

**OTTER CREEK MINE  
SOILS BASELINE REPORT  
304L**



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Plate 1. Soils Baseline Map - Tract 2

Baseline Report 304L: Baseline Soils Report, Otter Creek Mine

ARM 17.24.304(1) Subsection:	Location of Required Information:
(k) a soil survey according to standards of the national cooperative soil survey and the department describing all soils on the proposed permit area and their suitability for reclamation purposes. The soil survey must include the following information:	Section 2.1
(i) description, sampling, and analysis of soils in sufficient detail to identify the soil series, phases, and mapping units present including:	Sections 2.1 and 2.2, Plate 1
(A) series and phase descriptions;	Section 3.2, Appendix D
(B) mapping unit (complex and consociation) descriptions;	Section 3.2, Appendix D
(C) descriptions of representative soil pedons; and	Section 4.3, Table 3, Table 4, Appendix D
(D) results of chemical and physical analyses of soil horizon samples. Each horizon sample must be analyzed in accordance with ARM 17.24.302(3) for pH, particle size distribution (texture), and other parameters that must be determined in consultation with the department;	Section 4.1, Section 4.2, Table 3, Table 4
(ii) a soils map acceptable to the department. The scale must be 1" = 400' unless otherwise altered or approved by the department. Enlarged aerial photographs may be used as a map base. The map or photograph must include:	Section 2.3, Plate 1
(A) the soil mapping units, their boundaries, a legend of the soil mapping units and the estimated salvage depths of soils within each mapping unit, consistent with the information submitted under ARM 17.24.313(1)(f);	Plate 1, Table 1
(B) soil sampling locations; and	Plate 1
(iii) further soil studies or information determined by the department to be useful or necessary to evaluate the application;	Appendix C

## 1.0 INTRODUCTION

Arch Coal, Inc. (Arch) contracted WESTECH Environmental Services, Inc. (WESTECH) to conduct an Order 2 baseline soils inventory within the Tract 2 and Facilities Area (study area) of the proposed Otter Creek Coal mine. The study area is located in Powder River County approximately 8 miles southeast of Ashland, Montana. The study area is approximately 14.5 square miles, containing primarily private lands, although State of Montana and Federal (Bureau of Land Management) lands are also present. The soils baseline inventory was designed to satisfy mine planning requirements and regulations promulgated by The Department of Environmental Quality (MDEQ).

An Order 2 soil survey was conducted within the study area to provide the data presented in this Baseline Report. The primary Objectives of the Order 2 soils survey were to:

- Identify, delineate and classify dominant soils;
- Sample representative soil horizons from identified soils;
- Analyze soil samples for selected physical and chemical characteristics;
- Determine soil suitability for reclamation;
- Assess the potential for Prime Farmland, in consultation with the local Natural Resources Conservation Service (NRCS) office; and
- Identify soils that may require special handling.

## 2.0 METHODOLOGY

The Plan of Study (POS) was based on soil survey procedures as outlined by the Soil Survey Manual (NRCS, 1993) and approved by MDEQ. Soil data included in this baseline report were compiled from literature review, field mapping, soil sampling, and laboratory analyses. These data were integrated with regulatory guidelines to determine salvage suitability for each soil type. A total of 91 sample sites were identified, described, and major horizons sampled to represent the characteristics of each soil series identified on the Baseline Soils Map (Plate 1). Laboratory data for each sample site were tabulated for the physical and chemical soil properties not discernible in the field. These data and existing NRCS soil survey data were used to develop descriptions of each soil mapping unit in narrative form.

Corey Baker conducted the field inventory and was assisted by Brian Kozar and Brian Eckenrod, as well as several soil survey technicians. Field work was conducted July-September 2011 and August-

September 2012. Energy Laboratories of Helena, Montana performed the laboratory analyses during the fall/winter of 2011/2012 and fall of 2012.

## **2.1 LITERATURE REVIEW**

A review of existing soils information for the study area included information from the Powder River Area Soil Survey (NRCS 2010). This information was used to identify dominant soil series in the area and develop a preliminary soils map. The NRCS soil data were used to summarize dominant soil characteristics and to estimate sample site locations.

WESTECH maintains a soil science library that includes the National Cooperative Soil Survey documents. Reference documents used in preparation of this report include: The Soil Survey Manual, Handbook 18 (NRCS, 1993); The National Soils Handbook, Handbook 430 (NRCS, 2007); Keys to Soil Taxonomy (10<sup>th</sup> Edition) Handbook 436 (NRCS, 2006); NRCS Field Book for Describing and Sampling Soils (NRCS, 2002) and other pertinent soils engineering, erosion, and salvage suitability documents.

WESTECH contacted the NRCS regarding soil mapping update status and NRCS designated soil interpretations, such as prime farmland.

## **2.2 FIELD PROCEDURES**

The mapping and evaluation of soils within the study area was completed using a two-step field analysis approach. Initial field surveys utilized 428 widely distributed description sites to identify the boundaries of discrete soils and soil complexes, using existing NRCS soils data as a guide. The second survey involved excavating, describing, and sampling soils at 91 sample site locations within the study area boundary.

### **2.2.1 Preliminary Soils Map**

A preliminary soils map was developed using data gathered at description sites and field observations within the study area. The locations of description sites were recorded using handheld GPS receivers, excavated using hand shovels and augers, and described using field data parameters. Sites were selected by traversing the landscape and observing soil variability resulting from differences in landform, topographical position, vegetation, and parent material. Soil profiles were investigated by hand digging and augering to a depth of 60 inches or to parent material, whichever was encountered first. The preliminary soils map was used to select soil sample sites and develop the Baseline Soils Map (Plate 1).

### **2.2.2 Soil Sample Sites and Laboratory Analysis**

Soil sample site locations were located in areas that were representative of the identified soil series, while maintaining adequate spatial distribution of sites within the study area.

At a minimum at least one site was characterized and sampled for each soil series identified in the study area. Two soil sample sites were characterized for each soil series between 40 and 320 acres, and three sample sites were characterized for each soil series in excess of 320 acres.

Soil sample sites were excavated with a backhoe when accessible, while inaccessible sites were excavated by hand. Soil profiles at sample sites were exposed to at least 84 inches (7 feet) by backhoe and to 60 inches (5 feet) by hand methods. Profiles were exposed to lesser depths if unsuitable soil, paralithic, or lithic materials were encountered. Some paralithic materials were investigated for reclamation use as subsoil, in the event suitable subsoil materials were inadequate.

Soil sample site locations were recorded using a hand-held Global Positioning System (GPS) device and are identified on the baseline soils map (Plate 1).

Each sample site was characterized using site characteristics descriptions, soil profile characterization, and horizon sampling for laboratory analysis. The following soil characteristics were recorded at each sample site in the field:

- Drainage class,
- Slope range,
- Parent material,
- Vegetation and land use,
- Physiography and position in the landscape,
- Aspect,
- Surface runoff,
- Groundwater, and
- Other comments pertinent to classification and soil suitability for salvage.

The major and subsidiary horizons of the exposed soil pedons were characterized and described using the following field observations:

- Designation, thickness, and arrangement of horizons,
- Structure,
- Color,
- Texture,
- Coarse fragment content,
- Carbonates,
- Salt crystals
- Abundance and diameter of roots, and
- Consistence and plasticity.

A two-quart sample was collected from each identified soil horizon within the sample site soil profile. Soil samples were placed in clean, polyethylene bags and transported to Energy Laboratories in Helena in a timely manner. Energy Laboratories performed the following soil analyses using methods outlined in the MDEQ 1998 guidelines.

- Ph,
- Conductivity,
- Saturation percentage,
- Organic matter content,
- Coarse fragment content,
- Sand percentage,
- Fine sand percentage,
- Silt percentage,
- Clay percentage,
- Sodium adsorption ratio (SAR),
- Magnesium,
- Sodium,
- Calcium,
- Boron,
- Molybdenum, and
- Selenium.

The field observations and laboratory data for each sample site are presented and summarized in Section 3.0 of this report.

### **2.2.3 Soil Salvage Depths**

The soil salvage depths and special material handling recommendations were developed using soil mapping, profile descriptions, laboratory data and other soils characterizations in accordance with current MDEQ Guidelines (MDEQ, 1998). Salvage depths and reclamation considerations were based on soil sample data for soil series within soil map units. Discussions of soil suitability and salvage information are presented in Section 4.0. Recommended salvage depths for each soil map unit are shown on Table 2.

### **3.0 RESULTS**

The climate of the study area is cold winters and warm summers with a growing season that extends from April to September in most years (USDA 1971). The average annual temperature in the region is 46 degrees Fahrenheit (F). Annual temperatures range from an average low of approximately 34 degrees F to an average high of 59 degrees F (NRCS 2012). During the growing season, average temperatures range from 47 to 76 degrees F and precipitation ranges from 12 to 14 inches annually. The majority of the annual precipitation occurs in May and June (NRCS, 2012).

Geology of the area is predominantly soft, dissected sandstones, siltstones, and claystones in the Tongue River Member of the Fort Union Formation (USDA, 1980). These landscapes contain a variety of landscape features ranging from sandstone or scoria buttes and benches in the uplands, to very deep, finely textured alluvial soils on lower slopes and floodplains. The dissected uplands contain a mixture of sedimentary materials, including claystone, siltstone and mudstone layers along with scattered shale and sandstone.

#### **3.1 BASELINE SOILS MAP**

A baseline soils map of the study area is provided as Plate 1 and includes an aerial photograph base, topographic contours, location of soil sample sites and delineated soils mapping units. The Soils Map Legend (Table 1) includes the soil map unit symbols, map unit names, slope ranges, relative composition and recommended salvage depths for each soil map unit in the study area.

#### **3.2 SOIL MAPPING UNIT DESCRIPTIONS**

A total of 22 soil series were identified within 30 soil map units comprising the study area. The most prevalent soils are fine textured silty and silty clay loams such as McRae, Midway, Delpoint, and Fort Collins soil series. These soils are located on gentle slopes, alluvial fans and floodplains below sandstone ridges and above the Otter Creek floodplain. Other dominant soils in the study area consist of shallow skeletal soil derived from scoria and sandy loams of various depths in areas near sandstone ridges (Blacksheep and Ringling), shallow to moderately deep sandy loams in areas of sandstone ridges (Blacksheep and Twilight), and shallow loams or silt loams (Cabba and Cabbart) derived from a mixture of thinly bedded sedimentary material. These shallower soils are typically located on moderate to steep slopes and contain gravel to cobble sized coarse fragments within the profile.

The soil forming factors and typical characteristics of each soil mapping unit and soils series listed on the soil map legend (Table 2) are described below. Site photos depicting the landscape position and site



conditions at each of the soil sample sites are presented in Appendix C. Official soil series descriptions and range of characteristics are presented in Appendix D.

*Av: Arvada Clay Loam (0 -10% Slopes)*

This very deep, well drained soil is located on gentle hillslopes and alluvial fans. It forms in alluvium and colluvium overlying sodic shale parent material and contains high salinity/sodicity throughout the soil profile. Other soils in this mapping unit include Hydro soils which are located in depressions, swales and depositional areas.

*BCC: Blacksheep-Cabba-Cabbart Complex (15 – 60% Slopes)*

This map unit primarily contains shallow soils located on steep slopes, breaks and ridges associated with features such as rock outcrops and high terraces. These soils form in residuum and colluvium from a variety of sedimentary bedrock parent materials. Blacksheep soils have sandy loam to loam textures and frequently contain greater than 5% sandstone coarse fragments in the profile. Blacksheep soils are located on shoulders and ridges overlying sandstone rock outcrops. Cabba soils have loam to silt loam textures and contain greater than 10% siltstone or hard shale coarse fragments. Cabba soils are located on ridges and steep slopes overlying primarily siltstone and shale parent materials. Cabbart soil textures range from clays to sandy loams, although the majority of these soils exhibit loam and silt loam textures. Cabbart soils are located on narrow ridges and steep slopes consisting of weathered loamy sedimentary beds with occasional inter-bedding of sandstone and shale bedrock.

*BCT: Blacksheep-Cabba-Twilight Complex (10 – 30% Slopes)*

This soil map unit is located on slopes and terraces associated with sandstone rock outcrops. Shallow soils, such as Blacksheep and Cabba, form on moderate to steep slopes and shoulders of these features. Twilight soils are moderately deep, sandy textured soils that form in sandstone residuum on terraces.

*BL-RO: Badlands – Rock Outcrop (25 – 70% Slopes)*

This mapping unit delineates surface or near surface outcrops exposing a mixture of sedimentary bedrock material. Typically these features are isolated on the landscape and consist of steep slopes and ridges that contain little to no vegetation.

*CC: Cabbart-Cabba shallow loams (20-70% Slopes)*

This map unit contains shallow soils located on steep slopes and breaks. These soils form in residuum and colluvium from a variety of sedimentary bedrock parent materials. Cabbart soil textures range from clays to sandy loams, although the majority of these soils exhibit loam and silt loam textures. Cabbart soils are located on narrow ridges and steep slopes consisting of weathered loamy sedimentary beds with occasional inter-bedding of sandstone and shale bedrock. Cabba soils have loam to silt loam textures and contain greater than 10% siltstone and hard shale coarse fragments. Cabba soils are located on ridges and steep slopes overlying primarily siltstone and shale parent materials.

*Cu: Cushman silt loam (0-5% Slopes)*

This mapping unit consists of very deep, well drained soils formed in residuum on upland terraces. Cushman soils contain loam to clay loam soil textures. Other soils in this mapping unit include Cabbart shallow loams which are located on shoulders and upper slopes of Cushman terraces.

*DL: Disturbed Lands*

This map unit delineates areas that were previously disturbed for agricultural purposes, such as construction of stock ponds or impoundments.

*Fa: Farland silt loam (0 – 10% Slopes)*

This map unit consists of very deep, well drained soils located in swales and drainages on the Otter Creek floodplain. These are silty clay loam to loam textured soils that formed in stratified alluvial deposits. Other soils in this map unit include Havre and Nihill loams that also formed in alluvium. Havre soils formed in mixed alluvium on swales and gentle drainages while Nihill soils are found in steeper areas.

*FtD: Fort Collins – Delpoint silt loams (5 – 30% Slopes)*

This map unit consists of moderately deep to very deep soils that formed in colluvium and sheetwash alluvium of loamy sedimentary beds. Fort Collins soils are very deep, well drained soils located on gently sloping toeslopes, swales and terraces. Delpoint soils are moderately deep, well drained soils that formed on gentle slopes, small ridges and terraces. Other soils in this map include Midway shallow clays located on steeper slopes or ridges and Barvon loams located in isolated depressions and broad swales.

*Top: Fort Collins – Hesper silt loams (5 – 15% Slopes)*

This map unit consists of very deep, well drained soils formed in alluvium on gentle slopes and lower terraces. Fort Collins soils have clay loam to loam textures and are typically found on gentle slopes or broad terraces. Hesper soils have silty clay loam to loam textures and are most common in depositional areas such as swales and toeslopes. Other soils in this map unit include Twilight soils on upland terraces or toeslopes below sandstone rock outcrops and Delpoint soils on small ridges and steeper slopes.

*H: Haverson silty clay (0 - 5% Slopes)*

This map unit consists of very deep, well drained soils that formed in alluvium on broad stream terraces and upland swales. Other soils in this map unit include Heldt soils on stream terraces adjacent to Otter Creek and McRae soils on toeslopes and terraces.

*H-S: Haverson silty clay - Saline (0 - 5% Slopes)*

This map unit is similar to the Haverson map unit in terms of topographic position and physical soil properties. However, soils in this map unit contain elevated salinity and/or sodicity within sub-surface horizons. Sources of salinity include the deposition of alluvial material in upland swales while stream terraces receive both saline alluvial deposits on the surface and saline groundwater at depth. High salinity was not detected in surface horizons of this soil and was typically encountered at depths of 7 to

25 inches below the ground surface. Other soils in this map unit include Delpoint soils on slopes adjacent to upland swales and intermittent sites of Heldt soils within drainage floodplains.

*He: Heldt silty clay loam (0 - 5% Slopes)*

This soil map unit consists of very deep, well drained soils located on alluvial fans and stream terraces. These soils form in fine textured alluvium and contain silty clay loam to loamy textures throughout the profile. Other soils in this map unit include Haverson soils dispersed on stream terraces and Fort Collins soils on slopes adjacent to terraces.

*He-S: Heldt silty clay loam - Saline (0 - 5% Slopes)*

This soil map unit consists of Heldt soils within the Otter Creek floodplain that contain saline and sodic properties below a depth of approximately 14 inches. These soils have a similar distribution to the Haverson saline soils, but are more finely textured. Other soils in this map unit are Haverson, both saline and non-saline phases, on stream terraces and Fort Collins soils on slopes above the terraces.

*Hp: Hesper silty clay loam (5 - 15% Slopes)*

This soil map unit consists of very deep, well drained soils located on upland plains and terraces. These clay loam and silty clay loam textured soils formed in finely textured calcareous alluvial and eolian deposits. Other soils in this mapping unit include Fort Collins soils on slopes and small ridges.

*HyHp: Hydro - Hesper silty clay loams (0 - 15% Slopes)*

This soil map unit consists of very deep, well drained soils located on terraces, plains, footslopes and swales. Both Hydro and Hesper soils formed in finely textured calcareous materials of mixed origins. Hydro soils are most prevalent in depositional areas such as large swales and footslopes, while Hesper soils are more common on gentle slopes and terraces. Both Hesper and Hydro soils exhibit moderate saline and/or sodic properties in the deeper soil horizons at some sites. Other soils in this map unit include Delpoint silty clay loams on moderate slopes and Midway clays on steep slopes and small ridges.

*McR: McRae silt loam (0 - 15% Slopes)*

This soil map unit consists of very deep, well drained soils located on terraces, alluvial fans and footslopes. These silty clay loam to silty clay textured soils form in calcareous alluvium from a mixture of sedimentary bedrock. Other soils in this map unit include Ringling loams on steep slopes and ridges and Barvon loams on small swales and gentle slopes.

*McR-S: McRae silt loam - Saline (0 - 15% Slopes)*

This soil map unit consists of very deep, well drained soils located on terraces, alluvial fans and footslopes. These silty clay loam to silty clay textured soils form in calcareous alluvium from saline/sodic sedimentary materials. Moderate saline/sodic properties are present in sub-surface horizons below depths of approximately 16 inches. Other soils in this map unit include Delpoint silty clay loams on slopes and Twilight soils on broad upland ridges and terraces.

*Mi-E: Midway clay loam - Eroded (10 - 30% Slopes)*

This soil map unit consists of shallow, well drained soils located on slopes and ridges of eroding calcareous shale. These soils are unique in that they contain a very thin A-horizon overlying highly saline/sodic material. Textures of these soils are most commonly silty clays and clays with paralithic contact at depths between 12 and 24 inches below the surface. Other components of this map unit include scattered Badland formations on ridges.

*MiCa: Midway - Cabbart shallow loams (5 - 15% Slopes)*

This soil map unit consists of shallow, well drained soils located on slopes, shoulders and ridges. Midway soils form in slope alluvium and residuum from calcareous shale parent material. Cabbart soils form in colluvium and residuum from loamy sedimentary bed parent material. Other soils in this map unit include Delpoint soils located on depositional landscape positions, such as swales and footslopes.

*MiDe: Midway – Delpoint silty clay loams (5 - 15% Slopes)*

This soil map unit consists of shallow to moderately deep, well drained soils located on slopes and ridges of eroding calcareous shale. Midway soils are shallow soils that form on slopes and ridges in alluvium and residuum of calcareous shale bedrock. Delpoint soils are moderately deep, well drained soils that form on gentle slopes, small ridges and terraces. Other soils in this map unit include Cabbart loams on slopes dominated by loamy sedimentary beds and Blacksheep soils on sandstone ridges and shoulders.

*NiHa: Nihill - Havre outwash areas (5 - 15% Slopes)*

This map unit consists of very deep soils located in alluvial channels and terraces. Nihill soils form in gravelly alluvium from mixed sedimentary sources and are well drained to somewhat excessively drained. Havre soils form in stratified, calcareous loamy alluvium and are well drained. Other soils in this map unit include Haverson soils in upland swales and McRae soils on slopes and floodplain terraces.

*Re: Relan loam (5 - 15% Slopes)*

This map unit consists of deep to very deep soils located on terraces, alluvial fans and swales in scoria uplands. These well drained soils form in colluvium or alluvium from eroded scoria material. These soils consist of loamy textured materials and often contain gravel to cobble size coarse fragments within the profile. Other soils in this map unit include Ringling loams on ridges, shoulders and small terraces above scoria bedrock.

*Ri: Ringling loam (0 - 15% Slopes)*

This map unit consists of shallow to moderately deep soils located on ridges, slopes, and terraces. These excessively drained soils form in colluvium and residuum derived from scoria parent material. Ringling soils typically contain greater than 15% gravel and cobble sized coarse fragments through the profile, with volumes in excess of 50% coarse fragments at depth. Other soils in this map unit include Relan soils depositional areas such as swales, alluvial fans and terraces and Twilight soils on terraces or gentle slopes overlying unaltered sandstone bedrock.

*RmT: Remmit-Twilight sandy loams (5 - 20% Slopes)*

This map unit consists of moderately to very deep soils located on slopes, upland terraces and gently sloping ridges. These well drained soils form in sandy alluvium and eolian deposits from nearby sandstone rock outcrops. Remmit soils are very deep loam and sandy loam textured soils located on footslopes, swales and broad terraces. Twilight soils are moderately deep loam to sandy loam textured soils located on slopes, ridges and small terraces. Other soils in this map unit include Blacksheep soils on shoulders and ridges of sandstone features and Delpoint soils in isolated areas adjacent to loamy sedimentary parent material.

*RTB: Ringling-Twilight-Barvon sandy loams and loams (5 - 30% Slopes)*

This map unit consists of shallow to moderately deep soils that formed from scoria or sandstone parent material. Ringling loams are located on ridges, slopes and small terraces overlying shallow scoria bedrock residuum or colluvium. Twilight sandy loams form in sandstone colluvium and residuum on terraces and slopes. Barvon loams are located on depositional areas such as swales and terraces overlying various sedimentary parent material.

*SO: Saline Overflow*

This map unit consists of very deep silty and clayey soils which have characteristics similar to Heldt soils, but contain high salinity levels throughout the profile, often with highly saline sodic material in the topsoil and near-surface horizons. These soils are located in the Otter Creek floodplain, primarily in small depressions such as abandoned stream channels and along outside bends of stream meanders. These soils formed in finely textured alluvium from mixed sedimentary parent materials and appear to be influenced by occasional flooding from Otter Creek.

*TwB: Twilight-Blacksheep sandy loams (0 - 20% Slopes)*

This map unit consists of shallow to moderately deep, well drained soils derived from sandstone colluvium or residuum parent material. Twilight soils are moderately deep and located on terraces and footslopes, while Blacksheep soils are shallow and located on ridges, shoulders and slopes.

*W: Water*

This map unit delineates areas of permanent, intermittent or ephemeral surface water.

### **3.3 SOIL PHYSICAL AND CHEMICAL PROPERTIES**

The physical and chemical characteristics of each soil series are presented in Tables 3 and 4 of Appendix B. Soil profile properties (Table 3) include soil horizon designations, horizon thickness and depth, boundary distinctions, Munsell colors, structure, root size and abundance, consistence, coarse fragments, depth to bedrock, depth to groundwater, and percent slope. Physical properties derived from the laboratory data in Table 4 include soil texture (percent sand, silt, clay), organic matter content, fine coarse fragments, and saturation percentage.

Soil physical factors that affect suitability for salvage include organic matter content, saturation percentage, soil texture, coarse fragment content, depth to bedrock, depth to groundwater, and slope.

Chemical soil properties that were evaluated through laboratory analyses (Table 4) include pH, electrical conductivity (EC), percent saturation, sodium adsorption ratio (SAR), cation saturation (Ca, Mg, Na), total nitrates( $\text{NO}_3$ ), Molybdenum (Mo), Boron (B), and Selenium (Se). Effervescence (presence of  $\text{CaCO}_3$ ) was qualitatively described in the field through application of hydrochloric acid (HCL) and is presented in Table 3.

The chemical properties listed above can influence soil salvage suitability and were used to evaluate soil handling and salvage depths. These data were also used to refine soil classification and mapping.

### 3.4 PRIME FARMLANDS

The NRCS Service Center office in Miles City, MT was contacted regarding the presence of Prime Farmlands within the study area. The soil series shown below were listed as Prime Farmland Soils or Soils of Statewide Importance in the most recent update to the NRCS Powder River Area Soil Survey (NRCS 2010). The soils listed below are classified as Prime Farmland soils only if the areas containing these soils are irrigated through surface applications or via sub-irrigation.

Prime Farmland Soils	Slope	Farmland of Statewide Importance	Slope
Fort Collins silt loam	0-4%	Fort Collins	4-8%
Haverson loam, silt loam and silty clay loam	Not listed	Haverson (channeled)	Not listed
Heldt silty clay loam	0-4%	Heldt silty clay loam	4-8%
Hesper silty clay loam	0-4%	Hesper silty clay loam	4-8%
McRae silt loam	0-4%	McRae silt loam	4-8%
Remmit fine sandy loam	2-8%	Relan loam	4-8%

During consultations with the NRCS, it was determined that no Prime Farmlands are present within the study area due to the absence of active surface irrigation (Appendix A, Figure 2).

## 4.0 SOIL SUITABILITY AND SALVAGE

The physical and chemical characteristics of soils within the study area were analyzed to determine suitability for use as redistributed soils during mine reclamation. Unsuitable soils are described by MDEQ as “materials which are not conducive to revegetation techniques, establishment, and growth (that) must not be left on the top nor within 8 feet of the top of regraded spoils.” The specific soil suitability determinations, based on regulatory guidelines, are listed in Table 5 (MDEQ, 1998).

These guidelines were applied to the physical and chemical soils data in the study area to identify soil salvage constraints. A summary of soils containing unsuitable characteristics are presented in Section 4.1 and 4.2. A discussion of unsuitable properties present in each soil series as well as soil salvage and handling considerations for each soil type are presented in Section 4.3.

### 4.1 PHYSICAL PROPERTIES

Soil physical properties that affect suitability for salvage include texture, coarse fragment content, depth to bedrock, depth to groundwater, slope, saturation percentage and organic matter content.

#### Soil Texture

Soil textures consisting of high sand, silt, or clay content can pose reclamation problems such as droughty soils or low plant moisture availability. The soil textures identified as unsuitable for reclamation include: clays (C), silty clays (SiC), silts (Si), sands (S), and sandy clays (SC). The soils listed below contain at least one horizon with unsuitable textures in the soil portion of the profile:

Soil Series	Textures	Depth (inches)	Sample Site ID
Arvada	SiC	43-65	CB-103
	C	2-9	LB-96
Barvon	C	6-23	CB-152
Cabbart	SiC, C	0-10	LB-67
Delpoint	SiC	0-39	LB-111
Haverson	SiC	2-26	LB-41
	SiC	6-12	CB-83
	SiC, C	4-60	CB-21
	SiC	63-90	CB-123
	SiC	6 - 20	SS 12-24
	C	0 - 6	SS 12-37
SiC	55 - 76		
Havre	SiC	62-90	CB-70
Heldt	SiC	14-27	CB-120
Hesper	SiC	0-8	LB-124

Soil Series	Textures	Depth (inches)	Sample Site ID
Hydro	C	17-28	LB-102
	SiC	0-11	LB-58
		48-76	
	SiC, C	0-14	CB-77
McRae	SiC	7-92	CB-140
	SiC	0-31	CB-155
Midway	SiC, C	2-12	LB-136
	SiC	0-3	LB-137
		9-24	
	SiC, C	3-16	CB-156
	C	0-16	LB-79
	C, SiC	0-8	BK-71
	SiC	0 - 4	SS 12-07
	SiC	4 - 12	
	C	12 - 24	
	SiC	24 - 40	
Relan	SiC	2-11	CB-125
Ringling	S	14-28	SS 12-29
Saline Overflow	C	73 - 93	SS 12-31
	SiC	0 - 6	SS 12-32
	SiC	6 - 16	
	SiC	16 - 24	
	SiC	24 - 44	
	SiC	44 - 66	

Finely textured soils are prevalent in the study area and typically support native vegetation communities consisting of a mixture of native grasses and forbs. Salvaging, mixing and redistributing these soils could provide some operational challenges in the form of slick and sticky soils during wet weather. However, based on the vigor and diversity of existing native vegetation communities and overall site stability, the reclamation potential of these soils is suitable for revegetation.

