.

To do field retting, lay the pulled flax in windrows behind the puller, exposing the flax to dew and rain. Depending on temperature and moisture, retting usually takes 2 to 4 weeks under good conditions. Be sure to turn the windrows to expose both sides to moisture and promote uniform retting. Specialized, self-propelled machines turn flax at about 1.6 acres per hour. You may need to turn windrows two or three times depending on weather conditions.



Bale dry, retted flax straw for storage and processing using modified round balers that insert strands of baling twine between each layer of flax. Round bales allow the windrows to be unrolled into the processing machinery as a continuous ribbon, greatly reducing hand labor.

Moisture content of flax straw should not exceed 16 percent. If flax bales become wet, the retting process will continue, usually degrading fiber quality.

Yield

Dryland spring oilseed flax with adequate moisture can yield 2,000 to 3,000 lb of seed per acre. Winter oilseed flaxseed yield without irrigation usually ranges from 1,800 to 2,400 lb/acre.

Total biomass yield (seed and stems) after field retting of fiber flax averages about 6,000 lb/acre in the Willamette Valley. Approximately 30 percent (2,000 lb/acre) can be extracted as useful fiber, and about 15 percent (900 lb/acre) is seed. The remaining biomass is mostly shives, unrecoverable fiber, and chaff.

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Published February 2008



[Skip to content](#)



Lentil – Fertility

Fertility Management

TILLAGE	• Less tillage means slower breakdown of crop residues, such as straw and chaff, as well as soil organic matter.
DIRECT SEEDING	• Nitrogen contained in crop residue is tied up for a longer time in a direct seeding system and is less available to plants. If the lentil crop is properly inoculated, however, this should not pose a problem.
SPRING BANDING	• Spring banding is the most efficient method of applying fertilizer – banding fertilizer in a lentil crop is better than broadcasting, since less fertilizer will be available for weed growth, especially if the fertilizer is placed close to the seed.
SEED PLACEMENT	• Never sacrifice seed placement for fertilizer placement – proper seeding depth and soil-to-seed contact is critical. • In heavy clay soils, seed and fertilizer separation may be reduced due to soil lumping. • High seeding speeds may affect seed and fertilizer separation by collapsing the banding trenches. • Too much seed-placed fertilizer can hurt crop emergence, cause severe crop damage and/or increased days to maturity. • Studies on seed-placed phosphorus using double disc openers suggest a maximum of 30 lb./acre of P2 O5. • Soil moisture conditions, row width and width of spread, soil texture and fertilizer type dictate what rate of fertilizer can be safely placed with the seed (higher moisture levels allow for more seed-placed fertilizer). • Row width and width of spread of the seeding tool determines the Seedbed Utilization (SBU) or how fertilizer is scattered in relation to the seed – wider row spacings lead to reduced seedling emergence and yield loss (the same holds true for narrow spread patterns). • The higher the percentage of Seedbed Utilization (SBU), the more fertilizer may be placed with the seed.

Fertility Requirements

AMOUNT REQUIRED

- Understanding the fertilizer requirements of lentil is critical to reaching optimal yields. The crop will respond to added fertilizer nutrients when soil test level is low to medium. It is always best to soil test as an aid in developing a sound fertilizer management program.

NITROGEN (N)

- Lentils can derive up to 80% of its nitrogen requirements through nitrogen fixation. The remaining nitrogen comes from the soil (available at time of seed plus mineralized during growing season).
- As the supply of nitrogen from soil and fertilizer increases, the amount of nitrogen fixed by the plant decreases.
- Nitrogen is necessary for high yields, but generally nitrogen fertilizer application is not required for lentil.
- N starvation may occur during and immediately following emergence. Lentil plants begin root nodule formation about two weeks after plant emergence. During this period, plants may turn pale green, called the "period of N starvation" and it is normal. With proper inoculation, nodules will soon start to function and eliminate this problem.
- Where combined levels of soil and fertilizer nitrogen reach 28 to 40 kilograms per hectare (kg/ha) or 25 to 35 pounds per acre (lb/ac), development of nodules and nitrogen fixation may be delayed. Combined soil and fertilizer nitrogen levels greater than 55 kg/ha (50 lb/ac) can prevent effective nodulation and nitrogen fixation.
- It can take three up to four weeks following planting for nodules to become functional.
- Early plant growth may be poor in soils with nitrogen levels less than 11 kg/ha (lb/ac), causing plants to appear yellow prior to the onset of active nitrogen fixation due to nitrogen deficiency. This early deficiency can be corrected by adding low levels (10 to 15 kg/ha) of starter nitrogen at seeding.
- Although high levels of starter nitrogen may appear to help the crop overcome nitrogen deficiency during early crop growth stages, final seed yields may not increase. Typical application levels of monoammonium phosphate (ex. 12-5) often provide the small amount of nitrogen needed for early plant growth and depending on the soil test, may provide the starter nitrogen required.
- If called for, N should never be seed placed. Instead, applications before seed (or side-banding where there is separation of the seed and N band) are recommended.
- Yellowing of a lentil crop may also be due to flooding, which deprives roots of needed oxygen (these conditions, if they persist, will also cause inoculant failure). Yellowing may also be a condition of seedling root rot.
- Soils with high N content prior to planting will inhibit nodule formation and are unsuitable for lentil production.
- Mid-season N applications are normally not recommended. An exception would be under conditions of failed inoculation and obvious N deficiency.
- Too much soil N reduces yield by encouraging rank plant growth and delaying maturity.

PHOSPHORUS (P₂O₅)	• Lentils have a relatively high requirement for phosphorus. • Phosphorus promotes the development of extensive root systems and vigorous seedlings. Encouraging vigorous root growth is an important step in promoting good nodule development. • Phosphorus also plays an important role in the nitrogen fixing process and in promoting earlier, more uniform maturity. • Lentils grown on soils testing low in available phosphorus or under cool wet conditions may respond to phosphate fertilizer. However, dramatic yield responses are not always achieved. Even if seed yield increases are not achieved every year, a lentil crop may benefit from improved stress tolerance as a result of phosphorus application. • The maximum safe rate of actual phosphate applied with the seed is 22 kg/ha (10 lb/ac) with 10% to 15% seedbed utilization (SBU) under good to excellent moisture conditions. • Calculate SBU by dividing seed spread by row spacing. For e.g. a 2.5 cm (1 in) seed spread with 25.4 cm (10 in) row spacing, equates to 1/10 or 10% SBU. Rates of seed-placed phosphate should be reduced if less than ideal moisture conditions exist. • Higher rates of phosphate fertilizer placed in the seed row with narrow openers like discs or knives can damage the emerging seedling and reduce the stand. • If higher phosphate rates are required, band the fertilizer away from the seed (sideband or to the side and below), or increase phosphate levels in the year prior to growing lentils. • Lentil is moderately tolerant to seed-placed phosphate. Up to 15 lb. of P₂O₅ per acre may be safely applied with the seed. • Even though seed yield may not be increased every year in response to phosphorus fertilizer, the crop may still benefit from earlier maturity. • Research has also shown that although phosphorus is a limiting factor in many Alberta soils, build-up of soil phosphorus tends to raise available soil phosphorus levels and phosphorus fertilizer responses are often not dramatic.
POTASSIUM (K₂O)	• Lentils have a high demand for potassium. • Use a soil test to determine whether additional potassium is needed. • Seed-placing potassium may cause seedling damage. As with phosphate, a narrow opener may allow for slightly higher safe seed-placed rates. • The sum of seed-placed potassium (K₂O) plus phosphate fertilizers must not exceed the recommended safe rate of phosphate mentioned previously (22 lb/ha or 20 lb/ac). • Most of the potassium taken up remains with soil residue and is not removed with the grain. • Many Alberta soils are medium to high in exchangeable potassium, often ranging from 400 to 1000 lb. of potassium/acre in the 0 inch to 6 inch depth of soil. • Potassium deficiencies are most likely to occur on sandy soils that are intensively cropped or on Grey-Black transition soils and Grey Wooded soils.
SULPHUR (S)	• Sulphur is required in a relatively significant amount. • A 30 bu/ac lentil crop requires approximately 9 to 11 kg/ha (8 to 10 lb/ac) as lentils remove about 0.2 lb/bu of sulphur. • Soils testing low in available sulphur should have this deficiency corrected by side-banding, mid-row banding, or broadcasting ammonium sulphate, which contains sulphur in a plant-available form.

	• Most research indicates limited yield response from the addition of sulphur fertilizer except in fields testing very low in sulphur. • Sulphur is normally not limited in most irrigated soil as irrigation water contains substantial amounts of sulfate-sulphur (amounts in the water vary over time) approximately 30 lb./ac. of sulfate/sulphur is added to the soil with 12 inches irrigation water. • Some soils are deficient in plant-available sulphur in the topsoil but have enough sulphur in the subsoil to meet crop requirements. • In wetter, cooler conditions, plants may suffer from a lack of sulphur before roots grow down into the subsoil containing sulphur. • Sulphur deficiencies are frequently a problem in the Black and Grey Wooded areas of Alberta and occasionally a problem in the Brown and Dark Brown soil areas. • Test soil to a depth of 24 inches to determine if sulphur fertilizer is required - analysis levels are less than 20 lb./ac., follow recommendations of the analysis report.
MICRONUTRIENTS	• Micronutrient deficiencies for lentil production have not been identified as a widespread problem through lentil growing areas of Western Canada. • Micronutrients namely boron (B), chlorine (Cl), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo) and zinc (Zn) are usually adequately supplied by most types. • If a micronutrient deficiency is suspected, it is advisable to analyze soil and plant samples within the suspect area and compare the analysis to soil and plant samples collected from a non-affected area of the same field. • If the analysis confirms a micronutrient deficiency at a relatively early growth stage, a foliar application of the appropriate micronutrient fertilizer may correct the problem.
IMPACT OF MICRONUTRIENTS ON OTHER CROPS	• Note that lentil is not grown continuously on the same land – other rotation crops such as flax, wheat, canola and barley may respond optimally to the top up levels of these minerals: ◦ The three remaining micro-nutrients – iron, manganese and molybdenum have a much more critical effect. ◦ Most Alberta soils are adequate for iron but high pH soils or alkaline soils may lock up manganese availability so that a foliar application of this micronutrient may be necessary. ◦ Molybdenum becomes much less available in acidic soils (below pH 6.5 especially at pH 5.5 or less. ◦ Molybdenum is absolutely essential in the nitrogen fixation process in legumes – without it, no nitrogen can be fixed (in Europe, producers normally apply 200 to 300 grams of actual molybdenum to the seed crop or soil every few years or lime the soil to bring up the pH and release more molybdenum). • Based on soil test results, micro-nutrient fertilizer should be applied in test soils the first year. Sandy, low organic matter may show best response. • For more information, recommended soil micronutrient levels are tabulated in fact sheet: Minerals for Plants, Animals and Man, Agdex 531-3 and Micronutrient Requirements of Crops, Agdex 531-1. (https://www1.agric.gov.ab.ca/\$department/deptdocs.nsf/all/agdex789/\$file3.pdf?OpenElement)

RESOURCES

- Intercropping Pulses with Mustard (<https://albertapulse.com/wp-content/uploads/2020/05/Intercropping-Pulses-with-Mustard.pdf>)
- Lentil Response to Soils with High Residual Nitrogen or Nitrogen Fertilizer (<https://albertapulse.com/wp-content/uploads/2020/05/Lentil-Response-to-Soils-with-High-Residual-Nitrogen-or-Nitrogen-Fertilizer.pdf>)
- Phosphorus Management for Pulses (<https://albertapulse.com/wp-content/uploads/2020/05/Phosphorus-Management-for-Pulses.pdf>)
- Safe rates of seed placed fertilizer for pulses and soybeans (<https://albertapulse.com/wp-content/uploads/2020/05/Safe-rates-of-seed-placed-fertilizer-for-pulses-and-soybeans.pdf>)

LINKS

- Phosphorus in Pulse Production (<https://harvest.usask.ca/bitstream/handle/10388/8817/J.J.%20Schoenau%2c%202016.sequence=1&isAllowed=y>)
- Phosphorus Fertilization in Crop Production (<https://www.saskatchewan.ca/business/agriculture-natural-resources-and-industry/agribusiness-farmers-and-ranchers/crops-and-irrigation/soils-fertility-and-nutrients/phosphorus-fertilization-in-crop-production>)
- Potassium Fertilization in Crop Production (<https://www.saskatchewan.ca/business/agriculture-natural-resources-and-industry/agribusiness-farmers-and-ranchers/crops-and-irrigation/soils-fertility-and-nutrients/potassium-fertilization-in-crop-production>)
- Sulphur Fertilization in Crop Production (<https://www.saskatchewan.ca/business/agriculture-natural-resources-and-industry/agribusiness-farmers-and-ranchers/crops-and-irrigation/soils-fertility-and-nutrients/sulphur-fertilization-in-crop-production>)

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Edible Mustard

D. Wysocki and M.K. Corp

History

Mustard and rapeseeds (*Brassica* sp.) are native to the temperate regions of Europe. They were among the first domesticated crops. Mustard has been cultivated for at least 4,000 years as an oil, spice, and medicinal plant. It has been cultivated not only for seed, but also as a forage, green manure, and garden crop. It was introduced into western and northern Europe in the early Middle Ages.



Mustard has been a major specialty crop in North America since the mid-1940s. Production of mustard in the Upper Midwest began in the early 1960s. Production acres in Canada peaked in the mid 1980s. Alberta, Manitoba, and Saskatchewan currently grow a large share of the world's mustard crop. In 1996, Saskatchewan harvested 470,000 acres with a yield of 425 million pounds.

Yellow, brown, and oriental mustards are grown in North America. Yellow mustard (*Brassica hirta*) comprises the majority of the acreage grown in Oregon. Brown and oriental mustards (*Brassica juncea*) are not produced currently in Oregon.

Today, people consume more than 700 million pounds of mustard worldwide each year. Yellow mustard usually is used as a condiment and as dry mustard. Brown and oriental mustards are used for oil and spices.

Don Wysocki, Extension soil scientist, CBARC; and Mary K. Corp, Extension agent, Umatilla County, Oregon State University.



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Description

Yellow mustard is a spring annual broad-leaf with a well-defined taproot. Mustard emerges rapidly (5 to 10 days) and grows quickly under favorable moisture and temperature conditions. The crop canopy covers the ground completely in about 30 days after planting. At approximately 35 to 40 days after sowing, plants begin to bud. Five to 7 days later, flowering begins. Plants reach full bloom 7 to 10 days after flower initiation.

A long bloom period (longer than 15 days) is ideal. Seed yield is related directly to length of bloom.

Varieties of yellow mustard usually mature in 80 to 85 days. Brown and oriental types require 90 to 95 days. Mature plants vary in height from 30 to 45 inches, depending on genetic potential and environmental conditions.

Conditions for growth

Climate

Mustard is a cool season crop with a short growing season. Adequate water and cool temperatures (less than 85°F) favor a long bloom period. Seedlings are tolerant of mild frosts (26 to 33°F) after emergence, but severe frosts (below 26°F) can destroy the crop.

Mustard, especially the brown and oriental types, has a drought tolerance between that of wheat and rapeseed. Moisture stress caused by hot, dry conditions during the flowering period frequently causes lower yields.

Soil

Mustard is adapted best to fertile, well-drained, loamy soils, but it can grow in variable soil types with good drainage. Soils prone to crusting prior to seedling emergence can cause problems. Avoid dry sand and dry, sandy loam soils, also.



Photo courtesy of University of Saskatchewan (<http://interactive.usask.ca/skinteractive/modules/agriculture/crops/oilseeds/mustard.html>)

Seed germination

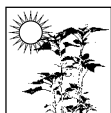
Seed will germinate at a soil temperature as low as 40°F.

Cultural practices

Small grains following mustard usually yield more than when they follow continuous small grain. Sunflower, canola, safflower, flax, dry bean, field peas, lentils, and soybean have similar diseases and insect pests to mustard. Avoid close rotation of these crops to mustard.

Seedbeds

Seedbeds for mustard are similar to those required for small grains. The soil should be firm and fairly level. Till deep enough to kill weeds, but keep soil moisture close to the



surface and leave a firm seedbed. Roll or pack the seedbed (before sowing) if the soil is loose or uneven, and also if soil moisture varies.

Sowing depth and seed placement

Seed depth depends on seedbed, soil and weather conditions, and the type of seeding equipment available. Ideally, sow mustard into firm, moist soil with a minimum of soil cover. When sowing with a disc or hoe drill, place seed 0.5 to 1 inch deep into moist soil and press over the row. Uniform placement assures even, vigorous emergence.

You can plant mustard successfully into small grain stubble provided the seed makes good contact with moist soil and is not more than 1.5 inches deep (preferably not more than 1 inch). You can use disc and hoe drills or air seeders to seed mustard, but **uniform depth control is critical** for seed placement.

Row spacing

If mustard stands are poor (less than 4 to 5 plants per square foot 10 days after planting), decide rapidly whether to replant. Uniform, competitive stands are important, as with all spring crops.

It is best to plant mustard at a 6- to 7-inch row spacing to ensure a competitive stand. You can use a row spacing up to 12 inches; however, the canopy will not close as quickly. Therefore, weed competition and evaporative water loss may be greater. Row spacing wider than 12 inches is not recommended.

Sowing rate and date

Yellow mustard has approximately 100,000 seeds per pound. Sow seed at a rate of 18 to 27 seeds per square foot. This rate is equivalent to 8 to 12 pounds per acre, depending on seed size. Research trials in Umatilla County, Oregon consistently have achieved adequate stands with 7 pounds per acre. Use higher rates where seedbed conditions are poor or emergence may be a problem.

Sow mustard when the soil temperature in the seedbed consistently exceeds 40°F. Gener-

ally, at Pendleton, Oregon, soil temperature reaches this condition about mid-March. Delayed planting can impact yield, because the flowering period is later in the season, which increases chances of late-season heat stress. Timely planting is important.

Variety selections

The contracting company has supplied the mustard seed, so growers generally have not had the option to select or purchase other varieties. Commercial varieties of yellow mustard available currently include 'Gisiba,' 'Ochre,' 'Tilney,' and 'AC Pennant.'

Fertilizer

Mustard responds to nitrogen and phosphate fertilizer in a manner similar to small grains or spring canola. As with small grains, nitrogen is used in the greatest quantities.

Yellow mustard is a new crop to eastern Oregon, and there is limited information on nitrogen fertility rates specific to the area. A North Dakota fertilizer guide (SF 718, *Fertilizing Mustard, Canola, and Crambe*) recommends 6.5 pounds N per 100 pounds of expected seed yield. Table 1 is based on the North Dakota recommendation and amended with information from fertility trials in Oregon. Oregon experience shows best response at about 8 pounds N per 100 pounds seed production expected.

A series of fertility trials conducted in northern Idaho in 1994-97 showed that a total N supply of 125 pounds per acre (both residual

Table 1. Nitrogen need based on expected mustard yield.

Expected yield lb/a	Soil N-NO ₃ + Fertilizer N lb/a
1,000	80
1,500	120
2,000	150
2,500	180

soil N and applied) was adequate for yields up to 1,500 pounds per acre. Nitrogen beyond this level delayed flowering and increased lodging in some instances (both undesirable effects).

Add phosphorus and sulfur according to the recommendations for spring wheat. Spring crops respond to these nutrients, particularly in an annual crop rotation. An application of 20 pounds P_2O_5 and 10 pounds S per acre is typically adequate. Work in Idaho showed that mustard was not responsive to higher rates of sulfur, as is canola.

Mixing low rates of dry phosphorus fertilizer (less than 100 pounds per acre 16-20-0-14) with mustard seed and planting them together has been effective. However, the combination must be mixed thoroughly and must stay well-mixed to assure uniform seeding.

Weed control

Weed control starts with clean field selection combined with shallow seeding for quick and uniform emergence to achieve a competitive stand.

Weeds have not been a serious problem in mustard production in eastern Oregon. However, cow cockle seeds are a potential contaminant in mustard. Cow cockle has a black seed approximately the same size and weight as a mustard seed. These seeds can cause cleaning losses and market grade reductions. Such losses reduce profits to the grower.

Weeds growing as an understory in a mustard crop do not reduce yield. However, they may contribute seed to perpetuate weed problems in future crops.

Mustard plants are sensitive to herbicides such as 2,4-D, Banvel, and MCPA. You must avoid spray drift. Sulfonylurea herbicides used on previous grain crops can cause emergence problems in mustard.

Insects

Insects have not caused serious problems on yellow mustard in eastern Oregon. But, as mustard acreage increases, growers should

monitor fields for potential problems. Flea beetles and diamondback moth caterpillars are the most likely insects to cause damage.

Adult flea beetles feed on cotyledons and first true leaves, causing a shotholed appearance. Severely damaged seedlings may die, while less seriously damaged plants often suffer a reduction in vigor and stamina. Hot, sunny weather is conducive to feeding activity, while cool, damp weather slows feeding and favors crop growth. Once the crop advances beyond the seedling stage, serious damage is rare, because mustard can outgrow beetle defoliation.

Diamondback moth caterpillars attain a length of 0.5 inch and are light yellow-green to green. Larvae eat leaves, flowers, and green pods and are extremely active when touched.

Aphids have been observed in some eastern Oregon fields. They have not been a problem to date.

Diseases

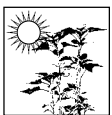
Sclerotinia stalk rot (white mold) is the only disease that has been observed on mustard in eastern Oregon. It has been observed only at low levels. However, canola, dry edible bean, crambe, and safflower have a similar problem with white mold. Do not grow mustard in short rotation with these crops, or the problem could build to economic levels.

Mustard grown in rotation with small grains is relatively free of disease. The rotation prevents serious disease problems and provides an excellent biologic break for cereal root diseases.

Harvesting

Wind, rain, and normal drying generally do not cause mustard to shatter before cutting.

Yellow mustard can be direct-combined if the field is not weedy and the crop is uniformly ripe. The harvest operation can cause some shatter if the crop is overripe or extremely dry. When direct-combining, wait until the crop is mature and dry. You can remove the reel or lift it above the crop if the stand is good. If the reel is needed, operate it at a reduced speed.



Adjust the combine so that the seeds are completely threshed while using the lowest possible cylinder speed. Set cylinder speed at approximately 600 rpm. Careful adjustment of the cylinder speed and cylinder opening is important to avoid cracking.

To test for cracking, run your hand into the threshed seed. If there is cracked mustard, pieces of the seed coat will adhere to the hair on the back of your hand. If this occurs, adjust the combine further. **Cracked seed is considered dockage and is a loss to the producer.**

You may need to vary the cylinder speed during the day as crop moisture content varies. Reduce fan speed to limit seed loss, but maintain sufficient air to ensure clean seed.

Drying and storage

Mustard harvested in eastern Oregon typically does not need drying. You may need to make some arrangements for short-term storage, on or off the farm, to coordinate delivery.

Yield potential

Mustard yields in eastern Oregon have been variable due to differences among varieties, cultural practices, and environmental conditions. Table 2 lists yields from research trials in Pendleton and Moro. Data is from the 1995-1996 growing seasons.

Economics

Production

Cash production costs for mustard are similar to growing a spring grain crop. There are no herbicides currently registered for mustards in the United States, so that is not a part of production costs. Insects have not developed as a problem to date, so insecticides also are not a production cost.

Table 2. Yield of mustard at Pendleton and Moro under fallow and recrop conditions.