#### Coarse Fragments

High volumes of coarse fragments can limit soil salvage and inhibit reclamation success. Therefore, unsuitable soils are described as those with coarse fragment volumes in excess of 20% in Lift 1 material and 35% in Lift 2 materials. The soils and depths listed below contained unsuitable coarse fragment volumes:



Soil Series	Depth (inches)	Sample Site ID
Cabba	0-22	LB-18
	0-42	LB-38
	0-9	LB-21
Farland	64-90	CB-119
Havre	7-17	CB-70
Nihill	64-92	DP-01
	50 - 60	SS 12-28
Ringling	2-12	CB-126
	0-12	CB-141
	5-17	RU-01
	2 - 14	SS 12-29

Coarse fragments of various sizes exist on the native landscape and throughout many of the soil profiles. However, the low density and broad distribution of rocky material in respread soils will not inhibit reclamation potential. These rocky soils will provide temporary stability on regarded slopes and micro-sites for seed germination.

#### Depth to Bedrock

A total of 10 soils with potential limitations to soil salvage were found to form over lithic or paralithic bedrock materials at depths less than 48 inches from the soil surface. Of these soils, the Blacksheep, Cabba, Cabbart, Twilight, Relan and Ringling series are associated with lithic materials including unweathered sandstone and scoria. The remaining soils, Arvada, Barvon, Delpoint, and Midway typically formed over weathered loamy beds or soft shale.

Most soils listed above often contain coarse fragments in one or more horizons throughout the profile. Therefore, mitigation for reclamation of these soils is similar to that of high coarse fragment soils and will involve mixing with more finely textured soils during soil salvage and redistribution.

#### Depth to Groundwater

Shallow groundwater can restrict equipment operation and, therefore, soil salvage. Soils such as Haverson, Heldt, and Saline Overflow areas are located on the low elevation terraces of the Otter Creek Floodplain and thus often contain groundwater within the upper 60 inches of the profile. Groundwater depth along the floodplain was found at depths ranging from 36 to 90 inches below the soil surface.

No mining is anticipated to occur within the shallow groundwater areas, so construction activity will be limited to road building and other surficial construction.

## Slope

Very steep slopes (over 45 percent) limit soil salvage due to safety hazards associated with equipment and operations in these areas. Slopes that may pose safety hazards occur on the sides of dissected drainages and in areas of shallow bedrock. Soils commonly located on steep slopes include:

- Blacksheep
- Cabba,
- Cabbart,
- Delpoint,
- Midway,
- Ringling, and
- Twilight.

Soil salvage in these soils will only occur where salvage equipment can be operated safely.

## Saturation Percentage

Extremely high or low saturation percentage values combined with other soil properties, such as certain soil textures and EC and/or SAR values can influence soil suitability determinations. High saturation percentage was uncommon in the study area but was observed at 2 sample site each for Midway and Saline Overflow soils. Other samples exceeding the suitability criteria (greater than 90% Saturation Percentage) were collected from paralithic parent material of Midway soils, at sites LB-136 and CB-156.

The extremely sparse distribution of this soil property will not inhibit reclamation potential of these soils.

## Organic Matter

Organic matter (OM) content is considered a beneficial soil physical characteristic and is directly associated with fertility, thus influencing soil salvage depths.

“Organic substances play a direct role in the formation of a fertile soil because they provide plant nutrients that become available during mineralization. Organic matter also has a fundamental effect on the physical properties of soil, such as water-holding capacity, structure, and heat regime. It also influences such physiochemical properties as cation exchange and buffering capacities. These properties influence nutrient uptake, water, and nutrient availability, and the deleterious effect of soil acidity and alkalinity” (Kononova *et al.* 1966).

In the western rangelands of the United States, organic matter content levels range from 0.5 to 3.4 percent (Smith *et al.* 1987). The U.S. Forest Service rates topsoil as “good” if it contains more than 1.5 percent organic matter, “fair” if it contains 0.5 to 1.5 percent organic matter, and “poor” at less than 0.5 percent. The Utah Department of Natural Resources rates topsoil as “poor or unsuitable” if it contains less than 2 percent organic matter (Smith *et al.* 1987).

Within the study area, organic matter content was considered marginal if less than 2.0 percent for 1<sup>st</sup> Lift material and 0.5 percent for 2<sup>nd</sup> Lift Material. Organic matter contents were measured at 2% or greater for the majority of surface and near surface soil horizons. Although organic matter content alone did not determine prescribed soil salvage depths, organic matter content was strongly considered when evaluating the quality of plant growth media.

## 4.2 CHEMICAL PROPERTIES

Chemical properties that affect soil suitability for reclamation include pH, electrical conductivity (EC), sodium adsorption ratio (SAR), boron (B), molybdenum (Mo), and selenium (Se).

### pH

Soils with highly acidic (below 5.5) or basic (above 8.5) properties are considered unsuitable for reclamation purposes. The pH of soil horizons within the study area ranged between 6.1 and 8.9. Soils such as Blacksheep, Heldt, McRae, and Saline Overflow contained 1 to 2 soil horizons with pH values slightly above the suitability criteria. Soils with pH values greater than 8.5 and are listed below.

Soil Series	pH value	Depth (inches)	Sample Site ID
Blacksheep	8.8	34-60	SS 12-03
Delpoint	8.7	20-48	BK-69
Heldt	8.6	54-76	CB-120
	8.6	45-71	CB-87
	8.7	33-58	SS 12-25
	8.9	60-84	SS 12-22
Hydro	8.6	48-76	LB-58
McRae	8.7	16-31	CB-155
	8.9	28-42	SS 12-17
	8.8	42-60	
Saline Overflow	8.6	16-31	SS 12-31
Twilight	8.6	60-80	BK-57

Although these soils are common on the landscape, the limited extent of high pH material within each soil profile suggests strongly that this soil property alone is not anticipated to impact site reclamation.

### Electrical Conductivity (EC)

Salinity is caused by the concentration of soluble salts (ionic charged particles) in the soil, and is measured using electrical conductivity (EC). Elevated soil salinity can interfere with plant productivity by preventing the transfer of soil water into the plant root (Brady and Weil, 2008). Soils with EC greater than 4 mmhos/cm are considered unsuitable for salvage and reclamation and are presented below.

Soil Series	EC value	Depth (inches)	Sample Site ID
Arvada	4.7 - 23.1	0-92	CB-103
	10.3 - 18.1	2-66	LB-96
Haverson	10.7 - 17.2	25-60	CB-21
	13.5 - 18.2	7-60	CB-121
	8.1 - 9.0	24-90	CB-123
	8.5	36-60	SS 12-14
	8.9	60-84	
	4.6	6-20	SS 12-24
	11.7	20-36	
	15.0	36-50	
	19.0	50-74	
	9.2	74-96	SS 12-35
	8.0	0-6	
	16.6	6-14	
	11.7	14-30	
	7.9	30-54	
Haverson	7.6	54-78	SS 12-35
	6.4	0-6	SS 12-37
	4.9	6-12	
Havre	11.3	53-74	BK-14
	4.4	50-60	SS 1204
Heldt	5.7	0-6	BK-46
	8.8 - 17.7	14-90	CB-120
	8.9	60-84	SS 12-22
	10.2	33-58	SS 12-25
	11.3	58-80	
Hesper	16.7	60-90	CB-113
Hydro	8.6	28-44	LB-102
	17.1 - 19.8	48-96	LB-58
McRae	13.6	50-92	CB-111
	9.0 - 11.4	31-92	CB-140
	16.6 - 20.3	16-60	CB-155
	13.2	60-84	SS 12-13
Midway	7.0 - 17.8	2-60	LB-136
	18.3 - 19.0	24-60	LB-137
	6.0 - 19.6	16-88	CB-156
	5.3 - 13.2	7-88	LB-79
	14.2 - 16.9	3-60	BK-31
	9.1 - 11.3	24-93	BK-71
	8.7	12-24	SS 12-07
	10.9	24-40	

Soil Series	EC value	Depth (inches)	Sample Site ID
Nihill	10.3	0-2	CB-159
	4.2	30-50	SS 12-28
	4.5	50-60	
Relan	8.8	8-21	SS 12-02
Saline Overflow	31.5	0-4	SS 12-31
	27.0	4-16	
	26.9	16-31	
	11.4	31-55	
	4.8	55-73	SS 12-32
	18.0	0-6	
	14.7	6-16	
	7.0	16-24	
	4.8	24-44	

#### Sodium Adsorption Ratio

Sodic soils are caused by the lack of neutral soluble salts, thereby allowing exchangeable sodium (Na) to occupy a large percentage of the total exchange capacity. Sodium also causes the dispersion of clay particles causing unsatisfactory physical conditions for plant growth. Sodicity is measured using the sodium adsorption ratio (SAR) which is the ratio between sodium and other exchangeable soluble salts (Brady & Weil, 2008) (NSSH 2010).

Soils are considered unsuitable if the SAR levels are greater than 10 for 1<sup>st</sup> Lift Material and greater than 15 for 2<sup>nd</sup> Lift Material. The majority of soils containing sodic material also contained high EC values. The soils and soil horizons listed below contain unsuitable material due to high salinity. The soil depths identified in with an asterisk (\*) were also identified as saline soil material.

Soil Series	SAR value	Depth (inches)	Sample Site ID
Arvada	21.8 - 27.2	0-92*	CB-103
	18.3 - 25.8	2-66*	LB-96
Haverson	16.5 - 22.4	25-60*	CB-21
	16.7 - 22.1	7-60*	CB-121
	17.3	36-50	SS 12-24
	20.1	50-74	
	17.5	6-14	SS 12-35
	19.7	14-30	
Havre	16.0	53-74*	BK-14
Heldt	17.3 - 28.9	14-90*	CB-120
	19.0	33-58	SS 12-25

Soil Series	SAR value	Depth (inches)	Sample Site ID
	21.9	58-80	
Hydro	19.8 - 17.1	48-96	LB-58
McRae	18.3	16-60*	CB-155
Midway	17.1 - 31.6	2-60*	LB-136
	26.8 - 27.6	24-60*	LB-137
	15.0 - 19.1	30-88*	CB-156
	15.1 - 26.8	7-88*	LB-79
	31.2 - 33.9	3-60*	BK-31
	15.7	24-40	SS 12-07
Nihill	11.5	0-2*	CB-159
Saline Overflow	33.8	0-4	SS 12-31
	35.8	4-16	
	38.9	16-31	
	17.3	31-55	
	28.2	0-6	SS 12-32
	19.7	6-16	
	16.2	16-24	

Saline and Sodic soils are common in the study area and exist on various topographic positions in a wide range of soil types. The proposed Soil Testing Plan (Exhibit 313F) will identify highly Saline or Sodic soils prior to salvage so that they can be buried or reseeded with appropriate species, as described in the Revegetation Plan (313G).

#### Boron

Soils with Boron (B) content in excess of 5 parts per million (ppm) are considered unsuitable for salvage.

Boron levels were acceptable for all soils tested in the study area.

#### Selenium

Soils with Selenium (Se) values greater than 0.1 mg/kg (ppm) are considered unsuitable for salvage. Four soil horizons within the study area were found to have Se concentrations in excess of the 0.1 ppm threshold and are listed below.

Soil Series	Selenium (ppm)	Depth (inches)	Sample Site ID
Heldt	0.2	38-60	SS 12-22
Hesper	0.2	60-90	CB-113
Hydro	0.3	64-92	CB-77
McRae	0.2	31-64	CB-140

The low concentrations and broad distribution of Selenium will not inhibit reclamation potential or result in significant plant uptake.

### Molybdenum

Soils with Molybdenum (Mo) values greater than 1.0 mg/kg (ppm) are considered unsuitable for salvage. The only soil containing horizons with elevated Mo levels was Midway with 1.5ppm at 50-93 inches (sample site BK-71).

### **4.3 SOIL SUITABILITY BY SOIL SERIES**

Soil suitability for each soil series was evaluated using physical and chemical soil properties. Soil salvage depths were determined by averaging total depths with physical or chemical constraints for each soil series sample site. Suitability evaluations were used to determine soil salvage depths for each soil or were grouped with other similar soils to develop recommended salvage depths for each soil map unit. Soil salvage depths for 1<sup>st</sup> Lift and 2<sup>nd</sup> Lift salvage as well as total salvage depths are shown on the map legend (Table 2).

#### Arvada Clay Loam

Arvada soils are highly saline and sodic throughout the soil profile and some sub-surface horizons consist of clay or silty clay soil textures. However, these soils are of limited extent within the study area and thus the influence of these properties on reclamation success would be negligible. The recommended salvage depth of these soils is 12 inches for 1<sup>st</sup> Lift and no salvage for the 2<sup>nd</sup> Lift.

#### Barvon Loam

The Barvon Loam contained only two unsuitable properties within the soil pedons, which were a clay soil texture at depths between 6 and 23 inches at Sample Site CB-152 (the limiting factor being depth to bedrock, which ranges from 23 to 38 inches below the surface) and shallow bedrock 36 inches below the surface at SS 12-36 (the limiting factor being depth to bedrock, which typically exists a maximum of 50 inches below the surface and consists of weathered scoria, sandstone or shale depending on the location). In general, the salvage depths will not intercept the bedrock in these soils. However, in the event bedrock was collected as part of the 2<sup>nd</sup> lift, these materials should not adversely influence reclamation due to the weathered condition of bedrock underlying these soils. The recommended salvage depth of this soil is 12 inches for the 1<sup>st</sup> Lift and 24 inches for the 2<sup>nd</sup> Lift.

#### Blacksheep Sandy Loam

Blacksheep soils are typically located on steep, eroded slopes that limit topsoil salvage due to the operational limits of salvage equipment. These soils are also shallow, with bedrock depths ranging between 12 and 37 inches. On steep topography such as slopes and shoulders (map unit BCC) salvage depths are 12 inches for the 1<sup>st</sup> Lift and no 2<sup>nd</sup> Lift salvage. On gentle slopes and terraces (map units BCT and TwB) salvage depths are 12 inches for both 1<sup>st</sup> and 2<sup>nd</sup> lift salvage, for a total salvage of 24 inches.

### Cabba Loam

The reclamation potential of Cabba loams is limited by coarse fragment content that ranges from 10 to 50 percent throughout the soil profile. In addition, Cabba soils are typically shallow with depths to bedrock between 9 and 42 inches below the surface. However, since the majority of soils in the study area contain low to moderate densities of coarse fragments, the deleterious effects of this material will be mitigated through mixing during salvage and redistribution. The salvage depth for Cabba soils on steep slopes (map units BCC and CC) is 12 inches for 1<sup>st</sup> Lift and no 2<sup>nd</sup> lift salvage. Salvage on lower angled slopes in the BCT map unit is 12 inches for both 1<sup>st</sup> Lift and 2<sup>nd</sup> Lift for a total salvage depth of 24 inches.

### Cabbart Loam

Cabbart soils are similar in distribution and soil properties to Cabba loams, with the exception that these soils typically contain less than 10 percent coarse fragments. However, these soils are very shallow with lithic or paralithic contact between 10 and 20 inches below the surface. Due to the steep slopes and shallow depth of these soils the salvage depth is limited to 12 inches in the 1<sup>st</sup> Lift and zero 2<sup>nd</sup> lift salvage.

### Cushman Silt Loam

Cushman soils were not found to contain any unsuitable physical or chemical properties. These soils will be salvaged at 12 inches in the 1<sup>st</sup> Lift and 36 inches in the 2<sup>nd</sup> Lift.

### Delpoint Loam

Overall Delpoint soils were found to have few reclamation limitations with the exception of some instances of bedrock contact within 24 inches of the surface on some hills and ridges and one horizon with a pH of 8.7. On landforms such as steeper hills and ridges (map unit MiDe) these soils will be salvaged to a depth of 12 inches in the 1<sup>st</sup> Lift and 12 inches in the 2<sup>nd</sup> Lift. On terraces, fans and gentle to moderately sloping ridges (map unit FtD) these soils will be salvaged to 12 inches in the 1<sup>st</sup> Lift and 36 inches in the 2<sup>nd</sup> Lift.

### Farland Silt Loam

Farland silt loams exceeded the suitability criteria for coarse fragment at depths between 64 and 90 inches below the surface. However, because coarse fragments are limited to deep horizons, coarse fragments will not impact soil quality. Salvage depth for Farland soils are 12 inches for 1<sup>st</sup> Lift and 36 inches for 2<sup>nd</sup> Lift.

### Fort Collins Silt Loam

Fort Collins soils did not exhibit any properties that exceeded the salvage suitability criteria. These soils will be salvaged using 12 inches for the 1<sup>st</sup> Lift and 36 inches for the 2<sup>nd</sup> Lift.



### Haverson Silty Clay Loam

Haverson soils (non-saline phase) do not exhibit dominant chemical properties that restrict salvage or reclamation. Soil textures for horizons between 2 and 26 inches are silty clays, which is listed as an unsuitable reclamation property; however, the influence of these soil textures would be mitigated through mixing with other 1<sup>st</sup> Lift and 2<sup>nd</sup> Lift soil material. In addition, the presence of moderate to high concentrations of organic material in these soils compensates for reclamation impacts such as lower water availability and permeability of fine textured soils. Salvage of Haverson soils will be 12 inches for 1<sup>st</sup> Lift and 36 inches for 2<sup>nd</sup> Lift.

### Haverson Silty Clay Loam – Saline Phase

Many areas of Haverson soils exhibit sodic and/or saline conditions within certain sub-surface soil horizons. Saline conditions are the result of saline material deposited on the surface that is then leached deeper via downward water movement, by fluctuating saline/sodic groundwater, and the combination of these processes. The extent of these soils is limited to the Otter Creek floodplain, immediately adjacent to the channel and an isolated upland drainage swale. The salvage depths of these soils is the same as other floodplain soils, 12 inches in the 1<sup>st</sup> Lift and 36 inches in the 2<sup>nd</sup> Lift.

### Havre Clay Loams

Havre soils contain very few limiting properties for salvage or reclamation. Although coarse fragment volumes in this soil are typically less than 10 percent, the horizon between 7 and 17 inches at site CB-70 did contain over 50 percent coarse fragments. Site CB-70 also contained a horizon with silty clay textures between 62 and 90 inches. At site (SS 12-04) some slightly saline properties were detected at depths between 50 and 60 inches. These properties should not adversely impact mine reclamation due to the limited nature of unsuitable characteristics and scarcity of this soil on the landscape. The salvage depth of Havre soils is 12 inches for the 1<sup>st</sup> Lift and 36 inches for the 2<sup>nd</sup> Lift.

### Heldt Silty Clay Loam

Heldt soils are typically highly productive and contain few reclamation suitability limitations. Heldt sample sites did contain saline and/or sodic conditions below depths of 33 to 38 inches. As a result, the amount of saline material salvaged would constitute 15 inches or less of the total salvage (48 inches of total soil salvage, with saline materials occurring at depths below 33 inches). The salvage depth of this soil is 12 inches for the 1<sup>st</sup> Lift and 36 inches for the 2<sup>nd</sup> Lift.

### Hesper Silty Clay Loam

The dominant characteristics of Hesper soils are conducive to salvage and reclamation. The three sample sites for this series each contained one horizon with properties that exceeded the suitability criteria. The three unsuitable properties are: 1) Site CB-87 had a pH of 8.6 at depths between 45 and 71 inches, 2) Site CB-113 had an EC of 16.7 between the depths of 60 and 90 inches, and 3) Site LB-124 had silty clay textures between 0 and 8 inches. Based on the isolated nature of these unsuitable properties

the salvage and reclamation potential of these soils will not be negatively impacted. Hesper soils will be salvaged to a depth of 12 inches on the 1<sup>st</sup> Lift and 36 inches on the 2<sup>nd</sup> Lift.

#### Hydro Clay Loam

Hydro soils have some horizons with unsuitable properties including texture, pH, EC and SAR. The unsuitable horizons are scattered throughout the soil profiles of the three sample sites and, in some cases, occur below the designated salvage depth. Sample Site LB-102 contains clay textured soil from 17 to 28 inches and an EC of 8.6 between 28 and 46 inches. Site LB-58 contains silty clay textures between 0 and 11 inches. Site LB-58 also contains silty clay texture and a pH of 8.6 between 48 to 76 inches, as well as SAR of 17-20 in horizons deeper than 48 inches. Site CB-77 contains silty clay and clay textures between 0 and 14 inches. Soil texture is the only dominant property of this soil that exceeds suitability criteria within the salvage horizons. Fine textured soils are present in many locations of the study area and are not anticipated to cause significant adverse reclamation impacts. Salvage depths for Hydro soils is 12 inches for 1<sup>st</sup> Lift and 36 inches for 2<sup>nd</sup> Lift.

#### McRae Silt Loam

McRae soils contain suitable reclamation properties within most soils horizons with the exception of high EC in one horizon and high pH in another. These horizons are at or below the soil salvage depth of this soil and thus will not adversely influence reclamation. The salvage depth for McRae soils is 12 inches in the 1<sup>st</sup> Lift and 36 inches in the 2<sup>nd</sup> Lift.

#### McRae Silt Loam - Saline

McRae soils with saline conditions at depth are isolated to the Three-Mile Creek floodplain and adjacent terraces. Some surface and sub-surface horizons in McRae-Saline soils contain unsuitable properties such as high pH, undesirable textures, and high EC and SAR. The salvage depths for this soil are 12 inches for 1<sup>st</sup> Lift and 24 inches for 2<sup>nd</sup> Lift.

#### Midway Clay Loam

Midway soils exhibit the greatest variety of unsuitable properties of any soil in the study area. These shallow soils consist of silty clay and clay textures, and contain high EC and SAR values, particularly in sub-surface horizons. However, the majority of the unsuitable material for this soil was found below the nominal soil salvage depth, in the paralithic material and horizons immediately overlying the parent material. Midway soils on steep slopes and ridges (map units MiCa and Mi-E) will be salvaged in a single lift at a 1<sup>st</sup> Lift salvage depth of 12 inches. Midway soils on gentler slopes and terraces (map unit MiDe) will be salvaged at a depth of 12 inches for 1<sup>st</sup> Lift and 12 inches for 2<sup>nd</sup> Lift.

#### Nihill Silt Loams

Nihill soils contain occasional gravel lenses distributed in the profile and an isolated surface horizon of high EC and SAR. The properties within any given profile of the soil vary according to the properties of

the surrounding upland soils and the alluvial deposition. Within the study area Site CB-159 was found to contain high EC and SAR values within the top 2 inches of the profile. These conditions are likely the result of intensive precipitation during spring runoff that deposited fine-textured saline/sodic material in the drainage channel. Site DP-01 contained an excess of 60% coarse fragments in gravel lenses below a depth of 64 inches. Similarly, site SS 12-28 exhibited EC values slightly above the suitability criteria at depths below 30 inches, as well as high coarse fragment content in these same horizons. The limited distribution of these soils on the landscape and the isolated nature of the unsuitable horizons will not impact overall reclamation potential of these soils. The salvage depth of Nihill soils is 12 inches for 1<sup>st</sup> Lift and 36 inches for 2<sup>nd</sup> Lift.

#### Relan Loams

Relan loams are appropriate for mine reclamation and do not present any dominant, unsuitable properties. The horizon between 2 and 11 inches at Site CB-125 does contain silty clay textures; however, this soil is surrounded by sandy loam and loamy soils in the adjacent uplands. As a result, the soil textures of salvaged and redistributed soils will provide a suitable soil for reclamation. The salvage depth of Relan soils is 12 inches for the 1<sup>st</sup> Lift and 36 inches for the 2<sup>nd</sup> Lift.

#### Remmit Sandy Loams

Remmit soils do not exhibit any unsuitable soil properties and in fact, could improve overall project reclamation via mixing other finely-textured soils with these sandy textured soils. The salvage depth of Remmit soils is 12 inches for the 1<sup>st</sup> Lift and 36 inches for the 2<sup>nd</sup> Lift.

#### Ringling Loams

Ringling loams do not contain any unsuitable chemical properties but are prone to high coarse fragment content throughout the soil profile. Coarse fragments in these soils range between 15 and 60 percent and primarily consist of gravel sized scoria within the soil portion of the profile. Deeper horizons of weathered scoria bedrock will break to cobble or even stone sized fragments during excavation. Salvage of Ringling soils will be limited to an average 1<sup>st</sup> Lift depth of 12 inches in most areas.

#### Twilight Sandy Loams

Twilight soils do not contain any horizons with unsuitable physical properties and only one horizon with slightly elevated pH (BK-57 with a pH of 8.6 between the depths of 60 and 80 inches). The salvage of Twilight soils will primarily be limited by slope, with steep slopes (map units BCT and TwB) salvaged to a depth of 12 inches for the 1<sup>st</sup> Lift and 12 inches for the second lift. Gentler slopes and terraces will be salvaged to a depth of 12 inches for the 1<sup>st</sup> Lift and 24 to 36 inches for the 2<sup>nd</sup> Lift.

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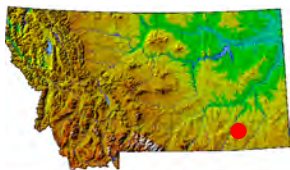
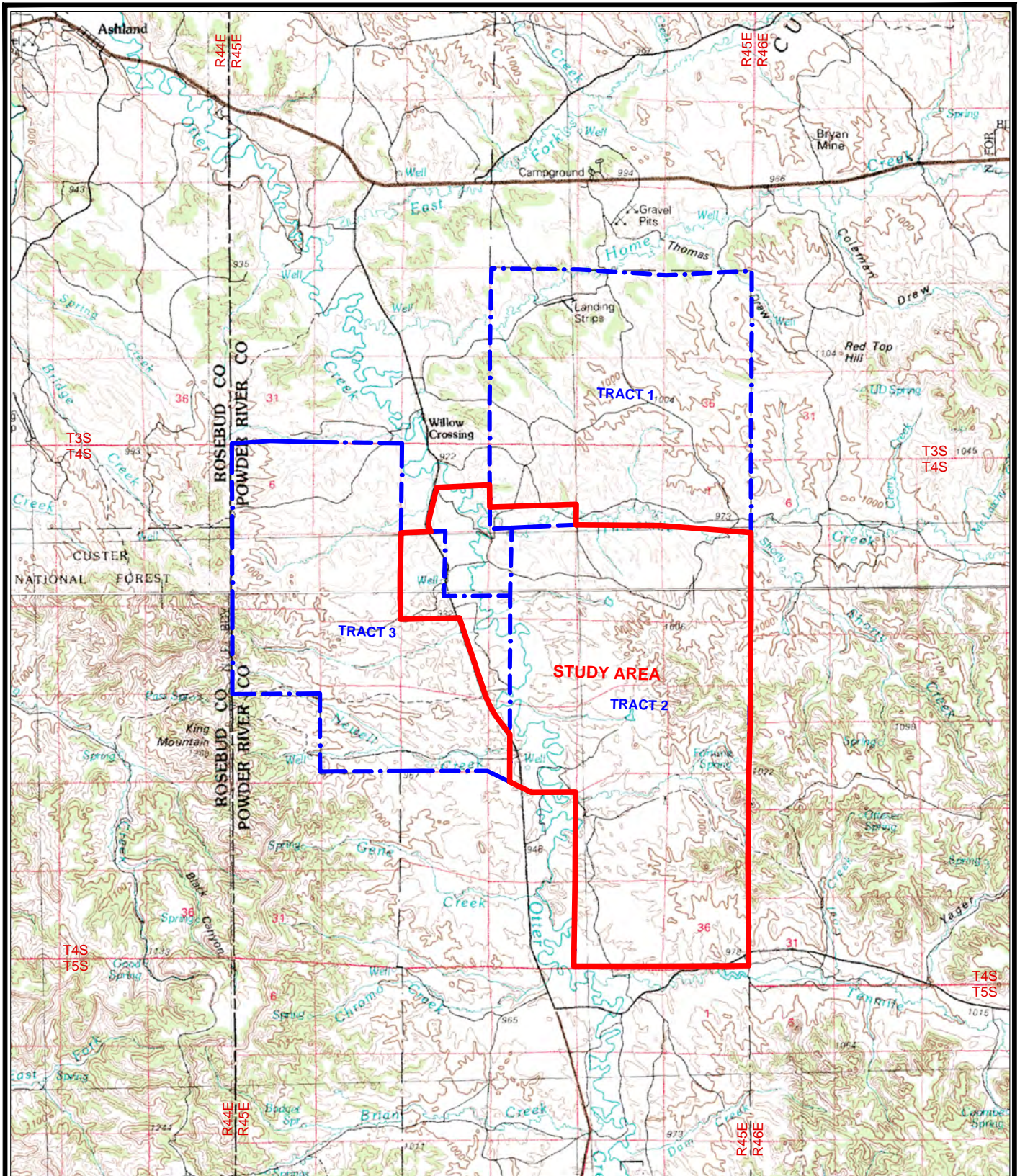
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Smith, P.L., E.F. Redente, and E. Hooper. 1987. Soil organic matter. *In* Reclaiming mine soils and overburden in the western United States, analytic parameters and procedures. Edited by R.D. Williams and G.E. Schumans. Soil Conservation Society of America. Ankeny, Iowa.