	Pendleton recrop		Pendleton fallow		Moro recrop		Moro fallow		Overall avg.	
	Rank* /27	Yield lb/a	Rank /27	Yield lb/a	Rank /27	Yield lb/a	Rank /27	Yield lb/a	Rank /27	Yield lb/a
1995										
Gisiba	8	1,565	4	1,465	9	1,264	20	1,129	6	1,356
Kirby	1	1,789	1	1,712	5	1,308	1	1,480	1	1,572
Ochre	7	1,579	6	1,387	1	1,471	15	1,180	3	1,404
Tilney	27	1,347	20	1,098	27	1,077	2	1,365	21	1,222
Trial avg.		1,507		1,162		1,222		1,256		1,371
1996										
	/12	lb/a	/12	lb/a	/12	lb/a	/12	lb/a	/12	lb/a
Gisiba	2	859	3	1,148	6	579	8	1,110	4	924
Kirby	7	730	1	1,218	2	621	2	1,220	1	947
Ochre	8	684	4	1,119	7	577	9	1,047	9	857
Tilney	3	815	7	1,083	5	584	3	1,155	5	909
Trial avg.		717		1,058		563		1,075		853

* /XX indicates number of entries in trial. Entries not listed were experimental lines.

Markets

Mustard is produced as a specialty grain. Grow mustard under contract to guarantee a selling price and market. Prices have ranged from \$0.08 to \$0.18 per pound. Contract prices usually are not set until January for the following season.

Mustard grown in eastern Oregon has an early-to-market advantage, often as much as 4 weeks ahead of Canadian production areas. Eastern Oregon mustard also is noted for its excellent milling qualities.

Consumption of mustard has been steady. Growth of the mustard market is related directly to population growth.

There are a limited number of alternative markets when a surplus is produced.

For more information

OSU Extension publications

Other publications in the Dryland Cropping Systems set:
Garbanzo Beans (Chickpea), EM 8791 (2002).
Safflower, EM 8792 (2002).
Sudangrass, EM 8793 (2002).
Grain Sorghum, EM 8794 (2002).
Dryland Alfalfa, EM 8795 (2002).

These are available online at eesc.oregonstate.edu, or contact one of the following county offices:
Baker, Clackamas, Crook, Gilliam, Jefferson, Josephine, Klamath, Linn, Malheur, Marion, Morrow, Sherman, Umatilla, Union, Wallowa, Wasco, Yamhill

World Wide Web

You can access our Publications and Videos catalog and many of our publications on the Web at eesc.oregonstate.edu

Bibliography

Alternative Field Crops Manual, Mustard. 1991. E.S. Oplinger, University of Minnesota, St. Paul, MN. Extension Publication A3532.
Fertilizing Mustard, Canola, and Crambe. North Dakota State University, Fargo, ND. Extension Publication SF 718.

Seed sources

Montana Specialty Mills, P.O. Box 2208, Great Falls, MT 59403. (406) 761-2338
McKay Seeds, P.O. Box 1407, Pendleton, OR 97801. (541) 966-9977

Green Pea Nutrient Management Inland Northwest—east of the Cascades

Clive Kaiser, Don Horneck, Rich Koenig, Lyndon Porter, and Linda Brewer



Photo: Clive Kaiser, © Oregon State University

Good management practices are essential to optimize crop response to fertilizer inputs. Response to fertilization depends on adequate available water over the growing season. Other optimal practices include:

- Good seedbed preparation
- Crop rotation
- Use of adapted varieties
- Proper weed control
- Proper insect and disease control
- Proper seeding methods
- Timely planting and harvesting

Soil pH

While traditional tillage can provide a good seed bed, minimum tillage or direct seeding can help conserve soil organic matter and soil water; improve water infiltration; limit exposure of the weed seed bank to light, thus reducing germination; and reduce the need for weed control. However, long-term

minimum tillage or no-till practices may lead to the development of acidified layers in the soil profile. For more on managing soil pH in these systems, see [*Evaluating Soil Nutrients and pH by Depth in Situations of Limited or No Tillage in Western Oregon*](#) (EM 9014). Follow recommended soil sampling and testing procedures to estimate fertilizer needs. Keep in mind that peas root primarily in the top 2 feet of soil. For the purposes of this publication, all recommendations are based on the results from a representative sample from the top 1 foot of soil. For pea production, “low soil pH” is less than 5.5.

Clive Kaiser, Oregon State University Extension horticulturist, Umatilla County; Don Horneck, former Oregon State University Extension agronomist and professor; Rich Koenig, professor and associate dean and director, Washington State University Extension; Lyndon Porter, research plant pathologist, USDA-ARS, Prosser, Washington; and Linda Brewer, senior research assistant II, Oregon State University

Crop rotation

Crop rotation to suppress disease pressure is another important management practice. Where possible, avoid rotations of 2 or 3 years between pea crops. Short rotations can lead to the build-up of soilborne pathogens and yield reduction. Where soilborne disease pressure is high, up to 6 years without legumes in the rotation can be required to suppress damping-off pathogens such as *Fusarium*. The typical rotation in dryland production areas of eastern Washington and north-central and north-eastern Oregon is 3 years, which will not suppress these plant diseases.

Inoculation

When peas have not been in the rotation in the last 3 years, they require inoculation with a fresh, effective, live culture of *Rhizobium leguminosarum* specific to peas. Inoculation is an easy, inexpensive, risk-reducing practice that is becoming standard regardless of the length of the rotation. Inoculate pea seed immediately before planting to provide an adequate rhizobium population for good nodulation. Follow the storage and handling recommendations on the product label.

Soil pH below 5.5 in the surface foot of soil and low calcium concentrations will reduce populations of *R. leguminosarum* and nodulation. When soil pH is below 5.5 in the top foot or if stratified pH is below 5.5 in the upper 6 inches, inoculum should be added to the pea seed regardless of the rotation interval. Other elements essential for nodulation include phosphorus (P), iron, sulfur, and molybdenum.

Inoculation is less important in fields that are in a 2-year pea-wheat rotation, particularly if pea yields have been satisfactory. Where potatoes are grown in rotation with peas and soils are fumigated, inoculation is necessary.

See “**Nitrogen (N)**” to learn more about the relationship between soil N levels, nodulation, N fixation by legumes, and the value of *R. leguminosarum* inoculation.

Fertilizer Recommendations

Fertilizer placement

Fertilizer placement is an important management practice in any production system. When banding fertilizer, avoid placing nitrogen (N), potassium (K), or sulfur (S) with the seed. These nutrients are highly soluble and may damage emerging roots. Instead, place fertilizers 2 inches directly below or 2 inches below and to the side of the seed. In legumes, placing N away from the roots also encourages nodulation. P may be placed with the seed at amounts of less than 10 lb/acre P_2O_5 . Seedling injury from banded fertilizers tends to be more serious:

- In drier or coarse-textured, sandy soils
- When high rates are banded, including bands at wider row spacing
- Where the fertilizer band is placed less than 2 inches from the seed

In the recommendations that follow, the higher rates are recommended when water is not limited during the growing season. When water is limited, choose the lower rate. Recommendations are based on field experiments conducted in Hermiston, OR.

Nitrogen (N)

In most cases, supplemental N is not required for peas since *R. leguminosarum* can fix atmospheric N. If soil tests indicate a need for N, apply 15–20 lb N/acre banded with P and K, if indicated, at planting. Peas generally respond to N when soil pH is low, because low pH results in poor nodulation. When N from any source is supplied, peas take up more soil N and depend less on fixed N. The same is true when residual soil N levels are more than 35 to 40 lb/acre¹. Too much N supports excess vegetative growth and may result in weaker plants that are more susceptible to *Sclerotinia* and other diseases.

A water-soluble formulation of N such as calcium nitrate may be applied through fertigation, although it is fairly expensive. Avoid liquid fertilizers made from urea. They are prone to volatilization at soil pH above 8.0 and at temperatures above 77°F. Ammonium-based fertilizers acidify the soil. See “Lime” below for more on acid soils.

¹ <http://publications.gov.sk.ca/documents/20/86385-0c18f233-c517-4510-b398-e08fd216aad2.pdf>

For organic production systems, see the “[Organic Fertilizer and Cover Crop Calculator](#)” developed by OSU.

Phosphorus (P)

Phosphorus is essential for vigorous, even growth of seedlings. Band P to optimize availability to emerging roots and to reduce application rates. While P can be broadcast and incorporated prior to planting, P applied in this way will be less available to emerging roots. Double or triple superphosphate is more available to plant roots and has the added advantage of supplying calcium as well.

Base the decision to apply P, and the amount of P to apply, on soil test analysis (Table 1). Confirm the test method used by your lab before deciding how much P to apply.

Table 1. Phosphorus fertilizer rates for peas based on results from the Olsen soil test (sodium bicarbonate extract). Rates are for banded applications. If P is to be broadcast, apply at twice the rate recommended in the table.

Soil P concentration (ppm)	Amount of P as P_2O_5 (lb/acre) to apply
0–10	40–60
10–20	0–40
>20	0

Potassium (K)

Apply K fertilizers only if a soil test identifies a deficiency. Apply and incorporate K before planting, or band quantities less than 20 lb/acre at planting. If banding N, P, and K, do not exceed 60 lb N+P+K/acre. If additional K is required, broadcast and incorporate it into the soil prior to planting. Table 2 provides recommended K rates based on soil test K levels.

Table 2. Potassium fertilizer rates for peas based on broadcast application methods

Soil K concentration (ppm)	Amount K as K_2O (lb/acre) to apply
0–75	90–120
75–150	60–90
150–200	40–60
>200	0

Sulfur (S)

Plants absorb S in the form of sulfate (SO_4). Soil bacteria convert elemental S and certain thiosulfate and sulfide forms to sulfate before S becomes available to the plant. This conversion is more rapid when soils are warm and moist, but does require time. For that reason, plan ahead when providing S to early-planted annual crops. Apply elemental S in the fall or at regular intervals so that sulfate is available when required. Conversion of S to sulfate will acidify the soil and lower soil pH.

Peas have a low S requirement that can be provided with an application of 15–20 lb S/acre as sulfate at planting if the soil test result is less than 10 ppm sulfate-sulfur (SO_4S). A sulfur soil test has limited value in making S recommendations. However, when soil test results indicate more than 20 ppm S, additional S will likely not improve yields.

Ammonium thiosulfate applied at planting may injure emerging roots.

Other nutrients

The response of peas to micronutrients has been mixed; however, low soil boron (B) can limit yield when other nutrients are adequate. In research trials, the application of 0.5 to 1 lb B/acre increased yields by up to 500 lb/acre when boron soil-test results were below 0.5 ppm. Boron should be broadcast. Never apply boron with the seed.

Zinc applied at rates of up to 5 lb/acre may increase yields when the soil zinc test is below 0.8 ppm. Zinc can be broadcast or banded.

Molybdenum becomes less available at low soil pH. Apply molybdenum when soil pH drops below 5.5, as peas are at risk of nodulation problems and possibly molybdenum deficiency. A seed coat application of molybdenum may improve performance and delay the need for lime. Growers in Washington have seen improved nodulation from added molybdenum on lower pH, sandy soils.

Lime

In studies in eastern Oregon and eastern Washington, pea yields did not increase significantly after liming. However, soil pH below 5.5 in the top foot limits N fixation and pea growth. Under such conditions, consider applying 1 to 2 t/acre of ≤ 100 -score lime. A lime requirement soil test will support

a more accurate decision. Apply lime and incorporate it into the surface 6 inches of soil at least several weeks before seeding. A lime application is effective for several years. See *Eastern Oregon Liming Guide* (EM 9060).

For More Information

Acidifying Soil for Crop Production: Inland Pacific Northwest (PNW 599-E) <https://catalog.extension.oregonstate.edu/pnw599>

Eastern Oregon Liming Guide (EM 9060) <https://catalog.extension.oregonstate.edu/em9060>

Evaluating Soil Nutrients and pH by Depth in Situations of Limited or No Tillage in Western Oregon (EM 9014) <https://catalog.extension.oregonstate.edu/em9014>

Laboratories serving Oregon: Soil, Water, Plant Tissue, and Feed Analysis (EM 8677) <https://catalog.extension.oregonstate.edu/em8677>

Monitoring soil nutrients using a management unit approach (PNW 570) <https://catalog.extension.oregonstate.edu/pnw570>

Northern Idaho Fertilizer Guide: Peas and Lentils. University of Idaho. <http://www.webpages.uidaho.edu/~karenl/wq/wqfert/cis448.html>

Soil Test Interpretation Guide (EC 1478) <https://catalog.extension.oregonstate.edu/ec1478>

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Published April 2016

RADISH

Raphanus sativus

Last revised February 15, 2010

Photo credit: Bill Mansour, Oregon State University

Radishes take many forms and are used in a large variety of ways world-wide. The common red and icicle types are commonly used fresh as salad vegetables and garnish in the U.S. Oriental types, such as the elongated and round daikon radishes, are less well-known in the U.S. but are important staple foods in countries like Korea, Japan, Taiwan, and others in Asia, and by these ethnic groups in the U.S. These types are used fresh, pickled (as is Kimchi), dried for future use, and cooked in countless Oriental dishes. Seeds of radish are sprouted and these sprouts are another important food in these Asian countries.

Many varieties of radish exist. Some are unique novelties, others are popular for home garden use, and still others are important in commerce. Most are adapted to production in the Pacific Northwest. Only a few are listed below.

VARIETIES

See the Vegetable Variety Selection Resources page to find varieties that have been shown to perform well in the Pacific NW.

SOIL

Radishes do best on either light mineral soils or muck soils but may be grown on a wide range on soils. Daikon radish requires deep, friable soil for best quality roots.

SEED AND SEED TREATMENT

Radish seed numbers approximately 2,000-4,000 per ounce depending on type and variety. Use hot-water treated seed and fungicide treat seed to protect against several serious seed borne diseases. Hot water seed treatments are very specific (122 F exactly, for 25 to 30 minutes; the wet seed then quickly cooled and dried). The seed treatments are best done by the seed company, and can usually be provided upon request.

SEEDING

Important: Before planting this Crucifer crop, consider the following important factors:

1. No crucifer crop, or related weed has been present in the field for at least 2 years, 4 years preferable. Crucifer crops include cabbage, cauliflower, broccoli, kale, kohlrabi, Brussels sprouts, Chinese cabbage, all mustards, turnips, rutabagas, radishes etc. Cruciferous weeds include wild radish, wild mustards etc. Also, crucifer plant waste should not have been dumped on these fields.

2. Soil pH should be 6.5 or higher. Soil pH over 6.8 is necessary to manage club root. The application of 1500 lb/acre of hydrated lime, 6 weeks prior to planting is recommended for soils with pH less than 7.5 for club root control when planting club root susceptible radishes.

Use a drill with a 2 or 4-inch scatter shoe to drop 24 seeds 1/2 inch deep per foot of row. Space rows 8 inches apart. Oregon growers commonly apply a mixture of sawdust and chicken manure to a depth of 1/4 to 1/2 inch over the planted beds.

Daikon in-row spacing should be 4-6 inches, with rows 24-36 inches apart. Adjust planting rates accordingly. Some Chinese radishes can weigh 100 lbs. These would be spaced 24-36 inches apart in rows 36-48 inches apart.

FERTILIZER

For the most current advice, see Nutrient Management for Sustainable Vegetable Cropping Systems in Western Oregon, **available as a free download from the OSU Extension Catalog**

A soil test is the most accurate guide to fertilizer requirements. The following recommendations are general guidelines.

Maintain a pH 6.5-7.0, adding lime or dolomitic lime (if magnesium is needed) as indicated by soil test.

For red globe radish, poultry manure is often used to supply 50-75 lb N/acre. Care is needed to guard against excessive top growth. Excessive N is particularly bad during periods of warm, wet weather. Buildup of soil N during the season results in progressively larger tops, so N applications should be reduced as the season progresses.

Add P and K as indicated below.

Nitrogen rates for Daikon radish should be 130-150 lb/acre. Divide this among several applications, applying two thirds of the total during the last half of the growth period. Adjust N rates and irrigation as necessary to maintain vigorous, uniform growth.

In the absence of a soil test, for both red globe and daikon radish, P, K, S and B, should be applied as follows:

Phosphate: 130-150 (P₂O₅) lb/acre

Potash: 100-150 (K₂O) lb/acre

Sulfur: 30-50 lb/acre per season

Boron: 1-5 lb/acre, or as needed according to soil test.

If fertilizer is to be banded at time of seeding, rates greater than 60 lb/acre of potash should be broadcast and incorporated before seeding.

IRRIGATION

Globe radishes are shallow rooted and quick growing, requiring frequent, uniform irrigation for optimum growth and tenderness. Earliest plantings may receive sufficient rain to mature the crop, later plantings may need a total of 5-6 inches of water depending on planting date, seasonal variation, and variety. Use care to prevent excessive top growth.

Daikon radishes require full season to reach maturity, and 12-15 inches of water under western Oregon conditions. For best root quality, irrigate to maintain uniform, vigorous growth.

Soil type does not affect the amount of total water needed, but does dictate frequency of water application. Lighter soils need more frequent water applications, but less water applied per application.

HARVESTING, HANDLING, AND STORAGE

The University of California-Davis has a file on Minimal Processing of Fresh Vegetables that discusses film wrapping and other topics.

Red radish may yield up to 800 cartons/acre per crop. Three or four crops may be obtained per season on the same ground. Daikon radish yields would be approximately 15-20 tons/acre.

All harvesting is done by hand. Red radishes are pulled and tied in bunches. The bunches are washed and should be cooled immediately after harvest for best shelf life. Bunches are packed either 2 or 4 dozen/carton. About 90 percent are currently packed in 4-dozen cartons. The 2-dozen cartons are mostly used for shipments to California. Average yield of the 4-dozen cartons is 500-800/acre.

Radishes should be kept moist and cool at all times to prevent dehydration. Daikon radish may be mechanically undercut before harvest.

STORAGE (Quoted or modified from USDA Ag. Handbook 66 and other sources)

Hold radishes at 32 F and 95 to 100% relative humidity. Most spring radishes are topped and packaged in plastic bags. They should be cooled quickly to 40 F or below to maintain their crispness. Hydrocooling is an effective method of cooling radishes. Black spot is reduced by washing radishes in chlorinated water. Topped radishes can usually be held for 3 to 4 weeks at 32 F and a somewhat shorter time at 40 F. They will keep at least a week at 45 F. When temperatures are higher than 32, low oxygen (1%) is beneficial in reducing tip and root growth and softening. The regrowth of tops can be greatly retarded by trimming off the growing points, which are aggregated within a few millimeters on to of the root.

Bunched radishes have a much shorter market life because of the perishability of the tops. They can be held at 32 F and a relative humidity of 95% for 1 to 2 weeks. Addition of package and top ice aids in keeping the tops fresh.

Daikon, Chinese, or black, radishes require the same storage conditions as topped carrots and should keep in good condition for 2 to 4 months at 32 F.

PACKAGING

Topped radishes are commonly packed in 15-lb cartons containing 30 film bags each 6 ounces (Florida); 11.5-lb cartons of 30 film bags each 6 ounces (California) or 25-lb loose packed film bags.

Bunched radishes are packed in cartons of 24-48 count bunches of 6-9 radishes per bunch.

Daikon may be marketed in cartons or 20-lb plastic bags.

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Spelt

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May, 1990.



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I. History:

Spelt (*Triticum aestivum* var. *spelta*) is a sub-species of common wheat. It has been grown in Europe for about 300 years. Spelt was introduced to the United States in the 1890s.

Most of the nation's spelt acreage is in Ohio. That state grows between 100,000 and 200,000 acres of spelt annually, about 10 times more than any other state. A few varieties of spelt were developed in the early part of this century. They are no longer identifiable, and spelt has been considered an undeveloped crop. In 1986, The Ohio State University released an improved winter variety, named 'Champ'.

Spelt is often erroneously called "speltz." Sometimes emmer, another subspecies of wheat that includes durum wheat, is incorrectly called spelt.

II. Uses:

Ground spelt is used primarily as an alternative feed grain to oats and barley. Its nutritional value is close to that of oats. The protein content of the Champ variety of spelt is about 11.7%, compared to 12% to 13% for oats. The spelt hull has nearly as much feeding value as the kernel.

Spelt can also be used as a food grain after removal of the hulls. It is popular in Europe, particularly in Germany. American food manufacturers in this country have begun to use spelt to meet the nation's increasing demand for pasta and high fiber cereals. Spelt can also be used in flour and baked goods to replace soft red winter wheat.

III. Growth Habits:

The growth habits of spelt are similar to those of winter wheat. Spelt generally lodges less than soft red wheat, but more than semi-dwarf hard red spring or winter wheat. Under conditions where soft red wheat tends to lodge, spelt has produced more grain. Spelt has large pithy stems. As with oats, the hulls remain on the grain in threshing and comprise 20% to 30% of the grain weight. No official test weight has been established for spelt, but recent tests show that unhulled it averaged 28 lb/bu. The test weight of hulled seed is close to that of wheat (60 lb/bu).

IV. Environment Requirements:

A. Climate:

Spelt is generally more winter hardy than most soft red winter wheat, but less winter hardy than most hard red winter wheat varieties. There is very little evidence that any spring types of spelt exist. The new Champ variety from Ohio is a winter type.

B. Soil:

Spelt can be grown on poorly-drained, low-fertility soils. It grows well on sandy soils in the Midwest. Some growers claim it can produce more grain than oats on a bushel basis on these soils. However, the test weight of spelt is often less than that of oats.

C. Seed Preparation and Germination:

Seed should be cleaned and tested for germination before planting. Seed treatment with a fungicide, such as Vitavax, would prevent problems with bunts; however, the label should be consulted to see if the fungicide is cleared for use on spelt. Because the hulls are attached, germination is slower than for wheat.

V. Cultural Practices:

A. Seedbed Preparation:

Soil preparation is the same as that for winter wheat.

B. Seeding Date:

Sunflower
Vernonia

The seeding date is the same as that for winter wheat -- mid-September in the Upper Midwest.

Other

Canarygrass
Cool Season Grasses
Ginseng
Hop
Industrial Hemp
Jerusalem Artichoke
Kenaf
Rutabaga
Sugarcane
Sugarbeet
Turnip

C. Method and Rate of Seeding:

Spelt should be seeded with a drill set as for oats to plant 80 to 100 lb/acre. When the seedbed is dry, spelt should be seeded slightly deeper than winter wheat. The grain drill should be calibrated to ensure that the desired seeding rate is obtained.

D. Fertility and Lime Requirements:

Requirements for fertilization are similar to those for winter wheat. On soils with optimum or lower soil tests, apply a complete fertilizer with a combination drill at seeding time. Avoid direct contact of the fertilizer with the seed. An additional topdressing of nitrogen in early spring may improve yields. The topdressing should contain 10 to 20 lb less nitrogen per acre than for wheat; the straw of spelt is tall, and excess nitrogen can cause lodging. Common rates of nutrients to be applied are 50 to 60 lb/acre N, 25 lb/acre P₂O₅ and 30 lb/acre K₂O. Apply lime to maintain soil pH at about 6.0.

E. Variety Selection:

Champ is the only improved variety that has been released (Ohio State, 1986) in recent decades. Champ is awnless, brown-hulled, and about the same maturity as common spelt. Although Champ is slightly taller than common spelt, its straw strength is considerably improved. Its winter hardiness is about equal to that of common spelt. Table 1 compares yields and other performance characteristics for Champ with common spelt from trials in Ohio. Champ has very good resistance to leaf rust but is only moderately resistant to powdery mildew. The protein content of champ has consistently been 1 to 1.5% higher than common spelt. Certified seed of this variety is available from Certified seed growers in Ohio.

Table 1. Comparative performance of Champ spelt and common spelt at three locations in Ohio, 1981-85.						
Entry	Yield (lb/a)	Date headed (June)	Plant ht. (in.)	% lodged	Test wt. (lb/bu)	% protein
No. of tests	(10)	(6)	(8)	(12)	(10)	(2)
Champ	3009	2	51	12	27.7	11.7
Common	2442	3	49	48	27.9	10.5

F. Weed Control:

The best weed control practices are tillage, establishment of a good stand, and weed control in previous crops. Since no chemicals are specifically cleared for use on spelt, all the recommended cultural practices for winter wheat need to be followed to assure a dense, vigorous crop that competes well with weeds.

G. Diseases and Their Control:

Spelt is not resistant to loose smut or stinking smut (bunt). Treatment of the seed with a fungicide prior to planting could help prevent a smut problem, but the label should be consulted for clearance for use on spelt. Stem or leaf rust also can be a problem for spelt. Other foliage diseases can occur, but can be reduced by crop rotation. Avoid planting spelt after other cereal crops.

H. Insects and Other Predators and Their Control:

The Hessian fly, greenbug, and wheat stem sawfly are the primary insect pests that attack wheat fields. Spelt has the same susceptibility to the Hessian fly as wheat. Early fall seeding may result in weak plants with poor root systems that are more susceptible to the Hessian fly in some areas of the Midwest. However, these insects have not been a problem on wheat in the Upper Midwest and may not be a serious concern on spelt.

I. Harvesting:

Spelt can be direct combined or windrowed and threshed similar to winter wheat. For direct combining, the moisture content of the crop should be 14% or less. If there are many weeds, the crop should be windrowed and the windrow allowed to dry for a few days. The crop can then be picked up and threshed with a combine fitted with a pick-up attachment. The combine should be adjusted in a manner similar to that for harvesting oats.

J. Drying and Storage:

Follow same practices as for winter wheat.

VI. Yield Potential and Performance Results:

In plot yield trials in Ohio in the early 1980s, Champ produced an average of 3,009 lb/acre and common spelt produced an average of 2,442 lb/acre (See Table 1). Newly released soft red winter wheat varieties such as 'Cardinal' yielded 10% more than Champ in Ohio. No performance data are available for Minnesota or Wisconsin.

VII. Economics of Production and Markets:

The value of spelt for feed is similar to oats on a per pound basis. However, because the test weight of spelt can vary considerably, the feeding value could be lower than for oats. Hence, the demand for seed is limited.

The demand for spelt may increase in the coming decade, however, because of its recently developed uses in the food industry. Some acreage in Ohio is contracted for production of spelt for pasta. It is advisable to identify a market before growing spelt.

VIII. Information Sources:

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CONSIDER THE VALUE OF PLANT NUTRIENTS IN YOUR HAY AND CORN SILAGE

Glenn E. Shewmaker¹

ABSTRACT

Alfalfa and corn silage are major crops in acreage and economic importance for the Pacific Northwest and are marketed for and used by dairy cows, beef cattle, and other livestock. With the large increases in fertilizer prices, the value of nutrients in a ton of hay or corn silage can no longer be considered insignificant! How many pounds of nutrients are you exporting? What is the cost to replace the major nutrients? This paper describes a process and uses some current values to determine the magnitudes, sustainability, and economics of nutrient export.

Keywords: nutrient uptake, nutrient export, alfalfa hay, corn silage, fertilizer prices

INTRODUCTION

There are published values for nutrient uptake and crop use of nutrients. You can download a document “Nutrients Removed in Harvested Portion of Crop” from International Plant Nutrition Institute (IPNI) (<http://www.ipni.net/> International Plant Nutrition Institute, 2012). Although IPNI has some values, I wanted to use more local crops and concentrations and include sulfur (S) to estimate nutrient export and cost.

METHODS

I used a series of spreadsheets to generate data. Thus the results are “book values” and actual nutrient analyses of crops exported would provide more accurate results. However, the magnitudes of nutrients exported should be within 30% of these values. I focused this study on the macro-minerals nitrogen (N), phosphorus (expressed on the fertilizer analysis form of available phosphoric acid or phosphate, P_2O_5), potassium (expressed as the water soluble potash form, K_2O), and sulfur (S). Certainly other nutrients such as calcium (Ca), magnesium (Mg), and micro nutrients such as copper (Cu), zinc (Zn), manganese (Mn), etc. are also exported and will have to be replaced eventually. Replacement of some of the nutrients comes from the weathering or mineralization of soil particles, but the time required is long-term, and there is a limit to the soils ability to mineralize nutrients.

Nutrient Concentrations in Crops

I used a feed mineral table in a spreadsheet to generate the data:

Table 1 (Feed Mineral Table 2008.xls) uses selected feeds from Table 11-1 Means and SD for Composition Data of Feeds Commonly Used in Beef Cattle Diets, in the Nutrient Requirements of Beef Cattle, 2000, by the National Research Council. I have substituted some values from forage quality databases from University of Idaho research because they should be more reflective of actual soil, environmental, and agronomic management in Idaho.

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Nutrients Removed in Crops

Table 2 (Nutrients Removed Table 2012.xls) is used to calculate the value of nutrients exported in various crops. The P and K concentrations must be converted to the oxide form by multiplication of $2.29 * P = P_2O_5$ and $1.2 * K = K_2O$. Yield is multiplied by the nutrient concentration of each crop to determine nutrients removed in the crop.

Cost of Replacement of Nutrients Exported in Crops

This step calculates the cost of replacing nutrients exported in crops by applying nutrients as commercial fertilizers. Average fertilizer prices for southern Idaho are summarized by Patterson and Painter (2011) and shown in Table 3. Fertilizer prices should be compared on the basis of cost per pound of nutrient, not on the cost per pound of fertilizer material. I calculated the price of fertilizer on a multiple nutrient basis to fairly compare fertilizers (Table 4). The following process compares mixed blends of fertilizer sources:

1. First calculate the pounds of nutrients in a ton of fertilizer. To do this, add the percentage of nutrients together and multiply a ton by the sum.
(2,000 lb. per ton x total percent nutrients = pound of nutrients in a ton of fertilizer.)

Example 1: Urea (46-0-0-0)

$2,000 \text{ lb./ton} \times (0.46 + 0 + 0 + 0) = 920 \text{ lb. of nutrients in a ton of Urea.}$

Example 2: Mono-ammonium phosphate, MAP (11-52-0-0)

$2,000 \text{ lb./ton} \times (0.11 + 0.52 + 0 + 0) = 1,260 \text{ lb. of nutrients in a ton of 11-52-0-0.}$

There is quite a difference in the amount of nutrients you receive per ton of fertilizer. What does this mean economically?

2. I calculated fertilizer nutrient prices on the “Fert Price Multiple” sheet with data from Patterson and Painter 2011: Idaho Crop Input Price Summary for 2011. The cost per pound of nutrients in each fertilizer is calculated by dividing the cost per ton of fertilizer by the pounds of nutrients per ton.
(Cost per ton ÷ pounds of nutrient per ton = cost per pound of nutrient.)

Example 1: Urea (46-0-0-0)

$\$555 \text{ per ton} \div 920 \text{ lb. of nutrient per ton} = \$0.60 \text{ per lb. of nutrient.}$

Example 2: Mono-ammonium phosphate (11-52-0-0)

$\$725 \text{ per ton} \div 1,260 \text{ lb. of nutrient/ton} = \$0.58 \text{ per lb. of nutrient for N and } P_2O_5.$

In this example, 11-52-0-0 would be the better value if you need both N and P_2O_5 . This method works as a basic comparison of multiple nutrient fertilizers, but does not take into account any difference in price between the different nutrients, as all nutrients have an equal value. This method can also be used to compare single nutrient fertilizers.

3. I used the price of N from urea and P_2O_5 from MAP for fertilizer products that are currently available in Idaho. The crop nutrient utilization data from IMC was also used as a comparison.
4. The lowest price of each nutrient (dollars/lb nutrient) is multiplied by the pounds of nutrient removed in the crop, which produces the value of nutrients in dollars/acre.

RESULTS

Amount of Nutrients Removed in Crops Each Year

The concentrations of nutrients in crops generally decline with plant maturity—especially forages where the whole plant 3 inches or more above the soil is harvested. For example, Figure 1 shows the nutrient concentrations of alfalfa forage as a function of growth stage. Soil type, fertility management, irrigation management, and harvest management also affect the nutrient composition of forages. Some nutrients are mobilized as grass crops senesce resulting in low concentrations in the straw, e.g. barley and wheat straw. We have focused on the mature stages of forages because yield and crop removal are maximized.

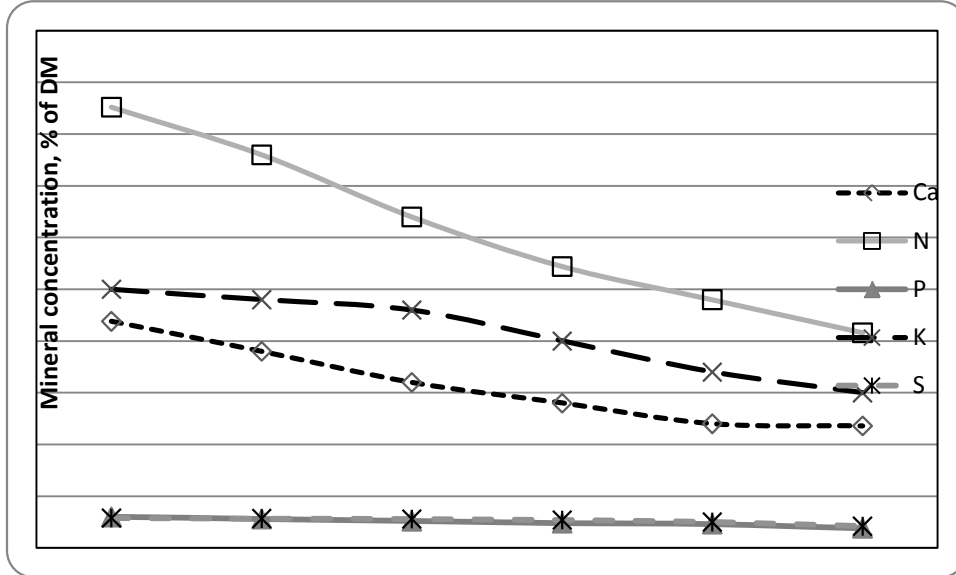


Figure 1. Mineral concentrations of alfalfa on a dry matter (DM) basis as a function of plant maturity or growth stage when harvested.

Yield is the largest variable in mineral removal that we can manage. The higher the yield, the higher the amount of nutrients removed. Alfalfa removes the most nutrients (913 lbs/acre) followed by corn silage at 809 lbs/acre, then barley silage at 295 lbs/acre (Table 2). The grain crops remove smaller amounts of nutrients (193 to 314 lbs/acre) but still important amounts in the long term.

The largest amount of N is removed in alfalfa. However, since alfalfa is a legume it uses the *Rhizobia* bacteria in the nodules to fix atmospheric N into the plant, and can leave up to 200 lbs N which can be mineralized and available to crops in the year following rotation out of alfalfa, even with the forage removed. This is called a N credit and considering this credit is a good nutrient management practice, especially in organic operations. Although alfalfa at bud stage removes 456 lbs N/acre and at full bloom 384 lbs N/acre, we can assume that N concentrations in the soil are not negatively affected. Peas and beans are also legumes which fix N, but less is available for a N credit in the year after production. Corn silage removes the second most N at 282 lbs/acre, and those pounds need replacement.

Phosphate removal is mostly a function of yield at sufficient or higher soil levels of P, since plant maturity doesn't affect the concentration much. There are some differences between crops. The largest amount of P_2O_5 removed is in corn silage, 116 lbs/acre at 11 tons DM yield or about 32 tons fresh silage/acre. Alfalfa at bud stage removes 84 lbs P_2O_5 /acre at 8 tons/acre.

Potassium (K_2O) is the largest amount of nutrient removed with 456 lbs K_2O /acre in barley silage, 346 lbs K_2O /acre for alfalfa, and 385 lbs K_2O /acre for corn silage. Although most of our Idaho soils have had adequate soil levels of K_2O historically, 100 years of crop removal have mined the soils and we are seeing more soil test levels below 200 ppm K_2O (or 166 ppm K). Corn, alfalfa and other crops can take up more K than necessary for plant growth. This is called luxury consumption and will export more K if soil

levels are high, often from high rates of manure application. Animal nutritionists do not want high K concentrations in forages because an improper ratio of $K/(Ca + Mg)$ causes problems with milk fever and grass tetany.

Value of Nutrients Removed Each Year in Crops

Table 5 shows the value of nutrients removed each year in crops. Since the N removed in alfalfa is not a negative in the soil, we will deduct the N value from the total, resulting in \$228 value of nutrients removed in alfalfa. Corn silage removes nutrients valued at \$438/acre, followed by barley silage at \$424/acre. Barley grain and straw combined removes nutrients valued at \$313/acre. Corn grain removes nutrients valued at \$163/acre. Grass hay removes much N and K which results in nutrients removed at \$231/acre.

RECOMMENDATIONS

The removal of nutrients by crops, especially forage crops, should cause producers to consider the long term mining of nutrients from the soil. How sustainable is your nutrient management? In 100 years corn silage could remove over 22 tons of nutrients per acre from your soil. It should also be considered when marketing forage crops. With current fertilizer prices, how long can you afford to sell hay and corn silage and not get some of the nutrients back from the dairy or feedlot? It may be unreasonable in the short term to market forage crops based totally on nutrient removal because you would need to sell alfalfa hay at \$38/ton and grass hay at \$58/ton just to replace the N, P, K, and S (Table 5). Corn silage would require \$40/ton DM or about \$11/ton fresh corn silage to recover nutrient costs.

I recommend negotiating with your forage crop consumer to get back some of the nutrients in the form of manure, if you are close to the consumer, or compost if you are further away. That is simply good nutrient management and benefits both parties.

Table 1. Feed Mineral Table: Selected feedstuffs and nutrient concentration on a dry matter basis.

Feedstuff	DM	CP	Ash	Ca	N	P	K	S
	%	%	%	%	%	%	%	%
Alfalfa, bud stage	90	21	7	1.90	3.80	0.28	2.4	0.29
Alfalfa hay full bloom	88	16	8	1.20	2.40	0.23	1.7	0.25
Barley hay	90	9	8	0.30	1.44	0.28	1.6	0.19
Barley silage	35	12	9	0.46	1.92	0.30	2.4	0.22
Barley straw	90	4	7	0.33	0.64	0.08	2.1	0.16
Barley grain	89	13	3	0.06	1.92	0.38	0.6	0.16
Corn fodder	80	9	7	0.50	1.44	0.25	0.9	0.14
Corn stover mature	80	5	7	0.35	0.80	0.19	1.1	0.14
Corn silage mature	34	8	5	0.28	1.28	0.23	1.1	0.12
Corn grain whole	88	9	2	0.02	1.44	0.30	0.4	0.13
Grass hay	88	10	6	0.60	1.60	0.21	2.0	0.20
Meadow hay	90	7	9	0.61	1.12	0.18	1.6	0.17
Oat hay	90	10	8	0.40	1.60	0.27	1.6	0.21
Oat straw	91	4	8	0.24	0.64	0.07	2.4	0.22
Oat grain	89	13	4	0.05	2.08	0.41	0.5	0.20
Pea straw	89	7	7	0.60	1.12	0.15	1.1	0.15
Peas cull	89	25	4	0.15	4.00	0.45	1.1	0.26
Potatoes cull	21	10	5	0.03	1.60	0.24	2.2	0.09
Sorghum stover	87	5	10	0.49	0.80	0.12	1.2	
Sorghum silage	32	9	6	0.48	1.44	0.21	1.7	0.11
Sudangrass hay	88	9	10	0.50	1.44	0.22	2.2	0.12
Timothy hay full bloom	88	8	5	0.43	1.28	0.20	1.8	0.13
Triticale hay	90	10	8	0.30	1.60	0.26	2.3	
Triticale silage	34	14	7	0.58	2.24	0.34	2.7	0.28
Wheat straw	91	3	8	0.16	0.48	0.05	1.3	0.17
Wheat grain	89	14	2	0.05	2.24	0.43	0.4	0.15
Wheatgrass crested hay	92	10	7	0.33	1.60	0.20	2	

Table 2. Nutrient concentrations and mass of nutrients removed in selected crops.

Field Crops		Nutrient concentration				Nutrients removed in crop				
	Yield	N	P ₂ O ₅	K ₂ O	S	N	P ₂ O ₅	K ₂ O	S	Sum
	ton/ac	lb/ton dry matter basis				----- lb/acre -----				
Barley grain	3.1	38.4	17.4	19	3.2	120	54	59	10	243
Corn grain	5.0	28.8	13.7	13	2.6	145	69	66	13	293
Oat Grain	2.4	41.6	18.8	16	4.0	100	45	38	10	193
Wheat Grain	3.9	44.8	19.7	13	3.0	175	77	51	12	314
Forage Crops										
Alfalfa hay at bud *	6	76	13	58	5.7	456	77	346	34	913
Alfalfa hay full bloom	8	48	11	41	5.0	384	84	326	40	835
Barley hay	6	29	13	51	3.8	173	77	306	23	578
Barley silage	6	38	14	76	4.4	230	82	456	26	795
Barley straw	4	13	4	66	3.2	51	15	264	13	343
Corn stover mature	7	16	9	35	2.8	112	61	245	20	438
Corn silage mature	11	26	11	35	2.4	282	116	385	26	809
Grass hay	4	32	10	63	4.0	128	38	252	16	434
Meadow hay	5	22	8	51	3.4	112	41	255	17	425
Oat hay	5	32	12	51	4.2	160	62	255	21	498
Oat straw	4	13	3	76	4.4	51	13	304	18	386
Pea straw	1	22	7	35	3.0	22	7	35	3	67
Timothy hay full bloom	4	26	9	57	2.6	102	37	228	10	378
Triticale hay	3	32	12	73	3.0	96	36	219	9	360
Triticale silage	2	45	16	85	5.6	90	31	170	11	302
Wheat straw	2	10	2	41	3.4	19	5	82	7	113

* Legumes obtain most of their N from the air.

Table 3. Current and historical fertilizer component prices for southern Idaho: 2009 – 2011 and percentage change from 2010 to 2011 (Patterson, 2011).

Source	Nutrient concentration	2009	2010	2011	Change
	(N-P ₂ O ₅ -K ₂ O %)				
Dry nitrogen	(46-0-0)	\$0.50	\$0.47	\$0.61	30%
Liquid nitrogen	(32-0-0)	\$0.56	\$0.48	\$0.70	46%
P ₂ O ₅ dry	(11-52-0)*	\$0.46	\$0.34	\$0.57	68%
P ₂ O ₅ liquid	(10-34-0)*	\$0.63	\$0.50	\$0.76	52%
K ₂ O	(0-0-60)	\$0.69	\$0.43	\$0.51	19%
Sulfur		\$0.19	\$0.17	\$0.22	29%
*Nitrogen in 11-52-0 and 10-34-0 was valued at the price of N in urea and Solution 32, respectively					

Table 4. The value of fertilizer nutrients as commercial fertilizer.

Product	Fertilizer cost		Nutrient concentration				Total nutrients	Nutrient cost ¹			
			N	P ₂ O ₅	K ₂ O	S		N	P ₂ O ₅	K ₂ O	S
<u>Nitrogen:</u>	\$/ton	\$/lb	%	%	%	%	lb/ton	\$/lb	\$/lb	\$/lb	\$/lb
Ammonium sulfate	\$410	\$0.21	20	0	0	24	880	\$0.47	--	--	\$0.47
Urea	\$555	\$0.28	46	0	0	0	920	\$0.60	--	--	--
Anhydrous ammonia	\$945	\$0.47	82	0	0	0	1640	\$0.58	--	--	--
Solution 32 liquid	\$445	\$0.22	32	0	0	0	640	\$0.70	--	--	--
Thio Sul liquid	\$345	\$0.17	12	0	0	26	760	\$0.45	--	--	\$0.45
<u>Phosphate:</u>											
16-20-0	\$550	\$0.28	16	20	20	0	1120	\$0.49	\$0.49	\$0.49	--
11-52-0 (MAP)	\$725	\$0.36	11	52	0	0	1260	\$0.58	\$0.58	--	--
10-34-0 (liquid)	\$657	\$0.33	10	34	0	0	880	\$0.75	\$0.75	--	--
3-30-0-4	\$575	\$0.29	3	30	0	4	740	\$0.78	\$0.78	--	\$0.78
11-37-0	\$600	\$0.30	11	37	0	0	960	\$0.63	\$0.63	--	--
<u>Potash:</u>											
Muriate of potash	\$615	\$0.31	0	0	60	0	1200	--	--	\$0.51	--
Sulfate of potash	\$680	\$0.34	0	0	50	17	1340	--	--	\$0.51	\$0.51
Liquid potash	\$180	\$0.09	0	0	13	0	260	--	--	\$0.69	--
<u>Sulfur:</u>											
Elemental (90%)	\$390	\$0.20	0	0	0	90	1800	--	--	--	\$0.22

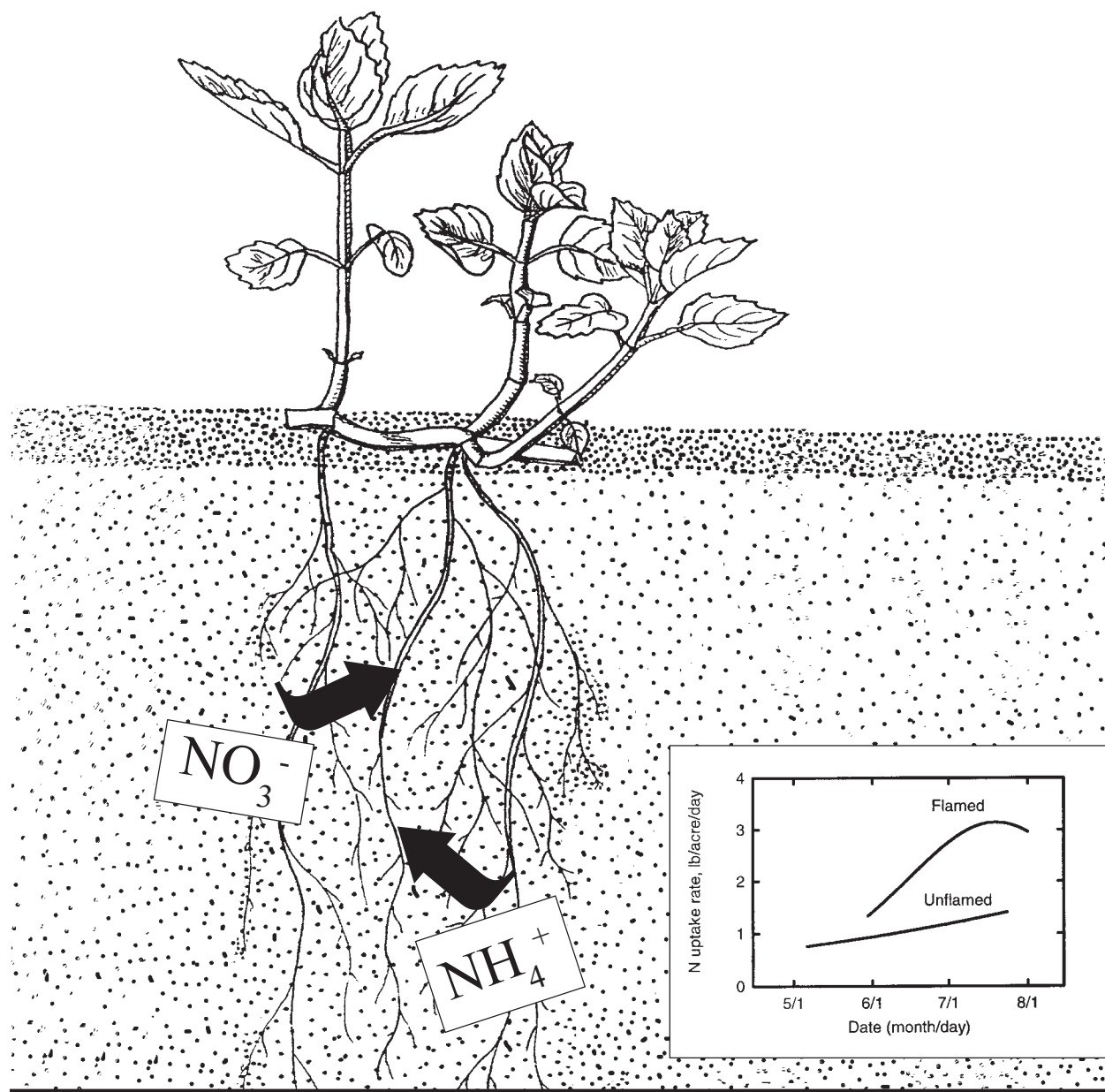
Table 5. The value of nutrients removed in selected crops. Nutrient values used were: N at \$0.60/lb, P₂O₅ at \$0.58/lb, K₂O at \$0.51/lb, and S at \$0.22/lb.