# **APPENDIX A**

## **FIGURES**





USGS 100k: Birney & Lame Deer



**OTTER CREEK COAL, LLC**  
P.O. BOX 7152 Billings, Mt. 59103

## Soils Study Area



**WESTECH**  
Environmental Services, Inc.  
P.O. Box 6045  
Helena, Montana 59604

SCALE: 1:100,000  
DATE: 07/31/14  
DRAWN BY: DC  
CHECKED BY: NS  
FILE: OC14 Soils SA.dwg

Figure

**1**

SHEET: 1 of 1





Natural Resources Conservation Service  
Miles City Area Office  
3120 Valley Drive East  
Miles City, MT 59301-5500

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July 21, 2014

To whom it may concern:

Re: Otter Creek Farmland Classification

The National Cooperative Soil Survey (NCSS) is a nationwide partnership of Federal, regional, State, local agencies, private entities, and institutions. This partnership works to cooperatively investigate, inventory, document, classify, interpret, disseminate, and publish information about soils of the United States and its trust territories and commonwealths.

The Natural Resources Conservation Service is responsible for the leadership of soil survey activities of the U.S. Department of Agriculture, for the leadership and coordination of NCSS activities, and for the extension of soil survey technology to global applications.

Soil data and information produced by the National Cooperative Soil Survey is retained in Web Soil Survey ([websoilsurvey.nrcs.usda.gov/app/](http://websoilsurvey.nrcs.usda.gov/app/)). The Natural Resources Conservation Service updates and maintains this source of soil information.

Web Soil Survey provides customers (producers, agencies, technical service providers, and others) electronic access to relevant soil and related information needed to make wise land use and management decisions.

It is from Web Soil Survey that the ratings for Farmland Classification were obtained. Farmland Classification identifies soil map units as prime farmland, farmland of statewide importance, farmland of local importance, or unique farmland. It identifies the location and extent of the soils that are best suited to food, feed, fiber, forage, and oilseed crops. NRCS policy and procedures on prime and unique farmlands are published in the Federal Register, Vol. 43, No. 21, January 31, 1978.

Ratings for Farmland Classification in the Otter Creek Area can be found in the attached table. While some of the soil map units are rated as "prime farmland if irrigated", at present none of the soils in the area are actively being irrigated, and therefore would not be considered prime farmland. In the Otter Creek Area, 1666 acres or 18% of the area is classified as "prime farmland if irrigated".

A handwritten signature in blue ink, appearing to read "Robert Mitchell", is written over a white background.

Robert Mitchell  
Resource Soil Scientist



Map Unit	Map Unit Name	Farmland Classification
Ab	Arvada-Bone complex, 0 to 4 percent slopes	Not prime farmland
Be	Bew silty clay, 2 to 4 percent slopes	Prime farmland if irrigated
Ca	Cabba association, 15 to 50 percent slopes	Not prime farmland
Ce	Cushman-Elso silt loams, 4 to 8 percent slopes	Not prime farmland
Ec	Elso silt loam, 8 to 15 percent slopes	Not prime farmland
El	Elso silt loam, 15 to 45 percent slopes	Not prime farmland
Fm	Farland and Havrelon soils, 4 to 8 percent slopes	Farmland of statewide importance
Fn	Fergus-Relan association, 2 to 8 percent slopes	Farmland of statewide importance
Fr	Fort Collins silt loam, 2 to 4 percent slopes	Prime farmland if irrigated
Ha	Haverson loam	Prime farmland if irrigated
Hc	Haverson silt loam	Prime farmland if irrigated
Hd	Haverson silty clay loam	Prime farmland if irrigated
He	Haverson silty clay	Prime farmland if irrigated
Hf	Haverson soils, channeled	Farmland of statewide importance
Hg	Haverson soils, saline	Not prime farmland
Hh	Heldt silty clay loam, 0 to 2 percent slopes	Prime farmland if irrigated
Hk	Heldt silty clay loam, 2 to 4 percent slopes	Prime farmland if irrigated
Hm	Heldt silty clay loam, 4 to 8 percent slopes	Farmland of statewide importance
Hn	Hesper silty clay loam, 0 to 2 percent slopes	Prime farmland if irrigated
Ho	Hesper silty clay loam, 2 to 4 percent slopes	Prime farmland if irrigated
Hp	Hesper silty clay loam, 4 to 8 percent slopes	Farmland of statewide importance
Mc	McRae silt loam, 0 to 2 percent slopes	Prime farmland if irrigated
Md	McRae silt loam, 2 to 4 percent slopes	Prime farmland if irrigated
Me	McRae silt loam, 4 to 8 percent slopes	Farmland of statewide importance
Mf	Midway silty clay loam, 2 to 8 percent slopes	Not prime farmland
Mg	Midway-Elso association, 8 to 35 percent slopes	Not prime farmland
Mw	Midway and Elso rocky soils, 35 to 75 percent slopes	Not prime farmland
Nh	Nihill-Elso association, 8 to 15 percent slopes	Not prime farmland
Rk	Relan gravelly loam, gravelly variant, 4 to 8 percent slopes	Not prime farmland
Rs	Ringling slaty loam, 20 to 50 percent slopes	Not prime farmland
Rt	Ringling-Cabba association, 15 to 50 percent slopes	Not prime farmland
Ru	Ringling-Relan association, 6 to 25 percent slopes	Not prime farmland
Te	Terrace escarpments	Not prime farmland
Vr	Vona-Remmit fine sandy loam, 4 to 8 percent slopes	Farmland of statewide importance
W	Water	Not prime farmland

## **APPENDIX B**

### **TABLES**

Table 1 Soil Map Legend

MUSYM	Map Unit Name	Slope (%)	Topsoil Salvage (in)	Subsoil Salvage (in)	Total Salvage (in)	Components and Proportions (%)	Acres
Av	Arvada clay loam	0-10	12	0	12	90% Arvada / 10% Hydro	51.37
BCC	Blacksheep-Cabba-Cabbart Complex	15-60	12	0	12	30% Blacksheep / 30% Cabba / 30% Cabbart / 5% Twilight / 5% Delpoint	1053.14
BCT	Blacksheep-Cabba-Twilight Complex	10-30	12	12	24	40% Blacksheep / 40% Cabba / 40% Twilight	499.42
BL-RO	Badlands-Rock Outcrop	25-70	0	0	0	90% Badlands or Rock Outcrop / 5% Cabbart / 5% Midway	23.07
CC	Cabbart-Cabba shallow loams	20-70	12	0	12	40% Cabbart / 40% Cabba / 10% Midway / 10% Blacksheep	71.37
Cu	Cushman silt loam	0-5	12	36	48	95% Cushman / 5% Cabbart	13.84
DL	Disturbed Land	0-20	0	0	0	100% Disturbed soils	17.34
Fa	Farland silt loam	0-10	12	36	48	80% Farland / 10% Havre / 10% Nihill	15.74
FtD	Fort Collins-Delpoint silt loams	5-30	12	36	48	50% Fort Collins / 40% Delpoint / 5% Midway / 5% Barvon	1005.99
FtHp	Fort Collins-Hesper silt loams	5-15	12	36	48	40% Fort Collins / 40% Hesper / 10% Twilight / 10% Delpoint	345.39
H	Haverson silty clay	0-5	12	36	48	90% Haverson / 5% Heldt / 5% McRae	249.79
He	Heldt silty clay loam	0-5	12	36	48	90% Heldt / 5% Haverson / 5% Fort Collins	266.87
He-S	Heldt silty clay loam - Saline	0-5	12	36	48	90% Heldt / 5% Haverson / 5% Fort Collins	162.89
Hp	Hesper silty clay loam	5-15	12	36	48	90% Hesper / 10% Fort Collins	79.99
H-S	Haverson silty clay - Saline	0-5	12	36	48	90% Haverson / 5% Delpoint / 5% Heldt	377.27
Hy	Hydro clay loam	0-10	12	36	48	90% Hydro / 5% Arvada / 5% Hesper	102.17
HyHp	Hydro-Hesper silty clay loams	0-15	12	36	48	50% Hydro / 40% Hesper / 5% Delpoint / 5% Midway	305.83
McR	McRae silt loam	0-15	12	36	48	90% McRae / 5% Ringling / 5% Barvon	535.21
McR-S	McRae silt loam - Saline	0-15	12	24	36	80% McRae / 10% Delpoint / 10% Twilight	267.55
Mi-E	Midway clay loam - Eroded	10-30	12	0	12	90% Midway / 10% Badlands	134.41
MiCa	Midway-Cabbart shallow loams	5-15	12	0	12	60% Midway / 30% Cabbart / 10% Delpoint	951.36
MiDe	Midway-Delpoint silty-clay loams	5-15	12	12	24	40% Midway / 40% Delpoint / 10% Cabbart / 10% Blacksheep	1205.27
NiHa	Nihill-Havre outwash areas	5-15	12	36	48	40% Nihill / 40% Havre / 10% Haverson / 10% McRae	278.32
Re	Relan loam	5-15	12	36	48	90% Relan / 10% Ringling	277.76
Ri	Ringling loam	0-15	12	0	12	90% Ringling / 5% Relan / 5% Twilight	336.06
RmT	Remmit-Twilight sandy loams	5-20	12	36	48	40% Remmit / 40% Twilight / 10% Blacksheep / 10% Delpoint	47.09
RTB	Ringling-Twilight-Barvon Complex	5-30	12	24	36	40% Ringling / 40% Twilight / 20% Barvon	406.50
SO	Saline Overflow	0-5	0	0	0	80% Saline Overflow / 10% Haverson / 10% McRae	35.79
TwB	Twilight-Blacksheep sandy loams	0-20	12	12	24	70% Twilight / 30% Blacksheep	127.40
W	Water	0	0	0	0	100% Water	101.06

### Soil Profiles - Field Data

Soil Series	Map Unit Symbol	Sample Site (SS)	Soil Horizon	Depth <sup>1</sup> (inches)	Boundary	Color <sup>2</sup>	Texture <sup>3</sup>	Structure <sup>4</sup>	Consistence <sup>5</sup>	Coarse Fragment %		Slope %	Roots <sup>6</sup>	Effervescence <sup>7</sup>	Notes	
										Gravel	Cobbles					
Delpoint	FtD	BK-01	A	0-4	cs	10YR 4/3	SiL	mtnpl	so, so, po	0	0	5-15	mf, fm	ME	mixed sedimentary beds 2-6", weathered shale and sandstone, 29 inches and below. moist soil below 29"	
			Bt	4-11	cs	10YR 4/2	CL	mmpr, mcabk	h, ss, mp	0	0		cf	ME		
			B/C	11-29	gw	10YR 5/4	CL	wfabk	vh, ss, mp	5-10	2		ff	VE		
			Cr1	29-60	gw	-	L	-	-	-	-		-	-		VE
			Cr2	60-89	-	-	SL	-	-	-	-		-	-		NE
Blacksheep	BCT	BK-05	A	0-4	cs	2.5YR 4/3	L	wvfr	s, vfr, s/po	20	0	13	cvf, ff	VE		
			Bk1	4-9	gs	2.5YR 5/3	L	wvfbk	s, vfr, ss/po	15	0		cvf, ff	VE		
			Bk2	9-14	as	2.5YR 5/6	SiL	wvfbk	s, fr, ss/po	15	0		fvf	VE		
			R	14+	-	-	-	-	-	-	-		-	-		
Havre	NiHa	BK-14	A	0-5	cs	2.5Y 3/2	L	mmp	sh, so, po	5	0	3-8	mf, fc	STE	Intermittent gravel lenses from 5" to 94". Soil moist below 50"	
			C1	5-28	gw	2.5Y 4/3	SCL	wmsbk, m	mh, ss, sp	5-10	0		mf, fc	VE		
			C2	28-53	gw	2.5Y 4/3	SCL	m	mh, ss, sp	10-15	0		cf	VE		
			C3	53-74	gw	2.5Y 5/3	L	m	s, ss, sp	5	0		ff	VE		
			C4	74-94	-	2.5Y 5/3	L	m	s, ss, mp	5	0		-	VE		
Fort Collins	FtD	BK-15	A	0-5	cw	7.5 YR 4/2	CL	mtnpl	s	5	0	5-15	mf, fm	NE	Moist at 42" and below.	
			Bk	5-12	cs	7.5 YR 4/3	SiCL	mmpr, mmabk	h, ms, mp	10-15	0		cf	VE		
			B/C	12-23	gs	7.5 YR 4/4	SiCL	wfabk, m	mh, ss, mp	5-10	0		cf	VE		
			C1	23-39	gs	7.5 YR 5/4	CL	m	sh, ss, mp	10-15	0		ff	VE		
			C2	39-58	gs	7.5YR 5/4	CL	m	so, ss, sp	5-10	0		ff	VE		
			C3	58-90	-	7.5YR 4/3	L	m	l, so, po	0	0		ff	VE		
Cabbart	BCC	BK-19	O	1-0	-	-	-	-	-	-	-	25	-	-		
			A	0-4	cs	2.5Y 4/3	SCL	mvfr	l, vf, ns/po	5	0		fvf, ff, fm	NE		
			Bw	4-9	cs	2.5Y 5/4	SCL	wmsbk	s, vf, ns/po	10	20		ff, cm, fc, cvc	NE		
			Bk	9-15	as	2.5Y 5/4	SL	wvfbk	s, vf, ss/po	5	0		cm, ff, fc	VE		
			C	15-20	as	2.5Y 6/3	SL	sg	l, vf, ss/po	10	0		ff, fm, fc, fvc	VE		
			R	20+	-	-	-	-	-	-	-		-	-		
Midway	MiDe	BK-31	A	0-3	cs	10YR 5/3	SiCL	wvnpl	vh, fi, ss/mp	0	0	5-10	cvf, cf	SE		
			B	3-16	ds	10YR 5/4	SiCL	m, scpr	mh, fi, ms/vp	2	0		cvf	VE		
			C	16-60+	-	2.5YR 5/4	SIC	ma	fi, ms/mp	2	0		fvf	VE		
Fort Collins	FtD	BK-36	A	0-3	cs	2.5Y 5/3	SiCL	mvn-m, pl	mh, fi, sg/mp	0	0	7	mf, fvf	SL		
			Bk	3-24	ds	2.5Y 5/4	CL	mmpr, wcosbk	mh, fi, ss/mp	0	0		fvf, ff	ST		
			C	24-60+	-	2.5Y 6/3	SiCL	ma	s, f, ms/mp	0	0		fvf	ST		
Ringling	RTB	BK-44	A	0-4	cw	2.5YR 2.5/3	L	wfsbk/l	l, so, po	15	0	10-25	mf, cm	NE	Calice covered scoria. Heavily fractured sandstone 0.5-1.5" flagstone. Dark red scoria, 1-4" thick flagstone	
			C	4-16	cs	2.5YR 3/3	L	m	l, so, po	20	0		cf	ME		
			R1	16-32	-	-	-	-	-	>50	25		ff	VE		
			R2	32-72	-	-	-	-	-	>50	25		-	VE		
Heldt	He	BK-45	A/Bt	0-8	cw	7.5YR 4/3	SiCL	mmpr, hmabk	h, ss, sp	0	0	3-10	mf, cm	-	1" lens of peagravel and sand	
			B/C	8-21	gs	7.5YR 4/4	SiCL	wmpr, mcabk	h, ss, sp	0	0		mf, cm	VE		
			C1	21-47	gs	7.5YR 4/3	L	wmabk, m	mh, ss, sp	0	0		cf	VE		
			C2	47-68	gs	7.5YR 4/2	CL	m	mh, ss, sp				ff	VE		
			C3	68-92	-	7.5YR 4/3	CL	m	so, ss, po	0	0		ff	VE		

### Soil Profiles - Field Data

Soil Series	Map Unit Symbol	Sample Site (SS)	Soil Horizon	Depth <sup>1</sup> (inches)	Boundary	Color <sup>2</sup>	Texture <sup>3</sup>	Structure <sup>4</sup>	Consistence <sup>5</sup>	Coarse Fragment %		Slope %	Roots <sup>6</sup>	Effervescence <sup>7</sup>	Notes
										Gravel	Cobbles				
Heldt	He	BK-46	Ap	0-6	cs	2.5Y 4/2	SiCL	wcsbk	mh, ss, mp	0	0	0-3	mf, cm	SL	Soil moist to surface, Saturated @ 64",
			A	6-11	cw	2.5Y 4/2	SiCL	mmsbk	mh, ss, mp	0	0		mf, cm	SL	
			Bt	11-32	cw	2.5Y 4/3	SiCL	wmabk	mh, ms, mp	0	0		cf, fm	SL	
			C1	32-64	gs	2.5Y 5/3	L	m	sh, ss, sp	0	0		ff	SL	
			C2	64-80	-	2.5Y 5/3	L	m	sh, ss, sp	0	0		ff	SL	
McRae	McR	BK-50	Ap	0-6	cs	2.5Y 3/3	SiCL	mcsbk	ha, ms, mp	0	0	0-3	mf, cm	NE	
			B	6-18	cw	2.5Y 3/2	SiCL	mmsbk	mh, ms, sp	0	0		mf, fm	ME	
			C1	18-34	gs	10YR 4/3	SiL	m	sh, ms, mp	0	0		ff	STE	
			C2	34-60	gs	10YR 4/4	SiL	m	sh, ms, mp	0	0		-	STE	
			C3	60-80	-	10YR 4/3	SiL	m	sh, ms, mp	0	0		-	STE	
Cushman	Cu	BK-53	A	0-3	cs	7.5YR 4/3	L	wvfr	l, fr, so/po	0	0	2	mvf	NE	
			Bt	3-16	as	7.5YR 4/4	CL	wmpr, mcoabk	vh, fi, so/sp	0	0		fvf	NE	
			Bk	16-26	gs	7.5YR 5/3	CL	smabk, ma	vh, fr, so/po	0	0		fvf	VE	
			C	26-60	-	7.5YR 5/2	L	ma	s, vfr, so/po	0	0		-	VE	
Cabbart	MiCa	BK-55	A	0-3	cs	7.5YR 4/4	L	mfgr	l, vfr, so/po	5	0	15	mvf, cf	SE	Moderate volumes of highly weathered para-fragments
			Bk1	3-12	cs	7.5 YR 5/4	L	wvfbk	s, vfr, so/po	5	0		cvf, cf	VE	
			C	12-18	aw	10YR 5/6	L	ma	s, vfr, so/po	10	0		ff	VE	
			Cr	18+	-	-	SiL	-	-	-	-		-	-	
Cabba	BCT	BK-56	A	0-4	cs	10YR 3/3	L	wfsbk, loose	w, so, po	10	0	10-15	mf, fm	-	Weathered siltstone Sandstone Sedimentary
			B/C	4-11	cs	10YR 5/4	SiL	mcsbk	sh, ss, sp	0	0		mf	-	
			Cr1	11-25	as	-	SiL	m	-	-	-		-	-	
			Cr2	25-32	as	-	SiL	m	-	-	-		-	-	
			Cr3	32-49	as	-	SiL	m	-	-	-		-	-	
Twilight	TwB	BK-57	A	0-3	cs	10YR 3/2	L	wfsbk	s, so, po	0	0	3-8	mf, fc	NE	
			B	3-13	cw	10YR 4/2	L	mcsbk	sh, ss, sp	0	0		mf, fm	NE	
			B2	13-36	gs	10YR 5/3	L	wcsbk	mh, ms, mp	0	0		cf	VE	
			C	36-60	gs	10YR 5/3	L	m	s, ss, sp	0	0		ff	VE	
			C	60-80	-	10YR 4/3	L	m	s, ss, sp	0	0		ff	STE	
Twilight	BCT	BK-64	A	0-3	cs	7.5YR 4/2	L	wvfr	s, vfr, so/po	5	0	4	mvf, cf	NE	
			Bw	3-14	gs	7.5YR 5/3	L	sm/cosbk	sh, fr, ss/sp	0	0		fvf, ff	NE	
			Bk	14-21	cs	10YR 6/3	CL	smabk	ha, fr, ss/sp	0	0		fvf	VE	
			C	21-60+	-	10YR 5/4	L	ma	s, ms/po	0	0		ma	VE	
Blacksheep	BCT	BK-68	A	0-2	cs	2.5Y 4/2	SL	wfsbk, l	w, so, po	0	0	3-10	mf, fm	ME	Highly weathered sandstone Highly weathered sandstone Highly weathered sandstone
			B	2-12	cw	2.5Y 4/3	L	mmsbk	mh, so, po	0	0		mf, fm	VE	
			C	12-19	cs	2.5Y 5/3	SL	m	mh, so, po	0	0		cf	VE	
			Cr1	19-44	gs	2.5Y 4/4	SL	m	s, so, po	0	0		ff	NE	
			Cr2	44-68	gs	2.5Y 5/4	SL	m	s, so, po	0	0		ff	NE	
			Cr3	68-90	-	2.5Y 4/3	SL	m	s, so, po	0	0		-	NE	
Delpoint	MiDe	BK-69	A	0-2	cs	2.5Y 3/2	CL	smabk	vh, ss, vp	0	0	3-10	mf, fc	SL	
			Bt	2-8	cw	2.5Y 3/3	C	mcpr, scabk	vh, ss, vp	1	0		ff	SL	
			Btk	8-20	gs	2.5Y 4/3	SiCL	mcpr, scabk	vh, ss, vp	1	0		ff	VE	
			C	20-48	gs	2.5Y 4/4	L	m	-	0	0		ff	VE	
			Cr1	48-72	gs	2.5Y 5/3	SiCL	m	-	0	0		-	SL	
			Cr2	72-90	-	-	SL	m	-	0	0		-	NE	

### Soil Profiles - Field Data

Soil Series	Map Unit Symbol	Sample Site (SS)	Soil Horizon	Depth <sup>1</sup> (inches)	Boundary	Color <sup>2</sup>	Texture <sup>3</sup>	Structure <sup>4</sup>	Consistence <sup>5</sup>	Coarse Fragment %		Slope %	Roots <sup>6</sup>	Effervescence <sup>7</sup>	Notes
										Gravel	Cobbles				
Midway	MiDe	BK-71	A	0-2	cs	2.5Y 5/2	C	mcabk	h, ss, mp	0	0	5-15	mf, cm	VE	Columnar structure with 1/8" cracks Intermittent lenses of hard red shale throughout Moderately cemented shale. Moist below 24" Moderately cemented shale w/carbonaceous loose carbonaceous material
			C	2-8	cw	2.5Y 6/2	SIC	m	mh, ss, mp	20	10		mf, cm	VE	
			Cr1	8-24	cs	2.5Y 6/1	C	m	-	20	10		ff, fm	VE	
			Cr2	24-50	cs	5Y 4/2	SIC	m	-	0	0		ff	STE	
			Cr3	50-74	-	5Y 5/1	C	m	-	0	0		-	STE	
			Cr4	74-93	-	-	SL	m	-	0	0		-	-	
Haverson	H-S	CB-21	A	0-4	cs	2.5Y 4/4	SiCL	mvnpl	ha, vfr	0	0	0-5	cf	ST	
			Btk	4-25	gs	2.5 4/4	SIC	mcosbk, wtkpl	ha, vfr, ss/vp	0	0		fvf	VE	
			C1	25-54	gs	2.5Y 3/3	SIC	m	s, vfr, ss/vp	0	0		fvf	VE	
			C2	54-60+	-	2.5Y 3/3	C	m	s, vfi, ss/vp	0	0		-	VE	
Havre	NiHa	CB-70	A	0-7	cs	2.5Y 4/3	SiCL	wcsbk	mh, ms, mp	0	0	3-10	mf, fm, fc	STE	Intermittent 1-2" pea gravel lenses from 17-90" Moist
			C1	7-17	gs	2.5Y 4/3	L	m	l	60	0		cf, fm	VE	
			C2	17-39	gw	2.5Y 5/3	L	m	mh, ss, mp	5	0		cf, fm	VE	
			C3	39-62	cw	2.5Y 4/3	CL	m	h, vs, mp	5	0		ff	VE	
			C4	62-90	-	2.5Y 3/3	SIC	m	mh, vs, up	5	0		ff	VE	
Nihill	NiHa	CB-72	A	0-3	as	2.5Y 4/4	L	wvfr	sh, fr, ss/spo	5	0	8	cvf, ff	SL	
			Bk	3-10	cs	2.5Y 5/4	SiCL 30	wfsbk	mh, fi, ss/mp	5	0		cvf	VE	
			Ck	10-34	gs	2.5Y 5/4	L	ma	vh/r, fi, ss/mp	0	0		fvf, fm	VE	
			C2	34-60+	-	2.5Y 5/4	L	ma	s, fi, ss/m	0	0		-	ST	
Hydro	HyHp	CB-77	A	0-6	cw	2.5Y 4/3	SIC	mcpr, mmabk	mh, ms, sp	0	0	5-15	cf, fm	NE	5" thick shale/sandstone gravel lens, 55%gr, 29-34" mixed gravels, mostly pea sized shale
			Btk	6-14	cs	2.5Y 5/4	C	mcpr, mmabk	mh, ss, mp	0	0		cf, fm	ST	
			C1	14-26	cs	2.5Y 5/3	CL	m	mh, ms, mp	2	0		cf	VE	
			C2	26-39	gs	2.5Y 5/4	SiCL	m	mh, ms, mp	0	0		ff	VE	
			C3	39-64	gs	2.5Y 5/4	CL	m	vh, ss, mp	3	0		ff	VE	
			C4	64-92	-	2.5Y 5/4	CL	m	h, ss, mp	3	0		-	ST	
Remmit	RmT	CB-79	A	0-4	cw	2.5Y 4/2	SiL	smsbk	mh, ms, sp	0	0	10-25	mf, fm	SLE	Loose soft sand below 30"
			Bk	4-14	cw	2.5Y 4/3	L	mcsbk	mh, so, po	0	0		fm, cf	VE	
			B/C	14-30	cw	2.5Y 6/4	L	wmsbk	mh, so, po	5	0		cf	VE	
			C1	30-60	gw	2.5Y 5/4	L	m	s, so, po	15	0		ff	VE	
			C2	60-96	-	2.5Y 5/4	SL	m	s, so, po	25	0		ff	VE	
Haverson	H	CB-83	Ap	0-6	cs	2.5Y 3/3	SiCL	mcpl	h, vs, mp	0	0	0-2	mf, fc	NE	
			Bk1	6-12	cw	2.5Y 3/3	SIC	wmpr, mfabk	h, ss, mp	0	0		cf, fc	STE	
			Bk2	12-28	gs	2.5Y 4/2	SiCL	wmpr, mcabk	h, ms, mp	0	0		ff	VE	
			C1	28-50	cs	10YR 3/3	L	m	sh, ss, sp	0	0		ff	VE	
			C2	50-68	cs	10YR 4/3	SL	m	s, so, po	0	0		ff	VE	
			C3	68-92	-	10YR 4/3	LS	m	s, so, po	0	0		-	STE	