Field Crops		Value of nutrients exported					
	Yield	N	P ₂ O ₅	K ₂ O	S	Total	
	ton/ac	Dollars/acre					\$/ton
Barley grain	3.1	72	31	30	2	136	\$ 44
Corn grain	5.0	87	40	33	3	163	\$ 32
Oat Grain	2.4	60	26	20	2	108	\$ 45
Wheat Grain	3.9	105	45	26	3	178	\$ 46
Forage Crops							
Alfalfa hay at bud *	6	274	45	176	8	228	\$ 38
Alfalfa hay full bloom	8	230	49	166	9	224	\$ 28
Barley hay	6	104	45	156	5	309	\$ 52
Barley silage	6	138	48	233	6	424	\$ 71
Barley straw	4	31	9	135	3	177	\$ 44
Corn stover mature	7	67	35	125	4	232	\$ 33
Corn silage mature	11	169	67	196	6	438	\$ 40
Grass hay	4	77	22	129	4	231	\$ 58
Meadow hay	5	67	24	130	4	225	\$ 45
Oat hay	5	96	36	130	5	267	\$ 53
Oat straw	4	31	7	155	4	197	\$ 49
Pea straw	1	13	4	18	1	36	\$ 36
Timothy hay full bloom	4	61	21	116	2	201	\$ 50
Triticale hay	3	58	21	112	2	192	\$ 64
Triticale silage	2	54	18	87	2	161	\$ 81
Wheat straw	2	12	3	42	1	58	\$ 29
* Legumes obtain most of their N from the air.							

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- Patterson, Paul E., and Kathleen M. Painter. 2011. Idaho Crop Input Price Summary for 2011. Agricultural Economics Extension Series No 2011-04, University of Idaho. <http://www.cals.uidaho.edu/aers/PDF/AEES/2011/AEES110411.pdf>

Nitrogen Uptake and Utilization by Pacific Northwest Crops



A Pacific Northwest Extension publication
Oregon • Idaho • Washington

Acknowledgments

This publication includes research information collected over a number of years by cooperating scientists across the Pacific Northwest. Scientists representing Washington State University, University of Idaho, Oregon State University, and the United States Department of Agriculture, Agriculture Research Service contributed to this publication. Scientists working with specific projects are listed in “For more information” sections of this publication and in the figure captions.

Research support also was provided by many other organizations, including:

- Agri-Check, Inc. Agricultural Testing Laboratory
- Agrium
- Anheuser-Busch Inc.
- Idaho-Eastern Oregon Onion Committee
- Oregon Department of Agriculture
- Oregon Department of Environmental Quality
- Oregon Hop Commission
- Oregon Mint Commission
- Oregon Processed Vegetable Commission
- Oregon Seed Council
- Unocal Corporation
- Washington State Potato Commission

A host of reviewers provided helpful comments and insights to improve this publication, including:

- Alan Blaylock, Agrium Inc., Denver, CO
- Brad Brown, University of Idaho, Parma Research and Extension Center
- Clint Shock, OSU, Malheur Experiment Station, Ontario
- Craig Cogger, WSU, Puyallup Research and Extension Center
- Del Hemphill, OSU, North Willamette Research and Extension Center, Aurora
- Don Horneck, AgriCheck Inc., Umatilla, OR
- Ed Peachey, OSU, Horticulture, Corvallis
- Ernie Marx, OSU, Crop and Soil Science, Corvallis
- Gale Gingrich, OSU Extension, Marion County
- Gary Pelter, WSU Extension, Grant County
- Ken Rykbost, OSU, Klamath Experiment Station
- Kerry Locke, OSU Extension, Klamath County
- Mark Mellbye, OSU Extension, Linn County
- Peter Sexton, OSU, Central Oregon Agricultural Research Center, Madras
- Robert Stevens, WSU, Irrigated Agriculture Research and Extension Center, Prosser
- Russ Karow, OSU Extension, Corvallis
- Steve Petrie, Unocal, Boise, ID

Nitrogen Uptake and Utilization by Pacific Northwest Crops

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This publication provides information on the timing and pattern of biomass accumulation and nitrogen (N) uptake for a variety of Pacific Northwest crops. You can use this information to schedule N fertilizer applications for maximum efficiency. To achieve near-maximum crop yields, an adequate supply of available N must be present during the period of rapid N uptake by the crop. Supplying N when it's most needed usually reduces the amount of N lost via nitrate leaching, denitrification, and other processes.

Improving the timing of N applications can provide three benefits:

- It can improve crop yield and quality.
- It can reduce fertilizer costs.
- It can help protect the environment.

How to use this publication

This publication is a resource for refining the timing of N applications. It is not a fertilizer guide with specific recommendations for crops in a designated geographic area. Use it together with other resources (your observations, crop production and soil test data, and other publications) to improve N management practices for your cropping system.

Biomass accumulation and N uptake for a number of crops are described in this publication. A consistent format, as shown in Figure 1, is used throughout the publication. For a given crop, each of the three graphs presented has the same time scale (days or date) on the X axis. For any time during the growing season (x value on the graph), the cumulative biomass accumulation, cumulative N uptake, and N uptake rate can be read directly from the graphs.

Dan Sullivan, Extension soil scientist; John Hart, Extension soil scientist; and Neil Christensen, professor of soil science; Oregon State University.

Cumulative biomass accumulation

This graph (Figure 1a) shows the cumulative biomass accumulation by the crop during the growing season. The sigmoid, or S-shaped, crop growth curve can be divided into three parts (designated by dotted lines):

- Slow growth early in the season (exponential)
- Rapid growth during midseason (linear)
- Slow growth (approaching a plateau) late in the season as the crop matures

For most crops, the shift from vegetative growth (leaves, stems) to reproductive growth (seeds, tubers) occurs shortly after the crop attains maximum leaf area. Some crops (wheat, grass seed, potatoes) are harvested at plant maturity. Other crops (broccoli, cauliflower, peppermint) are harvested during the period of rapid, linear growth.

Cumulative N uptake

This graph (Figure 1b) shows the cumulative above-ground N uptake by the crop during the growing season. Cumulative N uptake also follows a sigmoid curve over the growing season. This sigmoid curve is divided into three phases:

- Phase I: Slow N uptake corresponding to slow early growth
- Phase II: Rapid N uptake as the crop grows rapidly, increasing its leaf area
- Phase III: Slow or no crop N uptake. During this phase, nitrogen is redistributed within the plant from leaves to stems or reproductive structures (tubers, seeds). Biomass continues to accumulate.

The period of rapid N uptake begins about the time of rapid biomass accumulation (see Figure 1a); it is complete long before the crop reaches maturity. The maximum amount of above-ground crop N is called “maximum N uptake.” For crops that are not grown to maturity, maximum N uptake is the N uptake at harvest.

Nitrogen uptake rate

The N uptake rate curve in this graph (Figure 1c) is mathematically derived from the cumulative N uptake graph (Figure 1b). Nitrogen uptake rate is the slope of the cumulative N uptake curve at any point in time. The maximum N uptake rate gives an indication of how rapidly the crop utilizes N during the period of rapid N uptake.

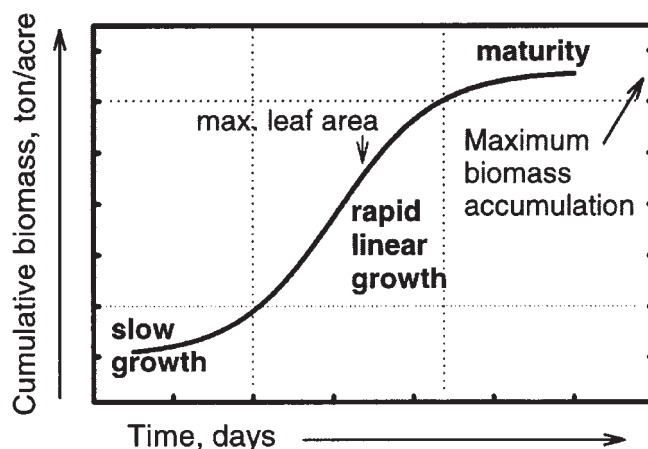


Figure 1a.—Example biomass curve.

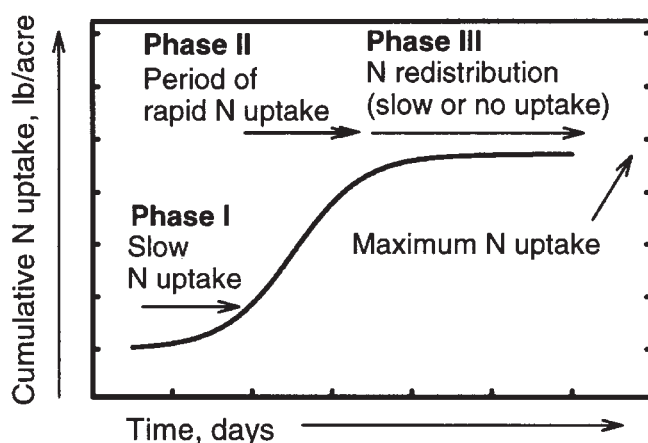


Figure 1b.—Example cumulative N uptake curve.

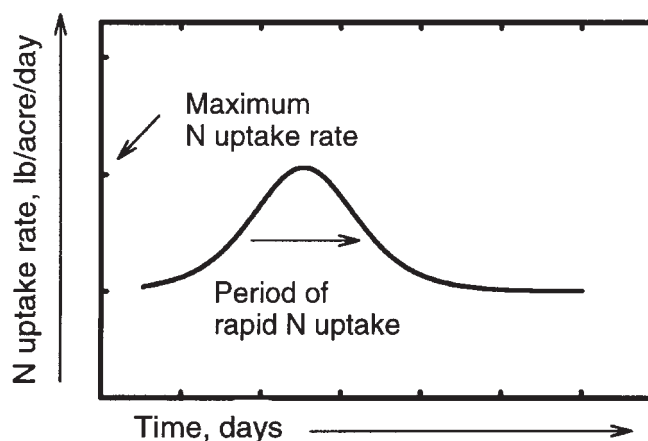


Figure 1c.—Example N uptake rate curve.

Table 1 shows the crops included in this publication and summarizes biomass and N accumulation data from Figures 2–10. The yield and N uptake attained in the examples presented do not represent a “maximum” for all growing conditions. Cumulative biomass and N accumulation vary with cultivar, plant population, cultural practices, climate, and other factors. The “maximum cumulative biomass” and “maximum N accumulation” listed in Table 1 refer only to points on the yield and N uptake curves as illustrated in Figure 1.

Where did we get the data presented here?

The data presented here were developed from field studies where crops were fertilized with adequate N for near-maximum yield. To measure biomass accumulation, we repeatedly collected samples of the above-ground portion of the crop during the growing season. Rapidly growing crops usually were harvested at 7- to 14-day intervals. Biomass samples were oven dried to determine tons of dry matter per acre. Nitrogen uptake was calculated by multiplying the biomass by its N concentration.

For some crops, we collected more data than are presented here. For field studies with multiple locations, years, and other management factors, we selected the most representative data. Crop cultivar and plant population sometimes affected the quantity of maximum N uptake, but did not change the timing of N uptake.

You will need to adapt the biomass and N uptake curves presented here for local and seasonal

environmental conditions. Variations in weather from year to year affect the calendar date at which a crop reaches Phase II (the period of maximum N uptake). However, the crop growth stage corresponding to Phase II (e.g., jointing for winter wheat) remains the same from year to year. Growing degree days can be used to predict the onset of growth stages and the period of maximum N uptake for most crops.

For additional data on nitrogen management for a specific crop, see publications listed in “For more information.”

Matching crop N needs

Table 2 summarizes our data for crops during Phase II, the period of rapid N uptake. This is the critical period for adequate available N in the root zone. Phase II lasts from 30 to 60 days for most crops. Crop N uptake during Phase II accounts for 50 to 85 percent of cumulative N uptake during the growing season. The maximum N uptake rate usually is in excess of 2 lb N/a/day.

Postharvest N management

The crop N uptake values presented here also can be used to plan for N carryover to the succeeding crop. Table 3 shows the amount of N removed from the field with the harvested crop, and the amount remaining in the field. For example, for a 100 bushel/a wheat crop, the unharvested straw contains about 35 lb N/a. As wheat straw decomposes, only a small amount of plant-available N is released (“low” residue N availability in

Table 1.—Examples of crop biomass accumulation and crop nitrogen uptake measured at harvest.^a

Example figure	Crop	Location ^b	Yield level (unit/a)	Maximum cumulative biomass (dry ton/a)	Maximum N accumulation (lb/a)
2	Winter wheat (soft white)	WV	100 bu	10	120
3	Tall fescue and perennial ryegrass for seed	WV	1,500 lb	5	110
4	Hops	WV	7 bales	2	90
5	Broccoli	WV	6 ton fresh	3	190
6	Cauliflower	WV	10 ton fresh	4	200
7	Peppermint (unflamed)	WV	100 lb oil	5	170
7	Peppermint (flamed)	WV	100 lb oil	4	200
8	Potatoes (Russet Burbank)	CB	660 cwt (33 ton)	—	240
10	Onions (dry bulb)	TV	630 cwt (32 ton)	4	120

^a Example data are derived from data presented in Figures 2–10. The maximum values listed are maximums for the example field data. Maximum cumulative biomass and N accumulation vary with cultivar, plant population, cultural practices, and climate.

^b Locations: WV = Willamette Valley, OR; CB = Columbia Basin, WA; TV = Treasure Valley, ID.

Table 3). Therefore, wheat contributes little N to succeeding crops. In contrast, broccoli and cauliflower contribute more than 100 lb N/a in crop residues with high N availability.

The relative “N availability” listed for the residues in Table 3 is related to N concentration. Immature plants

with much leaf tissue have high tissue N concentrations (>1.5 percent N) and high N availability (similar to animal manure). This residue group includes hops, peppermint, broccoli, and cauliflower. Grass seed straw (0.8–1.5 percent N) has moderate N availability. Wheat straw (0.3–0.5 percent N) has low N availability.

Table 2.—Examples of crop N uptake during the period of rapid N uptake (Phase II).^a

Example figure	Crop	Location ^b	Phase II period dates	Phase II period growth stage		Maximum N uptake rate (lb N/a/day)	Phase II N uptake (lb N/a)
2	Winter wheat (soft white)	WV	1 Mar to 30 Apr	jointing	heading	2 to 3	60
3	Tall fescue and perennial ryegrass for seed	WV	1 Apr to 30 Apr	jointing	heading	2 to 3	70
4	Hops	WV	10 Jun to 10 July	vegetative	cone initiation	3 to 4	80
5	Broccoli	WV	50 to 90 days after seeding	4 to 6 leaf	head formation	4 to 7	160
6	Cauliflower	WV	40 to 90 days after transplanting	4 to 6 leaf	curd formation	2 to 4	160
7	Peppermint (unflamed)	WV	10 May to 1 Aug	3 to 6 in high	harvest	1 to 2	80
7	Peppermint (flamed)	WV	1 June to 1 Aug	3 to 6 in high	harvest	2 to 3	160
8	Potatoes (Russet Burbank)	CB	40 to 100 days after planting	late vegetative Growth Stage I	middle of tuber Growth Stage III	4 to 5	150
10	Onions (dry bulb)	TV	1 July to 15 Aug	6 to 8 leaf	tops down	1 to 2	70

^a Example data are derived from crop N uptake curves presented in Figures 2–10. Crop N uptake rate varies with cultivar, plant population, cultural practices, and climate.

^b Locations: WV = Willamette Valley, OR; CB = Columbia Basin, WA; TV = Treasure Valley, ID.

Table 3.—Examples of nitrogen removed from the field and recycled via crop residues.^a

Example figure	Crop	N removed via harvest (lb N/acre)	Crop residue (lb N/acre)	Crop residue N availability
2	Winter wheat (soft white)	85	35	low
3	Tall fescue and perennial ryegrass for seed	35	75	medium ^b
4	Hops	45	65	high ^c
5	Broccoli	85	105	high
6	Cauliflower	90	110	high
7	Peppermint (unflamed)	210		high ^c
7	Peppermint (flamed)	190		high ^c
8	Potatoes (Russet Burbank)	210	30	high
10	Onions (Sweet Spanish)	70	50	high

^a Other data for these examples are presented in Tables 1 and 2, and Figures 2–10.

^b For perennial grasses, substantial amounts of N (100–300 lb/a) are stored in the unharvested portions (crowns and roots) and in soil organic matter. A portion of this stored N becomes available to the succeeding crop when perennial grass sod is plowed down.

^c Although these residues are removed via harvest, they usually are field applied after processing.

Nitrogen fertilizer management

The goal of N fertilizer management is to provide adequate N for maximum crop yield and quality, while minimizing nitrate leaching. The data presented here on the rate and pattern of crop N uptake can be used to help you decide what timing, rate, and form of N fertilizer is most appropriate. Important questions relating to N fertilizer management include:

Is the amount of N accumulated by the crop the amount of fertilizer N I should apply?

No. In developing a fertilizer recommendation, you should consider other N sources besides fertilizer N as well as the efficiency of fertilizer N uptake by the crop. The major source to consider is N mineralized (converted to available forms) as organic matter decomposes in the soil. Mineralization occurs in the absence or presence of fertilizer N.

Estimates of soil N supply or mineralization in the Willamette Valley commonly range from 40 to 120 lb N/a, depending on soil type and crop management practices. Crop residues that are relatively high in N, such as those from alfalfa, hop vines, mint residues, cole crops, or sugar beets, can increase the N supplied from the soil for the next crop. Sites with a history of repeated applications of animal manure or other organic byproducts also have greater amounts of N supplied by mineralization.

In drier areas of the Northwest, some of the N for the crop can be provided by nitrate that remains in the soil profile over the winter. In drier areas, spring soil tests for preplant nitrate-N provide important information for determination of appropriate N fertilizer rates.

How far in advance of crop needs should I apply N?

Generally, applying available N just before it is needed by the crop is the most efficient strategy. Where irrigation water is available to move N into the root zone, N can be applied in split applications during the period of rapid uptake.

West of the Cascades, for rain-fed crops that take up most of their N over a 30- to 60-day period, a single N application 2 to 4 weeks prior to the rapid uptake period usually is a good strategy. This allows enough time for urea or ammonium-N conversion to nitrate-N and for movement into the top foot of soil with rainfall.

How can I be certain that enough N will be present during the period of rapid crop N uptake?

For some crops, soil testing for nitrate-N 2 to 4 weeks before the period of rapid N uptake will allow

enough time for supplemental N fertilizer applications. This is the principle behind the pre-sidedress soil nitrate test for corn (see publication EM 8650).

A similar approach can be used for other crops. If the soil test shows substantial nitrate-N already present in the soil, then you can apply lower rates of N to meet crop needs. Plant tissue tests can provide an assessment of current plant N status, but generally do a poor job of predicting the quantity of available N in the soil.

For most irrigated crops, irrigation water must be managed carefully to keep soluble nitrate-N in the root zone. For additional information on irrigation management, consult the publications listed in the "For more information" section of this publication.

In what situations are split N fertilizer applications more effective than a single N application?

Split N fertilizer applications often increase the efficiency of crop N use for crops with a long interval between planting and Phase II (e.g., fall-planted crops). For such crops, a small amount of N is applied at seeding, with the remainder applied shortly before Phase II.

A single N fertilizer application shortly before Phase II often is as effective as split N applications during Phase II. Split applications have the most value on soils with high leaching potential (sandy soils), if irrigation is imprecise (e.g., furrow irrigation), or for crops with shallow root systems (e.g., onions). Sprinkler irrigation systems are ideal for delivering split N applications.

When is slow-release N most effective?

Slow-release N sources (e.g., sulfur or resin-coated urea) sometimes are used as a substitute for split applications of soluble N fertilizers. Like split N applications, slow-release N applications can be beneficial in situations where a high potential for nitrate loss from the root zone exists. The best timing for slow-release N application is prior to Phase II, the period of rapid N uptake. Slow-release N applied after the crop has achieved its maximum N uptake rate is less effective than soluble N.

When is it too late to apply N fertilizer?

N fertilizer applied when Phase II is complete is not effective in increasing crop yields. For most crops, late N fertilizer applications reduce crop quality. Some examples of the detrimental effects of excessive N late in the season include high protein in soft white winter wheat and high sugar content and dark fry color in potatoes. In addition, N remaining in the soil after harvest is vulnerable to loss by leaching during winter. Excess soil N after harvest is a potential pollutant of groundwater.

Biomass accumulation and N uptake for selected crops

Seed crops

Winter wheat

Biomass. Winter wheat planted in October typically accumulates 400 to 500 lb dry matter per acre by late tillering, Feekes growth stage 5, which occurs between February 1 and mid-March in western Oregon and between mid-March and mid-April in eastern Oregon. Beginning at jointing, Feekes growth stage 6, biomass accumulates rapidly, reaching a maximum during grain filling.

N uptake. A small amount of N, 20 to 40 lb/a, is accumulated through the end of tillering, Feekes growth stage 5. As jointing begins at Feekes growth stage 6, so does rapid accumulation of N. In a 5- to 8-week period, wheat takes up 100 to 150 lb N/a, with a peak N uptake rate of 2 to 3 lb N/a/day. By the boot stage, Feekes 10, the plant has accumulated most of its N, but only about half of its biomass. As grain begins to form, N is translocated from leaves and stems to the head.

Management. Sufficient N early in the growth of winter wheat is extremely important. A shortage of N during jointing (Feekes 6–8) cannot be overcome by adding fertilizer N late in the growing season. Split applications of N (a small application during tillering, with the remainder at Feekes 5–6) can provide benefit where substantial early season losses are expected (sandy soils with high rainfall).

An adequately fertilized wheat crop will not produce additional yield if fertilized with N after Feekes 8, the appearance of the last or flag leaf. Late-season N fertilization will make N vulnerable to loss before the next cropping season. Late-season N has been shown to increase grain protein, particularly if applied as a foliar application.

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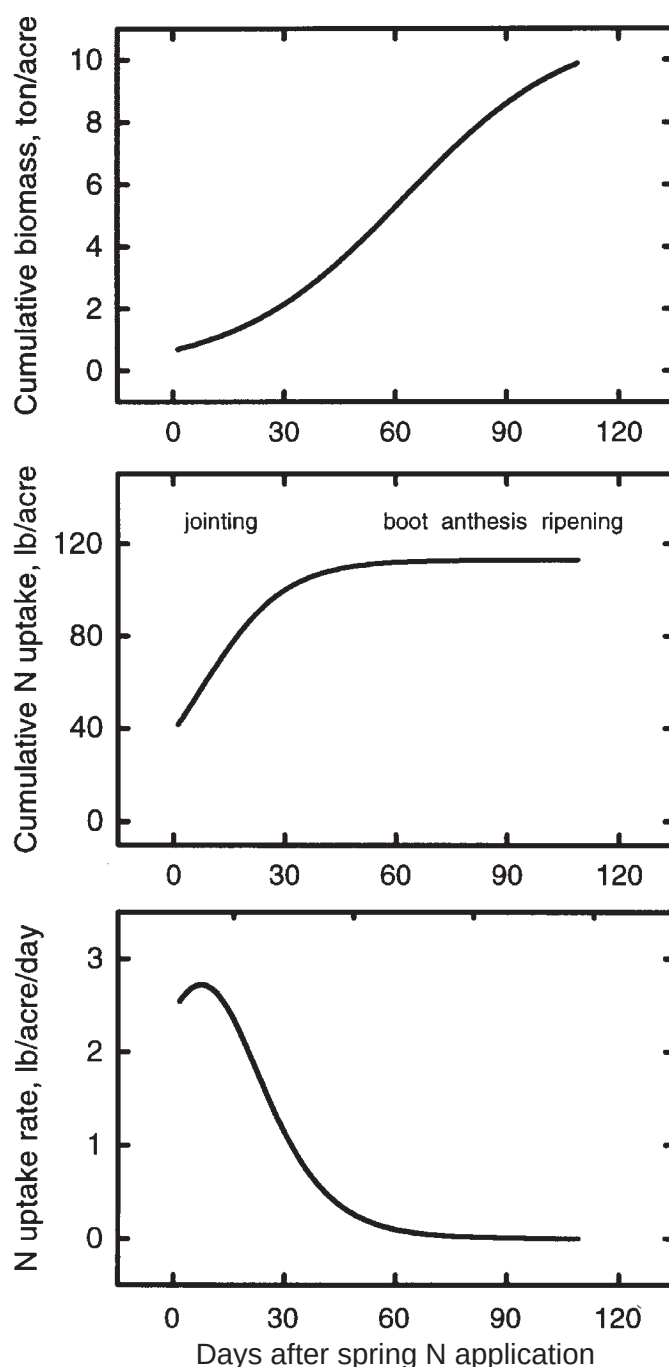


Figure 2.—Biomass accumulation and N uptake for winter wheat grown in the Willamette Valley. Day 0 is approximately March 1 (tillering growth stage). Data from one growing season. Source: Christensen and Brett, 1988.

Grass for seed

Biomass. For perennial grasses, the slow growth of Phase I occurs in the fall and early spring. Depending on species and cultivar, 300 to 2,000 lb/a dry matter is accumulated above ground from regrowth in the fall to mid-March. Less than 20 percent of the above-ground biomass is accumulated by the latter half of March. The rate of biomass accumulation is almost linear from the end of March to harvest in western Oregon.

N uptake. N uptake is rapid during April and essentially complete by mid-May, or more than 6 weeks before harvest. The amount of N taken up by a grass crop is cultivar-dependent, primarily a function of biomass production. Total N uptake usually ranges from 100 to 150 lb/a. Peak N uptake of 2 to 4 lb/a/day occurs in April.

Management. Nitrogen fertilizer rates of 75 to 150 lb N/acre are adequate for grass seed during the rapid vegetative growth period (Phase II) in April. Most growers choose to split N applications. Research in the Willamette Valley has shown no seed yield advantage for split N application compared to a single application. Late-season N application, after May 1, does not increase yield or crop N uptake.

At harvest, the straw contains most of the N. One thousand pounds of seed contains 20 to 25 lb N. One ton of straw contains 15 to 30 lb N. At harvest, a crop producing 1,500 lb of seed and 4.5 tons of straw/a removes 30 to 40 lb N in seed and contains 70 to 135 lb N in straw. Thus, when straw is chopped back on the field, N is recycled on-site.

Growers often are concerned with slow growth or with yellow grass plants during the early spring growth period. Cool weather and/or saturated soil generally are the cause of slow growth. Additional N will not stimulate plants to grow in this situation. Be patient and wait for warmer, drier weather to stimulate plant growth. Soil analyses for ammonium + nitrate-N also can be used to assess the need for additional N.

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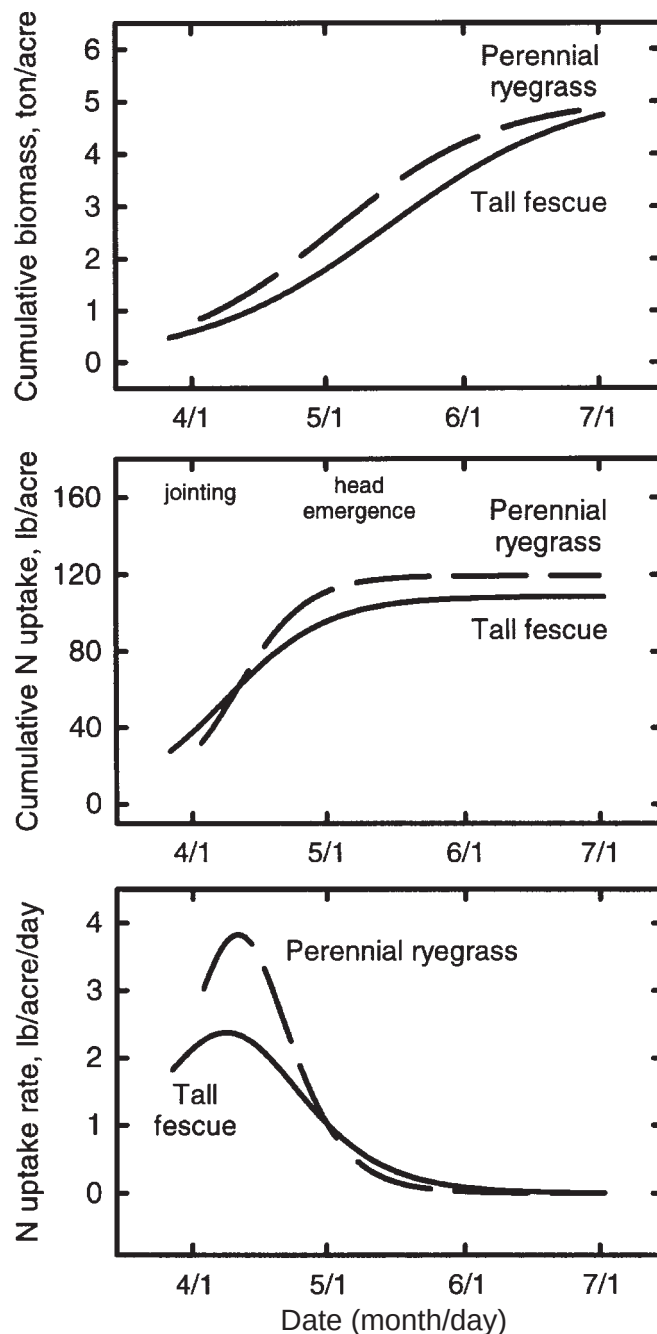


Figure 3.—Biomass accumulation and N uptake for tall fescue and perennial ryegrass grown for seed in the Willamette Valley. Data for tall fescue in 1993 combined across four field locations (Qureshi, 1995). Data for perennial ryegrass in 1997 from one field location (Griffith et al., 1998).

Hops

Biomass. Hops exhibit the same initial slow Phase I growth through the first half of June as do grass seed crops during the winter months. Spring growth produces long shoots with little leaf area. This growth depends primarily on rootstock reserves. Only 10 percent of total biomass is accumulated through mid-June. Phase II growth from mid-June until the latter part of July is linear and rapid. Maximum biomass accumulation occurs by the end of July.

N uptake. Nitrogen uptake and biomass accumulation occur at similar rates. Only 10 percent of total uptake is accumulated through mid-June. The 30-day period from mid-June to mid-July is the period of rapid uptake. The N uptake rate is 3 to 4 lb/a/day near the end of June. By the end of July, the crop has accumulated 80 to 150 lb N/a in the trained biomass.

Management. Apply nitrogen fertilizer by early June to mid-June so it will be available during the period of rapid uptake. A single N application in April was as effective as split applications in western Oregon trials. Consider yield levels when determining N fertilizer rate. Cones contain 5 to 6 lb N/bale or one-third to one-half the total amount of N harvested in the biomass.

Most yards are harvested by removing vines, leaves, and cones. After the cones are removed from the vines, the leaves and stems generally are returned to the yards. Leaves and stems contain approximately 40 lb N/t of dry material. Reduce N fertilizer inputs where hop vine residues are applied.

N status can be assessed by tissue testing. Collect hop petioles when hops are between three-fourths of the way to the wire and just reaching the wire. This amount of growth generally occurs by mid-June in the Willamette Valley. Choose petioles from mature leaves on the main vine, 5 to 6 feet from the ground. Have the petioles analyzed for nitrate-N. Small-scale N rate experiments and large-scale field demonstrations have shown no yield increase if additional fertilizer is applied when petioles contain more than 4,000 ppm nitrate-N in June.

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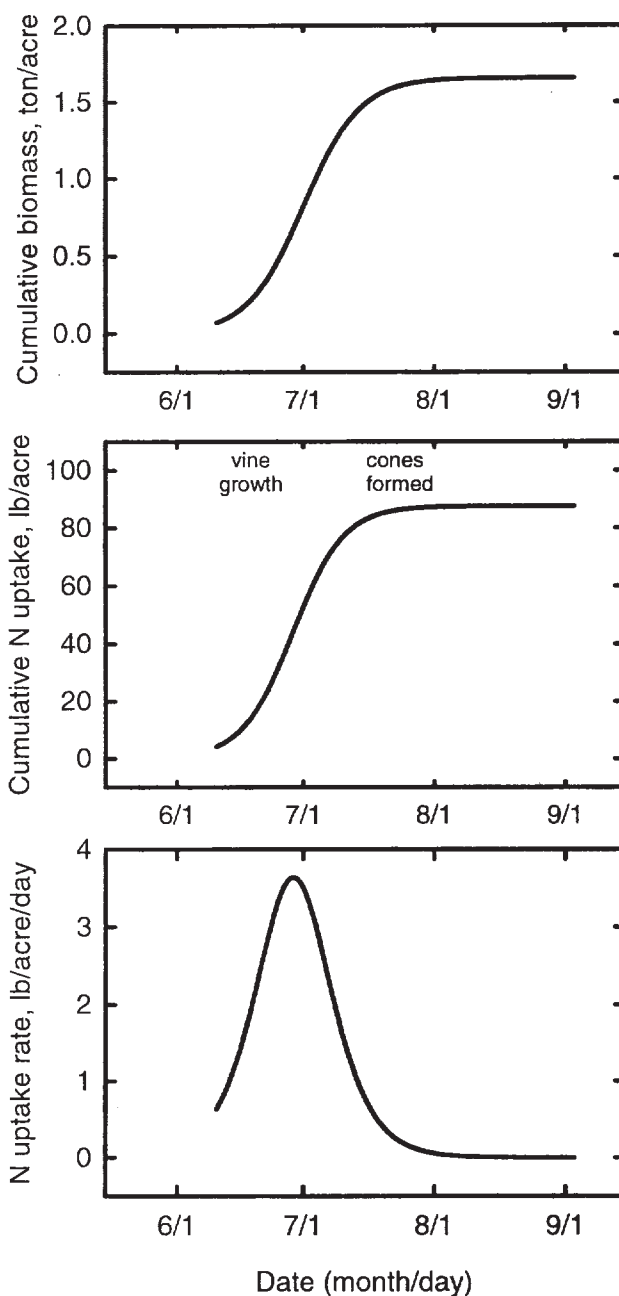


Figure 4.—Biomass accumulation and N uptake for hops grown in the Willamette Valley. Combined data from two field locations (1991). Source: N.W. Christensen, M.D. Kauffman, and G. Gingrich, Oregon State University.

*See ordering instructions on page 18.

Broccoli and cauliflower

Broccoli and cauliflower are closely related and have a similar pattern of biomass and N uptake. Both crops are harvested at the end of rapid growth, Phase II, before nutrients are translocated from the leaves to seeds.

Broccoli

Biomass. June-seeded broccoli in the Willamette Valley exhibits typical Phase I growth for the first 60 days after seeding. Less than 10 percent of the biomass is accumulated when the plant has four to six leaves. The next 30-day period, August, is characterized by typical rapid Phase II growth.

N Uptake. Nitrogen uptake and biomass accumulation occur at similar rates. Less than 50 lb N/a is taken up by broccoli in the first 60 days of growth or until four to six leaves have emerged. The limited uptake observed in the first 60 days is in sharp contrast to the N uptake that follows. During the rapid growth period between four to six leaves and the appearance of the first buds, a broccoli crop takes up 5 to 7 lb N/a/day. As the head develops, translocation of nutrients from leaves to the newly forming heads occurs.

Total N uptake is a function of cultivar, plant density, and environmental conditions. Nitrogen uptake of “Gem” broccoli seeded at a density of 35,000 plants/a and grown in the Willamette Valley is 200 to 250 lb N/a. The expected yield is 5 to 6 tons of fresh heads/a. Nitrogen uptake as high as 350 lb/a has been reported from British Columbia and Arizona in higher density plantings.

Management. Since most of the N is accumulated 90 to 100 days after seeding, an adequate supply of N during rapid growth is crucial, as yield will be decreased if a shortage of N occurs during this time. Late-season high rates of N cannot overcome an early-season N deficit.

Fresh broccoli heads contain 15 to 20 lb N/t. A 5 t/a yield (fresh wt. basis) removes 75 to 100 lb N/a. More than 150 lb N/a remains in the field in the leaves and stems. When this crop residue is tilled into the soil, it rapidly decomposes, releasing available N.

For more information

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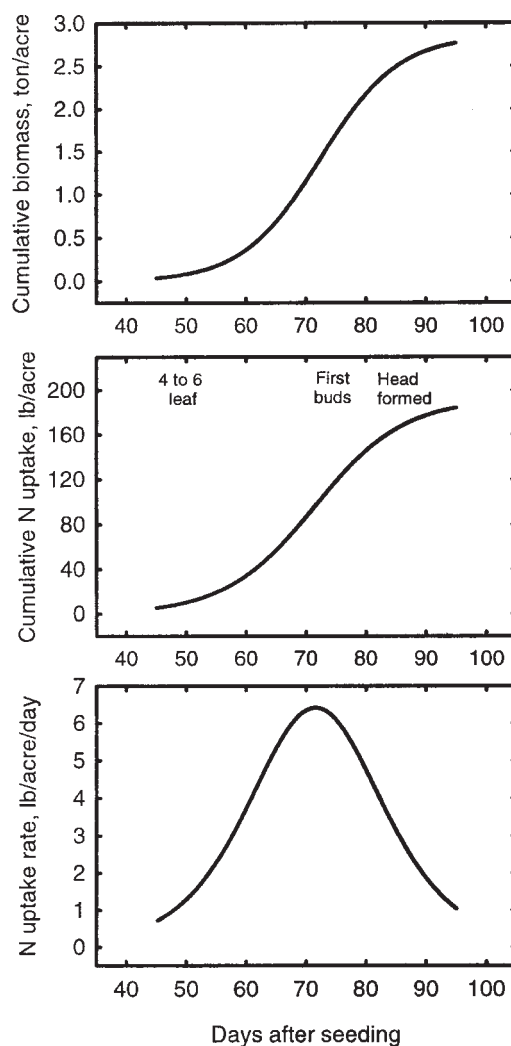


Figure 5.—Biomass accumulation and N uptake for early-June-seeded broccoli in the Willamette Valley. Data from one field location (1991). Source: J. Hart and D. Hemphill, Oregon State University.

Cauliflower

Biomass. Cauliflower transplanted in early July exhibits gradual Phase I growth for the first 40 to 50 days, accumulating approximately 25 percent of its biomass in this period. In contrast, Phase II growth in the next 50 days produces approximately 75 percent of the crop biomass.

N Uptake. Nitrogen uptake and biomass accumulation occur at similar rates. Approximately 50 lb N/a is taken up by broccoli in the first 50 days of growth or until four to six leaves have emerged. The limited uptake observed in the first 60 days is in sharp contrast to the N uptake that follows. During the rapid growth period between four to six leaves and curd formation, a cauliflower crop takes up about 3 lb N/a/day. As the head develops, translocation of nutrients from leaves to the newly forming heads occurs.

Management. Since most of the N is accumulated by 90 to 100 days after transplanting, an adequate supply of N during rapid growth is critical. Yield is decreased if a shortage of N occurs during the rapid growth period. Apply N fertilizer in late July through early August to ensure the crop a sufficient and timely nutrient supply. Cauliflower transplanted in early July accumulates N at the highest rate in early September.

Cauliflower contains substantial N in the leaves and stems that remain in the field after harvest. Live plants can hold N during winter months. Spring desiccation and tillage allows some of the N contained in the plants remaining after harvest to become available for the subsequent crop. If broccoli or cauliflower residues are incorporated shortly after harvest, the best N management practice is to seed a fast-growing crop soon after tillage. Nitrogen uptake by the following crop will reduce the amount of nitrate-N available for leaching.

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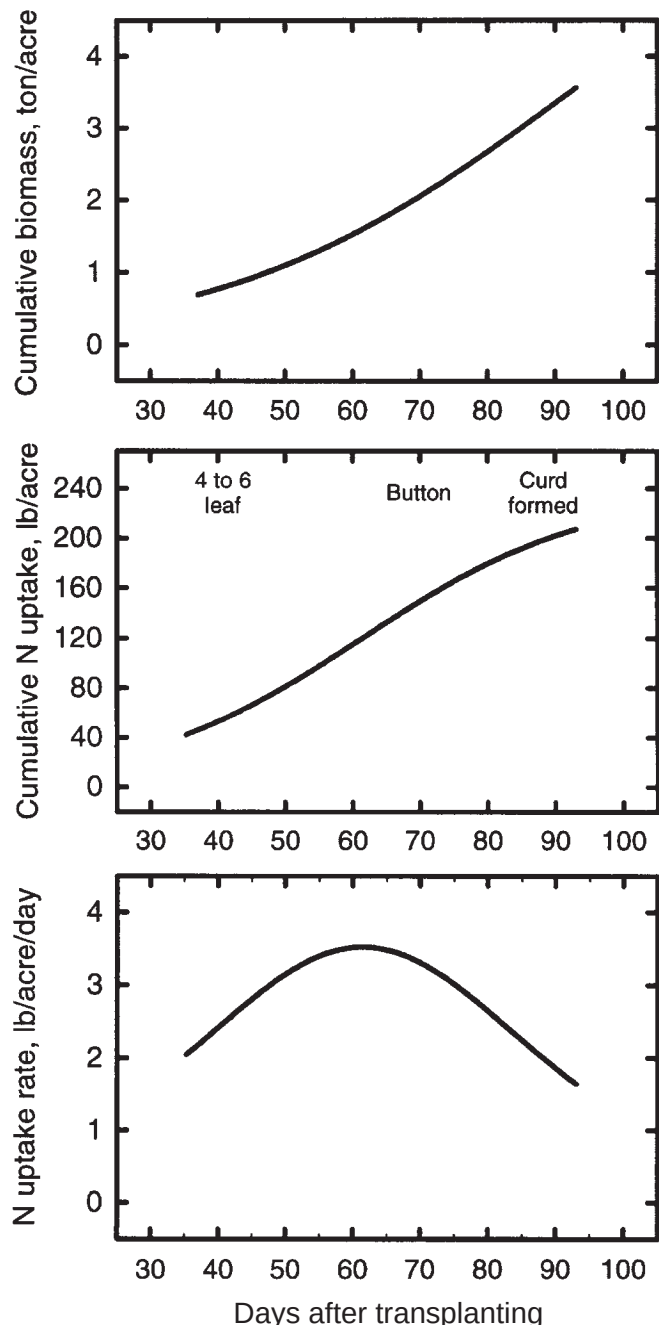


Figure 6.—Biomass accumulation and N uptake for early-July-transplanted cauliflower in the Willamette Valley. Data from one field location (1992). Source: J. Hart and D. Hemphill, Oregon State University.

Peppermint

Biomass. The major factor affecting time of biomass accumulation for peppermint is the method of rust control (flaming vs. chemical control). Peppermint that is flamed produces biomass over a shorter growing season than do fields where chemical rust control is used. Fields flamed for rust control begin harvestable biomass accumulation approximately 30 days later than unflamed fields. Vigorously growing fields where chemical control is used produce more biomass than fields that are flamed. Peppermint growth follows a similar pattern when either method of rust control is used, producing between 8,000 and 10,000 lb dry matter/a.

N Uptake. Peppermint that is flamed accumulates N at a faster rate than fields where chemical control of rust is practiced. However, both techniques produce plants at harvest with approximately the same amount of N, 170 to 250 lb/a. This conclusion is based on data collected over 3 years from large on-farm plots in the Willamette Valley.

Flamed and unflamed peppermint have different N uptake rates. Flamed mint has a maximum N uptake rate of approximately 3 lb/a/day, while unflamed peppermint's maximum N uptake rate is about 1.5 lb/a/day. The peak N uptake period is between June 15 and July 15.

Management. Nitrogen fertilizer rates of no more than 200 to 250 lb/a are necessary for adequately irrigated peppermint. N can be supplied through the irrigation water or to the soil early in the growing season. Supply approximately 175 lb/N/a before mid-June where peppermint is flamed or by mid-May where chemical rust control is used. N applied in late July or August is likely to remain in the soil after harvest.

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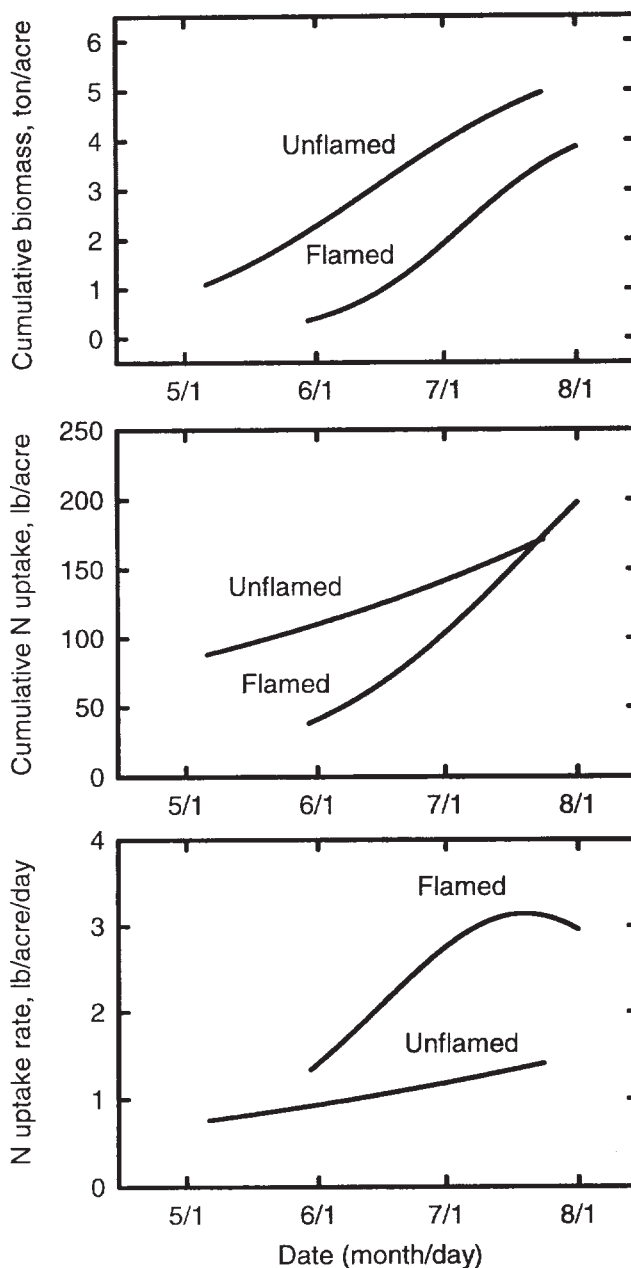


Figure 7.—Biomass accumulation and N uptake for peppermint in the Willamette Valley. Representative data selected from among six field locations (1995–97). Source: N.W. Christensen, J. Hart, G. Gingrich, and M. Mellbye, Oregon State University.