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Soil Series	Map Unit Symbol	Sample Site (SS)	Soil Horizon	Depth <sup>1</sup> (inches)	Boundary	Color <sup>2</sup>	Texture <sup>3</sup>	Structure <sup>4</sup>	Consistence <sup>5</sup>	Coarse Fragment %		Slope %	Roots <sup>6</sup>	Effervescence <sup>7</sup>	Notes
										Gravel	Cobbles				
Hesper	Hp	CB-87	A	0-2	cs	2.5Y 4/2	L	mtnpl	sh, ss, po	0	0	2-8	mf, fm	NE	8" sand lens in lower half of horizon Moist below 71"
			B	2-7	gs	2.5Y 4/3	L	wmsbk	mh, ms, sp	0	0		mf, fm	NE	
			Bk	7-13	gs	2.5Y 4/2	CL	wfsbk	h, ss, mp	0	0		cf	VE	
			C1	13-27	gs	2.5Y 5/3	L	m	so, so, sp	5	0		ff	VE	
			C2	27-45	gs	2.5Y 4/3	SL	m	so, so, po	0	0		ff	VE	
			C3	45-71	gs	2.5Y 4/3	L	m	so, so, po	0	0		-	ST	
Twilight	TwB	CB-95	A	0-3	cs	10YR 4/2	SL	wvfr	l, vfr, so/po	0	0	0-5	cf, cvf	NE	Very soft, weathered sandstone,
			Bw	3-9	as	10YR 4/3	SL	mcosbk	sh, vfr, so/po	0	0		ff, fvf	NE	
			Bk	9-19	gs	10YR 4/3	SL	wmsbk	s, vfr, so/po	0	0		fvf	VE	
			C	19-50	cs	2.5Y 5/3	SL	sg	l, vfr, so/po	0	0		fvf	VE	
			Cr	50-60+	-	-	L	-	-	0	0		-	-	
Midway	MiDe	CB-101	A	0-3	cs	5YR 4/6	CL	mvfr	s, fi, ss/mp	10	0	10-15	cvf, ff	SE	slightly weathered, thinly layered shale
			Bw1	3-12	gs	5YR 5/4	CL	mvnpl	mm, fr, ss/mp	20	0		fvf, ff, fco	SE	
			Bw2	12-19	as	5YR 5/4	SiCL	mvnpl, mmabk	vh, fl, ms/mp	0	0		fvf, fco, fm	SE	
			Cr	19+	-	-	SiCL	-	-	-	-		-	SE	
Arvada	Av	CB-103	A	0-8	cs	5YR 5/4	CL	mmpr, mmabk	h, ss, up	0	0	2-8	mf, fm	-	Soft, dispersed clays in profile
			Bk	8-16	cs	5YR 6/6	CL	mmpr, mfabk	h, ss, mp	0	0		cf, fm, fc	VE	
			C1	16-29	gs	10YR 6/4	SiCL	m	so, ss, mp	0	0		cf, fm	VE	
			C2	29-43	gs	10YR 5/3	SiCL	m	h, ss, mp	0	0		ff, fm	VE	
			C3	43-65	gs	10YR 6/4	SIC	m	h, ss, mp	0	0		ff	SLE	
McRae	McR	CB-111	Ap	0-4	cs	2.5Y 4/4	CL	mfp	mh, so, sp	0	0	0-3	mf, fm	STE	Moist
			B	4-12	cw	2.5Y 5/3	SiCL	mmabk	mh, so, sp	0	0		cf, fm	VE	
			B/C	12-22	gs	2.5Y 5/4	SiCL	wmabk, m	vh, so, sp	0	0		ff	VE	
			C1	22-32	gs	2.5Y 4/4	L	m	vh, so, sp	0	0		ff	VE	
			C2	32-50	gs	2.5Y 5/3	L	m	mh, ss, sp	0	0		ff	VE	
			C3	50-92	-	2.5Y 5/3	L	m	so, so, sp	0	0		ff	VE	
Hesper	Hp	CB-113	A	0-5	cs	2.5Y 3/3	CL	wmpr, mmabk	vh, ss, mp	0	0	3-8	fm, mf	NE	
			B	5-10	cs	2.5Y 4/3	SiCL	wmpr, mcabk	vh, ms, mp	10	0		cf	NE	
			Bk	10-35	gs	2.5Y 5/3	CL	mcabk	mh, ms, mp	15	0		ff	VE	
			C1	35-60	gs	2.5Y 5/4	CL	m	s, vs, sp	15	0		ff	VE	
			C2	60-90	-	2.5Y 5/4	CL	m	s, ss, sp	5	0		-	VE	
Barvon	FtD	CB-113-2	A	0-5	cw	10YR 3/2	SL	wmpr, mmsbk	sh, so, po	5	0	5-15	mf, fm	NE	Hard sandstone, flagstone or larger rock frags
			B	5-16	cw	10YR 3/3	SL	mfsbk	mh, so, po	5-10	0		mf, fm	ME	
			C	16-38	-	10YR 5/3	SL	m	sh, so, po	10-15	0		cf	VE	
			R	38+	-	-	-	-	-	-	-		-	-	
Farland	Fa	CB-119	A1	0-3	cs	2.5Y 4/3	SiCL	mmpl, mmabk	h, ms, up	0	0	3-10	mf, cm, fc	SLE	
			A2	3-7	cs	2.5Y 2.5/1	SiCL	mtnpl, mfabk	h, ss, sp	0	0		mf, fm, fc	SLE	
			Bk	7-19	gw	2.5Y 3/3	SiL	mmabk	h, so, po	0	0		cf, fm	STE	
			C1	19-27	gw	2.5Y 4/3	L	m	h, so, po	0	0		ff	VE	
			C2	27-43	cs	2.5Y 4/3	L	m	h, so, po	0	0		ff	VE	
			C3	43-64	cs	2.5Y 5/4	L	m	h, so, po	0	0		-	VE	
C4	64-90	-	2.5Y 4/4	L	m	s, ss, po	60	2	-	VE					

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Soil Series	Map Unit Symbol	Sample Site (SS)	Soil Horizon	Depth <sup>1</sup> (inches)	Boundary	Color <sup>2</sup>	Texture <sup>3</sup>	Structure <sup>4</sup>	Consistence <sup>5</sup>	Coarse Fragment %		Slope %	Roots <sup>6</sup>	Effervescence <sup>7</sup>	Notes
										Gravel	Cobbles				
Heldt	He-S	CB-120	Ap	0-6	cs	2.5Y 3/3	SiCL	mmsbk	h, ss, mp	0	0	1	mf, fm	SLE	
			B	6-14	gs	2.5Y 4/3	SiCL	mmabk	h, ss, mp	0	0		mf, fm	VE	
			C1	14-27	gs	2.5Y 4/3	SIC	m	f, ss, mp	0	0		cf	VE	
			C2	27-54	cs	10YR 4/2	SiCL	m	f, ss, mp	0	0		ff	VE	
			C3	54-76	cs	10YR 5/4	SL	m	l, so, po	0	0		ff	VE	
			C4	76-90	-	10YR 4/4	L	m	s, ms, po	0	0		-	VE	
Haverson	H-S	CB-121	A	0-7	cw	10YR 4/3	L	wcsbk	mh, ss, sp	0	0	0-3	mf, fc	ME	
			B	7-18	cs	10YR 4/2	SiCL	wcpr, wmsbk	w, ss, sp	0	0		mf	STE	
			C1	18-36	gs	10YR 4/2	SL	loose	lo, so, po	0	0		cf	STE	
			C2	36-60	gs	2.5Y 4/2	L	m	so, so, po	0	0		ff	STE	
			C3	60-81	-	-	SL	m	lo, so, sp	0	0		-	STE	
Haverson	H-S	CB-123	Ap	0-5	cs	10YR 3/2	SiL	mmppl	mh, so, sp	0	0	0-3	mf, fm	SLE	
			Bt	5-13	cs	2.5Y 4/3	L	mmabk	mh, so, sp	0	0		cf	ME	
			Bk	13-24	gs	2.5Y 4/3	SiCL	mmabk	mh, ss, sp	0	0		ff	VE	
			C	24-46	gs	2.5Y 4/3	L	m	so, ss, ss	0	0		ff	VE	
			C	63-90	-	2.5Y 4/2	SIC	m	so, ss, ss	0	0		ff	ST	
Relan	Re	CB-125	A	0-2	cs	2.5Y 4/4	CL	mfabk, mthpl	vh, ms, sp	0	0	3-10	mf, fm	NE	
			Bt	2-11	cw	2.5Y 5/3	SIC	mmpr, mmabk	vh, ms, mp	0	0		cf	NE	
			C1	11-23	cw	2.5Y 5/3	CL	m	vh, ms, mp	3	1		ff	STE	
			C2	23-47	cw	2.5Y 5/4	CL	m	vh, ss, sp	3	1		fvf	STE	
			R	47-70	-	2.5Y 6/3	L	-	-	-	-		-	VE	
Ringling	Ri	CB-126	A	0-2	cs	5YR 3/3	L	l	lo, so, sp	15	0	3-10	mf, cm	NE	
			C	2-12	cw	5YR 3/4	L	m	lo, so, sp	25	15		mf, cm	STE	
			Cr	12-32	cw	5YR 4/6	SL	-	-	40	20		ff	VE	
			R	32-96	-	5YR 3/4	SL	-	-	-	-		-	VE	
Relan	Re	CB-128	A	0-4	cs	5YR 3/3	L	loose	lo, ss, sp	15	0	3-10	mf, fc	ME	
			B/C	4-14	cs	5YR 3/4	L	msbk	w, ss, sp	20	0		mf, fc	ME	
			C1	14-40	cw	5YR 4/4	SL	m	lo, ss, sp	30	0		ff	VE	
			C2	40-64	gw	5YR 4/4	L	m	so, ss, sp	15	0		ff	VE	
			C3	64-90	-	5YR 4/4	SL	m	lo, so, po	25	0		-	VE	
Twilight	RTB	CB-138	A	0-2	cs	2.5Y 4/3	L	wvfr	l, vfr, so/po	0	0	0-2	mvf, cf	ST	
			Bk1	2-5	cs	2.5Y 4/3	L	mmskb	sh, vfr, so/po	0	0		cvf	ST	
			Bk2	5-11	as	2.5Y 4/3	L	wf/m, sbk	s, vfr, so/po	0	0		fvf	VE	
			C	11-60+	-	2.5Y 5/3	SL	sg, ma	l, vfr, so/po	0	0		fvf	VE	
McRae-Saline	McR-S	CB-140	A	0-2	cs	10YR 3/2	CL	smabk	vh, ms, vp	0	0	0-5	cf, fm	NE	
			Bt	2-7	cs	2.5Y 3/3	SiCL	mcpr, scabk	vh, ms, vp	0	0		cf, fm	SL	
			Btk	7-31	gs	2.5Y 4/3	SIC	mcpr, scabk	vh, vs, vp	0	0		ff	VE	
			C1	31-64	gs	2.5Y 5/3	SIC	m	so, vs, vp	0	0		ff	VE	
			C2	64-92	-	2.5Y 4/3	SIC	m	so, vs, vp	-	-		-	ME	



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Soil Series	Map Unit Symbol	Sample Site (SS)	Soil Horizon	Depth <sup>1</sup> (inches)	Boundary	Color <sup>2</sup>	Texture <sup>3</sup>	Structure <sup>4</sup>	Consistence <sup>5</sup>	Coarse Fragment %		Slope %	Roots <sup>6</sup>	Effervescence <sup>7</sup>	Notes											
										Gravel	Cobbles															
Ringling	Ri	CB-141	A	0-2	cs	5YR 3/3	SL	loose	lo, so, po	25	10	3-20	mf, cm, fc	NE	Highly weathered sandstone Fractured scoria, upper 3-8" carbonate coating on scoria											
			C	2-12	cw	5YR 3/3	SL	m	lo, so, po	50	20		cf	ME												
			Cr	12-30	cw	7.5YR 7/4	LS	-	-	-	-		cf	VE												
			R	30-70	-	2.5Y 4/6	LS	-	-	-	-		-	ME												
Blacksheep	BCT	CB-148	A	0-8	gs	10YR 5/4	L	mvfgr	l, vfr, so/po	5	0	-	mvf, cf	VE												
			Bk	8-15	cs	2.5Y 5/3	CL	wvfbcb	s, fr, so/po	5	0		cvf, cf	VE												
			C	15+	-	2.5Y 6/4	L	sg	l, vfr, so/po	-	-		sg	VE												
Barvon	RTB	CB-152	O	1-0	-	-	-	-	-	-	-	32	-	-	Soft, highly eroded sandstone											
			A	0-6	gs	10YR 3/3	SiCL	wvnpl	sh, fr, ss/sp	10	0		ff, fm, fco	SL												
			Bw	6-23	cs	10YR 4/2	C	mmsbk	sh, fr, ss/sp	10	0		fm, fco, fvc	SL												
			Cr	23+	-	-	CL	-	-	-	-		-	-												
McRae-Saline	McR-S	CB-155	A	0-2	gw	10YR 3/4	SIC	wvnpl	mh, fr, ss/sp	5	0	5	cf, fm	ST												
			Bt	2-16	gw	10YR 5/2	SIC	sccopr/mcoagk	vh, fi, ms/vp	0	0		ff, fm, fc	VE												
			Bk	16-31	cw	10YR 5/3	SIC	mmpr	vh, fi, ms/vp	0	0		fvf	VE												
			C	31-60+	-	10YR 4/3	SiL	ma	fi, ms/sp	10	0		-	SL/ST												
Midway	MiCa	CB-156	A	0-3	cs	2.5Y 4/2	CL	mmabk	mh, ss, mp	0	0	5-15	mf, fm	VE	Columnar cracks 1/8" wide 9-11", hard red shale Black carbonaceous material											
			B	3-9	cs	2.5Y 4/4	SIC	mcpr, mfabk	h, ms, mp	0	0		mf, fm	STE												
			Cr1	9-16	cs	2.5Y 4/4	C	m	-	0	0		ff	STE												
			Cr2	16-30	as	2.5Y 4/2	C	m	-	0	0		ff	STE												
			Cr3	30-46	gs	black	SCL	m	-	0	0		ff	NE												
			Cr4	46-68	gs	2.5Y 5/2	SIC	m	-	0	0		ff	STE												
Cr5	68-88	-	2.5 5/2	L	m	-	0	0	-	-	-	-	-	-												
															A	0-2	cs	7.5YR 4/2	SiCL	wfgr	s, fr, so/sp	0	0	cvf, cf, fm	ST	Moist, angular channers
															A/C	2-14	gs	7.5YR 4/3	SiCL	mtnpl/ma	fr, so/po	5	0	fvf, ff, fm	ST	
															C1	14-22	gs	7.5YR 5/4	CL	ma	fr, so/po	15	5	fvf	ST	
C2	22-42+	-	7.5YR 5/4	CL	ma/sg	fi, ss/sp	25	5	-	VE																
Twilight	TwB	CB-167	A	0-3	cs	10.5YR 4/3	L	svfgr	l, fr, so/po	0	0	3	mvf, cf	NE												
			Bt	3-17	as	10.5YR 4/4	CL	wmpr, mcosbk	vh, fi, ss/mp	0	0		cvf, ff	NE												
			Bk	17-30	gs	10.5YR 5/3	CL	mmabk	vh, fr, ms/sp	5	0		fvf	VE												
			C	30-60+	-	10.5YR 5/3	L	ma, sa	l/s, vfr, ss/po	0	0		-	VE												
Delpoint	MiDe	LB-09	A	0-4	cs	2.5Y 3/5	CL	wvnpl	vh, fi, ss/vp	0	0	6	cvf, ff	NE												
			Btk	4-22	cs	2.5Y 4/3	CL	scoaak	mh, fi, ss/vp	0	0		fvf	VE												
			C	22-60+	-	2.5Y 4/4	CL	ma	mh, fi, ss/mp	0	0		fvf	VE												
Cabba	BCC	LB-18	A1	0-2	gs	5YR 3/3	L	mvfgr	l, fr, ss/sp	45	0	5	cf, fm	NE												
			Bw	2-7	gs	5YR 3/3	L	wvfbcb	s, fr, ss/sp	40	5		ff, fm, fco	NE												
			C	7-22	-	4YR 5/3	CL	sg	l, fr, ms/sp	45	30		vf	NE												
Cabba	CaC	LB-21	A	0-2	gs	5YR 5/4	SiCL	tnpl	sh, fi, ms/jp	40	0	59	f, vf	VE	Thinly bedded highly weathered shale, Fractured											
			B/C	2-9	as	5YR 5/4	SiCL	vfsbk, ma	sh	45	0		f, vf	VE												
			Cr	9+	-	-	-	-	-	-	-		-	-												

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Soil Series	Map Unit Symbol	Sample Site (SS)	Soil Horizon	Depth <sup>1</sup> (inches)	Boundary	Color <sup>2</sup>	Texture <sup>3</sup>	Structure <sup>4</sup>	Consistence <sup>5</sup>	Coarse Fragment %		Slope %	Roots <sup>6</sup>	Effervescence <sup>7</sup>	Notes
										Gravel	Cobbles				
Blacksheep	BCC	LB-24	Ac	0-5	ds	2.5Y 5/4	SL	sg	l, vfr, ns/np	0	0	35-40	ff, fm, fco	SE	Slightly weathered sandstone
			C	5-12	as	2.5Y 5/3	SL	sg, ma	l, l, ns, np	5	0		ff, fm, fco	SE	
			Cr	12+	-	-	-	-	-	-	-		-	-	
Midway	MiDe	LB-33	A	0-2	cs	2.5Y 4/4	L	wvfr	s, fr, ns/sp	0	0	5-10	fvf, cf	SE	Moderately weatherd shale
			Btk	2-10	cs	2.5Y 4/4	CL	mmp, mcosbk	mh, fi, ss/sp	0	0		fvf, ff	VE	
			Bk	10-19	cs	2.5Y 5/4	SiCL	sosbk	mh	0	0		fvf	VE	
Cabba	BCC	LB-38	Cr	19+	-	-	-	-	-	-	-	16	-	-	
			A	0-3	gs	7.5YR 4/3	L	mvfr	l, fr, ss/np	30	0		cvf, cf, fm	VE	
			Bk	3-7	gw	7.5YR 4/2	L	fwsbk	s, fi, ss/sp	40	0		cvf, ff, fm	VE	
Haverson	CaC	LB-41	C	7-42+	-	7.5YR 4/4	SL	sg	l, fr, ss/po	42	30	3	cvf, ff	VE	
			A	0-2	as	10YR 4/4	SiCL	mvnpl	mh, fi, ss, mp	0	0		fvf, cf, fm	NE	
			Btk	2-13	gs	10YR 5/3	SIC	mcoabk/wvnpl	ha, fi, ss/vp	0	0		fvf, fm	ST	
Hydro	HyHp	LB-58	Btk2	13-26	gs	10YR 5/4	SIC	sco/mabk	vh, fi, ss/vp	0	0	3-8	fvf	VE	Moist at 52" Carbonaceous material
			C	26-60+	-	10YR 5/4	SiCL	ma	s, fi, ms, mp	5	0		fvf	VE	
			A	0-11	cw	2.5Y 4/3	C 40	mmp, smabk	vh, ms, vp	0	0		mf, fm, fc	SLE	
Cabbart	MiCa	LB-67	Bk	11-28	gs	2.5Y 4/4	SIC 35	mmp, mmabk	v, mss, vp	0	0	4	mf, fm	VE	
			Bkw	28-48	gs	2.5Y 5/3	SIC 35	scabk	vh, ms, mp	0	0		ff	VE	
			C1	48-76	gs	2.5Y 4/4	C 45+	m	vh, ss, vp	0	0		-	VE	
Midway	MiCa	LB-79	C2	76-96	-	2.5Y 4/4	SCL 28	m	h, ss, sp	0	0	5-15	-	VE	highly weathered shale Dense, moist shale
			A	0-3	cs	2.5Y 5/6	SIC	mfr	s, fr, ms/mp	10	0		fvf, cf	ST	
			C	3-10	aw	2.5Y 5/4	C	mmp/ma	s	10	0		fvf, ff	VE	
Fort Collins	FtHp	LB-85	Cr	10+	-	-	-	-	-	-	-	5	-	-	Moderately weathered thinly bedded shale
			A	0-7	cs	2.5Y 4/2	C	mcd, scabk	vh, ms, vp	0	0		cf	NE	
			B	7-16	cs	2.5Y 4/3	C	mcd, smabk	vh, ms, vp	5	0		ff	NE	
Delpoint	FtD	LB-91	C	16-45	cs	2.5Y 5/3	CL	m	h, ms, vp	5-10	0	7	-	VE	
			C/Cr	45-64	gs	2.5Y 5/6	C	m	h, ms, vp	0	0		-	VE	
			Cr	64-88	-	10YR 5/6	SIC	m	h, ms, vp	0	0		-	SLE	
Arvada	Av	LB-96	A	0-2	cs	10YR 3/4	SiL	mvfr	s, fr, ss/np	0	0	3-15	cvf, ff	SL	Thinly bedded soft shales Thinly bedded soft shales
			Bt1	2-10	cs	10YR 4/3	CL	mcobsk	s, fr, ss/sp	0	0		ff, fm	SL	
			Bt2	10-17	cs	10YR 4/4	SiCL	mmp	sh, fl, ss/mp	0	0		fvf	SL	
Arvada	Av	LB-96	Bk	17-35	gs	10YR 5/4	CL	mmsbk	s, fl, ss/mp	0	0	7	fvf	VE	
			C	35-60	-	10YR 4/4	CL	ma	s, vfr, ss/sp	0	0		-	VE	
			A	0-4	cs	10YR 4/3	SiCL	vnpl, fr	sh, fr, ns/sp	0	0		vf, f	SL	
Arvada	Av	LB-96	Bw	4-13	gs	10YR 4/3	CL	msbk	mh, fr, ss/sp	0	0	3-15	vf, f	SL	
			Bk	13-23	cs	10YR 4/3	CL	cosbk	mh, fr, ss/sp	0	0		vf	VE	
			R	23+	-	-	-	-	-	-	-		-	-	
Arvada	Av	LB-96	A	0-2	cs	2.5Y 5/4	CL	smabk	vh, ss, vp	0	0	3-15	cf	-	Thinly bedded soft shales Thinly bedded soft shales
			C1	2-9	cs	2.5Y 4/4	C	wcpr, m	vh, ms, vp	0	0		ff	-	
			C2	9-24	cs	5Y 5/2	SiCL	m	s, so, mp	0	0		-	-	
Arvada	Av	LB-96	Cr1	24-42	cs	-	SIC	m	-	-	-	3-15	-	-	Thinly bedded soft shales Thinly bedded soft shales
			Cr2	42-66	-	-	C	m	-	-	-		-		

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Soil Series	Map Unit Symbol	Sample Site (SS)	Soil Horizon	Depth <sup>1</sup> (inches)	Boundary	Color <sup>2</sup>	Texture <sup>3</sup>	Structure <sup>4</sup>	Consistence <sup>5</sup>	Coarse Fragment %		Slope %	Roots <sup>6</sup>	Effervescence <sup>7</sup>	Notes
										Gravel	Cobbles				
Fort Collins	FtHp	LB-99	A	0-4	cs	2.5Y 3/2	L	wmsbk	mh, ss, sp	0	0	0-6	mf, fm, fc	NE	
			Bt	4-11	gw	2.5Y 3/3	CL	mcabk	h, ms, mp	0	0		cf, fm	NE	
			Btk	11-34	gw	2.5Y 4/3	L	mcabk	mh, ss, sp	0	0		ff, fm	VE	
			C1	34-64	gs	2.5Y 4/4	SL	m	s, so, po	0	0		ff	SLE	
			C2	64-92	-	2.5Y 4/4	SL	m	s, so, po	0	0		-	SLE	
Hydro	Hy	LB-102	A	0-2	cs	10YR 4/2	CL	mtnpl	sh, so, sp	0	0	3-8	cf	NE	1" lenses of fine gravels throughout horizon
			Bt	2-9	cw	10YR 4/3	CL	mmpr, mcabk	rff, ss, mp	0	0		cf	NE	
			Bk	9-17	cw	10YR 4/3	CL	wfabk	mh, ss, mp	0	0		ff	VE	
			C1	17-28	gw	2.5Y 5/2	C	m	vh, ms, vp	0	0		ff	VE	
			C2	28-44	gw	2.5Y 5/3	CL	m	h, ss, mp	0	0		-	VE	
			C3	44-80	gw	2.5Y 5/2	CL	m	h, ss, mp	50	0		-	VE	
Delpoint	MiDe	LB-111	A	0-4	cs	10YR 4/3	SIC	mvnpl, mmpr	eh, fi, ss/mp	0	0	5	cvf, ff	SL	Soft weathered shale
			Btk	4-14	gs	2.5Y 5/3	SIC	smpr	mh, fi, ss/mp	0	0		fvf	VE	
			C	14-28	gs	2.5Y 5/3	SIC	ma	s, fi, ms/mp	0	0		fvf	VE	
			Cr	28-39+	-	-	SIC	ma	-	-	-		-		
Hesper	Hp	LB-124	A	0-8	cw	2.5Y 4/3	SIC	mcpr, mmabk	h, ms, mp	0	0	3-8	mf, cm	ST	
			B	8-24	cw	2.5Y 4/3	SiCL	wmpr, mcabk	mh, ms, mp	0	0		mf, fm	VE	
			B/C	24-45	gw	2.5Y 4/3	CL	wmabk	mh, ss, mp	0	0		cf	VE	
			C1	45-70	s	2.5Y 5/3	L	m	sh, ms, mp	0	0		ff	VE	
			C2	70-93	-	2.5Y 4/3	L	m	s, ss, sp	0	0		ff	VE	
Havre	NiHa	LB-129	A	0-3	cs	10.5YR 4/3	SiCL	mtkpl, wfg	mh, fi, ss/mp	0	0	2	cvf, ff, fm	ST	
			Bt	3-16	gs	10.5YR 4/3	SiCL	mvnpl, ma	vh, fi, ss/vp	0	0		fvf, ff	SL	
			C	16-30	gs	10.5YR 4/4	CL	ma	s, fi, ss/mp	0	0		fvf	SL	
			Cr	30+	-	-	CL	-	-	-	-		-		
Midway	Md-E	LB-136	A	0-2	gs	2.5Y 5/4	SiCL	wtnpl, wvfg	vh, fi, ms/mp	5	0	8	fvf, ff	VE	
			Bt	2-12	ds	5Y 5/3	SIC	mm/cosbk	fi, ms/vp	0	0		fvf	VE	
			C	12-26	cs	2.5Y 6/4	C	ma	fi, ss/vp	0	0		fvf	SL	
			C	26-46	cs	2.5Y 5/3	C	ma	fi, ss/vp	0	0		-	SL	
			C	46-60+	-	5YR 4/6	C	sg/ma	fi, ms/mp	0	0		-	NE	
Midway	Md-E	LB-137	A	0-3	gs	10YR 4/3	SIC	tnpl	vh, fi, ms/mp	0	0	0-1	cvf, cf, cm	VE	
			Bw	3-9	cw	10YR 4/3	SiCL	cosbk	mh, fi, ms/mp	0	0		cvf, cf, cm	VE	
			Bc	9-24	gs	2.5Y 4/4	SIC	vnpl, ma	fi, ms/vp	0	0		fvf, ff, fm	VE	
			C1	24-50	gs	2.5Y 4/3	SIC	ma	fi, ss/mp	0	0		ma	ST	
			C2	50-60+	-	2.5Y 4/4	SIC	ma	fr, ms/sp	0	0		-	SL	
Blacksheep	BCC	LB-142	A	0-4	cs	10YR 4/3	L	wvfg/wvnpl	s, vfr, so/po	15	0	35	ff, fm, fvc	NE	Moderately weathered shale and sandstone
			Bk	4-16	gs	10YR 5/3	SL	wmsbk	s, vfr, so/po	15	0		ff, cm, fvc	VE	
			C	16-37	cs	10YR 5/4	SL	sg/ma	l, vfr, so/po	5	0		ff, cm	VE	
			Cr	37+	-	-	-	-	-	-	-		-		