Tuber, bulb, and root crops

The seasonal pattern for potato biomass and N uptake, highlighted here, has similar characteristics to the pattern for crops with vegetative storage organs (e.g., onions, sugar beets, carrots).

Potatoes

Biomass. Potato dry matter accumulation and distribution in the plant can be described by dividing growth stages into four periods, based on top and tuber growth and N uptake. The description used by Kleinkopf et al. (1981) follows:

- During growth stage I, “vegetative,” plants develop from planting until the start of tuber initiation. This period ranges from 30 to 70 days, depending upon planting date, soil temperatures, seed age, variety, and other environmental factors affecting growth.
- Growth stage II, “tuberization,” lasts 10 to 14 days, with tubers being formed at the tips of the stolons but not appreciably enlarging. The primary inflorescence may have a few open flowers at the end of this stage.
- Growth stage III, “tuber growth,” is the phase when tuber growth is linear if all growing conditions are adequate.
- During growth stage IV, “maturation,” vines start to yellow, leaf loss is evident, and tuber growth slows.

Nitrogen uptake. Nitrogen uptake by a potato crop is a function of yield potential and variety. Tuber yield and N uptake usually are not limited by growing season in the Columbia Basin or the Treasure Valley. A limited growing season reduces yield and N uptake in the Klamath Basin, central Oregon, and eastern Idaho.

During vegetative vine growth in growth stage I, about 80–100 lb N/a is taken up. In the figure for Russet Burbank potatoes planted about April 20, growth stage I ends approximately 60 days after planting.

Growth stage II, tuberization, is characterized by rapid N uptake with 4–5 lb N/a/day taken up by the potato crop.

Maximum whole plant N uptake is reached at about 100 days after planting in growth stage III, tuber growth. During this growth stage, the tuber N uptake rate peaks about 110 days after planting. At the peak N demand, tubers accumulate 3 to 4 lb N/a/day.

During growth stage IV, beginning about 120 days after planting, tubers continue to accumulate N. The

source of N for tubers in the last month of growth is primarily translocation of N from vines.

Management. Excessive amounts of nitrogen at planting can elevate salt levels, adversely affecting moisture availability in the root zone. Providing adequate, but not excessive N during growth stages I and II favors a balanced proportion of roots and shoots, resulting in enhanced tuber initiation and set. For indeterminate cultivars such as Russet Burbank, the most critical time for supplying nitrogen is from 40 to 100 days after planting (late vegetative growth stage I through the first half of tuber growth stage III).

The effects of deficient, adequate, and excess N application are demonstrated for Russet Burbank potatoes in the Columbia Basin (Patterson, WA) in Figure 9. When N is applied in excess of crop needs, vines accumulate excess N. Excessive N fertilization delays maturity and may result in reduced crop quality and crop value for fresh market or for processing. Negative effects of excessive N can include lower dry matter (specific gravity), lower market grade, and higher sugar content. At adequate or deficient rates of N, the plant moves N from the vine to the tubers, starting with the period of rapid tuber development.

Excess N fertilizer changes the amount of N in the vines more than in the tubers. Adequately fertilized potatoes (190 lb fertilizer N/a) contained 160 lb N in tubers, while potatoes grown with excess N (550 lb fertilizer N/a) contained 200 lb N in the tubers. Vines contained 300 lb N/a when excessively fertilized compared to less than 50 lb/a when adequately fertilized. Tuber yields were similar with adequate or excess N application.

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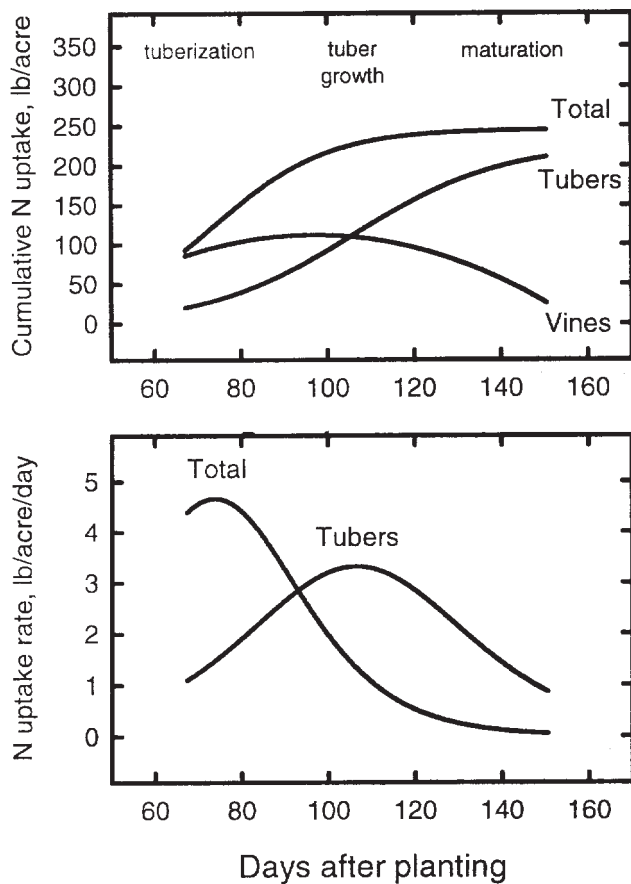


Figure 8.—Nitrogen uptake for Russet Burbank potatoes planted about April 20. Columbia Basin near Patterson, WA. Combined data from three growing seasons (1981–83). Source: Roberts et al. (1991).

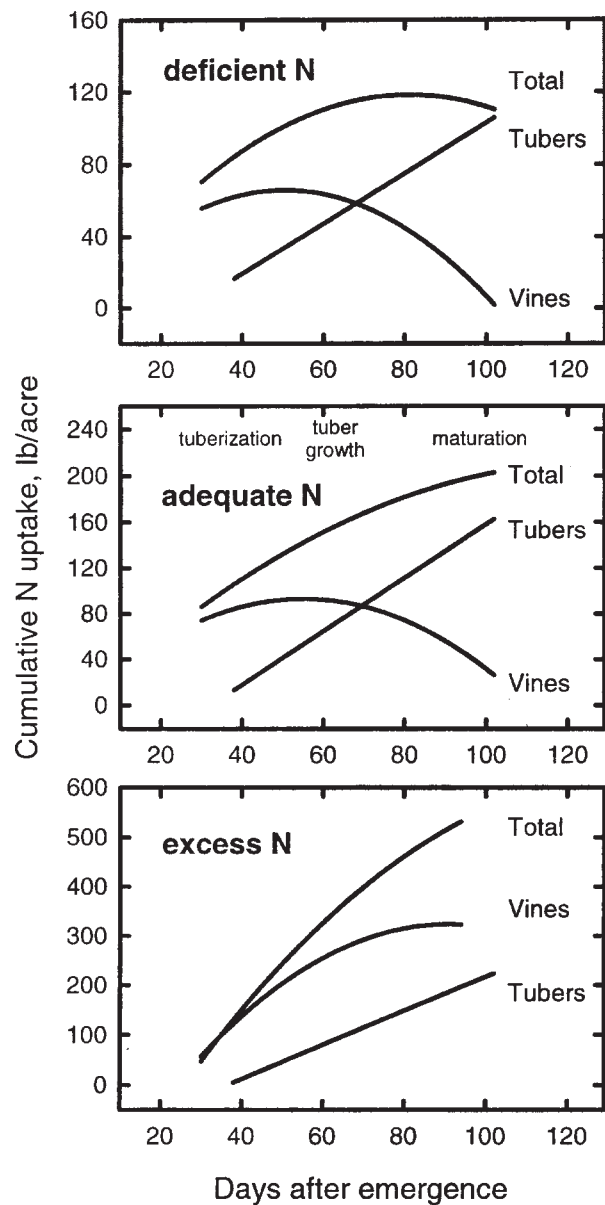


Figure 9.—Nitrogen uptake for Russet Burbank potatoes grown with deficient, adequate, and excessive levels of fertilizer N. Columbia Basin near Patterson, WA. Data from one growing season (1980). Source: Lauer, 1985.

Onions

Biomass. Onion biomass initially accumulates very slowly. From seeding in March or April to the six to eight-leaf stage in mid to late June, accumulated biomass is less than 40 lb/acre. Following rapid leaf production, bulb enlargement begins in July in response to day length and temperature. Bulb enlargement is complete by late August to early September, and maximum biomass is attained at that time.

In a recent eastern Washington field trial, sweet Spanish, globe, and red onion biomass and nutrient uptake were measured. The range of total biomass for all onion types was 9,000 to 12,000 lb/a (dry weight). Less than 2,000 pounds of the biomass was found in onion tops. In Malheur County, OR, sweet Spanish onions produced 6,500 pounds of biomass in bulbs and 1,300 pounds in tops. In both situations, approximately 85 percent of the biomass was in the bulbs. In Idaho, sweet Spanish type onions accumulated 1,000 to 2,000 lb biomass in plant tops by mid-July, when plants had 9 to 12 leaves (Figure 10).

N uptake. Rapid N uptake begins after the crop has six to eight true leaves and continues in a linear fashion through bulb growth. During the latter stages of bulb enlargement, generally August in irrigated onion-producing areas of the west, N is translocated from tops to bulbs, and little additional N is taken up from the soil. In a recent eastern Washington field trial, N uptake was 130 to 160 lb/a, with 10 to 30 lb N/a in the tops at harvest. A similar proportion of N was found in bulbs and tops in Malheur County, Oregon research: 80 to 90 lb/a N in the bulbs, and 15 to 20 lb/a N in the tops. In the Idaho studies summarized in Figure 10, a higher proportion of crop N uptake was found in onion tops.

Management. N uptake at harvest is a function of onion variety, plant population, and bulb size. Adjust the N fertilizer rate for projected yield. Crop N uptake (tops + bulbs) averages 0.15 to 0.20 lb N per cwt of harvested bulbs (3 to 4 lb N per ton of bulb fresh weight).

Research in Idaho and Colorado shows that seeded onions can benefit from split applications of N. Nitrogen applied preplant often is leached beyond the reach of roots by early-season rainfall or irrigation.

Preplant N also may reduce germination of onion seed and increase early-season weed control problems. Sidedress N can be applied several times during the growing season if soil or plant tissue tests indicate a

need. Applying the initial sidedress N at the three- to five-leaf stage provides N just prior to the period of rapid biomass production and N uptake. The last application of N fertilizer usually should be in mid- to late June.

For more information

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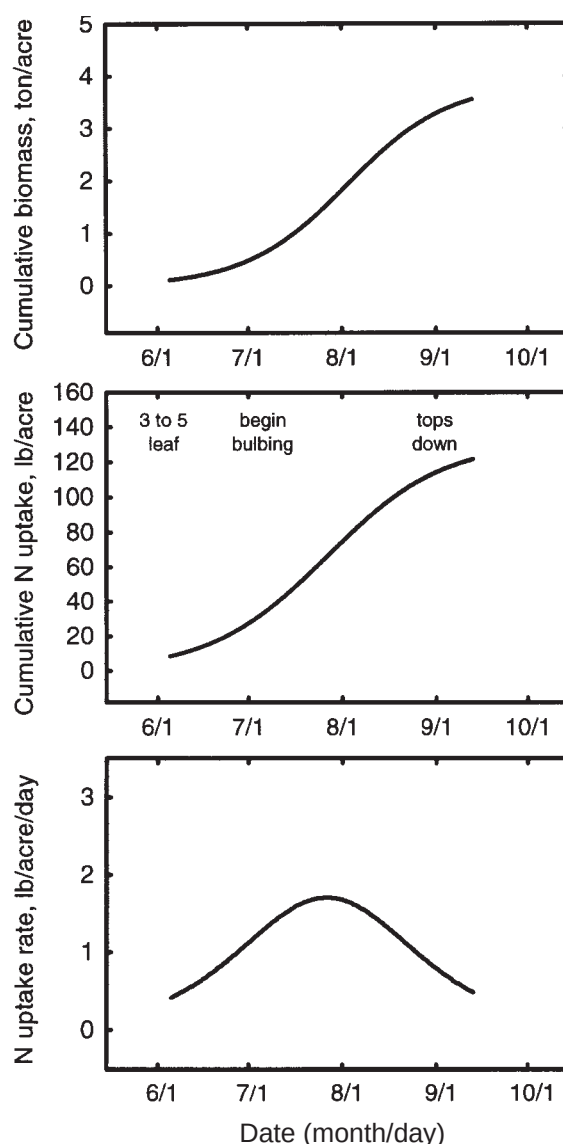


Figure 10.—Biomass accumulation and N uptake for seeded dry bulb onions in the Treasure Valley. Combined data from five locations. Source: Brad Brown, University of Idaho, Parma Research and Extension Center.

Questions and answers about nitrogen use by crops

Nitrogen management uses technical jargon. This section precisely defines our jargon, so you can compare the values presented here with other information on nitrogen management. This section also provides additional information for interpretation of the research results reported here.

What is plant-available N?

Plants utilize only the ammonium (NH_4^+) and nitrate (NO_3^-) forms of nitrogen. Nitrogen from the atmosphere and from organic sources is not available until conversion by microbial activity or a chemical reaction into ammonium or nitrate-N.

What sources provide available N for crops?

Crops utilize available N from several sources. Water-soluble N fertilizers supply N in an immediately available form. Plant-available nitrogen also is provided by bacteria living in association with the roots of legumes. The decomposition of organic N compounds in soil, a process called mineralization, also provides plant-available N. Organic sources of mineralizable N include soil organic matter, crop residues, manures, and other organic byproducts. In some areas, irrigation water may be a significant source of available N. Consider nitrogen from all of these sources when developing a plan for supplying N to meet crop needs.

Why are the N uptake values similar to recommended fertilizer rates for some crops?

This is the result of two factors that cancel each other out in some situations. First, as discussed above, available N is produced by the decomposition of soil organic matter and crop residues. This process reduces the amount of N needed from fertilizer. Second, some of the applied N is lost via volatilization, denitrification, immobilization, and leaching processes. This increases the amount of N needed from fertilizer. Sometimes, a balance between contributions from soil N mineralization and available N losses occurs. In these situations, crop N uptake and fertilizer rate recommendations are similar.

How is above-ground N uptake measured?

Nitrogen uptake, as reported here, is equal to the dry weight of the harvested above-ground biomass multiplied by the biomass N concentration. For example, for a peppermint crop producing 8,000 lb/a biomass (dry weight basis) and having an N concentration of 2.5 percent N, the calculated N uptake is 200 lb N/acre.

Did the measurement procedure recover all of the N that entered the plant?

No. We measured the N present in plants by harvesting at different growth stages. After uptake, some N is lost from small holes, called stomata, on the underside of leaves. Additional N is lost when leaves get old, turn yellow, and fall off the plant. Loss of N from the above-ground portion of the crop can account for 5 to 20 percent of the total above-ground N uptake by crops such as wheat or corn.

Except for potatoes, we do not report here the amount of N present below ground in roots and other vegetative structures. For actively growing crops, approximately one-quarter to one-third of the amount of N found in above-ground biomass usually is present in the roots. For annual crops, most of the N present in roots moves to plant tops by maturity. Therefore, the cumulative N uptake values reported here probably represent 75 to 95 percent of whole plant N uptake.

How efficient are plants in utilizing fertilizer N?

All of the N applied as fertilizer is not taken up by a crop, even when the fertilizer is applied at optimum rates. When crops are supplied adequate but not excess fertilizer N, between half and two-thirds of the fertilizer N will be found in the crop. Crop N uptake efficiency is less than 100 percent because of naturally occurring processes. Some of the N is lost as a gas via ammonia volatilization and denitrification. Some is incorporated into soil organic matter through microbial processes. Some is present in the soil at the end of the growing season as nitrate-N.

In developing an N fertilizer rate recommendation, crop N uptake efficiency usually is assumed to be 50 to 70 percent. This means that for 100 lb/a of fertilizer N applied, crop N uptake increases by 50 to 70 lb N/a.

What happens to nitrate-N not taken up by crops?

Nitrate-N moves with soil water. West of the Cascades, much of the nitrate remaining in the soil profile in October is lost over the winter. In lower precipitation areas, winter precipitation may not leach nitrate-N from the root zone but can move it deeper in the soil profile. Many crops are less efficient in utilizing available N that is below a depth of 2 feet.

Some nitrate-N is converted to organic N by soil microorganisms. Nitrogen stored in organic forms is not subject to leaching.

For more information

Irrigation

- *Cuenca, R.H., J.L. Nuss, A. Martinez-Cob, G.G. Katul, and J.M. Faci Gonzalez. *Oregon crop water use and irrigation requirements*, EM 8530 (Oregon State University, Corvallis, OR, 1992). \$5.00
- *English, M.J., R. Mittelstadt, and J.R. Miner. *Irrigation management practices checklist for Oregon*, EM 8644 (Oregon State University, Corvallis, OR, 1996). \$2.25
- *Hansen, H., and W. Trimmer. *Irrigation system walk-through inspection analysis*, PNW 293 (Oregon State University, Corvallis, OR, 1997). \$1.00
- *Ley, T.W., R.G. Stevens, R. Topielec, and W.H. Neibling. *Soil water monitoring and measurement*, PNW 475 (Oregon State University, Corvallis, OR, 1994). \$1.00
- *Trimmer, W., and H. Hansen. *Irrigation scheduling*, PNW 288 (Oregon State University, Corvallis, OR, 1994). 50¢

Soil testing

- *Marx, E.S., J. Hart, and R.G. Stevens. *Soil test interpretation guide*, EC 1478 (Oregon State University, Corvallis, OR, 1998). \$1.50
- *Marx, E.S., N.W. Christensen, J. Hart, M. Gangwer, C.G. Cogger, and A.I. Bary. *The pre-sidedress soil nitrate test (PSNT) for western Oregon and western Washington*, EM 8650 (Oregon State University, Corvallis, OR, 1996). 75¢

Additional sources of crop N uptake data

- Doerge, T.A., R.L. Roth, and B.R. Gardner. *Nitrogen Fertilizer management in Arizona*, Publ. 191025 (College of Agriculture, The University of Arizona, Tucson, AZ, 1991).
- Ritchie, S.W., J.J. Hanway, and G.O. Benson. *How a corn plant develops*, Spec. Report 48 (Iowa State University, Ames, IA, 1989).

Ordering instructions

Publications marked with an asterisk (*) are available from the Oregon State University Extension Service. To order copies, send the publication's complete title and series number, along with a check or money order for the amount listed, to:

Publication Orders
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Discounts are available on orders of 100 or more copies of a single title. Please call 541-737-2513 for price quotes.

For all other publications, contact the publisher or a library.

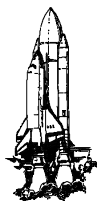
Quick summary

- This publication is a resource for scheduling N fertilizer applications for maximum efficiency. Improving the timing of N applications can provide the following benefits:
 - Reduced fertilizer costs
 - Improved crop yield and quality
 - Protection of water resources
- This publication summarizes, in a consistent format, above-ground crop N uptake data from project reports, conference proceedings, and journal articles.
- The crop N uptake data presented here were developed from field studies where crops were fertilized with adequate N for near-maximum yield.
- Crop N uptake occurs in three phases over the growing season:
 - Phase I: Slow crop N uptake corresponding to slow early growth
 - Phase II: Rapid N uptake as the crop grows rapidly, increasing its leaf area
 - Phase III: Slow or no crop N uptake. During this phase, nitrogen is redistributed within the plant from leaves to stems or reproductive structures (tubers, seeds). Biomass continues to accumulate.
- Crop N uptake during the phase of rapid N uptake (Phase II) accounts for 50 to 85 percent of cumulative N uptake during the growing season.
- Maximum crop N uptake rates during Phase II usually exceed 2 lb N/a/day.
- To achieve near-maximum crop yields, you must provide an adequate supply of available N during the period of rapid crop N uptake (Phase II).
- Crop cultivar and plant population affect the quantity of maximum N uptake, but not the timing of N uptake by a crop.
- The crop N uptake amounts listed here are not N fertilizer recommendations. Besides crop N uptake estimates, fertilizer recommendations consider:
 - The quantity of N supplied from other sources (e.g., decomposition of soil organic matter, manure, irrigation water)
 - Crop N uptake efficiency—the proportion of plant-available N removed by the crop (usually 50 to 70 percent)

APPENDIX E

Test Results

Biosolids Testing



UMPQUA Research Company - Table Rock

419 SW 5th Street
Pendleton, Oregon 97801
(541) 863-5201 Fax: (541) 863-6199
E-mail: TRLab@URCmail.net
Internet: www.umpquaresearch.com
ORELAP ID# OR100061

ANALYSIS REPORT

URC # T3F2111

Enterprise, City of
102 E North St.
Enterprise, OR 97828

Project: Wastewater
Project #: General Testing
Client Contact: Dave Wilkie

Date Reported: 06/26/23
Date Sampled: 06/21/23 09:00
Date Received: 06/21/23 13:35
Sampled By: Dave

Sample Location: Waste Water Digester Biosolids

URC Sample #: T3F2111-01

Matrix: Sludge

Inorganics

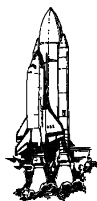
Analyte	Code	Result	Units	MRL	BML	Prepared	Analyzed	Analyst	Qualifier
SM 2540B									
Total Solids		0.756	% by Weight	0.030		06/22/23	06/26/23	DTD	B

UMPQUA Research Company/TR

Lacy McCamey For Amy Kasiska

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Internet: www.umpquaresearch.com
ORELAP ID# OR100061

ANALYSIS REPORT

URC # T3F2111

Enterprise, City of	Project: Wastewater	Date Reported: 06/26/23
102 E North St.	Project #: General Testing	Date Sampled: 06/21/23 09:00
Enterprise, OR 97828		Date Received: 06/21/23 13:35
	Client Contact: Dave Wilkie	Sampled By: Dave

Sample Location: Waste Water Digester Biosolids

URC Sample #: T3F2111-01

Matrix: Sludge

Microbiology

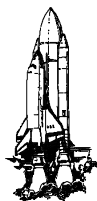
Analyte	Code	Result	Units	MRL	BML	Prepared	Analyzed	Analyst	Qualifier
SM 9221-B&E									
Fecal Coliforms		3400	MPN/g dry	26		06/22/23 14:50	06/23/23	DTD	

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Internet: www.umpquaresearch.com
ORELAP ID# OR100061

ANALYSIS REPORT

URC # T3F2111

Qualifiers and Definitions

B	Analyte detected in the method blank
DET	Analyte DETECTED
ND	Analyte NOT DETECTED at or above the MRL (minimum reporting limit)
NA	Not Applicable
NR	Not Reported
dry	Sample results reported on a dry weight basis
RPD	Relative Percent Difference
MRL	Minimum Reporting Limit
MDL	Minimum Detection Limit
BML	Benchmark Level
(‡)	ORELAP Accredited Analyte
(~)	Due to rounding of individual analytes, the "total" may vary slightly from the sum of the individual analyte values.

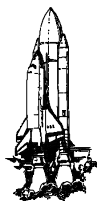
Analytes flagged with * were subcontracted to Umpqua Research Company/MC. ORELAP ID #: OR100031

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ORELAP ID# OR100061

ANALYSIS REPORT

URC # T3F2113

Enterprise, City of
102 E North St.
Enterprise, OR 97828

Project: Wastewater
Project #: General Testing
Client Contact: Dave Wilkie

Date Reported: 07/10/23
Date Sampled: 06/21/23 09:00
Date Received: 06/21/23 13:35
Sampled By: Dave

Sample Location: Influent

URC Sample #: T3F2113-01

Matrix: Aqueous

Inorganics

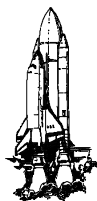
Analyte	Code	Result	Units	MRL	BML	Prepared	Analyzed	Analyst	Qualifier
SM 2540D									
TSS		162	mg/L	10.0		06/23/23	06/26/23	DTD	
SM 5210B									
5-day BOD		110	mg/L	2	20	06/22/23 17:01	06/26/23	DTD	

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ORELAP ID# OR100061

ANALYSIS REPORT

URC # T3F2113

Enterprise, City of
102 E North St.
Enterprise, OR 97828

Project: Wastewater
Project #: General Testing
Client Contact: Dave Wilkie

Date Reported: 07/10/23
Date Sampled: 06/21/23 09:00
Date Received: 06/21/23 13:35
Sampled By: Dave

Sample Location: Effluent

URC Sample #: T3F2113-02

Matrix: Aqueous

Inorganics

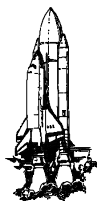
Analyte	Code	Result	Units	MRL	BML	Prepared	Analyzed	Analyst	Qualifier
SM 2540D									
TSS		1.5	mg/L	1.2		06/23/23	06/26/23	DTD	
SM 4500 NH3 B									
*Ammonia as N		ND	mg/L	0.30		06/28/23	06/28/23	JBN	
SM 5210B									
5-day BOD		3	mg/L	2	20	06/22/23 17:01	06/26/23	DTD	

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ANALYSIS REPORT

URC # T3F2113

Enterprise, City of
102 E North St.
Enterprise, OR 97828

Project: Wastewater
Project #: General Testing
Client Contact: Dave Wilkie

Date Reported: 07/10/23
Date Sampled: 06/21/23 09:00
Date Received: 06/21/23 13:35
Sampled By: Dave

Sample Location: Digester BioSolids

URC Sample #: T3F2113-03

Matrix: Sludge

Inorganics

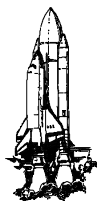
Analyte	Code	Result	Units	MRL	BML	Prepared	Analyzed	Analyst	Qualifier
SM 2540B									
*Total Solids		0.764	% by Weight	0.017		06/26/23	06/27/23	AHA	
SM 2540E									
*Volatile Solids		99.8	% by Weight (of TS)	0.017		06/26/23	06/27/23	AHA	
SM 4500 NH3 B									
*Ammonia as N		4430	mg/kg dry	981		07/07/23	07/07/23	JBN	
SM 4500-H B									
pH		7.0	pH Units			06/21/23 16:21	06/21/23	ABK	
SM 4500Norg B									
*Total Kjeldahl Nitrogen		66800	mg/kg dry	9810		06/29/23	06/30/23	JBN	
SM 4500P									
*Phosphorus-Total		4.20	% by Weight dry	0.654		07/03/23	07/03/23	JBN	
USEPA 300.0									
*Nitrite as N		ND	mg/kg dry	65.4		06/22/23 14:09	06/22/23	AHA	
*Nitrate as N		ND	mg/kg dry	262		06/22/23 14:09	06/22/23	AHA	

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ANALYSIS REPORT

URC # T3F2113

Enterprise, City of	Project: Wastewater	Date Reported: 07/10/23
102 E North St.	Project #: General Testing	Date Sampled: 06/21/23 09:00
Enterprise, OR 97828		Date Received: 06/21/23 13:35
	Client Contact: Dave Wilkie	Sampled By: Dave

Sample Location: Digester BioSolids

URC Sample #: T3F2113-03

Matrix: Sludge

Metals

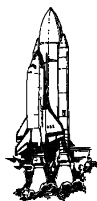
Analyte	Code	Result	Units	MRL	BML	Prepared	Analyzed	Analyst	Qualifier
EPA 6010D									
*Arsenic		ND	mg/kg dry	32.7		06/29/23	06/29/23	DST	
*Cadmium		ND	mg/kg dry	6.54		06/29/23	06/29/23	DST	
*Chromium		ND	mg/kg dry	65.4		06/29/23	06/29/23	DST	
*Copper		167	mg/kg dry	65.4		06/29/23	06/29/23	DST	
*Lead		ND	mg/kg dry	32.7		06/29/23	06/29/23	DST	
*Mercury		ND	mg/kg dry	13.1		07/05/23	07/05/23	DST	
*Molybdenum		ND	mg/kg dry	65.4		06/29/23	06/29/23	DST	
*Nickel		ND	mg/kg dry	65.4		06/29/23	06/29/23	DST	
*Potassium		0.608	% by Weight dry	0.131		06/29/23	06/29/23	DST	
*Selenium		ND	mg/kg dry	65.4		06/29/23	06/29/23	DST	
*Zinc		411	mg/kg dry	131		06/29/23	06/29/23	DST	

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ORELAP ID# OR100061

ANALYSIS REPORT

URC # T3F2113

Qualifiers and Definitions

QR-04	Duplicate RPD is above the control limit due to a non-homogeneous sample matrix.
DET	Analyte DETECTED
ND	Analyte NOT DETECTED at or above the MRL (minimum reporting limit)
NA	Not Applicable
NR	Not Reported
dry	Sample results reported on a dry weight basis
RPD	Relative Percent Difference
MRL	Minimum Reporting Limit
MDL	Minimum Detection Limit
BML	Benchmark Level
(‡)	ORELAP Accredited Analyte
(~)	Due to rounding of individual analytes, the "total" may vary slightly from the sum of the individual analyte values.

Analytes flagged with * were subcontracted to Umpqua Research Company/MC. ORELAP ID #: OR100031

UMPQUA Research Company/TR

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Soil Testing



soiltest
farm consultants, inc.

2925 Driggs Dr., Moses Lake, Wa 98837 • www.soiltestlab.com
Office: (509)765-1622 • Fax: (509)765-0314 • (800)764-1622



WALLOWA CO. GRAIN GROWERS

P.O. BOX 190

ENTERPRISE, OR 97828

Laboratory #: S23-28708

Date Received: 11/13/2023

Grower: CITY OF ENTERPRISE

Field: 1 NWN

Sampled By: KANE

Customer Account #:

Customer Sample ID:

Soil Test Results

Phosphorus	Olsen	mg/kg	13
Potassium	NH4OAc	mg/kg	485
Boron	DTPA	mg/kg	0.31
Zinc	DTPA	mg/kg	1.2
Manganese	DTPA	mg/kg	2.8
Copper	DTPA	mg/kg	0.7
Iron	DTPA	mg/kg	35
Calcium	NH4OAc	meq/100g	13.2
Magnesium	NH4OAc	meq/100g	3.5
Sodium	NH4OAc	meq/100g	0.33
Total Bases	NH4OAc	meq/100g	18.3

pH 1:1	6.0
E.C. 1:1	m.mhos/cm 0.33
Est Sat Paste E.C.	m.mhos/cm 0.86
Effervescence	None
Ammonium - N	mg/kg 26.1
Organic Matter W.B.	% 4.9
	ENR: 0

Lbs/Acre

Depth	Nitrate-N	Sulfate-S	Moisture
inches	mg/kg	lbs/acre	mg/kg
			Inches
0 - 12	28.0	90	213
Totals	28.0	90	213
Sum of Tested N:	174	lbs/acre N	

Other Tests:

Total-N (%) = 0.20

Total-C (%) = 2.0 C:N = 10.0

0 - 12 Mercury Mercury

0.10 mg/Kg

Interpretation Guide

Fertilizer recommendations for

80 BU of **WHEAT SOFT WINTER** after WHEAT SOFT WINTER
Low Medium High

Nitrogen	174	lbs/acre		70 lbs/acre of Nitrogen
Phosphorus	13	mg/kg		0 lbs/acre of P2O5
Potassium	485	mg/kg		0 lbs/acre of K2O
Sulfur	213	mg/kg		0 lbs/acre of Sulfur
Boron	0.31	mg/kg		0.5 lbs/acre of Boron
Zinc	1.2	mg/kg		0 lbs/acre of Zinc
Manganese	2.8	mg/kg		0 lbs/acre of Mn

We make every effort to provide an accurate analysis of your sample. For reasonable cause we will repeat tests, but because of factors beyond our control in sampling procedures and the inherent variability of soil, our liability is limited to the price of the tests. Recommendations are to be used as general guides and should be modified for specific field conditions and situations. Note: "u" indicates that the element was analyzed for but not detected

This is your Invoice #: S23-28708 Account #: 317300 Reviewed by: K. Bair, PhD, C List Cost: \$191.00



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farm consultants, inc.

2925 Driggs Dr., Moses Lake, Wa 98837 • www.soiltestlab.com
Office: (509)765-1622 • Fax: (509)765-0314 • (800)764-1622



WALLOWA CO. GRAIN GROWERS

P.O. BOX 190

ENTERPRISE, OR 97828

Laboratory #: S23-28709

Date Received: 11/13/2023

Grower: CITY OF ENTERPRISE

Field: 2 NWS

Sampled By: KANE

Customer Account #:

Customer Sample ID:

Soil Test Results

Phosphorus	Olsen	mg/kg	14
Potassium	NH4OAc	mg/kg	651
Boron	DTPA	mg/kg	0.36
Zinc	DTPA	mg/kg	0.9
Manganese	DTPA	mg/kg	2.4
Copper	DTPA	mg/kg	0.6
Iron	DTPA	mg/kg	32
Calcium	NH4OAc	meq/100g	16.6
Magnesium	NH4OAc	meq/100g	4.8
Sodium	NH4OAc	meq/100g	0.20
Total Bases	NH4OAc	meq/100g	23.2

pH 1:1	6.2
E.C. 1:1	m.mhos/cm 0.24
Est Sat Paste E.C.	m.mhos/cm 0.62
Effervescence	None
Ammonium - N	mg/kg 9.9
Organic Matter W.B.	% 5.1
	ENR: 0

Depth	Nitrate-N	Sulfate-S	Moisture
inches	mg/kg	lbs/acre	mg/kg
			Inches
0 - 12	20.2	65	195
Totals	20.2	65	195
Sum of Tested N:	97	lbs/acre N	

Other Tests:

Total-N (%) = 0.177

Total-C (%) = 2.01 C:N = 11.3

0 - 12 Mercury

Mercury

0.01 mg/Kg

Interpretation Guide

Fertilizer recommendations for

80 BU of **WHEAT SOFT WINTER** after WHEAT SOFT WINTER
Low Medium High

Nitrogen	97	lbs/acre		150 lbs/acre of Nitrogen
Phosphorus	14	mg/kg		0 lbs/acre of P2O5
Potassium	651	mg/kg		0 lbs/acre of K2O
Sulfur	195	mg/kg		0 lbs/acre of Sulfur
Boron	0.36	mg/kg		0.5 lbs/acre of Boron
Zinc	0.9	mg/kg		0.5 lbs/acre of Zinc
Manganese	2.4	mg/kg		0 lbs/acre of Mn

We make every effort to provide an accurate analysis of your sample. For reasonable cause we will repeat tests, but because of factors beyond our control in sampling procedures and the inherent variability of soil, our liability is limited to the price of the tests. Recommendations are to be used as general guides and should be modified for specific field conditions and situations. Note: "u" indicates that the element was analyzed for but not detected

This is your Invoice #: S23-28709 Account #: 317300 Reviewed by: K. Bair, PhD, C List Cost: \$191.00



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WALLOWA CO. GRAIN GROWERS

P.O. BOX 190

ENTERPRISE, OR 97828

Laboratory #: S23-28710

Date Received: 11/13/2023

Grower: CITY OF ENTERPRISE

Field: 3 MIDDLE W

Sampled By: KANE

Customer Account #:

Customer Sample ID:

Soil Test Results

Phosphorus	Olsen	mg/kg	14
Potassium	NH4OAc	mg/kg	767
Boron	DTPA	mg/kg	0.47
Zinc	DTPA	mg/kg	1.2
Manganese	DTPA	mg/kg	2.7
Copper	DTPA	mg/kg	0.6
Iron	DTPA	mg/kg	31
Calcium	NH4OAc	meq/100g	16.7
Magnesium	NH4OAc	meq/100g	4.1
Sodium	NH4OAc	meq/100g	0.17
Total Bases	NH4OAc	meq/100g	22.9

pH 1:1	6.3
E.C. 1:1	m.mhos/cm 0.23
Est Sat Paste E.C.	m.mhos/cm 0.60
Effervescence	None
Ammonium - N	mg/kg 10.7
Organic Matter W.B.	% 5.6
	ENR: 0

Lbs/Acre

Depth inches	Nitrate-N mg/kg	Sulfate-S mg/kg	Moisture inches
0 - 12	26.6	85	210
Totals	26.6	85	210
Sum of Tested N:	119	lbs/acre N	

Other Tests:

Total-N (%) = 0.213

Total-C (%) = 2.28 C:N = 10.7

0 - 12 Mercury Mercury 0.02 mg/Kg

Interpretation Guide

Fertilizer recommendations for

80 BU of **WHEAT SOFT WINTER** after WHEAT SOFT WINTER
Low Medium High

Nitrogen	119	lbs/acre		125 lbs/acre of Nitrogen
Phosphorus	14	mg/kg		0 lbs/acre of P2O5
Potassium	767	mg/kg		0 lbs/acre of K2O
Sulfur	210	mg/kg		0 lbs/acre of Sulfur
Boron	0.47	mg/kg		0 lbs/acre of Boron
Zinc	1.2	mg/kg		0 lbs/acre of Zinc
Manganese	2.7	mg/kg		0 lbs/acre of Mn

We make every effort to provide an accurate analysis of your sample. For reasonable cause we will repeat tests, but because of factors beyond our control in sampling procedures and the inherent variability of soil, our liability is limited to the price of the tests. Recommendations are to be used as general guides and should be modified for specific field conditions and situations. Note: "u" indicates that the element was analyzed for but not detected

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farm consultants, inc.

2925 Driggs Dr., Moses Lake, Wa 98837 • www.soiltestlab.com
Office: (509)765-1622 • Fax: (509)765-0314 • (800)764-1622



WALLOWA CO. GRAIN GROWERS

P.O. BOX 190

ENTERPRISE, OR 97828

Laboratory #: S23-28711

Date Received: 11/13/2023

Grower: CITY OF ENTERPRISE

Field: 4 MIDDLE E

Sampled By: KANE

Customer Account #:

Customer Sample ID:

Soil Test Results

Phosphorus	Olsen	mg/kg	12
Potassium	NH4OAc	mg/kg	564
Boron	DTPA	mg/kg	0.29
Zinc	DTPA	mg/kg	0.9
Manganese	DTPA	mg/kg	3.4
Copper	DTPA	mg/kg	0.5
Iron	DTPA	mg/kg	31
Calcium	NH4OAc	meq/100g	16.3
Magnesium	NH4OAc	meq/100g	4.0
Sodium	NH4OAc	meq/100g	0.32
Total Bases	NH4OAc	meq/100g	22.0

pH 1:1	6.1
E.C. 1:1	m.mhos/cm 0.35
Est Sat Paste E.C.	m.mhos/cm 0.91
Effervescence	None
Ammonium - N	mg/kg 24.8
Organic Matter W.B.	% 5.4
	ENR: 0

Lbs/Acre

Depth	Nitrate-N	Sulfate-S	Moisture
inches	mg/kg	lbs/acre	mg/kg
			Inches
0 - 12	26.7	85	229
Totals	26.7	85	229
Sum of Tested N:	164	lbs/acre N	

Other Tests:

Total-N (%) = 0.202

Total-C (%) = 2.18 C:N = 10.8

0 - 12 Mercury Mercury 0.02 mg/Kg

Interpretation Guide

Fertilizer recommendations for

80 BU of **WHEAT SOFT WINTER** after WHEAT SOFT WINTER
Low Medium High

Nitrogen	164	lbs/acre	80 lbs/acre of Nitrogen
Phosphorus	12	mg/kg	15 lbs/acre of P2O5
Potassium	564	mg/kg	0 lbs/acre of K2O
Sulfur	229	mg/kg	0 lbs/acre of Sulfur
Boron	0.29	mg/kg	0.5 lbs/acre of Boron
Zinc	0.9	mg/kg	1 lbs/acre of Zinc
Manganese	3.4	mg/kg	0 lbs/acre of Mn

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WALLOWA CO. GRAIN GROWERS

P.O. BOX 190

ENTERPRISE, OR 97828

Laboratory #: S23-28712

Date Received: 11/13/2023

Grower: CITY OF ENTERPRISE

Field: 5 SWN

Sampled By: KANE

Customer Account #:

Customer Sample ID:

Soil Test Results

Phosphorus	Olsen	mg/kg	14
Potassium	NH4OAc	mg/kg	662
Boron	DTPA	mg/kg	0.40
Zinc	DTPA	mg/kg	1.2
Manganese	DTPA	mg/kg	2.9
Copper	DTPA	mg/kg	0.6
Iron	DTPA	mg/kg	35
Calcium	NH4OAc	meq/100g	16.6
Magnesium	NH4OAc	meq/100g	4.4
Sodium	NH4OAc	meq/100g	0.20
Total Bases	NH4OAc	meq/100g	22.8

pH 1:1	6.2
E.C. 1:1	m.mhos/cm 0.29
Est Sat Paste E.C.	m.mhos/cm 0.75
Effervescence	None
Ammonium - N	mg/kg 27.5
Organic Matter W.B.	% 5.8
	ENR: 0

Lbs/Acre

Depth inches	Nitrate-N mg/kg	Sulfate-S mg/kg	Moisture inches
0 - 12	29.0	93	206
Totals	29.0	93	206
Sum of Tested N:	181	lbs/acre N	

Other Tests:

Total-N (%) = 0.232

Total-C (%) = 2.37 C:N = 10.2

0 - 12 Mercury Mercury 0.01 mg/Kg

Interpretation Guide

Fertilizer recommendations for

80 BU of **WHEAT SOFT WINTER** after WHEAT SOFT WINTER
Low Medium High

Nitrogen	181	lbs/acre		65 lbs/acre of Nitrogen
Phosphorus	14	mg/kg		0 lbs/acre of P2O5
Potassium	662	mg/kg		0 lbs/acre of K2O
Sulfur	206	mg/kg		0 lbs/acre of Sulfur
Boron	0.40	mg/kg		0.5 lbs/acre of Boron
Zinc	1.2	mg/kg		0 lbs/acre of Zinc
Manganese	2.9	mg/kg		0 lbs/acre of Mn

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WALLOWA CO. GRAIN GROWERS

P.O. BOX 190

ENTERPRISE, OR 97828

Laboratory #: S23-28713

Date Received: 11/13/2023

Grower: CITY OF ENTERPRISE

Field: 6 SWS

Sampled By: KANE

Customer Account #:

Customer Sample ID:

Soil Test Results

Phosphorus	Olsen	mg/kg	10
Potassium	NH4OAc	mg/kg	618
Boron	DTPA	mg/kg	0.37
Zinc	DTPA	mg/kg	0.7
Manganese	DTPA	mg/kg	2.3
Copper	DTPA	mg/kg	0.6
Iron	DTPA	mg/kg	31
Calcium	NH4OAc	meq/100g	13.0
Magnesium	NH4OAc	meq/100g	3.6
Sodium	NH4OAc	meq/100g	0.22
Total Bases	NH4OAc	meq/100g	18.4

pH 1:1	6.1
E.C. 1:1	m.mhos/cm 0.26
Est Sat Paste E.C.	m.mhos/cm 0.68
Effervescence	None
Ammonium - N	mg/kg 27.6
Organic Matter W.B.	% 4.6
	ENR: 0

Depth	Nitrate-N	Sulfate-S	Moisture
inches	mg/kg	lbs/acre	mg/kg
			Inches
0 - 12	36.4	116	205
Totals	36.4	116	205
Sum of Tested N:	204	lbs/acre N	

Other Tests:

Total-N (%) = 0.178

Total-C (%) = 1.75 C:N = 9.8

0 - 12 Mercury Mercury 0.01 mg/Kg

Interpretation Guide

Fertilizer recommendations for

80 BU of **WHEAT SOFT WINTER** after WHEAT SOFT WINTER
Low Medium High

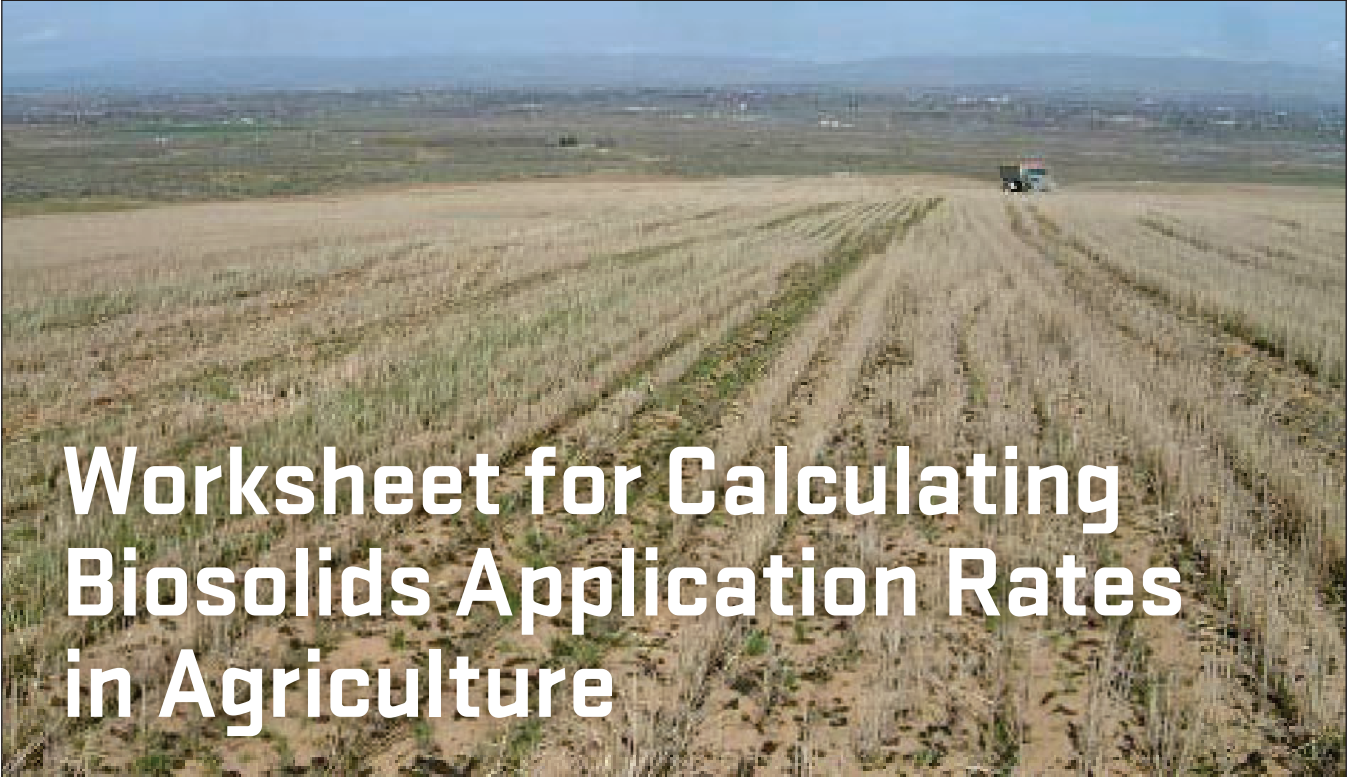
Nitrogen	204	lbs/acre	40 lbs/acre of Nitrogen
Phosphorus	10	mg/kg	30 lbs/acre of P2O5
Potassium	618	mg/kg	0 lbs/acre of K2O
Sulfur	205	mg/kg	0 lbs/acre of Sulfur
Boron	0.37	mg/kg	0.5 lbs/acre of Boron
Zinc	0.7	mg/kg	2.5 lbs/acre of Zinc
Manganese	2.3	mg/kg	0 lbs/acre of Mn

We make every effort to provide an accurate analysis of your sample. For reasonable cause we will repeat tests, but because of factors beyond our control in sampling procedures and the inherent variability of soil, our liability is limited to the price of the tests. Recommendations are to be used as general guides and should be modified for specific field conditions and situations. Note: "u" indicates that the element was analyzed for but not detected

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APPENDIX F

Example Nutrient Uptake Calculations



Worksheet for Calculating Biosolids Application Rates in Agriculture

Photo: Brian Campbell, Natural Selection Farms

Dan M. Sullivan, Deirdre Griffin LaHue, Biswanath Dari, Andy I. Bary and Craig G. Cogger

Biosolids are a product of municipal wastewater treatment. Raw sewage solids must be processed to meet U.S. Environmental Protection Agency standards before they can be called biosolids. Biosolids contain organic matter and nutrients that are beneficial for soil and crop productivity.