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Soil Series	Map Unit Symbol	Sample Site (SS)	Soil Horizon	Depth <sup>1</sup> (inches)	Boundary	Color <sup>2</sup>	Texture <sup>3</sup>	Structure <sup>4</sup>	Consistence <sup>5</sup>	Coarse Fragment %		Slope %	Roots <sup>6</sup>	Effervescence <sup>7</sup>	Notes	
										Gravel	Cobbles					
Nihill	NiHa	DP-01	A	0-5	cs	10YR 3/4	SiCL	mmpl	mh, ms, mp	0	0	3-8	mf, fm, fc	VE	Intermittent 1" gravel & sand lenses from 5-64" 2" sand lens @ 16-18"	
			B	5-16	gs	10YR 4/3	L	wcsbk	mh, ss, mp	5	0		cf, fc	VE		
			C1	16-40	cw	10YR 4/3	SL	m	sh, ss, po	5	0		cf	VE		
			C2	40-64	cw	10YR 3/4	SL	m	s, so, po	5	0		cf	VE		
			C3	64-92	-	10YR 4/4	L	lm	l, so, po	60	10		-	VE		
Ringling	RTB	RU-01	A	0-5	gs	7.5YR 4/3	L	mvfgr	s, f, ss/po	15	0	15	cf, fvf, fm	VE		
			Bk	5-17	gs	7.5YR 5/8	SL	wfsbk	s, vfr, ss, po	60	0		ff, fm	VE		
			C	17-37	gs	7.5YR 4/4	SL	sg	l, vfr, ss/po	15	0		fvf, ff, fm	VE		
			Cr	37+	-	-	-	-	-	-	-		-	-		
Relan	RTB	SS12-02	A	0-2	cs	2.5Y4/4	L	wfsbk		5	0	5-15	mf, cm	ST		
			Bt	2-8	cw	2.5Y5/3	SiL	wcsbk		5	0		mf, cm	ST		
			Bk	8-20	gw	2.5Y5/3	CL	wcsbk		15	0		cf	VE		
			C	20-38	gw	2.5Y6/4	SCL	m		25	0		ff	VE		
			Cr	38+	-	-	-	-	-	-	-		-	VE		auger refusal @ 38", weathered sandstone @ 34", not sampled
Blacksheep	RTB	SS12-03	A	0-3	cs	2.5Y4/3	L	l		10	0	10-20	mf, cm	ME		
			C	3-10	cs	2.5Y5/4	SL	wfsbk		15	0		cf, fm	VE		
			Cr1	10-34	cs	2.5Y6/4	SL	m		5	0		ff	VE		soft weathered sandstone with some soil
			Cr2	34-60	-	2.5Y5/6	SL	l/m		5	0		ff	VE		soft weathered sandstone
Havre	NiHa	SS12-04	A	0-3	cs	2.5Y4/4	CL	mmabk		0	0	0-5	mf, fm	NE		
			Bt	3-13	gs	2.5Y4/4	CL	mmabk		0	0		cf, fm	ST		
			Bk	13-30	gs	2.5Y5/4	CL	wmabk		0	0		ff	ST		
			C1	30-50	gs	2.5Y5/4	CL	m		0	0		ff	ST		
			C2	50-60	-	2.5Y5/4	CL	m		0	0		ff	ST		
Midway	BCC	SS12-07	A	0-4	cs	2.5Y5/6	SiC	wmabk/mfabk		15	0	15-40	cs	VE		
			Bt	4-12	cs	2.5Y4/1	SiC	mcpr/hcabk		0	0		cs	VE		
			C	12-24	cs	2.5Y6/2	C	m		0	0		cs	ST		15% soft shale channers
			Cr	24-40	-	2.5Y5/1	SiC	-		0	0		-	NE		soft grey and brown shale
Twilight	RTB	SS12-09	A	0-4	cs	2.5Y4/4	L	wfsbk		0	0	20-40	cs	NE		
			B	4-12	cw	2.5Y5/4	CL	hcabk		5	0		cw	ME		faint clay films
			C	12-30	cs	2.5Y6/4	L	m		25	0		cs	VE		3" concreted surface between BC, moderately hard sandstone gravels
			Cr	30+	-	-	-	m		0	0		-	NE		C2 not sampled
McRae	McR-S	SS12-13	A	0-6	cs	2.5Y3/3	SiCL	mmabk		0	0	2-5	mf, cm	NE		
			Bt	6-14	cs	2.5Y4/3	CL	wmpr/hmabk		0	0		mf, fm	VE		few clay films present
			Bk	14-36	gw	2.5Y5/4	SiL	mcabk		0	0		ff	VE		few clay films present
			C1	36-60	gw	2.5Y4/4	SiL	m		0	0		ff	VE		
			C2	60-84	-	2.5Y4/4	SiCL	m		0	0		-	VE		mix sand/gravel alluvium, RMF MF FMF 2.5Y 4/6-Fe, 2.5Y 2/1-Mn

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Soil Series	Map Unit Symbol	Sample Site (SS)	Soil Horizon	Depth <sup>1</sup> (inches)	Boundary	Color <sup>2</sup>	Texture <sup>3</sup>	Structure <sup>4</sup>	Consistence <sup>5</sup>	Coarse Fragment %		Slope %	Roots <sup>6</sup>	Effervescence <sup>7</sup>	Notes
										Gravel	Cobbles				
Haverson	H	SS12-14	A	0-4	cs	2.5Y4/3	SiL	mcpl		0	0	0-2	mf, cm	NE	
			Bk	4-17	cs	2.5Y4/4	SiL	mcabk		0	0		mf, cm	VE	few clay films present
			BC	17-36	gs	2.5Y4/4	L	m		0	0		ff, fm	VE	few clay films present
			C1	36-60	gw	2.5Y4/4	SiL	m		0	0		-	VE	moist below 36"
			C2	60-84	-	2.5Y4/3	L	m		0	0		-	VE	no GW observed
mix sand/gravel alluvium, RMF MF FMF 2.5Y 4/6-Fe, 2.5Y 2/1-Mn															
McRae	McR	SS12-17	A	0-5	cs	10YR4/3	L	wfsbk		0	0	0-5	mf, fm	NE	
			Btk	5-13	cw	10YR4/3	L	wmpr/mmabk		0	0		mf, fm	VE	
			Bk	13-28	gw	10YR5/3	L	wmabk		0	0		cf	VE	
			C1	28-42	gw	10YR5/4	L	m		0	0		-	VE	
			C2	42-60	-	10YR5/4	L	m		0	0		-	VE	
Farland	Fa	SS12-21	A	0-2	cs	10YR4/2	SiCL	wfpl		0	0	2-6	mf, cm	ME	thin platy A
			C1	2-14	cs	10YR4/3	SiCL	m		0	0		mf, cm	ME	evidence of wmsbk structure
			C2	14-28	cs	2.5YR5/4	SiCL	m		0	0		cf	VE	
			C3	28-46	cs	2.5YR5/4	L	m		0	0		ff	VE	
			C4	46-60	-	2.5YR4/4	L	m		0	0		ff	VE	mixed sandy alluvium w/ very small sandstone and scoria gravel
McRae	He	SS12-22	Ap	0-6	cs	10YR3/2	SiL	mcabk/wmpl		0	0	0-2	mf, mm, fc	NE	
			Bk	6-16	cs	10YR4/3	L	wmpr/mcabk		0	0		cf, fm, fc	VE	
			BC	16-38	gs	10YR4/2	SiL	wcsbk		0	0		ff	VE	
			C1	38-60	gs	10YR3/3	L	m		0	0		-	STE	carbonates present
			C2	60-84	-	10YR4/6	SL	m		0	0		-	STE	
Relan	Re	SS12-23	A	0-3	cs	7.5YR4/3	SL	L		5	0	5-15	cf, fm	NE	
			Bt	3-18	cs	7.5YR4/2	SL	wmsbk		5	0		cf	NE	argillic?
			Bk	18-32	cs	7.5YR5/3	SL	mmabk		0	0		ff	VE	
			C1	32-46	cs	7.5YR4/4	SL	m		10	0		ff	VE	fine soft sands
			C2	46-60	-	7.5YR4/4	SL	m		25	0		ff	VE	sandstone gravels
Haverson	H-S	SS12-24	A	0-6	cs	10YR4/3	SiCL	mcabk		0	0	0-2	mf, mm	NE	
			Btk	6-20	cs	10YR4/4	SiC	wcpr, mmabk		0	0		mf, cm	VE	
			BC	20-36	cs	10YR4/6	SL	wmsbk		0	0		mf, fm	SLE	moist below 20", no RMF, CaCO3 visible
			C1	36-50	cs	10YR5/4	L	m		0	0		cf	VE	RMF CM FMF 2.5Y4/6
			C2	50-74	cs	10YR4/6	L	m		5	0		cf	SE	RMF CM FMF 2.5YR 4/6-Fe, 2.5Y2/1-Mn, h2O @ 90"
			C3	74-96	-	10YR4/4	CL	m		0	0		ff	ME	mix sand/gravel alluvium, RMF MF FMF 2.5Y 4/6-Fe, 2.5Y 2/1-Mn

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Soil Series	Map Unit Symbol	Sample Site (SS)	Soil Horizon	Depth <sup>1</sup> (inches)	Boundary	Color <sup>2</sup>	Texture <sup>3</sup>	Structure <sup>4</sup>	Consistence <sup>5</sup>	Coarse Fragment %		Slope %	Roots <sup>6</sup>	Effervescence <sup>7</sup>	Notes
										Gravel	Cobbles				
Heldt	He	SS12-25	Ap	0-6	cs	10YR3/2	SiL	hcabk		0	0	0-2	mf, cm	NE	
			Bk	6-18	g	10YR3/4	SiL	mcpr, mmabk		0	0		cf, fm	NE	carbonates present
			B	18-33	g	2.5Y3/3	SiCL	mcpr, mmabk		0	0		ff	NE	carbonates present
			C1	33-58	ds	2.5Y4/2	L	m		0	0		ff	NE	
			C2	58-80	-	2.5Y4/4	SiCL	m		5	0		-	NE	1" gravel lens @58", moist below lens
Nihill	NiHa	SS12-28	A	0-2	cs	10YR3/3	CL	mmsbk		5	0	3-10	mf	NE	
			Bt	2-10	cs	10YR4/3	CL	mmabk		5-10	0		mf	VE	
			BC	10-30	cs	10YR4/3	CL	wmabk/m		15	0		ff	VE	dense gravel lens between Bt and BC
			C1	30-50	cs	2.5Y4/4	CL	m		5-10	0		-	VE	
			C2	50-60	-	2.5YR4/4	CL	m		45	0		-	VE	
Ringling	Ri	SS12-29	A	0-2	cs	10YR4/3	SL	l		15	5	0-5	-	STE	
			C1	2-14	cw	10YR4/3	SL	wmsbk/m		30	10		-	VE	soft weathered scoria w/few gravels
			C2	14-28	-	10YR4/4	S	l		10	0		-	NE	Auger refusal @ 28"
Saline Overflow	SO	SS12-31	Ap	0-4	cs	2.5Y4/4	SiCL	hcco, hmabk		0	0	0-2	mf, mm	NE	salt crust, RMF/FM FED 2 Gley 5/10 GY CLD
			Bk	4-16	cs	2.5Y5/4	SiCL	hcco, hmabk		0	0		mf, fm	SE	RMF / FM CLD 2 Gley 5/10 GY, CM FMM 2.5Y 3/2, carbonates>Ap
			BC	16-31	cs	2.5Y3/4	SL	wmsbk/m		0	0		ff	VE	RMF CF CLD 2 Gley 6/10GY
			C1	31-55	cs	2.5Y4/4	SiC	m		0	0		ff	VE	salt below 31", RMF CM F3M 2.5Y 3/6, MNM 25Y 3/2
			C2	55-73	cs	2.5Y5/4	SiC	m		0	0		-	VE	RMF CF FED 2Gley 5/10 GY, FF F3M 5Y 5/4
			C3	73-93	-	2.5Y4/4	C	m		0	0		-	VE	GW @ 73", RMF 5A C2, Mix sand and clay, carbonates and calving common
Saline Overflow	SO	SS12-32	Ap	0-6	cs	10YR4/3	SiC	mmco		0	0	0-2	mf, mm	VE	salt crust, RMF/FF-CLO 2Gley 5/10GY
			Bt	6-16	cs	10YR4/6	SiC	mmco		0	0		mf, mm	VE	salts visible, RMF/CM-FMM 5YR5/6, CM-CLO 2Gley 5/10GY
			BC	16-24	cs	10YR4/4	SiC	wmco/m		0	0		mf, mm	VE	Saturated at and below 16", RMF, no visible structure
			C1	24-44	cs	2.5Y4/4	SiC	m		0	0		-	VE	
			C2	44-66	cs	2.5Y5/4	SiC	m		0	0		-	VE	H2O @ 64"
			C3	66-90	-	2.5Y4/4	SiCL	m		0	0		-	VE	slightly darker hue, sands present, unable to sample due to calving
Haverson	H-S	SS12-35	Ap	0-6	cs	2.5Y4/4	L	hmabk		0	0	0-2	mf, mm	ME	
			Btk	6-14	cs	2.5Y4/4	SiCL	mpr/mcabk		0	0		mf, cm	VE	severe slumping below 14"
			C1	14-30	cs	10YR4/3	SiCL	m		0	0		mf, fm	VE	faint depletions Mn RMF
			C2	30-54	cs	10YR4/4	L	m		0	0		mf	VE	
			C3	54-78	-	10YR5/4	SL	m		0	0		ff	VE	saturated at 60"

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Soil Series	Map Unit Symbol	Sample Site (SS)	Soil Horizon	Depth <sup>1</sup> (inches)	Boundary	Color <sup>2</sup>	Texture <sup>3</sup>	Structure <sup>4</sup>	Consistence <sup>5</sup>	Coarse Fragment %		Slope %	Roots <sup>6</sup>	Efferves- cence <sup>7</sup>	Notes
										Gravel	Cobbles				
Barvon	RTB	SS12-36	A	0-3	cs	7.5YR3/2	SL	wfsbk		10	0	5-15	mf, mm	NE	
			Bk	3-9	gs	7.5YR3/3	L	mmsbk		10	0		cf, fm	SE	
			BC	9-24	gs	7.5YR3/4	L	wmsbk		30	0		ff, fm	VE	
			C	24-36	cs	7.5YR4/4	SL	m		25	0		—	VE	
			Cr	36+	-	-	-	-	-	-	-		-	—	VE
Haverson	SO	SS12-37	A	0-6	cs	2.5Y3/3	C	mcco/hmabk		0	0	0-2	mf, mm	NE	
			ABk	6-12	cs	2.5Y4/3	SiCL	mcco/hcabk		0	0		mf, cm	VE	
			BC	12-23	gs	2.5Y4/4	SiCL	wmabk		0	0		ff	VE	
			C1	23-36	gs	2.5Y4/4	SiL	m		0	0		ff	VE	RMF FM FMF/depletions
			C2	36-55	gs	10YR4/3	SiCL	m		0	0		—	STE	RMF CM FMF, CM depletions
			C3	55-76	gs	10YR3/4	SiC	m		0	0		—	STE	RMF-SA C2, C2/C3 same Hz, split for sampling
			C4	76-90	-	10YR3/4	SL	m		0	0		—	STE	H2O @ 76", saturated sands



Properties exceed DEQ unsuitability criteria for Lift 1 material

Properties exceed DEQ unsuitability criteria for Lift 2 material

<sup>1</sup>Boundary:

a = abrupt, c = clear, g = gradual, d=diffuse; s=smooth, w = wavy, i=irregular, b=broken.

<sup>2</sup>Color:

Munsell color notations.

<sup>3</sup>Texture:

C = clay, CL = clay loam, L = loam, LS = loamy sand, LFS = loamy fine sand, SiL =silty loam, SiCL = silty clay loam, SiC = silty clay, S = sand, SL SCL = sandy clay loam, SC = sandy clay, g = gravelly, vg = very gravelly, eg = extremely gravelly, c = cobbly, vc = very cobbly, b = bouldery.

<sup>4</sup>Structure:

Grade: m = massive, 1 = weak, 2 = moderate, 3 = strong.

Size: vf = very fine, f = fine, m = medium, c = coarse, vc = very coarse.

Type: gr = granular, pl = platy, pr = prismatic, cl = columnar, abk = angular blocky, sbk = subangular blocky.

<sup>5</sup>Consistence:

Dry: lo = loose, so = soft, sh = slightly hard, h = hard, vh = very hard, eh = extremely hard.

Moist: lo = loose, vfr = very friable, fr = friable, fi = firm, vfi = very firm, efi = extremely firm.

Wet: so = nonsticky, ss = slightly sticky, s = sticky, vs = very sticky.

Plasticity: po = nonplastic, ps = slightly plastic, p = plastic, vp = very plastic.

<sup>6</sup>Roots:

Abundance: f = few, c = common, m = many.

Size: vf = very fine, f = fine, m = medium, co = coarse.

<sup>7</sup>Effervescence:

NE=non effervescent VS=very slightly effervescent SL=slightly effervescent ST=strongly effervescent VE=violently effervescent

## Soil Profiles - Laboratory Data

LABORATORY SOIL DATA SUMMARY											Chemical Data									
Soil Series	Map Unit Symbol	Sample Site (SS)	Horizon	Depth	Sand %	Silt %	Clay %	Texture, unitless	Percent Sat %	OM-WB %	pH-SatPst, s_u_	COND, mmhos/cm	SAR, unitless	Calcium, meq/l	Mg-SatPst, meq/l	Na-SatPst, meq/l	NO3-SatPst, mg/L	B, mg/kg	Se, mg/kg	Mo, mg/kg
Delpoint	FtD	BK-01	A	0-4	22	58	20	SiL	47.0	4.3	6.6	1.1	0.1	5.45	3.64	0.23	<0.4	<0.1	<0.1	<0.05
			Bt	4-11	24	42	34	CL	46.5	3.0	6.9	0.7	0.1	4.04	2.79	0.20	<0.4	0.1	<0.1	<0.05
			B/C	11-29	34	38	28	CL	38.9	1.6	7.8	0.5	0.4	1.42	2.38	0.55	<0.4	0.2	<0.1	<0.05
			Cr1	29-60	48	28	24	L	36.2	2.0	8.2	1.2	4.2	0.52	4.05	6.28	<0.4	0.3	<0.1	<0.05
			Cr2	60-89	62	20	18	SL	31.9	0.7	8.2	1.7	6.6	0.89	4.14	10.5	1.6	0.2	<0.1	0.07
Blacksheep	BCT	BK-05	A	0-4	34	48	18	L	57.2	6.4	7.4	0.6	0.2	4.01	0.78	0.34	<0.4	0.2	<0.1	<0.05
			Bk1	4-9	26	49	25	L	51.0	5.1	7.3	0.6	0.2	3.97	1.26	0.35	<0.4	0.2	<0.1	<0.05
			Bk2	9-14	24	53	23	SiL	51.7	4.3	7.4	0.5	0.2	2.96	1.25	0.30	<0.4	0.3	<0.1	<0.05
			R	14+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Havre	NiHa	BK-14	A	0-5	42	34	24	L	46.8	6.3	7.0	1.0	<0.1	6.35	1.84	0.18	<0.4	0.2	<0.1	<0.05
			C1	5-28	60	19	21	SCL	32.4	3.0	7.5	0.4	0.2	2.58	1.00	0.20	<0.4	0.2	<0.1	<0.05
			C2	28-53	50	26	24	SCL	37.7	3.2	7.7	5.7	4.5	18.2	28.6	21.6	<0.4	0.6	<0.1	<0.05
			C3	53-74	48	28	24	L	38.4	2.3	8.1	11.3	16.0	15.7	33.2	79.4	<0.4	0.6	<0.1	<0.05
			C4	74-94	38	36	26	L	44.3	1.3	7.9	6.6	9.8	12.0	18.5	38.4	<0.4	0.5	<0.1	0.06
Fort Collins	FtD	BK-15	A	0-5	24	46	30	CL	47.8	5.8	6.9	0.7	0.1	3.88	2.44	0.17	<0.4	0.2	<0.1	<0.05
			Bk	5-12	20	46	34	SiCL	46.0	4.8	7.5	0.4	<0.1	2.45	1.48	0.11	<0.4	0.2	<0.1	<0.05
			B/C	12-23	11	52	37	SiCL	47.3	3.9	7.8	0.3	0.1	1.24	1.43	0.14	<0.4	0.2	<0.1	<0.05
			C1	23-39	22	44	34	CL	48.1	1.9	8.1	0.4	0.8	0.62	2.32	0.96	<0.4	0.2	<0.1	<0.05
			C2	39-58	26	42	32	CL	50.7	3.0	8.3	0.5	3.0	0.40	1.49	2.88	<0.4	0.3	<0.1	0.06
Cabbart	BCC	BK-19	C3	58-90	45	33	22	L	34.9	2.0	8.5	0.7	4.7	0.39	1.65	4.71	<0.4	0.2	<0.1	<0.05
			O	1-0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			A	0-4	52	27	21	SCL	37.0	3.5	7.8	0.7	0.3	3.08	2.41	0.56	<0.4	0.1	<0.1	<0.05
			Bw	4-9	54	25	21	SCL	37.8	3.1	7.8	0.7	0.2	2.90	2.69	0.43	<0.4	0.1	<0.1	<0.05
			Bk	9-15	54	28	18	SL	45.7	3.8	8.0	0.6	0.2	2.53	2.31	0.30	<0.4	0.1	<0.1	<0.05
			C	15-20	54	28	18	SL	45.5	3.2	8.0	0.6	0.6	2.35	1.79	0.85	<0.4	0.1	<0.1	<0.05
Midway	MiDe	BK-31	R	20+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			A	0-3	4	57	39	SiCL	49.5	4.1	7.6	3.2	3.7	17.4	4.67	12.2	<0.4	0.4	<0.1	<0.05
			B	3-16	18	46	36	SiCL	51.9	2.2	8.3	16.9	33.9	17.0	33.0	157	<0.4	0.2	<0.1	<0.05
Fort Collins	FtD	BK-36	C	16-36	6	50	44	SIC	67.6	3.1	8.3	14.2	31.2	18.2	17.3	125	1.5	0.2	<0.1	0.06
			A	0-3	18	44	38	SiCL	56.6	6.0	7.5	0.7	0.2	3.72	1.32	0.38	<0.4	0.2	<0.1	<0.05
			Bk	3-24	28	39	33	CL	43.8	3.0	7.8	0.5	0.3	2.47	0.91	0.34	0.5	0.1	<0.1	<0.05
Ringling	RTB	BK-44	C	24-60+	18	43	39	SiCL	41.7	2.7	8.0	0.4	0.3	1.52	1.40	0.33	1.0	0.3	<0.1	<0.05
			A	0-4	46	42	12	L	49.1	4.1	6.6	0.5	0.1	2.21	1.32	0.15	<0.4	0.2	<0.1	<0.05
			C	4-16	46	42	12	L	45.9	2.8	7.6	0.4	0.1	2.49	0.96	0.19	<0.4	0.2	<0.1	<0.05
			R1	16-32	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
R2	32-72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		



## Soil Profiles - Laboratory Data

LABORATORY SOIL DATA SUMMARY											Chemical Data									
Soil Series	Map Unit Symbol	Sample Site (SS)	Horizon	Depth	Sand %	Silt %	Clay %	Texture, unitless	Percent Sat %	OM-WB %	pH-SatPst, s_u_	COND, mmhos/cm	SAR, unitless	Calcium, meq/l	Mg-SatPst, meq/l	Na-SatPst, meq/l	NO3-SatPst, mg/L	B, mg/kg	Se, mg/kg	Mo, mg/kg
Heldt	He	BK-45	A/B	0-8	16	48	36	SiCL	48.9	4.0	6.7	0.7	<0.1	3.57	2.08	0.12	<0.4	0.1	<0.1	<0.05
			B/C	8-21	14	54	32	SiCL	45.2	2.4	7.6	0.5	0.1	2.11	2.14	0.20	<0.4	0.2	<0.1	<0.05
			C1	21-47	30	46	24	L	39.6	1.6	8.2	0.6	2.1	0.53	2.67	2.69	<0.4	0.3	<0.1	0.07
			C2	47-68	28	44	28	CL	41.7	1.7	8.0	4.1	9.6	4.49	9.20	25.1	45	0.7	<0.1	0.10
			C3	68-92	28	44	28	CL	42.7	1.9	7.6	7.3	7.4	18.2	22.1	33.1	218	0.3	0.1	<0.05
Heldt	He	BK-46	Ap	0-6	13	52	35	SiCL	58.8	4.8	7.5	5.7	5.1	20.2	23.7	24.0	118	0.4	<0.1	0.10
			A	6-11	8	54	38	SiCL	57.0	3.9	7.7	1.9	4.4	5.30	4.22	9.57	35	0.4	<0.1	0.07
			Bt	11-32	14	50	36	SiCL	57.6	2.8	7.9	1.6	6.1	3.20	1.89	9.75	12	0.2	<0.1	0.05
			C1	32-64	46	33	21	L	35.5	1.9	7.8	1.9	4.7	6.56	2.53	10.1	3.2	0.1	<0.1	<0.05
			C2	64-80	44	36	20	L	35.7	1.7	7.8	2.1	5.1	6.89	2.72	11.2	1.3	0.1	<0.1	0.06
McRae	McR	BK-50	Ap	0-6	10	52	38	SiCL	56.2	6.7	7.2	0.7	0.3	3.32	1.64	0.48	<0.4	0.6	<0.1	0.08
			B	6-18	20	48	32	SiCL	47.4	3.9	7.8	0.5	0.7	1.98	1.84	0.99	<0.4	0.4	<0.1	<0.05
			C1	18-34	25	51	24	SiL	41.1	2.0	8.2	1.2	1.8	1.60	5.86	3.49	32	0.4	<0.1	0.07
			C2	34-60	14	60	26	SiL	45.2	1.8	8.1	2.2	2.7	2.60	11.0	6.92	89	0.4	<0.1	0.10
			C3	60-80	20	54	26	SiL	41.0	1.7	8.1	3.0	2.9	4.59	18.9	9.81	37	0.4	<0.1	0.08
Cushman	Cu	BK-53	A	0-3	36	49	15	L	39.8	4.4	6.5	0.8	0.2	4.30	2.97	0.34	<0.4	<0.1	<0.1	<0.05
			Bt	3-16	28	40	32	CL	42.4	4.4	6.1	0.3	0.5	0.98	0.85	0.49	<0.4	0.1	<0.1	<0.05
			Bk	16-26	34	36	30	CL	44.3	3.6	7.6	0.4	0.4	1.69	1.80	0.46	<0.4	0.2	<0.1	<0.05
			C	26-60	34	45	21	L	35.5	2.3	8.4	0.6	6.5	0.30	0.85	4.94	1.1	0.3	<0.1	<0.05
Cabbart	MiCa	BK-55	A	0-3	44	42	14	L	45.8	4.0	7.2	0.8	0.1	5.05	2.60	0.23	<0.4	0.1	<0.1	<0.05
			Bk1	3-12	40	42	18	L	42.9	2.7	7.3	0.7	0.1	4.43	2.25	0.27	<0.4	0.2	<0.1	<0.05
			C	12-18	44	40	16	L	39.5	2.5	7.6	0.5	0.2	2.34	1.47	0.33	<0.4	<0.1	<0.1	<0.05
			Cr	18+	36	50	14	SiL	35.6	2.0	8.4	0.6	0.8	0.69	2.77	1.02	1.1	0.2	<0.1	<0.05
Cabba	BCT	BK-56	A	0-4	27	48	25	L	44.2	4.6	7.3	1.0	0.2	7.64	2.56	0.36	<0.4	0.3	<0.1	0.05
			B/C	4-11	28	53	19	SiL	38.5	2.2	8.1	0.3	0.3	1.43	1.36	0.31	0.6	0.2	<0.1	0.07
			Cr1	11-25	24	60	16	SiL	39.2	0.8	8.5	0.4	0.8	0.78	1.95	0.97	0.5	0.2	<0.1	0.06
			Cr2	25-32	26	52	22	SiL	38.5	2.1	8.4	0.5	1.5	0.65	2.28	1.77	0.8	0.2	<0.1	0.23
			Cr3	32-49	15	66	19	SiL	40.4	0.6	8.5	0.4	2.6	0.55	1.11	2.37	0.6	<0.1	<0.1	0.09
			Cr4	49+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Twilight	TwB	BK-57	A	0-3	45	38	17	L	49.0	6.1	6.9	1.1	0.2	5.40	2.69	0.35	<0.4	0.3	<0.1	<0.05
			B	3-13	45	36	19	L	38.4	3.1	7.6	0.4	0.3	2.52	0.94	0.34	<0.4	0.2	<0.1	<0.05
			B2	13-36	31	43	26	L	39.7	2.8	7.9	0.4	0.3	2.15	1.60	0.37	<0.4	0.2	<0.1	<0.05
			C	36-60	41	42	17	L	33.6	1.9	8.5	0.5	1.3	0.54	2.75	1.69	0.8	0.2	<0.1	<0.05
			C	60-80	43	39	18	L	33.7	1.6	8.6	0.4	1.5	0.45	1.66	1.57	0.9	0.3	<0.1	0.09
Twilight	BCT	BK-64	A	0-3	52	30	18	L	40.7	4.2	6.9	0.8	0.2	3.94	2.58	0.49	<0.4	<0.1	<0.1	<0.05
			Bw	3-14	38	36	26	L	37.6	3.5	6.8	0.5	0.2	2.50	1.37	0.35	<0.4	<0.1	<0.1	<0.05
			Bk	14-21	33	37	30	CL	37.4	2.9	7.7	0.4	0.3	2.06	1.65	0.38	0.8	0.1	<0.1	<0.05
			C	21-60+	46	29	25	L	33.5	2.1	8.1	0.6	2.4	0.68	1.99	2.71	1.9	0.2	<0.1	<0.05

## Soil Profiles - Laboratory Data

LABORATORY SOIL DATA SUMMARY											Chemical Data									
Soil Series	Map Unit Symbol	Sample Site (SS)	Horizon	Depth	Sand %	Silt %	Clay %	Texture, unitless	Percent Sat %	OM-WB %	pH-SatPst, s_u_	COND, mmhos/cm	SAR, unitless	Calcium, meq/l	Mg-SatPst, meq/l	Na-SatPst, meq/l	NO3-SatPst, mg/L	B, mg/kg	Se, mg/kg	Mo, mg/kg
Blacksheep	BCT	BK-68	A	0-2	54	29	17	SL	38.5	3.0	7.5	0.6	<0.1	5.19	1.60	0.10	<0.4	0.6	<0.1	<0.05
			B	2-12	46	34	20	L	39.9	1.8	7.9	0.4	0.1	1.90	2.06	0.16	<0.4	0.1	<0.1	<0.05
			C	12-19	66	23	11	SL	35.4	1.3	8.1	0.3	0.2	1.22	1.87	0.22	<0.4	<0.1	<0.1	<0.05
			Cr1	19-44	70	20	10	SL	37.8	1.3	8.4	0.4	0.5	0.48	2.99	0.62	<0.4	<0.1	<0.1	<0.05
			Cr2	44-68	71	19	10	SL	37.3	1.1	8.2	1.9	3.4	4.01	7.71	8.15	<0.4	0.5	<0.1	0.14
			Cr3	68-90	56	32	12	SL	35.0	1.3	7.9	5.1	3.4	22.2	27.7	17.1	<0.4	1.3	<0.1	<0.05
Delpoint	MiDe	BK-69	A	0-2	24	40	36	CL	50.5	7.1	6.6	0.6	0.3	2.67	2.39	0.52	<0.4	0.2	<0.1	0.05
			Bt	2-8	12	38	50	C	60.3	5.2	7.1	0.7	0.4	2.98	2.75	0.76	<0.4	0.3	<0.1	<0.05
			Btk	8-20	18	47	35	SiCL	53.4	3.0	8.0	0.5	2.1	0.94	1.58	2.37	<0.4	0.3	<0.1	<0.05
			C	20-48	26	49	25	L	54.4	2.3	8.7	0.9	10.8	0.39	0.76	8.20	<0.4	0.4	<0.1	0.08
			Cr1	48-72	20	44	36	SiCL	57.6	3.2	8.1	5.4	10.5	6.53	20.5	38.7	0.6	1.2	<0.1	0.10
			Cr2	72-90	66	26	8	SL	93.9	78.6	3.6	10.8	12.4	21.1	48.1	72.7	91	2.8	<0.1	0.15
Midway	MiDe	BK-71	A	0-2	28	22	50	C	58.4	4.3	7.4	0.6	0.2	3.53	2.36	0.42	1.5	0.2	<0.1	<0.05
			C	2-8	<1	42	58	SIC	61.7	3.2	7.6	0.7	0.3	3.00	2.80	0.56	<0.4	0.1	<0.1	0.05
			Cr1	8-24	2	39	59	C	73.1	2.9	8.2	0.5	2.1	0.55	2.02	2.35	<0.4	<0.1	<0.1	0.05
			Cr2	24-50	<1	50	50	SIC	73.8	3.6	7.9	9.1	7.3	20.3	63.6	47.2	0.6	0.5	<0.1	<0.05
			Cr3	50-74	10	28	62	C	52.9	2.8	3.8	9.3	8.6	20.8	55.8	53.5	58	0.6	<0.1	0.33
			Cr4	74-93	72	14	14	SL	91.7	62.5	3.2	11.3	9.7	19.6	51.1	57.9	130	1.1	<0.1	1.50
Haverson	H-S	CB-21	A	0-4	9	53	38	SiCL	58.7	8.0	7.2	2.1	2.8	11.4	4.12	7.84	<0.4	0.3	<0.1	<0.05
			Btk	4-25	10	50	40	SIC	48.0	4.6	7.5	0.6	0.6	3.09	1.50	0.86	<0.4	0.1	<0.1	0.11
			C1	25-54	8	50	42	SIC	56.2	4.4	7.7	10.7	16.5	22.8	26.2	81.5	31	0.3	<0.1	0.11
			C2	54-60+	32	28	40	C	56.6	3.0	8.2	17.2	22.4	22.2	54.1	139	57	0.3	<0.1	0.15
Havre	NiHa	CB-70	A	0-7	16	50	34	SiCL	53.3	6.3	7.0	1.2	0.2	6.97	2.29	0.36	0.4	0.3	<0.1	<0.05
			C1	7-17	40	34	26	L	38.4	3.6	7.3	0.5	0.3	3.11	1.06	0.41	0.4	0.2	<0.1	<0.05
			C2	17-39	37	38	25	L	37.2	3.6	7.5	0.5	0.4	2.71	1.40	0.50	0.5	0.2	<0.1	<0.05
			C3	39-62	36	31	33	CL	46.4	4.1	7.6	1.1	1.2	4.38	2.83	2.22	0.9	0.2	<0.1	<0.05
			C4	62-90	10	48	42	SIC	56.7	5.0	7.4	2.5	0.8	12.3	10.6	2.54	76	0.3	<0.1	0.10
Nihill	NiHa	CB-72	A	0-3	40	36	24	L	44.3	4.2	7.3	0.7	0.3	4.73	1.74	0.48	<0.4	0.2	<0.1	<0.05
			Bk	3-10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			Ck	10-34	36	38	26	L	36.4	1.7	7.8	0.4	1.0	1.12	1.50	1.14	2	0.1	<0.1	<0.05
			C2	34-60+	38	36	26	L	54.2	1.6	7.8	6.9	11.1	18.9	21.5	50.1	0.9	1.5	<0.1	0.21
Hydro	HyHp	CB-77	A	0-6	12	47	41	SIC	55.5	6.6	6.4	0.6	0.5	2.89	1.56	0.68	<0.4	0.2	<0.1	<0.05
			Btk	6-14	20	40	40	C	53.7	5.0	7.3	0.5	0.3	2.53	1.55	0.47	<0.4	0.2	<0.1	<0.05
			C1	14-26	24	38	38	CL	50.7	4.1	7.7	0.5	0.6	1.31	2.08	0.77	<0.4	0.2	<0.1	0.07
			C2	26-39	19	43	38	SiCL	52.5	4.0	8.2	0.8	4.1	0.48	1.97	4.56	<0.4	0.3	<0.1	0.11
			C3	39-64	22	40	38	CL	54.1	3.7	8.4	1.4	6.4	0.54	3.02	8.60	<0.4	0.6	<0.1	0.18
			C4	64-92	24	42	34	CL	53.3	3.5	8.0	6.3	5.6	5.09	38.8	26.1	40	0.4	0.3	0.10

## Soil Profiles - Laboratory Data

LABORATORY SOIL DATA SUMMARY											Chemical Data																								
Soil Series	Map Unit Symbol	Sample Site (SS)	Horizon	Depth	Sand %	Silt %	Clay %	Texture, unitless	Percent Sat %	OM-WB %	pH-SatPst, s_u_	COND, mmhos/cm	SAR, unitless	Calcium, meq/l	Mg-SatPst, meq/l	Na-SatPst, meq/l	NO3-SatPst, mg/L	B, mg/kg	Se, mg/kg	Mo, mg/kg															
Remmit	RmT	CB-79	A	0-4	26	57	17	SiL	43.5	4.1	7.3	0.5	0.2	3.53	1.36	0.31	<0.4	0.2	<0.1	<0.05															
			Bk	4-14	36	46	18	L	35.5	2.7	7.4	0.4	0.3	2.21	0.98	0.38	0.4	0.1	<0.1	<0.05															
			B/C	14-30	38	44	18	L	34.5	2.0	7.6	0.3	0.4	1.65	1.34	0.45	0.7	<0.1	<0.1	<0.05															
			C1	30-60	50	34	16	L	30.0	1.5	8.2	2.1	3.9	1.63	11.7	10.1	0.7	0.2	<0.1	<0.05															
			C2	60-96	58	28	14	SL	30.0	1.3	8.1	4.7	6.2	5.33	26.6	25.0	1.1	0.1	<0.1	<0.05															
Haverson	H	CB-83	Ap	0-6	14	56	30	SiCL	50.0	4.5	7.3	0.8	0.2	4.25	1.77	0.26	<0.4	0.3	<0.1	<0.05															
			Bk1	6-12	2	52	46	SIC	61.5	5.6	7.7	0.6	0.2	2.75	1.72	0.26	<0.4	0.4	<0.1	<0.05															
			Bk2	12-28	2	64	34	SiCL	55.7	4.9	7.9	0.4	0.3	1.39	2.04	0.39	<0.4	0.3	<0.1	0.12															
			C1	28-50	46	30	24	L	33.1	3.1	8.0	0.6	1.7	1.61	2.07	2.25	<0.4	0.4	<0.1	<0.05															
			C2	50-68	66	20	14	SL	32.2	2.0	7.8	1.1	1.3	4.42	3.29	2.51	1.6	0.1	<0.1	<0.05															
C3	68-92	86	4	10	LS	32.8	1.8	7.9	0.8	1.2	3.19	2.05	1.94	5	0.1	<0.1	<0.05																		
																		A	0-2	46	38	16	L	37.9	4.2	6.4	0.6	<0.1	2.88	1.69	0.06	<0.4	0.1	<0.1	0.06
																		B	2-7	40	36	24	L	34.6	3.4	6.6	0.6	<0.1	3.33	2.05	0.13	<0.4	<0.1	<0.1	<0.05
																		Bk	7-13	26	44	30	CL	40.5	4.4	7.0	0.7	<0.1	4.16	2.63	0.10	<0.4	0.1	<0.1	<0.05
																		C1	13-27	42	32	26	L	37.4	2.7	7.9	0.5	0.2	1.29	2.69	0.22	<0.4	0.2	<0.1	<0.05
Hesper	Hp	CB-87	C2	27-45	66	20	14	SL	30.5	1.5	8.2	0.8	0.8	0.63	4.84	1.31	<0.4	0.1	<0.1	<0.05															
			C3	45-71	48	32	20	L	33.3	2.0	8.6	1.0	8.5	0.25	1.15	7.12	<0.4	0.4	<0.1	0.08															
			C4	71-96	30	48	22	L	42.7	2.1	8.3	6.1	11.7	2.51	21.0	40.1	<0.4	1.1	<0.1	0.10															
			A	0-3	56	32	12	SL	41.0	4.5	7.2	0.5	0.2	2.71	1.50	0.29	<0.4	<0.1	<0.1	<0.05															
			Bw	3-9	54	30	16	SL	33.7	2.9	7.1	0.6	1.2	2.27	1.51	1.58	<0.4	<0.1	<0.1	<0.05															
Twilight	TwB	CB-95	Bk	9-19	54	29	17	SL	32.6	2.3	7.9	0.3	0.3	1.80	0.83	0.34	0.5	0.1	<0.1	<0.05															
			C	19-50	56	28	16	SL	32.5	2.0	7.0	0.3	0.3	1.29	1.36	0.34	1.4	0.2	<0.1	<0.05															
			Cr	50-60+	34	42	24	L	38.9	2.6	8.3	0.4	0.4	0.53	2.51	0.52	1.4	0.3	<0.1	<0.05															
			A	0-3	28	42	30	CL	44.5	3.9	7.7	0.4	0.3	2.86	0.78	0.37	<0.4	<0.1	<0.1	0.05															
			Bw1	0-3	22	48	30	CL	46.0	3.6	7.6	0.4	0.3	2.34	0.86	0.39	<0.4	0.2	<0.1	0.05															
Midway	MiDe	CB-101	Bw2	12-19	18	46	36	SiCL	49.5	4.0	7.7	0.4	0.4	2.02	1.08	0.47	<0.4	0.3	<0.1	0.19															
			Cr	19 +	2	64	34	SiCL	60.0	3.1	7.9	0.4	2.4	0.94	0.68	2.12	1.0	0.3	<0.1	0.19															
			A	0-8	10	56	34	CL	51.5	3.7	8.0	4.7	22.3	1.62	4.60	39.3	<0.4	0.4	<0.1	0.07															
			Bk	8-16	8	42	50	CL	61.0	2.7	8.2	23.1	27.2	22.8	97.4	211	<0.4	0.5	<0.1	<0.05															
			C1	16-29	10	50	40	SiCL	67.4	1.7	8.3	17.6	24.4	14.8	57.3	147	<0.4	0.7	0.1	0.08															
Arvada	Av	CB-103	C2	29-43	4	58	38	SiCL	71.3	1.5	8.2	16.2	24.2	10.7	46.6	130	<0.4	1.2	<0.1	0.30															
			C3	43-65	2	44	54	SIC	71.0	1.5	8.2	21.9	26.6	23.1	79.6	191	<0.4	1.4	0.1	0.13															
			C4	65-92	40	38	22	L	37.5	1.0	8.3	17.0	21.8	17.9	57.3	134	<0.4	0.7	<0.1	0.07															
			Ap	0-4	22	50	28	CL	45.9	4.4	7.5	0.7	0.1	4.14	1.33	0.23	3.9	0.2	<0.1	<0.05															
			B	4-12	18	52	30	SiCL	42.4	4.5	7.7	0.5	0.2	2.58	1.21	0.25	<0.4	0.2	<0.1	<0.05															
McRae	McR	CB-111	B/C	12-22	19	51	30	SiCL	42.9	4.3	7.9	1.5	3.0	4.20	3.95	6.07	<0.4	0.5	<0.1	<0.05															
			C1	22-32	46	34	20	L	35.6	2.9	7.8	5.0	5.6	16.9	12.0	22.1	27	0.2	<0.1	<0.05															
			C2	32-50	40	38	22	L	37.7	3.1	8.0	1.8	4.5	5.05	3.53	9.27	14	0.2	<0.1	<0.05															
			C3	50-92	29	47	24	L	40.5	3.6	7.7	13.6	9.9	40.6	45.3	64.9	1230	0.4	<0.1	<0.05															

## Soil Profiles - Laboratory Data

LABORATORY SOIL DATA SUMMARY											Chemical Data									
Soil Series	Map Unit Symbol	Sample Site (SS)	Horizon	Depth	Sand %	Silt %	Clay %	Texture, unitless	Percent Sat %	OM-WB %	pH-SatPst, s_u_	COND, mmhos/cm	SAR, unitless	Calcium, meq/l	Mg-SatPst, meq/l	Na-SatPst, meq/l	NO3-SatPst, mg/L	B, mg/kg	Se, mg/kg	Mo, mg/kg
Hesper	Hp	CB-113	A	0-5	28	42	30	CL	46.1	4.7	7.0	0.6	0.1	3.35	2.06	0.19	<0.4	0.3	<0.1	<0.05
			B	5-10	18	46	36	SiCL	46.6	3.8	7.5	0.6	0.2	2.94	1.90	0.23	<0.4	0.2	<0.1	<0.05
			Bk	10-35	24	42	34	CL	47.2	2.4	8.2	0.5	2.6	0.58	1.48	2.59	<0.4	0.2	<0.1	<0.05
			C1	35-60	30	38	32	CL	45.7	1.4	8.0	7.6	7.9	13.3	28.2	37.4	<0.4	1.0	<0.1	<0.05
			C2	60-90	28	38	34	CL	49.2	1.5	8.2	16.7	13.2	17.9	92.0	100	<0.4	0.5	0.2	<0.05
Barvon	FtD	CB-113-2	A	0-5	56	30	14	SL	40.2	3.2	6.6	0.4	0.1	1.85	0.78	0.13	1.5	0.1	<0.1	<0.05
			B	5-16	60	24	16	SL	32.8	2.4	6.7	0.4	<0.1	1.71	0.73	0.10	<0.4	0.2	<0.1	<0.05
			C	16-38	56	26	18	SL	31.2	1.4	8.0	0.3	0.5	1.36	0.61	0.50	<0.4	0.2	<0.1	<0.05
			R	38+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Farland	Fa	CB-119	A1	0-3	8	56	36	SiCL	71.8	8.5	6.8	2.0	<0.1	15.3	5.04	0.19	<0.4	0.4	<0.1	<0.05
			A2	3-7	8	54	38	SiCL	74.9	9.0	7.0	1.3	<0.1	9.21	3.14	0.16	<0.4	0.4	<0.1	0.09
			Bk	7-19	20	54	26	SiL	44.0	3.1	7.2	0.7	0.2	4.61	1.47	0.26	<0.4	0.2	<0.1	0.06
			C1	19-27	37	43	20	L	38.0	2.2	7.5	0.5	0.2	3.27	1.01	0.32	<0.4	0.1	<0.1	0.08
			C2	27-43	46	36	18	L	33.2	1.8	7.8	0.6	0.2	2.41	1.68	0.34	1.7	0.2	<0.1	0.08
			C3	43-64	46	38	16	L	34.0	1.8	7.5	0.6	0.2	3.12	1.60	0.31	<0.4	0.1	<0.1	0.08
Heldt	He-S	CB-120	C4	64-90	51	28	21	L	30.6	2.2	7.8	0.9	0.5	4.26	3.44	1.06	1.3	0.1	<0.1	0.09
			Ap	0-6	8	54	38	SiCL	52.2	4.5	7.3	0.7	0.2	3.85	1.40	0.43	<0.4	0.3	<0.1	<0.05
			B	6-14	2	62	36	SiCL	48.6	3.2	7.6	0.9	0.9	3.81	2.76	1.61	0.8	0.4	<0.1	0.06
			C1	14-27	4	55	41	SIC	58.8	3.0	8.0	13.2	19.8	20.6	43.9	106	<0.4	0.5	<0.1	0.05
			C2	27-54	10	56	34	SiCL	51.6	2.4	8.3	17.7	28.9	19.2	48.1	156	11	2.3	<0.1	0.06
			C3	54-76	68	21	11	SL	30.0	0.8	8.6	8.8	18.6	2.16	27.3	68.4	11	1.1	<0.1	<0.05
Haverson	H-S	CB-121	C4	76-90	34	48	18	L	37.3	1.2	8.4	13.4	17.3	6.28	67.3	97.5	13	1.4	<0.1	0.08
			A	0-7	30	44	26	L	48.3	6.7	7.3	3.0	1.0	18.1	12.3	3.92	9	0.3	<0.1	<0.05
			B	7-18	10	60	30	SiCL	53.8	4.2	8.3	15.5	17.5	20.9	66.9	116	<0.4	1.6	<0.1	<0.05
			C1	18-36	68	18	14	SL	28.8	1.9	8.3	13.5	16.7	18.3	57.7	103	3	0.7	<0.1	<0.05
			C2	36-60	52	32	16	L	34.5	1.8	8.4	18.2	22.1	12.8	98.8	165	1.0	0.8	<0.1	<0.05
Haverson	H-S	CB-123	C3	60-81	66	24	10	SL	28.4	1.2	8.1	7.0	10.6	8.82	28.7	48.2	1.0	0.2	<0.1	<0.05
			Ap	0-5	30	54	16	SiL	52.3	6.3	7.2	2.7	3.5	12.2	7.94	11.2	<0.4	0.5	<0.1	<0.05
			Bt	5-13	46	32	22	L	37.1	3.1	7.5	2.1	3.1	7.50	5.66	7.95	<0.4	0.2	<0.1	<0.05
			Bk	13-24	18	52	30	SiCL	50.1	4.2	7.6	5.3	3.0	21.5	27.2	14.8	<0.4	0.7	<0.1	<0.05
			C	24-46	44	36	20	L	35.8	2.3	8.0	8.1	7.1	22.1	41.5	39.8	<5	0.8	<0.1	<0.05
Relan	Re	CB-125	C	46-63	14	56	30	SiCL	53.9	1.8	8.2	9.0	13.9	10.3	31.1	63.4	<0.4	1.1	<0.1	<0.05
			C	63-90	4	56	40	SIC	59.3	2.1	8.2	8.1	11.8	9.38	30.9	53.2	<5	1.1	<0.1	0.07
			A	0-2	26	44	30	CL	58.2	8.2	6.9	1.2	0.2	7.38	3.01	0.34	<0.4	0.4	<0.1	<0.05
			Bt	2-11	14	44	42	SIC	45.4	3.3	7.0	0.6	0.1	4.26	1.63	0.21	<0.4	0.3	<0.1	<0.05
			C1	11-23	22	40	38	CL	38.0	4.0	7.6	0.6	0.2	3.41	1.28	0.27	<0.4	0.2	<0.1	<0.05
			C2	23-47	22	40	38	CL	36.2	3.7	7.6	0.7	0.4	3.02	1.36	0.57	<0.4	0.2	<0.1	0.06
			R	47-70	49	33	18	L	35.9	3.1	7.7	0.6	0.8	2.69	1.20	1.06	0.6	0.1	<0.1	0.06

## Soil Profiles - Laboratory Data

LABORATORY SOIL DATA SUMMARY											Chemical Data										
Soil Series	Map Unit Symbol	Sample Site (SS)	Horizon	Depth	Sand %	Silt %	Clay %	Texture, unitless	Percent Sat %	OM-WB %	pH-SatPst, s_u_	COND, mmhos/cm	SAR, unitless	Calcium, meq/l	Mg-SatPst, meq/l	Na-SatPst, meq/l	NO3-SatPst, mg/L	B, mg/kg	Se, mg/kg	Mo, mg/kg	
Ringling	Ri	CB-126	A	0-2	46	40	14	L	46.4	5.8	7.2	0.8	0.3	5.67	1.38	0.64	<0.4	0.3	<0.1	<0.05	
			C	2-12	44	38	18	L	43.5	3.6	7.7	0.5	0.2	3.61	0.73	0.30	<0.4	0.2	<0.1	<0.05	
			Cr	12-32	68	24	8	SL	39.2	1.5	8.4	0.4	0.6	2.55	1.45	0.84	<0.4	<0.1	<0.1	<0.05	
			R	32-96	68	28	4	SL	46.0	0.5	8.7	1.6	3.9	1.63	5.66	7.41	0.8	0.3	<0.1	<0.05	
Relan	Re	CB-128	A	0-4	42	44	14	L	46.1	4.3	7.0	0.7	<0.1	4.13	1.71	0.14	<0.4	0.1	<0.1	<0.05	
			B/C	4-14	42	42	16	L	39.2	2.3	7.7	0.5	<0.1	2.79	0.89	0.10	<0.4	0.1	<0.1	<0.05	
			C1	14-40	62	25	13	SL	37.8	1.6	8.2	0.5	0.4	0.98	2.40	0.51	0.5	0.1	<0.1	<0.05	
			C2	40-64	47	36	17	L	35.7	1.5	8.3	1.1	3.3	1.42	2.83	4.87	0.9	0.4	<0.1	<0.05	
Twilight	RTB	CB-138	C3	64-90	63	26	11	SL	32.2	1.3	7.8	3.9	1.6	14.7	18.2	6.66	1.7	0.1	<0.1	<0.05	
			A	0-2	48	32	20	L	46.9	4.4	7.8	0.8	0.3	4.67	1.08	0.54	<0.1	0.2	<0.1	<0.05	
			Bk1	2-5	47	32	21	L	37.1	2.8	7.9	0.5	0.2	3.05	0.79	0.32	<0.4	0.1	<0.1	<0.05	
			Bk2	5-11	48	32	20	L	35.5	2.0	8.0	0.4	0.3	2.20	0.93	0.34	0.7	0.1	<0.1	<0.05	
McRae-Saline	McR-S	CB-140	C	11-60+	56	28	16	SL	64.0	1.1	8.4	0.7	0.8	1.20	2.97	1.18	1.9	0.2	<0.1	<0.05	
			A	0-2	22	44	34	CL	42.8	5.0	6.5	0.4	0.4	1.99	1.46	0.59	<0.4	0.1	<0.1	<0.05	
			Bt	2-7	20	46	34	SiCL	48.4	5.3	7.3	0.6	0.1	3.42	2.05	0.16	<0.4	0.2	<0.1	<0.05	
			Btk	7-31	12	44	44	SIC	52.5	4.0	8.3	0.8	4.4	0.63	2.10	5.09	<0.4	0.8	<0.1	<0.05	
Ringling	Ri	CB-141	C1	31-64	6	43	51	SIC	64.8	3.7	8.1	11.4	8.0	22.5	75.1	55.7	222	1.4	0.2	0.17	
			C2	64-92	8	50	42	SIC	54.0	3.8	8.0	9.0	6.3	23.3	47.7	37.4	276	0.8	<0.1	0.15	
			A	0-2	54	32	14	SL	51.0	6.3	7.0	0.8	0.1	5.45	1.64	0.18	1.2	0.2	<0.1	<0.05	
			C	2-12	58	31	11	SL	48.9	3.7	7.7	0.4	<0.1	3.53	0.63	0.10	<0.4	0.2	<0.1	<0.05	
Blacksheep	BCT	CB-148	Cr	12-30	84	12	4	LS	52.0	0.8	8.1	0.2	0.1	1.83	0.54	0.12	0.4	<0.1	<0.1	<0.05	
			R	30-70	86	11	3	LS	51.6	0.5	8.3	1.5	1.8	3.27	9.15	4.37	<0.4	0.1	<0.1	<0.05	
			A	0-8	48	30	22	L	42.1	4.0	7.4	0.7	0.1	4.68	0.96	0.27	<0.4	0.1	<0.1	<0.05	
			Bk	8-15	37	33	30	CL	42.2	3.2	7.7	0.4	0.2	2.05	1.39	0.29	0.5	0.2	<0.1	<0.05	
Barvon	RTB	CB-152	C	15-+	48	38	14	L	36.5	1.6	8.0	2.8	6.5	4.43	8.58	16.2	2.5	0.2	<0.1	0.09	
			O	1-0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			A	0-6	6	61	33	SiCL	57.0	11.9	7.2	1.4	0.4	11.0	4.20	1.08	<0.4	0.2	<0.1	<0.05	
			Bw	6-23	22	34	44	C	55.3	11.0	7.4	1.2	0.4	7.22	4.08	0.86	<0.4	0.2	<0.1	<0.05	
McRae-Saline	McR-S	CB-155	Cr	23-+	28	34	38	CL	55.1	3.6	8.0	0.7	1.0	1.34	3.92	1.65	<0.4	<0.1	<0.1	<0.05	
			A	0-2	12	48	40	SIC	57.1	9.0	6.7	0.8	0.3	3.47	3.11	0.69	<0.4	0.2	<0.1	<0.05	
			Bt	2-16	<1	48	54	SIC	54.9	5.3	8.2	2.0	8.2	2.62	3.86	14.7	<0.4	0.2	<0.1	<0.05	
			Bk	16-31	<1	45	55	SIC	63.7	5.1	8.7	20.3	18.3	26.5	152	173	1.2	0.3	<0.1	<0.05	
Midway	MiCa	CB-156	C	31-60+	4	84	12	SiL	66.5	5.2	8.4	16.6	14.0	22.9	102	110	0.4	0.4	<0.1	<0.05	
			A	0-3	23	46	31	CL	60.0	6.5	7.4	1.2	0.8	7.02	3.55	1.87	<0.4	0.3	<0.1	<0.05	
			B	3-9	2	49	49	SIC	54.7	4.4	7.8	0.6	1.2	2.06	1.48	1.53	0.5	0.1	<0.1	0.07	
			Cr1	9-16	6	30	64	C	94.9	5.2	8.4	0.6	7.6	0.46	0.40	4.98	0.7	0.4	<0.1	0.22	
			Cr2	16-30	<1	31	69	C	93.8	3.3	8.1	9.0	12.7	16.0	26.2	58.4	0.7	1.4	<0.1	0.12	
			Cr3	30-46	50	23	27	SCL	136	55.6	6.8	19.6	19.1	19.3	108	152	0.4	4.1	<0.1	<0.05	
Midway	MiCa	CB-156	Cr4	46-68	3	55	42	SIC	72.4	3.1	8.0	11.4	15.0	18.6	36.7	79.0	0.7	0.7	<0.1	0.06	
			Cr5	68-88	36	41	23	L	47.6	1.9	8.3	12.1	17.2	17.1	37.0	89.6	2.1	0.4	<0.1	<0.05	