This publication focuses on matching the nitrogen (N) supplied by biosolids to the nitrogen needs of the crop. Regulatory agencies require agronomic rate calculations for most biosolids applications to cropland.

Overview: agronomic rate calculation

There are six steps to calculate the agronomic rate of a biosolids application:

1. Collect information on the site and crop, including crop N requirement.
2. Estimate the plant-available N needed from the biosolids application.
3. Collect biosolids N data.
4. Estimate plant-available N per dry ton of biosolids.

5. Calculate the agronomic biosolids application rate on a dry ton basis.

6. Convert the application rate to an “as is” basis.

In determining biosolids application rates, it's important to evaluate trace element concentrations in biosolids and the regulatory limits for trace element application (see Appendix A). However, in almost all cases, nitrogen controls the biosolids application rate.

A companion publication, *Fertilizing with Biosolids* (PNW 508), provides additional information about the value of biosolids as a fertilizer. The “For more information” section of this publication gives a summary of Pacific Northwest research and Extension publications on land application of municipal biosolids.

Dan M. Sullivan, Extension soil scientist and professor of nutrient management, and Biswanath Dari, agronomist and assistant professor, both of the Department of Crop and Soil Science, Oregon State University; Deirdre Griffin LaHue, sustainable soil management specialist and assistant professor, Andy I. Bary, senior scientific assistant, and Craig C. Cogger, Extension soil scientist (emeritus), all of the Department of Crop and Soil Sciences, Washington State University

WORKSHEET

For guidance on completing this worksheet, see “How to Use the Worksheet,” starting on page 5.

Step 1. Collect site information

Soil and crop information:

Line number	Your information	Example
1.1	Soil series and texture (NRCS soil survey)	Hurwal/Powwatka Silt Loams
1.2	Yield goal (units/acre/year*) estimated from grower records or by agronomist**	1.5 tons per acre
1.3	Crop rotation (grower; e.g., wheat, fallow, wheat)	perennial grass
1.4	Plant-available N needed to produce yield goal (university fertilizer/nutrient management guide; agronomist) (lb N/acre/year)	120 pounds nitrogen per acre (lbs N/acre)
		200 lb N/acre

Plant-available N provided by other sources:

Line number	Your calculation	Example	Unit
Pre-application testing			
1.5	Nitrate-N applied in irrigation water	0	10
1.6	Preplant nitrate-N in root zone (east of Cascades)***	89	—
Adjustments to typical soil N mineralization			
1.7	Plowdown of cover or green manure crop***	--	—
1.8	Previous biosolids applications (see Table 1, page 7)	--	30
1.9	Previous manure applications	0	—
Grower information			
1.10	N applied at seeding (starter fertilizer)	0	—
Total			
1.11	Total plant-available N from other sources = sum of lines 1.5 through 1.10	89	40

* Yield goals may be expressed in weight (tons, pounds, etc.) or in volume (bushels).

** The American Society of Agronomy certifies professional agronomists as Certified Crop Advisors (CCAs). See <https://www.certifiedcropadviser.org> for more information.

*** Do not list here if these N sources were accounted for in the nitrogen fertilizer recommendation from a university fertilizer/nutrient management guide.

Step 2. Estimate the amount of plant-available N needed from biosolids

Line number		Your calculation	Example	Unit
2.1	Plant-available N needed to produce yield goal (from line 1.4)	120	200	lb N/acre
2.2	Plant-available N from other sources (from line 1.11)	89	40	lb N/acre
2.3	Amount of plant-available N needed from biosolids = line 2.1 – line 2.2	31	160	lb N/acre

Step 3. Collect biosolids data

Application information:

Line number		Your information	Example
3.1	Moisture content of biosolids	Dewatered	liquid
3.2	Biosolids processing method (see Table 3, page 10)	Aerobic digestion	anaerobic
3.3	Method of application (surface or injected)	Surface	surface
3.4	Number of days to incorporation of biosolids	No incorporation	no incorporation
3.5	Expected application season	Spring and fall	March to September

Laboratory biosolids analysis (dry weight basis):

If your biosolids analysis is on an “as is” or wet weight basis, you will need to divide your analysis by the percent total solids (line 3.10) and multiply the result by 100 to convert to a dry weight basis.

Line number		Your calculation	Example	Unit
3.6	Total Kjeldahl N (TKN)*	66,800	50,000	mg/kg
3.7	Ammonium N*	4,430	10,000	mg/kg
3.8	Nitrate N *,**	Not detected	not analyzed	mg/kg
3.9	Organic N*,*** = line 3.6 – line 3.7	62,370	40,000	mg/kg
3.10	Total solids	0.76	2.5	percent

* If your analysis is in percent, multiply by 10,000 to convert to mg/kg.

** Nitrate-N analysis required for composted or aerobically digested biosolids, but not for anaerobically digested biosolids.

*** Organic N = total Kjeldahl N – ammonium N.

Step 4. Estimate plant-available N per dry ton of biosolids

Convert biosolids N analysis to lb per dry ton:

Line number	Your calculation	Example	Unit
4.1	Total Kjeldahl N (TKN)*	133.60	100
4.2	Ammonium N*	8.86	20
4.3	Nitrate N*	Not detected	not analyzed
4.4	Organic N = line 4.1 – line 4.2	124.74	80

*Multiply mg/kg (from lines 3.6 through 3.9) × 0.002. If your analyses are expressed in percent, multiply by 20 instead of 0.002.

Estimate inorganic N retained:

Line number	Your calculation	Example	Unit
4.5	Percent of ammonium-N retained after application (see Table 2, page 9)	20	55
4.6	Ammonium-N retained after application = line 4.2 × (line 4.5 ÷ 100)	1.77	11
4.7	Biosolids inorganic N retained = line 4.3 + line 4.6	1.77	11

Estimate organic N mineralized:

Line number	Your calculation	Example	Unit
4.8	Percent of organic N that is plant-available in Year 1 (see Table 3, page 10)	35	35
4.9	First year plant-available organic N = line 4.4 × (line 4.8 ÷ 100)	43.66	28

Plant-available N:

Line number	Your calculation	Example	Unit
4.10	Estimated plant-available N = available inorganic N (line 4.7) + available organic N (line 4.9)	45.43	39

Step 5. Calculate the agronomic biosolids application rate

Line number		Your calculation	Example	Unit
5.1	Amount of plant-available N needed from biosolids (from line 2.3)	31	160	lb N/acre
5.2	Estimated plant-available N in biosolids (from line 4.10)	45.43	39	lb N/dry ton
5.3	Agronomic biosolids application rate = line 5.1 ÷ line 5.2	0.68	4.1	dry ton/acre

Step 6. Convert to “as is” biosolids basis

Desired units		Your calculation	Example
Gallons per acre =	(line 5.3 ÷ line 3.10) × 24,000	21,474	39,400
Inches per acre =	(line 5.3 ÷ line 3.10) × 0.88	0.79	1.44
Wet tons per acre =	(line 5.3 ÷ line 3.10) × 100	89.47	164

HOW TO USE THE WORKSHEET

Step 1. Collect site information

Soil series and surface soil texture (line 1.1)

Find the location on the Natural Resources Conservation Service (NRCS) soil survey. Record the series name and surface texture of the predominant soil. NRCS soil survey data is available online at <https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm>.

Crop yield goal (line 1.2)

Field records are the best source for crop yield estimates. You can find proven yields for most grain farms from the local Farm Service Agency office. For most other cropping systems, grower records are the only source available. Be sure to note whether the yield records are on an “as is” or dry matter basis.

A site used repeatedly for biosolids application should have yield data collected each year. Use this accumulated data for determining crop nitrogen requirement.

Yield data is typically not available for grazed pastures because grazing animals consume the crop in the field. In these cases, omit the yield goal and go directly to line 1.4. Estimate plant nitrogen needs from the appropriate university fertilizer/nutrient management guide, based on the level of pasture management.

Crop rotation (line 1.3)

Consult with the grower and discuss possible crop rotations. Rotations that include root crops or other crops with long post-application waiting periods are not suitable for Class B biosolids application. A companion publication (*Fertilizing with Biosolids*, PNW 508) provides more information about USEPA standards for Class A and Class B biosolids.

Plant-available N needed to produce yield goal (line 1.4)

You can estimate plant-available N needs by referring to university fertilizer/nutrient management guides.

University fertilizer and nutrient management guides

Land grant universities (for example, Washington State University, Oregon State University, and the University of Idaho) publish fertilizer and nutrient management guides that estimate plant-available N needs. Use the guide most appropriate for the site and crop. For major crops, guides may cover irrigated or rainfed (dryland) cropping and different geographic areas. Don't use guides produced for irrigated sites when evaluating dryland sites. When appropriate guides do not exist, consult university Extension agronomists/

soil scientists or professional agronomists (Certified Crop Advisors) who have expertise working within the cropping system.

Nitrogen fertilizer application rates listed in the fertilizer/nutrient management guides are based on field trials conducted under the specified climate and cultural conditions. Growth trial results are averaged over a variety of soil types and years. Note that guide recommendations are not the same as crop uptake. This is because the guides account for N available from mineralization of soil organic matter and the efficiency of N removal by the crop.

The N rate recommended in fertilizer/nutrient management guides assumes average yields, good management practices, and removal of N from the field through crop harvest or grazing. In terms of satisfying crop N needs, plant-available N from biosolids application is considered equal to fertilizer N.

Agronomist calculations

Because of the general nature of university fertilizer and nutrient management guides, it may be worthwhile to have a professional agronomist calculate how much plant-available N is needed for a specific field. The American Society of Agronomy certifies professional agronomists as Certified Crop Advisors (CCAs). See <https://www.certifiedcropadviser.org> for more information.

Always use the same method to calculate the N requirements. You will need to document your reasons for using agronomist calculations instead of the university guide.



Photo: Andy Bary, ©Washington State University
Dewatered biosolids stockpile at field application site

Plant-available N provided by other sources (lines 1.5 to 1.11)

To make sure there isn't too much nitrogen applied to a crop, you must determine how much nitrogen comes from sources other than biosolids and soil organic matter. These sources of N are grouped into three categories in the worksheet:

- Plant-available N estimated by pre-application testing
- Adjustments to typical soil organic N mineralization (usually obtained from an agronomist)
- Information supplied by the grower

N estimated by pre-application testing (lines 1.5 to 1.6)

Irrigation water

Since the amount of nitrate-N in irrigation water varies, it should be determined by water testing. Irrigation water containing 5 mg nitrate-N per liter will contribute 1.1 pounds of nitrogen per acre-inch applied; irrigation water containing 10 mg nitrate-N per liter will contribute 2.3 pounds of N per acre-inch.

Preplant nitrate-N in the root zone (east of Cascades)

You can estimate the preplant nitrate-N in the root zone by testing the soil in early spring. Sample in 1-foot increments to a depth of at least 2 feet.

Some university fertilizer/nutrient management guides use preplant soil nitrate-N when calculating N fertilizer application rates. If you use these guides, don't count soil test nitrate-N in our worksheet—it has already been accounted for in the recommended fertilizer N rate prescribed in the university fertilizer/nutrient management guide.

In dryland cropping systems, soil testing below 3 feet is used to assess long-term N management. Accumulation of nitrate below 3 feet indicates that past N applications were not efficiently utilized by the crop. However, soil nitrate-N below 3 feet is typically not included as a credit when making a N fertilizer recommendation.

Adjustments to typical soil N mineralization (lines 1.7 to 1.9)

Nitrogen mineralization is the release of nitrogen from organic forms to plant-available inorganic forms (ammonium and nitrate). Soil organic matter supplies plant-available N through mineralization, but this is accounted for in the university fertilizer/nutrient

management guides. Sites with a history of cover crops, biosolids applications, or manure applications supply more plant-available N than do sites without a history of these inputs, and biosolids recommendations must be adjusted based on this additional supply of N.

Plowdown of cover crops

Cover crops are not removed from the field, but are recycled back into the soil. You can get an estimate of the total N contributed by estimating the biomass dry matter (lb per acre) and the nitrogen concentration (percent total) in the cover crop. Plant-available N provided by a cover crop typically ranges from 10 to 40 percent of the total N contained in aboveground cover crop biomass. Consult *Estimating Plant-Available Nitrogen Release from Cover Crops* (PNW 636) for more information.

Previous biosolids applications

Previous biosolids applications contribute to plant-available nitrogen in the years after the initial application. In the worksheet, they are considered as “N from other sources.” We estimate that 8, 3, 1, and 1 percent of the organic N *originally applied* mineralizes in Years 2, 3, 4, and 5, respectively, after application (Table 1). After Year 5, biosolids N is considered part of “stable” soil organic matter and is not included in calculations.

In using Table 1, consider the following example. Suppose:

- You applied biosolids with an average organic N content of 30,000 mg/kg

- Applications were made the previous 2 years
- The application rate was 4 dry tons per acre

Table 1 gives estimates of nitrogen credits *in terms of the organic N originally applied*. Look up 30,000 mg/kg under Year 2 and Year 3 columns in the table. The table estimates 4.8 lb plant-available N per dry ton for year 2, and 1.8 lb plant-available N for year 3 (two-year credit of 6.6 lb N per dry ton). To calculate the N credit in units of lb per acre, multiply your application rate (4 dry ton per acre) by the N credit per ton (6.6 lb N per dry ton). The N credit is 26.4 lb plant-available N per acre.

Previous manure applications

Previous manure applications contribute to plant-available nitrogen in a similar manner to previous biosolids applications. To estimate this contribution, consider field history (manure type, application rate, and date of application). The Extension publication *Fertilizing with Manure and Other Organic Amendments* (PNW 533) provides plant-available N estimates.

Information supplied by the grower (line 1.10)

N applied at seeding

Some crops need a starter fertilizer (N applied at seeding) for best growth. These fertilizers usually supply N, P, and S. Examples are 16-20-0, 10-34-0. Starters are usually applied at rates that supply 10 to 30 lb N per acre. Enter all N supplied by starter fertilizer on line 1.10 in the worksheet.

Table 1. Estimated nitrogen credits for previous biosolids applications at a site

	Years after biosolids application			
	Year 2	Year 3	Year 4 and 5	Cumulative (Years 2, 3, 4, and 5)
	Percent of organic N applied first year			
	8	3	1	13
Biosolids organic N as applied (mg/kg dry weight basis)	Plant-available N released (lb N per dry ton)			
10,000	1.6	0.6	0.2	2.6
20,000	3.2	1.2	0.4	5.2
30,000	4.8	1.8	0.6	7.8
40,000	6.4	2.4	0.8	10.4
50,000	8.0	3.0	1.0	13.0
60,000	9.6	3.6	1.2	15.6



Photo: Brian Campbell, Natural Selection Farms
Dewatered biosolids application to dryland wheat during fallow

Step 2. Estimate plant-available N needed from biosolids

Next you will estimate the amount of plant-available N the biosolids must provide. This is the difference between the total plant-available N needed to produce the yield goal and the plant-available N from other sources.

Step 3. Collect biosolids data

To make the calculation, managers will need the following analyses:

- Total Kjeldahl N (TKN)
- Ammonium-N ($\text{NH}_4\text{-N}$)
- Nitrate-N ($\text{NO}_3\text{-N}$; composted or aerobically digested biosolids only)
- Percent total solids

If your laboratory results are on an “as is” or wet weight basis, you must convert them to a dry weight basis. To convert from an “as is” to a dry weight basis, divide your analysis by the percent solids in the biosolids and multiply the result by 100. Total Kjeldahl N includes over 95 percent of the total N in biosolids. In using the worksheet, we will assume that total Kjeldahl N equals total N.

Ammonium-N usually makes up most of the inorganic N present in biosolids. Depending on your laboratory, results for ammonium-N may be expressed as either ammonia-N ($\text{NH}_3\text{-N}$) or ammonium-N ($\text{NH}_4\text{-N}$). Make sure that the laboratory determines ammonium-N on a fresh (not dried) biosolids sample. The ammonium-N present in fresh biosolids is lost as gaseous ammonia when biosolids are dried.

There may be significant amounts of nitrate in aerobically digested biosolids or in composts. There is little nitrate in anaerobically digested biosolids; therefore, nitrate analysis is not needed for these materials.

Determine biosolids organic N by subtracting ammonium-N from total Kjeldahl N (line 3.6 minus line 3.7). Percent total solids analyses are used to calculate application rates. Biosolids applications are calculated as the dry weight of solids applied per acre (e.g., dry tons per acre).

Step 4. Estimate plant-available N per dry ton of biosolids

The estimate of plant-available N per dry ton of biosolids includes:

- Some of the ammonium-N
- All of the nitrate-N
- Some of the organic N

Inorganic N retained (lines 4.5 to 4.7)

Ammonium-N (lines 4.5 to 4.6)

Under some conditions, ammonium is readily transformed to ammonia and lost as a gas. This gaseous ammonia loss reduces the amount of plant-available N supplied by biosolids. The following section explains the factors used to estimate ammonia-N retained in plant-available form after application.

Biosolids processing

The following types of biosolids processing cause most of the ammonia-N to be lost as ammonia gas or converted to organic forms before application:

- Drying beds
- Alkaline stabilization at pH 12
- Composting

Application method

Ammonia loss occurs only with surface application. Injecting liquid biosolids eliminates most ammonia loss, since the injected liquid is not exposed to the air. Surface applications of liquid biosolids lose less ammonia than do dewatered biosolids. For liquid biosolids, the ammonia is less concentrated and is held as NH_4^+ on negatively-charged soil surfaces after the liquid contacts the soil.

Ammonia loss is fastest just after application to the field. As ammonia is lost, the remaining biosolids are acidified—that is, each molecule of NH_3 lost generates H^+ (acidity). Acidification gradually slows ammonia loss.

Biosolids that remain on the soil surface will eventually reach a pH near 7, and further ammonia losses will be small. Ammonia loss takes place very rapidly after application, with most of the loss occurring during the first two days after application.

Time to soil incorporation

Tillage to cover biosolids can reduce ammonia loss by adsorption of ammonium-N onto soil particles.

Table 2 estimates the amount of ammonium-N retained after field application. To use this table, you will need information on biosolids stabilization processes, method of application (surface or injected), and the number of days to soil incorporation.

Nitrate-N (line 4.3)

We assume 100 percent availability of biosolids nitrate-N.

Organic N mineralized (lines 4.8 to 4.9)

Biosolids organic N, which includes proteins, amino acids, and other organic N compounds, is not available to plants at the time of application. Plant-available N is released from organic N through microbial activity in soil. This process is called mineralization. It is more rapid in soils that are warm and moist, and is slower in soils that are cold or dry. Biosolids organic N mineralization rates in soil also depend on the treatment plant processes that produced the biosolids.

Use Table 3 (page 10) to estimate biosolids mineralization rates based on processing. Use the middle of the range presented, unless you have



Photo: City of Portland, Bureau of Environmental Services
Spring grass growth on dryland pasture following dewatered biosolids application (top) vs. no biosolids (bottom)

information specific to the site or biosolids that justify using higher or lower values within the range.

Step 5. Calculate the agronomic biosolids application rate

Perform this calculation using the results of the previous sections, as shown in lines 5.1 through 5.3.

Step 6. Convert agronomic biosolids application rate to “as is” basis

Use the appropriate conversion factors (given in Table 4, page 10) to convert to gallons, acre-inches, or wet tons per acre.

Table 2. Estimates of ammonium-N retained after biosolids application

	Surface-applied			Injected
	Liquid biosolids	Dewatered biosolids	Composted, air-dried, or heat-dried biosolids	All biosolids
Time to incorporation by tillage	Ammonium-N retained (percent of applied)			
Incorporated immediately	95	95	100	100
After 1 day	70	50	100	100
After 2 days	60	30	100	100
No incorporation	55	20	100	100

Table 3. First year mineralization estimates for organic N in biosolids

Processing	First-year organic N mineralization rate (percent of organic N)
Fresh*	
Anaerobic digestion, liquid or dewatered	30–40
Aerobic digestion, liquid or dewatered	30–40
Drying bed	30–40
Heat-dried	30–40
Lagoon	
Less than 6 months	30–40
6 months to 2 years	20–25
2 to 10 years	10–20
More than 10 years	5–10
Composting	0–10
Blends and soil products	†

*“Fresh” includes all biosolids that have not been stabilized by long-term storage in lagoons or composting.

†Because blends (with woody materials) and soil products that contain biosolids vary widely in composition and age depending on intended use, available N may vary widely among products. For blends, available N can be estimated through laboratory incubation studies.

Table 4. Conversion factors

1%	=	10,000 mg/kg or ppm 20 lb/ton
1 mg/kg	=	1 ppm 0.0001 % 0.002 lb/ton
1 wet ton	=	1 dry ton ÷ (percent solids × 0.01)
1 dry ton	=	1 wet ton × (percent solids × 0.01)
1 acre-inch	=	27,000 gallons

Other considerations for calculations

Small acreage sites without a reliable yield history

Some communities apply biosolids to small acreages managed by part-time farmers. In many of these cases, there is no reliable yield history for the site, and the goal of management is not to make the highest economic returns. You can be sure of maintaining agronomic use of biosolids nitrogen on these sites by applying at a rate substantially below that estimated for maximum yield.

Equipment limitations at low application rates

At some low-rainfall dryland cropping locations east of the Cascades, the agronomic rate calculated with the worksheet will be lower than can be spread with manure spreaders (usually 2 to 3 dry tons per acre). At these locations, you may be able to apply the dewatered biosolids at the equipment limit, but check with your permitting agency for local requirements.

Appendix A: Cumulative loading of trace elements

Under EPA regulations (40 CFR Part 503.13), managers must maintain records on cumulative loading of trace elements only when bulk biosolids do not meet EPA Exceptional Quality Standards for trace elements (Table 5). Contact your regulatory agency for details on record keeping if your biosolids do not meet the standards in Table 5.

Table 5. Trace elements concentration limits for land application

Element	Symbol	Concentration limit	
		Exceptional quality standard (EPA Table 3)* (mg/kg)	Ceiling limit (EPA Table 1)* (mg/kg)
Arsenic	As	41	75
Cadmium	Cd	39	85
Copper	Cu	1,500	4,300
Lead	Pb	300	840
Mercury	Hg	17	57
Molybdenum	Mo	**	75
Nickel	Ni	420	420
Selenium	Se	100	100
Zinc	Zn	2,800	7,500

Source: EPA 40 CFR Part 503

*EPA Table 3 and Table 1 refer to tables in EPA biosolids rule (40 CFR Part 503).

**Molybdenum concentration standard level is under review by the EPA.

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