## Soil Profiles - Laboratory Data

LABORATORY SOIL DATA SUMMARY											Chemical Data									
Soil Series	Map Unit Symbol	Sample Site (SS)	Horizon	Depth	Sand %	Silt %	Clay %	Texture, unitless	Percent Sat %	OM-WB %	pH-SatPst, s_u_	COND, mmhos/cm	SAR, unitless	Calcium, meq/l	Mg-SatPst, meq/l	Na-SatPst, meq/l	NO3-SatPst, mg/L	B, mg/kg	Se, mg/kg	Mo, mg/kg
Nihill	NiHa	CB-159	A	0-2	19	47	34	SiCL	57.3	6.8	7.7	10.3	11.5	21.4	41.1	61.2	26	0.4	<0.1	<0.05
			A/C	2-14	17	51	32	SiCL	45.5	3.9	7.6	3.2	3.9	13.6	7.65	12.8	1.3	0.1	<0.1	<0.05
			C1	14-22	30	39	31	CL	43.4	3.7	7.6	2.6	1.6	14.2	7.54	5.06	4.6	0.1	<0.1	<0.05
			C2	22-42+	34	32	34	CL	42.2	4.0	7.7	2.5	2.8	9.88	8.20	8.01	3.1	0.1	<0.1	<0.05
Twilight	TwB	CB-167	A	0-3	40	39	21	L	40.1	4.2	6.6	0.7	0.2	4.17	2.42	0.31	<0.4	<0.1	<0.1	<0.05
			Bt	3-17	30	40	30	CL	42.7	4.1	6.8	0.3	0.3	1.86	1.06	0.38	<0.4	0.1	<0.1	<0.05
			Bk	17-30	22	46	32	CL	38.3	3.3	7.8	0.4	0.5	1.48	1.57	0.58	0.8	0.2	<0.1	<0.05
			C	30-60+	30	46	24	L	37.2	2.2	8.5	0.6	4.0	0.50	1.43	3.88	0.9	0.2	<0.1	<0.05
Delpoint	MiDe	LB-09	A	0-4	32	40	28	CL	52.8	8.0	6.8	1.1	0.2	7.42	4.02	0.41	<0.4	0.2	<0.1	<0.05
			Btk	4-22	30	39	31	CL	43.0	4.4	7.6	0.4	0.2	2.46	1.67	0.28	<0.4	0.2	<0.1	<0.05
			C	22-60+	32	38	30	CL	40.5	4.2	7.5	0.8	1.0	3.22	2.33	1.71	0.7	0.2	<0.1	<0.05
Cabba	BCC	LB-18	A1	0-2	30	48	22	L	46.0	4.2	6.4	0.3	0.3	1.24	0.62	0.33	<1	0.2	<0.1	<0.05
			Bw	2-7	28	47	25	L	52.8	6.0	6.4	0.3	0.3	1.46	0.80	0.30	<0.4	0.2	<0.1	<0.05
			C	7-22	34	38	28	CL	47.1	5.0	6.5	0.4	0.3	2.59	1.27	0.37	<0.4	0.1	<0.1	<0.05
Cabba	CaC	LB-21	A	0-2	4	61	35	SiCL	48.9	1.9	7.7	0.5	0.3	3.07	1.32	0.48	8	0.5	<0.1	0.13
			B/C	2-9	1	69	30	SiCL	46.7	1.5	7.8	0.4	0.5	1.41	1.65	0.59	3	0.3	<0.1	0.19
			Cr	9+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Blacksheep	BCC	LB-24	Ac	0-5	76	14	10	SL	36.4	1.9	7.5	0.4	0.2	3.23	0.78	0.25	<0.4	<0.1	<0.1	<0.05
			C	5-12	70	15	15	SL	33.2	1.6	7.7	0.4	0.2	1.88	1.73	0.30	<0.4	<0.1	<0.1	<0.05
			Cr	12+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Midway	MiDe	LB-33	A	0-2	32	47	21	L	51.8	6.5	7.3	0.8	0.1	5.00	2.67	0.26	<0.4	0.2	<0.1	<0.05
			Btk	2-10	24	49	27	CL	45.8	3.1	7.5	0.6	0.2	3.61	1.72	0.30	<0.4	0.1	<0.1	<0.05
			Bk	10-19	18	52	30	SiCL	47.1	2.4	7.9	0.4	0.6	1.59	1.99	0.74	<0.4	0.1	<0.1	<0.05
			Cr	19+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cabba	BCC	LB-38	A	0-3	51	29	20	L	47.9	5.4	7.5	0.8	0.1	5.39	1.31	0.25	<0.4	0.2	<0.1	<0.05
			Bk	3-7	44	32	24	L	44.5	3.8	7.4	0.6	0.1	4.18	1.12	0.23	<0.4	0.2	<0.1	<0.05
			C	7-42+	60	24	16	SL	30.6	2.0	8.2	0.7	2.1	0.73	3.02	2.93	0.8	0.1	<0.1	0.15
Haverson	CaC	LB-41	A	0-2	16	46	38	SiCL	76.0	11.4	7.0	1.3	0.6	8.32	2.83	1.47	<0.4	0.3	<0.1	<0.05
			Btk	2-13	6	52	42	SIC	54.1	3.0	7.5	0.6	0.5	3.34	1.01	0.72	1.0	0.1	<0.1	<0.05
			Bkk2	13-26	10	50	40	SIC	50.6	2.7	7.5	0.6	0.5	3.23	1.19	0.70	0.5	0.1	<0.1	<0.05
			C	26-60+	17	51	32	SiCL	45.8	1.7	7.7	0.4	0.8	1.67	0.92	0.96	0.9	<0.1	<0.1	0.07
Hydro	HyHp	LB-58	A	0-11	12	46	42	SIC	57.7	4.2	7.2	0.7	0.2	4.28	1.66	0.36	<0.4	0.2	<0.1	<0.05
			Bk	11-28	20	48	32	SiCL	48.2	2.5	7.6	0.4	0.4	2.28	1.33	0.54	<0.4	0.1	<0.1	<0.05
			Bkw	28-48	38	34	28	CL	42.9	1.9	8.1	0.7	4.6	1.19	1.15	5.15	<0.4	0.1	<0.1	<0.05
			C1	48-76	12	43	45	SIC	86.4	2.1	8.6	5.6	19.8	1.09	12.0	49.2	1.4	0.7	<0.1	0.12
			C2	76-96	36	33	31	CL	57.4	1.9	8.2	7.7	17.1	8.89	23.2	65.6	41	0.4	<0.1	0.06
Cabbart	MiCa	LB-67	A	0-3	4	46	50	SIC	55.9	5.9	7.5	0.7	0.4	4.96	1.21	0.61	0.6	0.3	<0.1	0.10
			C	3-10	<1	40	60	C	63.4	4.2	7.6	0.5	0.4	3.12	0.69	0.57	0.6	0.2	<0.1	0.20
			Cr	10+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

## Soil Profiles - Laboratory Data

LABORATORY SOIL DATA SUMMARY											Chemical Data										
Soil Series	Map Unit Symbol	Sample Site (SS)	Horizon	Depth	Sand %	Silt %	Clay %	Texture, unitless	Percent Sat %	OM-WB %	pH-SatPst, s_u_	COND, mmhos/cm	SAR, unitless	Calcium, meq/l	Mg-SatPst, meq/l	Na-SatPst, meq/l	NO3-SatPst, mg/L	B, mg/kg	Se, mg/kg	Mo, mg/kg	
Midway	MiCa	LB-79	A	0-7	14	36	50	C	59.0	5.8	7.6	0.8	7.3	0.69	0.52	5.32	1.4	0.3	<0.1	<0.05	
			B	7-16	23	37	40	C	57.6	4.7	8.0	5.3	15.1	9.82	8.30	41.5	0.6	0.3	<0.1	<0.05	
			C	16-45	34	33	33	CL	54.4	2.7	8.2	11.1	20.6	16.4	24.3	82.7	11	0.2	<0.1	0.06	
			C/Cr	45-65	16	20	64	C	73.2	3.6	8.3	11.1	22.2	14.8	25.6	92.6	6.8	0.1	<0.1	<0.05	
			Cr	65-88	8	44	48	SIC	88.5	4.0	8.3	13.2	26.8	17.1	28.2	125	6.7	<0.1	<0.1	<0.05	
Fort Collins	FtHp	LB-85	A	0-2	28	50	22	SiL	55.6	6.1	6.9	0.6	0.4	3.52	2.18	0.61	<0.4	0.2	<0.1	<0.05	
			Bt1	2-10	22	50	28	CL	41.2	3.1	7.3	0.5	0.3	2.81	1.59	0.44	<0.4	0.2	<0.1	<0.05	
			Bt2	10-17	14	48	38	SiCL	48.6	2.9	7.6	0.5	0.3	1.90	2.15	0.45	<0.4	0.3	<0.1	<0.05	
			Bk	17-35	26	42	32	CL	42.3	2.2	7.8	0.4	0.6	1.31	2.40	0.89	0.5	0.2	<0.1	<0.05	
Delpoint	FtD	LB-91	C	35-60	38	35	27	CL	42.1	2.1	7.9	3.2	7.8	6.25	11.0	21.9	0.8	0.3	<0.1	0.06	
			A	0-4	16	56	28	SiCL	54.9	7.4	7.0	0.9	0.6	4.96	3.12	1.10	<0.4	0.3	<0.1	<0.05	
			Bw	4-13	21	47	32	CL	44.4	3.4	7.3	0.6	0.3	3.27	1.52	0.40	<0.4	0.2	<0.1	<0.05	
			Bk	13-23	22	40	38	CL	42.9	3.0	7.4	0.8	0.4	4.04	3.21	0.83	<0.4	0.2	<0.1	<0.05	
Arvada	Av	LB-96	R	23+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			A	0-2	28	40	32	CL	43.4	3.5	7.7	1.9	8.1	3.29	1.34	12.3	<0.4	0.1	<0.1	<0.05	
			C1	2-9	22	32	46	C	66.1	2.5	7.8	10.3	18.3	17.5	20.3	79.4	<0.4	0.2	<0.1	0.09	
			C2	9-24	<1	66	34	SiCL	83.1	1.3	8.3	18.1	25.8	17.9	54.7	156	4	0.1	<0.1	0.07	
			Cr1	24-42	2	49	49	SIC	83.5	1.4	8.2	16.1	24.7	16.1	37.8	128	13	0.2	<0.1	0.12	
Fort Collins	FtHp	LB-99	Cr2	42-66	36	20	44	C	93.4	1.5	8.2	11.7	25.1	10.0	23.7	103	15	0.5	<0.1	0.08	
			A	0-4	42	39	19	L	37.7	3.8	6.5	0.7	0.2	3.68	1.92	0.25	<0.4	<0.1	<0.1	<0.05	
			Bt	4-11	33	39	28	CL	39.5	3.6	6.1	0.5	0.2	1.96	1.07	0.30	<0.4	<0.1	<0.1	<0.05	
			Btk	11-34	34	40	26	L	36.7	1.7	7.9	0.5	0.8	0.87	2.28	0.96	1.2	0.2	<0.1	<0.05	
Hydro	Hy	LB-102	C1	34-64	58	24	18	SL	33.5	1.3	8.3	0.6	2.0	0.32	3.26	2.62	0.8	0.4	<0.1	0.11	
			C2	64-92	62	22	16	SL	47.1	1.5	8.4	0.8	5.0	0.33	1.94	5.38	0.8	0.6	<0.1	0.07	
			A	0-2	32	38	30	CL	55.2	7.6	6.7	1.0	0.3	4.81	3.67	0.56	<0.4	0.2	<0.1	<0.05	
			Bt	2-9	28	38	34	CL	45.7	4.0	7.3	0.9	0.4	3.81	2.94	0.82	<0.4	0.3	<0.1	<0.05	
			Bk	9-17	40	33	27	CL	38.7	2.1	7.6	1.0	2.9	2.06	2.33	4.32	<0.4	0.1	<0.1	<0.05	
			C1	17-28	18	34	48	C	87.3	2.7	8.5	1.0	12.8	0.78	0.75	11.2	<0.4	0.3	<0.1	0.15	
Delpoint	MiDe	LB-111	C2	28-44	38	30	32	CL	50.1	1.8	8.0	8.6	10.3	16.5	30.0	49.8	23	0.2	<0.1	<0.05	
			C3	44-80	34	35	31	CL	48.3	1.8	7.9	7.5	11.7	11.4	19.2	45.7	79	0.2	<0.1	<0.05	
			A	0-4	4	56	40	SIC	53.1	5.4	7.3	0.9	0.3	4.72	2.40	0.59	<0.4	0.2	<0.1	<0.05	
			Btk	4-14	2	52	46	SIC	49.8	4.1	7.9	0.4	0.3	1.71	1.25	0.40	<0.4	0.2	<0.1	<0.05	
Hesper	Hp	LB-124	C	14-28	2	53	45	SIC	47.3	3.7	8.1	0.6	2.5	0.90	1.85	2.92	<0.4	0.3	<0.1	<0.05	
			Cr	28-39+	6	50	44	SIC	49.0	4.1	8.0	2.3	5.7	4.21	6.28	13.0	3.5	0.3	<0.1	0.09	
			A	0-8	4	54	42	SIC	56.9	4.0	7.3	1.8	2.3	8.15	3.30	5.55	<0.4	0.4	<0.1	<0.05	
			B	8-24	8	56	36	SiCL	48.5	2.6	7.8	0.8	1.5	2.92	1.83	2.31	<0.4	0.3	<0.1	<0.05	
Hesper	Hp	LB-124	B/C	24-45	24	44	32	CL	41.6	2.8	8.0	1.1	6.6	1.41	0.93	7.11	<0.4	0.3	<0.1	<0.05	
			C1	45-70	28	46	26	L	41.1	2.4	7.8	4.5	6.5	14.9	10.7	23.3	3.4	0.2	<0.1	<0.05	
Hesper	Hp	LB-124	C2	70-93	30	44	26	L	43.9	2.8	7.8	3.2	6.0	8.36	7.48	16.7	93	0.3	<0.1	<0.05	

## Soil Profiles - Laboratory Data

LABORATORY SOIL DATA SUMMARY											Chemical Data									
Soil Series	Map Unit Symbol	Sample Site (SS)	Horizon	Depth	Sand %	Silt %	Clay %	Texture, unitless	Percent Sat %	OM-WB %	pH-SatPst, s_u_	COND, mmhos/cm	SAR, unitless	Calcium, meq/l	Mg-SatPst, meq/l	Na-SatPst, meq/l	NO3-SatPst, mg/L	B, mg/kg	Se, mg/kg	Mo, mg/kg
Havre	NiHa	LB-129	A	0-3	12	50	38	SiCL	53.7	4.8	7.5	2.6	4.9	6.97	4.30	11.6	0.6	0.2	<0.1	<0.05
			Bt	3-16	16	45	39	SiCL	45.6	3.5	7.6	2.0	3.2	6.76	4.11	7.56	<0.4	0.2	<0.1	<0.05
			C	16-30	24	44	32	CL	39.4	2.3	8.0	1.2	4.2	2.32	1.91	6.05	<0.4			<0.05
			Cr	30+	22	45	33	CL	41.5	2.1	8.2	1.2	8.5	1.03	0.82	8.15	3.0	0.4	<0.1	<0.05
Midway	Md-E	LB-136	A	0-2	16	48	36	SiCL	44.5	2.8	7.8	3.4	7.7	9.63	4.91	20.7	0.4	0.1	<0.1	<0.05
			Bt	2-12	6	48	46	SIC	60.3	2.0	8.0	7.0	17.1	8.68	8.43	50.0	<0.1	<0.1	<0.1	0.10
			C	12-26	12	23	65	C	89.6	2.1	8.3	16.4	26.7	19.8	32.3	136	0.2	<0.1	<0.1	<0.05
			C	26-46	30	22	48	C	116	2.3	8.2	15.7	26.6	19.6	22.7	122	0.2	<0.1	<0.1	0.11
			C	46-60+	20	28	52	C	155	4.7	8.2	17.8	31.6	16.5	30.0	152	0.2	<0.1	<0.1	<0.05
Midway	Md-E	LB-137	A	0-3	<1	54	46	SIC	51.1	3.1	7.5	3.8	8.1	9.13	7.02	23.0	<0.4	0.1	<0.1	<0.05
			Bw	3-9	20	44	36	SiCL	52.0	3.2	7.5	3.4	6.0	10.5	6.08	17.1	<0.4	<0.1	<0.1	<0.05
			Bc	9-24	4	51	45	SIC	58.0	3.5	7.6	3.6	7.3	9.13	5.56	19.9	<0.4	0.2	<0.1	<0.05
			C1	24-50	14	45	41	SIC	64.3	1.7	8.3	19.0	26.8	19.0	40.9	147	0.7	0.2	<0.1	<0.05
			C2	50-60+	16	44	40	SIC	64.6	1.8	8.4	18.3	27.6	20.1	43.9	156	0.4	0.2	<0.1	<0.05
Blacksheep	BCC	LB-142	A	0-4	52	30	18	L	37.6	4.1	7.5	0.5	0.2	2.99	1.80	0.36	<0.4	<0.1	<0.1	<0.05
			Bk	4-16	58	26	16	SL	36.2	2.9	7.7	0.4	0.2	2.73	1.19	0.32	<0.4	<0.1	<0.1	<0.05
			C	16-37	61	23	16	SL	33.5	2.7	7.7	0.4	0.2	2.55	1.25	0.33	<0.4	<0.1	<0.1	<0.05
			Cr	37+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nihill	NiHa	DP-01	A	0-5	6	61	33	SiCL	47.6	3.3	7.3	1.5	2.5	6.48	2.51	5.32	0.6	0.2	<0.1	<0.05
			B	5-16	27	47	26	L	38.0	2.1	7.4	1.2	1.8	5.60	2.58	3.61	<0.4	0.1	<0.1	0.05
			C1	16-40	59	24	17	SL	32.9	1.7	7.6	0.8	1.1	2.87	1.64	1.70	0.5	0.1	<0.1	0.06
			C2	40-64	62	21	17	SL	29.2	1.8	7.8	0.7	4.1	1.27	0.95	3.80	1.6	0.1	<0.1	0.06
			C3	64-92	47	29	24	L	35.2	2.8	7.6	1.4	2.2	4.32	4.41	4.19	1.0	0.3	<0.1	0.11
Ringling	RTB	RU-01	A	0-5	44	36	20	L	39.2	2.6	7.5	0.6	0.2	3.97	1.03	0.28	<0.4	0.2	<0.1	<0.05
			Bk	5-17	58	26	16	SL	31.2	1.3	7.6	0.4	0.3	1.83	1.42	0.31	1.5	0.1	<0.1	<0.05
			C	17-37	56	28	16	SL	29.2	1.2	7.9	0.5	0.3	1.07	2.61	0.42	1.0	0.3	<0.1	0.10
			Cr	37+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Relan	RTB	SS12-02	A	0-2	34	49	17	L	42.7	4.6	7.8	0.6	<0.1	3.89	1.14	0.09	<0.2	0.3	<0.1	<0.05
			Bt	2-8	25	54	21	SiL	43.3	3.1	7.8	0.5	<0.1	3.36	1.68	0.09	<0.2	0.1	<0.1	<0.05
			Bk	8-20	24	47	29	CL	40.5	2.9	8.3	0.5	0.8	0.89	2.70	1.03	0.6	0.2	<0.1	<0.05
			C	20-38	46	25	29	SCL	32.5	2.1	8.1	8.8	6.6	21.4	50.8	39.6	0.5	1.8	<0.1	<0.06
			Cr	38+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Blacksheep	RTB	SS12-03	A	0-3	50	35	15	L	43.1	3.6	7.8	0.5	<0.1	2.90	1.40	0.10	<0.2	0.2	<0.1	<0.05
			C	3-10	56	25	19	SL	40.2	2.5	8.0	0.3	<0.1	1.91	1.48	0.10	<0.2	0.1	<0.1	<0.05
			Cr1	10-34	64	21	15	SL	36.3	1.5	8.5	0.4	0.3	0.67	2.97	0.36	0.8	0.2	<0.1	<0.05
			Cr2	34-60	70	17	13	SL	39.6	1.7	8.8	0.5	0.9	0.39	3.08	1.14	0.6	0.2	<0.1	<0.05



## Soil Profiles - Laboratory Data

LABORATORY SOIL DATA SUMMARY											Chemical Data									
Soil Series	Map Unit Symbol	Sample Site (SS)	Horizon	Depth	Sand %	Silt %	Clay %	Texture, unitless	Percent Sat %	OM-WB %	pH-SatPst, s_u_	COND, mmhos/cm	SAR, unitless	Calcium, meq/l	Mg-SatPst, meq/l	Na-SatPst, meq/l	NO3-SatPst, mg/L	B, mg/kg	Se, mg/kg	Mo, mg/kg
Havre	NiHa	SS12-04	A	0-3	28	45	27	CL	56.2	7.3	7.4	1.1	0.2	6.07	2.85	0.36	24	0.4	<0.1	<0.05
			Bt	3-13	26	39	35	CL	44.2	3.6	7.6	0.4	<0.1	2.41	1.03	0.11	<0.2	0.1	<0.1	<0.05
			Bk	13-30	32	35	33	CL	42.4	3.9	7.7	0.6	0.7	2.85	1.96	1.10	<0.2	0.3	<0.1	<0.05
			C1	30-50	32	37	31	CL	45.4	3.8	7.7	3.4	1.7	23.3	11.8	6.93	7.7	0.4	<0.1	<0.05
			C2	50-60	32	37	31	CL	47.9	4.4	7.6	4.4	1.5	26.9	14.3	6.89	10	0.7	<0.1	0.11
Midway	BCC	SS12-07	A	0-4	8	45	47	SiC	59.0	6.3	7.8	0.7	0.4	3.20	2.07	0.73	0.2	0.1	<0.1	<0.05
			B	4-12	<1	47	53	SiC	72.2	4.3	8.2	1.0	5.6	1.12	1.61	6.54	<0.2	0.1	<0.1	<0.05
			C	12-24	5	40	55	C	80.4	4.1	8.0	8.7	8.9	20.1	34.0	46.1	<0.2	0.1	<0.1	0.10
			Cr	24-40	4	41	55	SiC	97.5	3.7	8.1	10.9	15.7	5.50	32.9	68.7	0.4	0.1	<0.1	0.08
Twilight	RTB	SS12-09	A	0-4	36	39	25	L	47.5	5.1	7.6	0.5	<0.1	2.98	1.77	0.09	<0.2	0.4	<0.1	<0.05
			B	4-12	36	37	27	CL	46.1	3.9	7.4	1.4	1.2	5.83	4.24	2.64	<0.2	0.1	<0.1	<0.05
			C	12-30	38	37	25	L	46.6	2.2	7.8	0.3	0.4	1.63	0.96	0.41	<0.2	<0.1	<0.1	<0.05
			Cr	30+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
McRae	McR-S	SS12-13	A	0-6	18	52	30	SiCL	50.3	5.7	7.0	0.7	0.1	4.28	1.96	0.17	<0.2	0.2	<0.1	<0.05
			Bt	6-14	22	50	28	CL	43.7	4.0	7.6	0.5	0.2	3.05	1.33	0.25	<0.2	0.2	<0.1	<0.05
			Bk	14-36	16	58	26	SiL	44	3.1	8.1	0.4	0.4	1.49	2.25	0.61	0.4	0.3	<0.1	<0.05
			C1	36-60	14	60	26	SiL	51.6	3.1	8.5	3.1	7.5	1.31	12.1	19.4	<0.2	1.1	<0.1	0.08
			C2	60-84	16	54	30	SiCL	54.4	2.8	8.3	13.2	13.0	16.1	56.4	72.6	11	0.9	0.1	0.07
Haverson	H	SS12-14	A	0-4	14	60	26	SiL	53.9	6.8	7.5	1.3	1.0	5.75	2.26	1.93	21	0.3	<0.1	0.06
			Bk	4-17	26	52	22	SiL	43.4	3.1	7.4	3.2	0.6	15.0	6.57	1.79	211	0.3	<0.1	<0.05
			BC	17-36	34	46	20	L	39.3	2.8	7.8	1.1	0.7	3.77	3.95	1.46	57	0.2	<0.1	<0.05
			C1	36-60	28	50	22	SiL	42.0	2.3	8.3	8.5	8.6	16.2	28.7	40.8	113	1.0	<0.1	0.07
			C2	60-84	32	48	20	L	41.8	1.6	8.2	8.9	11.1	17.1	22.3	49.2	148	1.0	<0.1	0.11
McRae	McR	SS12-17	A	0-5	46	29	25	L	54.5	5.4	6.9	0.6	<0.1	2.74	1.59	0.10	<0.2	0.2	<0.1	<0.05
			Btk	5-13	34	41	25	L	40.5	3.3	6.5	0.4	<0.1	1.85	1.15	0.10	<0.2	0.2	<0.1	0.05
			Bk	13-28	36	41	23	L	38.2	2.1	8.2	0.6	0.9	1.20	3.52	1.39	<0.2	0.5	<0.1	<0.05
			C1	28-42	32	47	21	L	39.2	1.5	8.9	1.0	6.6	0.59	1.77	7.14	1.0	1.0	<0.1	0.07
			C2	42-60	34	45	21	L	38.9	1.5	8.8	1.7	9.8	0.54	3.26	13.6	0.6	1.1	<0.1	0.10
Farland	Fa	SS12-21	A	0-2	8	59	33	SiCL	68.4	7.5	7.3	2.1	2.6	8.56	5.73	7.02	<0.2	0.3	<0.1	0.08
			C1	2-14	8	55	37	SiCL	61.0	4.2	7.6	0.7	2.3	2.31	1.26	3.07	<0.2	0.2	<0.1	0.14
			C2	14-28	18	49	33	SiCL	53.1	3.5	7.7	0.8	2.7	2.23	1.37	3.66	<0.2	0.2	<0.1	0.12
			C3	28-46	28	47	25	L	41.2	2.6	7.9	0.9	4.3	1.91	1.12	5.32	<0.2	0.2	<0.1	0.14
			C4	46-60	38	37	25	L	40.6	3.0	7.8	1.3	5.1	2.66	1.53	7.40	<0.2	0.2	<0.1	0.06
McRae	He	SS12-22	Ap	0-6	32	54	14	SiL	41.7	3.8	7.0	1.1	0.2	4.13	2.87	0.33	25	0.3	<0.1	0.09
			Bk	6-16	40	45	15	L	36.6	2.6	7.6	1.2	0.3	4.33	3.05	0.53	47	0.4	<0.1	<0.05
			BC	16-38	28	51	21	SiL	40.6	3.3	8.1	0.6	1.1	1.18	2.09	1.37	4.6	0.4	<0.1	<0.05
			C1	38-60	38	39	23	L	85.7	2.8	8.4	16.0	12.6	20.3	81.8	90.4	35	1.2	0.2	0.11
			C2	60-84	62	23	15	SL	10.1	1.5	8.9	2.0	13.6	0.56	1.64	14.3	1.9	0.8	<0.1	0.06

## Soil Profiles - Laboratory Data

LABORATORY SOIL DATA SUMMARY											Chemical Data									
Soil Series	Map Unit Symbol	Sample Site (SS)	Horizon	Depth	Sand %	Silt %	Clay %	Texture, unitless	Percent Sat %	OM-WB %	pH-SatPst, s_u_	COND, mmhos/cm	SAR, unitless	Calcium, meq/l	Mg-SatPst, meq/l	Na-SatPst, meq/l	NO3-SatPst, mg/L	B, mg/kg	Se, mg/kg	Mo, mg/kg
Relan	Re	SS12-23	A	0-3	64	27	9	SL	35.4	2.8	6.4	0.4	0.3	1.68	0.87	0.34	22	0.1	<0.1	0.10
			Bt	3-18	65	20	15	SL	33.3	1.9	6.9	0.4	<0.1	1.77	0.81	0.09	10	<0.1	<0.1	<0.05
			Bk	18-32	62	21	17	SL	32.8	2.1	8.0	0.4	0.4	1.83	1.53	0.53	1.5	0.2	<0.1	<0.05
			C1	32-46	74	17	9	SL	29.5	1.3	8.1	0.5	0.4	1.68	2.40	0.50	2.4	0.1	<0.1	0.06
			C2	46-60	68	21	11	SL	25.9	1.8	8.3	0.4	0.5	0.90	2.91	0.69	1.5	0.1	<0.1	<0.05
Haverson	H-S	SS12-24	A	0-6	18	48	34	SiCL	58.2	6.5	7.4	1.3	1.4	7.12	3.05	3.08	<0.2	0.5	<0.1	<0.05
			Btk	6-20	6	54	40	SIC	58.0	5.0	7.4	4.6	4.6	16.2	12.6	17.6	<0.2	0.5	<0.1	0.08
			BC	20-36	76	11	13	SL	31.2	1.5	8.3	11.7	14.4	16.8	31.6	70.7	2.0	0.1	<0.1	<0.05
			C1	36-50	47	32	21	L	39.8	2.3	8.4	15.0	17.3	17.1	47.9	98.4	3.1	0.3	<0.1	<0.05
			C2	50-74	44	33	23	L	40.5	2.3	8.4	19.0	20.1	19.8	64.6	130	3.6	0.6	<0.1	<0.05
Heldt	He	SS12-25	Ap	0-6	24	55	21	SIL	44.4	3.5	7.4	0.8	0.1	4.82	1.88	0.20	<0.2	0.2	<0.1	<0.05
			Bk	6-18	30	51	19	SIL	39.7	2.3	7.6	0.4	0.2	2.29	1.53	0.33	<0.2	0.2	<0.1	0.06
			B	18-33	10	54	36	SiCL	53.7	3.2	8.2	0.6	3.0	0.77	1.40	3.12	<0.2	0.4	<0.1	<0.05
			C1	33-58	28	46	26	L	46.6	2.0	8.7	10.2	19.0	3.00	25.5	71.9	0.4	1.7	<0.1	0.11
			C2	58-80	18	55	27	SiCL	57.3	2.0	8.7	11.3	21.9	2.40	25.6	81.9	1.4	1.8	<0.1	0.12
Nihill	NiHa	SS12-28	A	0-2	26	47	27	CL	60.1	9.6	7.3	0.7	<0.1	4.35	1.82	0.09	0.3	0.3	<0.1	0.09
			Bt	2-10	30	41	29	CL	43.0	3.9	7.7	0.5	0.3	2.82	1.75	0.50	<0.2	0.2	<0.1	0.08
			BC	10-30	26	39	35	CL	47.0	4.0	7.8	1.0	1.2	5.06	3.57	2.44	<0.2	0.5	<0.1	0.11
			C1	30-50	32	37	31	CL	44.7	3.7	7.6	4.2	1.2	25.1	14.0	5.33	94	0.3	<0.1	0.09
			C2	50-60	38	33	29	CL	41.1	3.9	7.6	4.5	1.0	29.4	14.1	4.48	140	0.3	<0.1	0.07
Ringling	Ri	SS12-29	A	0-2	60	29	11	SL	47.2	6.5	7.4	0.8	<0.1	5.94	1.71	0.06	<0.2	0.2	<0.1	0.12
			C1	2-14	60	27	13	SL	29.7	1.9	7.9	0.4	<0.1	1.80	1.60	0.12	0.9	<0.1	<0.1	0.10
			C2	14-28	90	5	5	S	28.8	1.6	8.1	0.3	0.2	0.87	1.75	0.27	1.9	<0.1	<0.1	0.06
Saline Overflow	H-S	SS12-31	Ap	0-4	14	53	33	SiCL	69.6	7.1	8.4	31.5	33.8	17.7	138	298	<0.2	1.4	<0.1	0.12
			Bk	4-16	14	56	30	SiCL	64.1	3.5	8.5	27.0	35.8	18.1	89.4	263	<0.2	1.4	<0.1	<0.05
			BC	16-31	62	24	14	SL	34.3	1.7	8.6	26.9	38.9	19.3	76.8	270	<0.2	0.9	<0.1	<0.05
			C1	31-55	<1	45	55	SIC	89.9	4.2	8.0	11.4	17.3	13.4	22.5	73.3	0.6	1.2	<0.1	<0.05
			C2	55-73	<1	43	57	SIC	98.9	3.8	8.1	4.8	14.9	3.45	6.46	33.1	<0.2	1.1	<0.1	0.08
Saline Overflow	SO	SS12-32	C3	73-93	28	31	41	C	60.3	2.6	8.2	2.7	13.0	1.47	3.44	20.3	<0.2	0.8	<0.1	0.09
			Ap	0-6	8	49	43	SIC	93.8	5.8	8	18.0	28.2	11.7	36.6	138	<0.2	4	<0.1	<0.05
			Bt	6-16	6	50	44	SIC	73.6	3.4	8.2	14.7	19.7	16.8	38.7	103	<0.2	1.5	<0.1	0.07
			BC	16-24	2	58	40	SIC	72.9	2.4	8.1	7.0	16.2	6.41	13.3	50.7	<0.2	1.3	<0.1	<0.05
			C1	24-44	4	55	41	SIC	66.6	2.5	8.1	4.8	14.0	3.33	7.22	32.1	3	0.9	<0.1	<0.05
			C2	44-66	<1	43	57	SIC	83.7	3.0	8.0	2.1	8.4	1.57	3.39	13.2	<0.2	0.8	<0.1	0.08
			C3	66-90	16	55	29	SiCL	53.1	2.4	8.2	2.1	11.5	1.16	2.36	15.3	<0.2	0.7	<0.1	0.06

## Soil Profiles - Laboratory Data

LABORATORY SOIL DATA SUMMARY											Chemical Data									
Soil Series	Map Unit Symbol	Sample Site (SS)	Horizon	Depth	Sand %	Silt %	Clay %	Texture, unitless	Percent Sat %	OM-WB %	pH-SatPst, s_u_	COND, mmhos/cm	SAR, unitless	Calcium, meq/l	Mg-SatPst, meq/l	Na-SatPst, meq/l	NO3-SatPst, mg/L	B, mg/kg	Se, mg/kg	Mo, mg/kg
Haverson	He	SS12-35	Ap	0-6	26	48	26	L	51.1	4.7	7.6	8.0	7.8	19.3	24.4	36.3	<0.2	0.7	<0.1	<0.05
			Btk	6-14	14	58	28	SiCL	57.5	3.4	8.4	16.6	17.5	15.7	54.0	103	3	0.8	<0.1	<0.05
			C1	14-30	12	58	30	SiCL	58.9	3.1	8.5	11.7	19.7	4.14	29.8	81.2	2.1	3.0	<0.1	<0.05
			C2	30-54	42	40	18	L	41.5	2.0	8.3	7.9	15.0	3.67	21.4	53.0	<0.2	1.2	<0.1	<0.05
			C3	54-78	66	24	10	SL	32.3	1.4	8.0	7.6	10.1	7.86	28.3	43.0	<0.2	0.4	<0.1	<0.05
Barvon	RTB	SS12-36	A	0-3	54	34	12	SL	52.8	5.5	7.3	0.6	<0.1	4.07	0.94	0.11	<0.2	0.3	<0.1	<0.05
			Bk	3-9	48	38	14	L	44.8	3.6	7.4	0.5	<0.1	3.70	0.82	0.07	<0.2	0.2	<0.1	<0.05
			BC	9-24	46	40	14	L	41.1	2.1	7.6	0.3	0.1	1.58	1.13	0.17	0.6	0.2	<0.1	<0.05
			C	24-36	56	28	16	SL	35.6	1.9	7.9	0.4	0.2	0.92	2.25	0.26	2.0	0.3	<0.1	<0.05
			Cr	36+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Haverson	H-S	SS12-37	A	0-6	2	38	60	C	81.6	5.8	7.3	6.4	5.9	19.2	18.3	25.5	43	0.4	<0.1	<0.05
			ABk	6-12	8	56	36	SiCL	55.6	3.5	7.3	4.9	4.6	20.9	11.9	18.8	10	0.3	<0.1	<0.05
			BC	12-23	8	58	34	SiCL	55.7	3.5	7.4	3.3	4.2	13.1	7.71	13.5	19	0.2	<0.1	<0.05
			C1	23-36	18	66	16	SiL	46.0	2.9	7.5	3.1	3.4	13.4	8.89	11.4	13	0.1	<0.1	<0.05
			C2	36-55	6	56	38	SiCL	58.4	3.6	7.6	2.3	2.8	9.05	8.46	8.18	2.2	0.3	<0.1	<0.05
			C3	55-76	6	54	40	SIC	62.5	3.6	7.6	2.4	3.2	8.05	8.90	9.26	1.0	0.4	<0.1	<0.05
			C4	76-90	66	22	12	SL	29.7	1.6	7.6	3.5	3.4	10.2	16.5	12.4	<0.2	0.3	<0.1	<0.05

Properties exceed DEQ unsuitability criteria for Lift 1 material  
 Properties exceed DEQ unsuitability criteria for Lift 2 material

**APPENDIX C**  
**SOIL SAMPLE SITE PHOTOS**



**Sample Site BK-01: Delpoint Series  
Landscape View**



**Sample Site BK-05: Blacksheep Series  
Landscape View**



**Sample Site BK-05: Blacksheep Series  
Soil Profile View**



**Sample Site BK-14: Havre Series  
Landscape View**



**Sample Site BK-14: Havre Series  
Pit View**



**Sample Site BK-15: Fort Collins Series  
Landscape View**





**Sample Site BK-19: Cabbart Series  
Landscape View**



**Sample Site BK-19: Cabbart Series  
Soil Profile View**

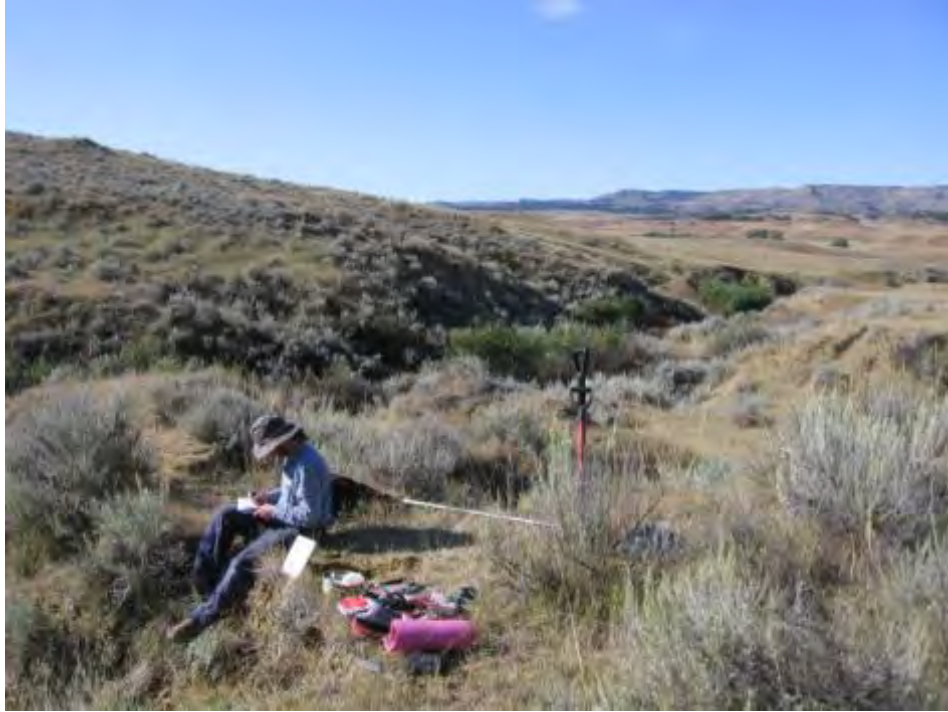




**Sample Site BK-31: Midway Series  
Landscape View**



**Sample Site BK-31: Midway Series  
Soil Profile View**



**Sample Site BK-36: Fort Collins Series  
Landscape View**



**Sample Site BK-36: Fort Collins Series  
Soil Profile View**



**Sample Site BK-44: Ringling Series  
Landscape View**



**Sample Site BK-44: Ringling Series  
Pit View**





**Sample Site BK-45: Heldt Series  
Landscape View**



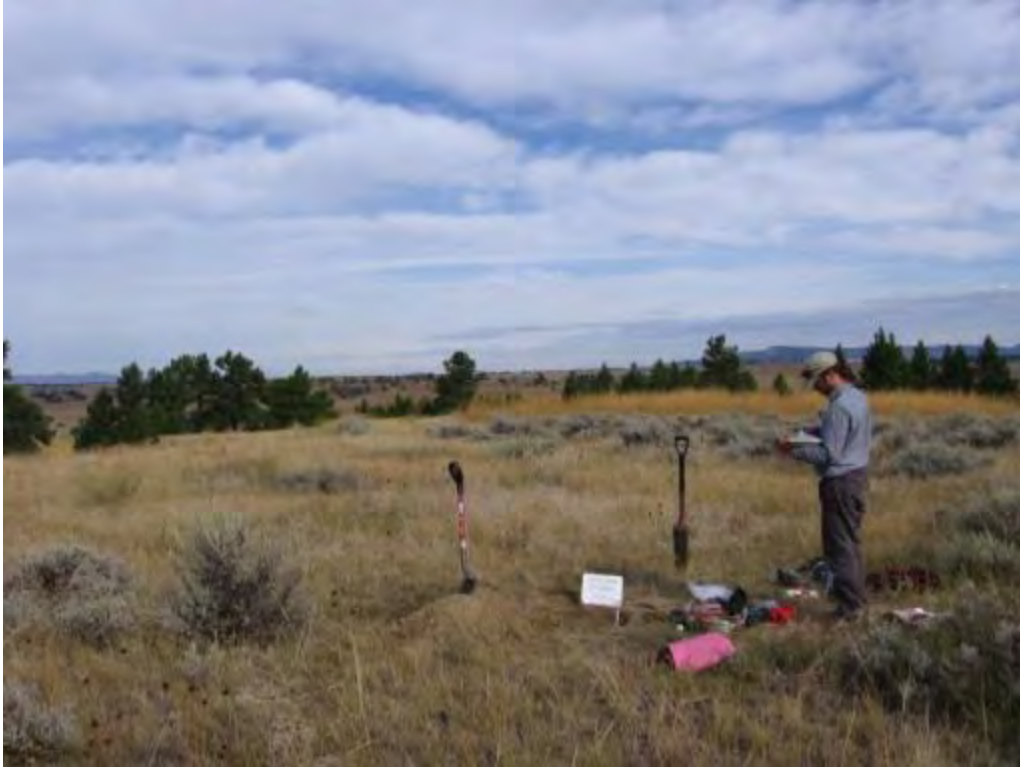
**Sample Site BK-45: Heldt Series  
Pit View**



**Sample Site BK-46: Heldt Series  
Landscape View**



**Sample Site BK-50: McRae Series  
Landscape View**



**Sample Site BK-53: Cushman Series  
Landscape View**



**Sample Site BK-53: Cushman Series  
Soil Profile View**





**Sample Site BK-55: Cabbart Series  
Landscape View**



**Sample Site BK-55: Cabbart Series  
Soil Profile View**



**Sample Site BK-56: Cabba Series  
Landscape View**

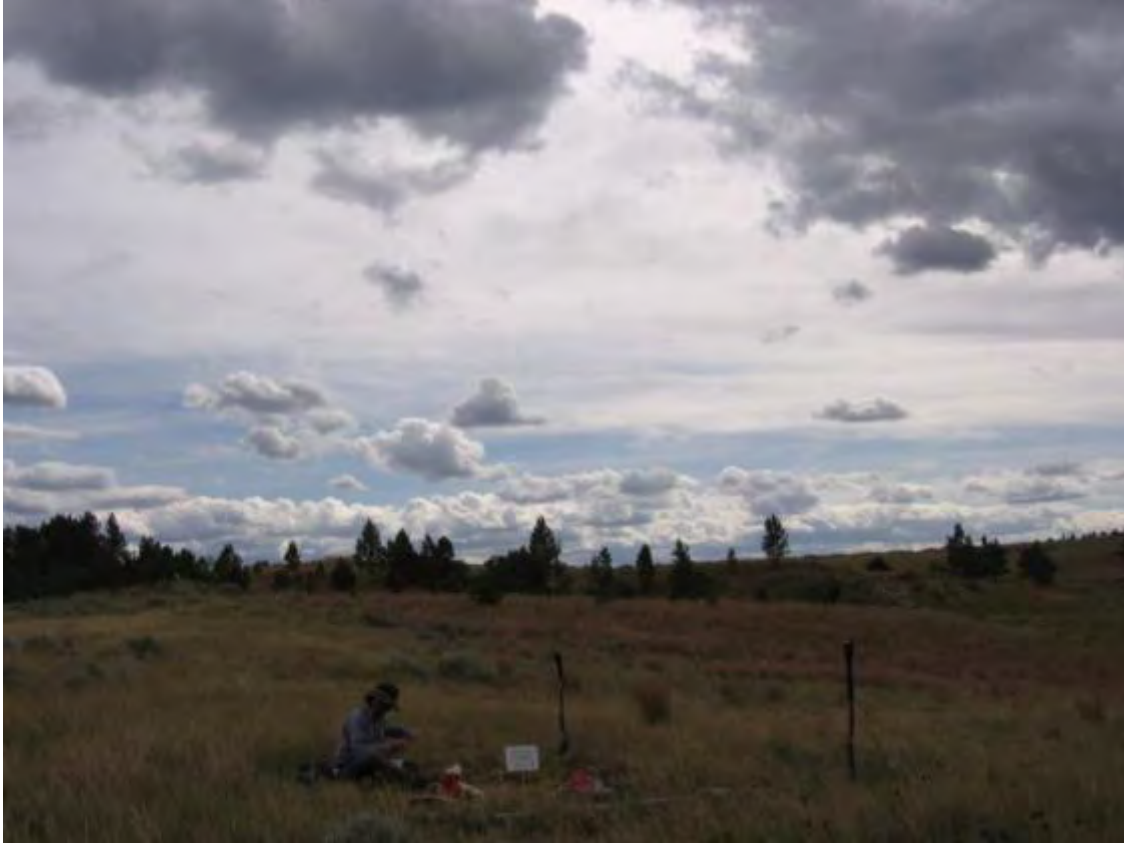


**Sample Site BK-56: Cabba Series  
Pit View**





**Sample Site BK-57: Twilight Series  
Landscape View**



**Sample Site BK-64: Twilight Series  
Landscape View**



**Sample Site BK-64: Twilight Series  
Soil Profile View**



**Sample Site BK-68: Blacksheep Series  
Landscape View**



**Sample Site BK-68: Blacksheep Series  
Pit View**





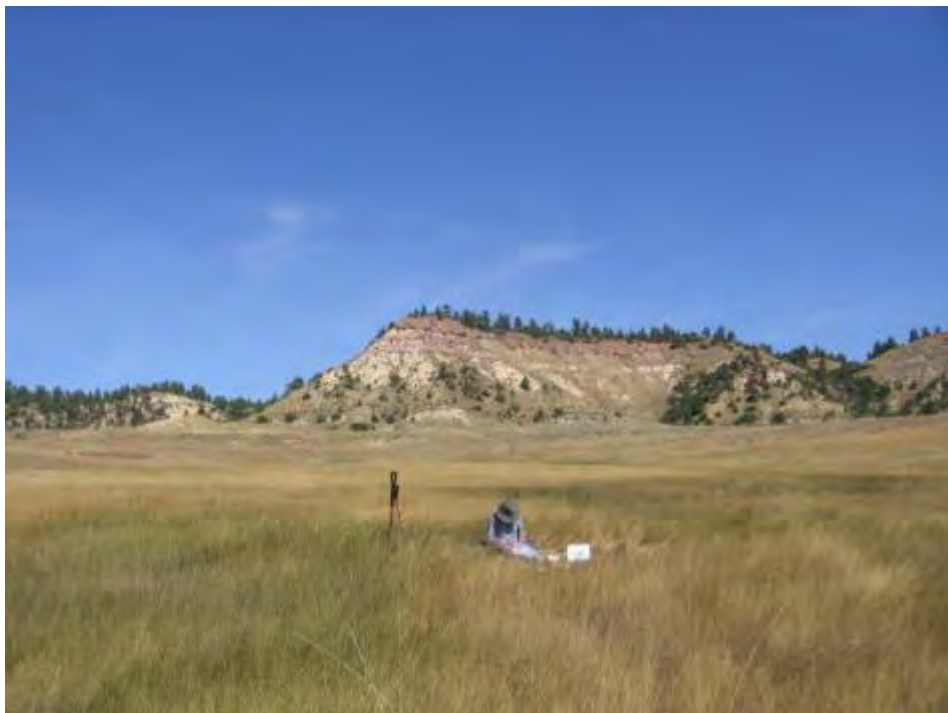
**Sample Site BK-69: Delpoint Series  
Landscape View**



**Sample Site BK-71: Midway Series  
Landscape View**



**Sample Site BK-71: Midway Series  
Pit View**



**Sample Site CB-21: Haverson Series  
Landscape View**



**Sample Site CB-21: Haverson Series  
Soil Profile View**



**Sample Site CB-70: Havre Series  
Landscape View**





**Sample Site CB-70: Havre Series  
Pit View**



**Sample Site CB-72: Nihill Series  
Landscape View**



**Sample Site CB-72: Nihill Series  
Soil Profile View**



**Sample Site CB-77: Hydro Series  
Landscape View**





**Sample Site CB-77: Hydro Series  
Pit View**



**Sample Site CB-79: Remmit Series  
Landscape View**



**Sample Site CB-83: Haverson Series  
Landscape View**



**Sample Site CB-83: Haverson Series  
Pit View**



**Sample Site CB-87: Hesper Series  
Landscape View**



**Sample Site CB-95: Twilight Series  
Landscape View**





**Sample Site CB-95: Twilight Series  
Pit View**



**Sample Site CB-101: Midway Series  
Landscape View**



**Sample Site CB-101: Midway Series  
Soil Profile View**



**Sample Site CB-103: Arvada Series  
Landscape View**



**Sample Site CB-103: Arvada Series  
Pit View**



**Sample Site CB-111: McRae Series  
Landscape View**





**Sample Site CB-113: Hesper Series  
Landscape View**



**Sample Site CB-113-2: Hesper Series  
Landscape View**



**Sample Site CB-119: Farland Series  
Landscape View**



**Sample Site CB-119: Farland Series  
Pit View**





**Sample Site CB-120: Heldt Series  
Landscape View**



**Sample Site CB-121: Haverson Series  
Landscape View**



**Sample Site CB-121: Haverson Series  
Pit View**



**Sample Site CB-123: Haverson Series  
Landscape View**



**Sample Site CB-125: Relan Series  
Landscape View**



**Sample Site CB-125: Relan Series  
Pit View**





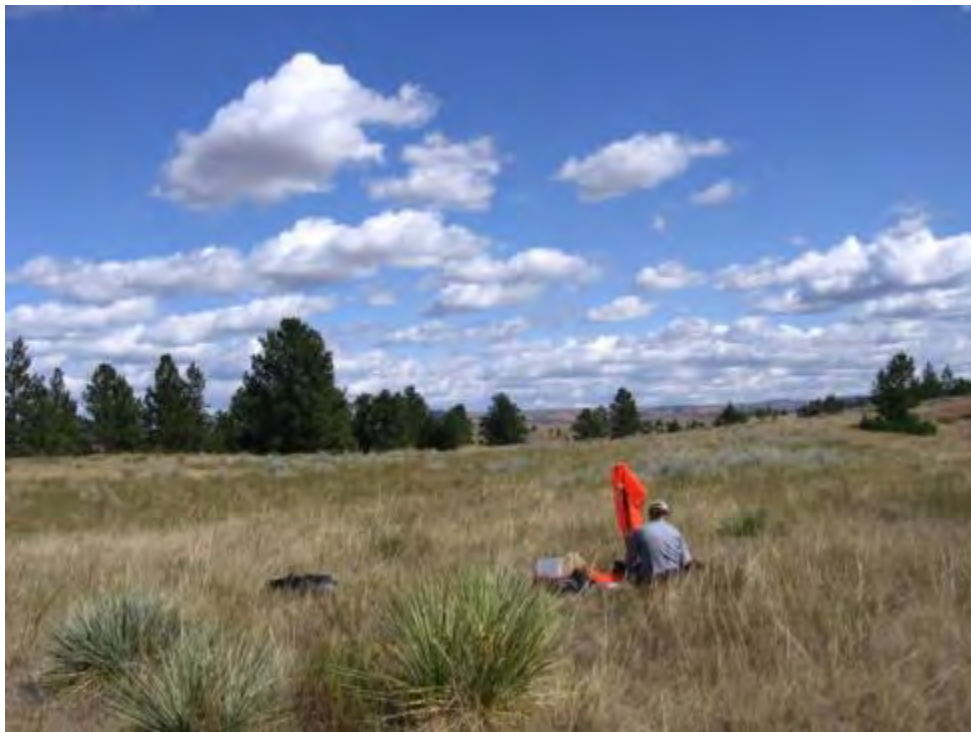
**Sample Site CB-126: Ringling Series  
Landscape View**



**Sample Site CB-126: Ringling Series  
Pit View**



**Sample Site CB-128: Relan Series  
Landscape View**



**Sample Site CB-138: Twilight Series  
Landscape View**



**Sample Site CB-138: Twilight Series  
Soil Profile View**



**Sample Site CB-140: McRae-Saline Series  
Landscape View**





**Sample Site CB-140: McRae-Saline Series  
Pit View**



**Sample Site CB-141: Ringling Series  
Landscape View**



**Sample Site CB-148: Blacksheep Series  
Landscape View**



**Sample Site CB-148: Blacksheep Series  
Soil Profile View**





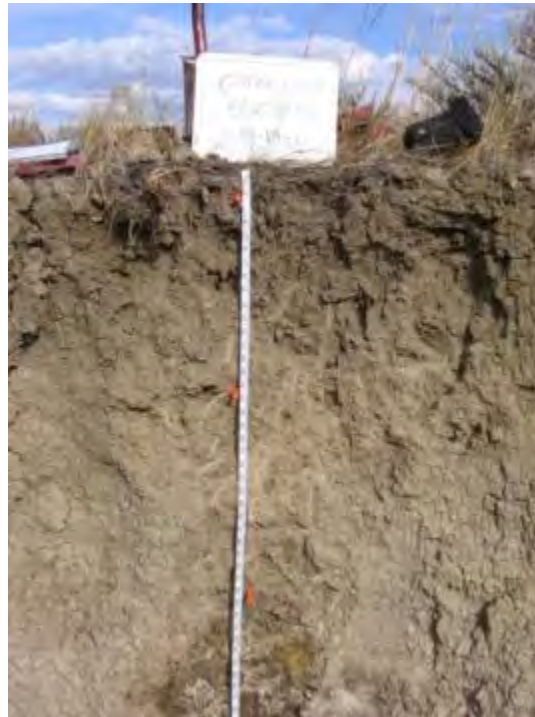
**Sample Site CB-152: Barvon Series  
Landscape View**



**Sample Site CB-152: Barvon Series  
Soil Profile View**



**Sample Site CB-155: McRae-Saline Series  
Landscape View**



**Sample Site CB-155: McRae-Saline Series  
Landscape View**



**Sample Site CB-156: Midway Series  
Pit View**



**Sample Site CB-159: Nihill Series  
Landscape View**





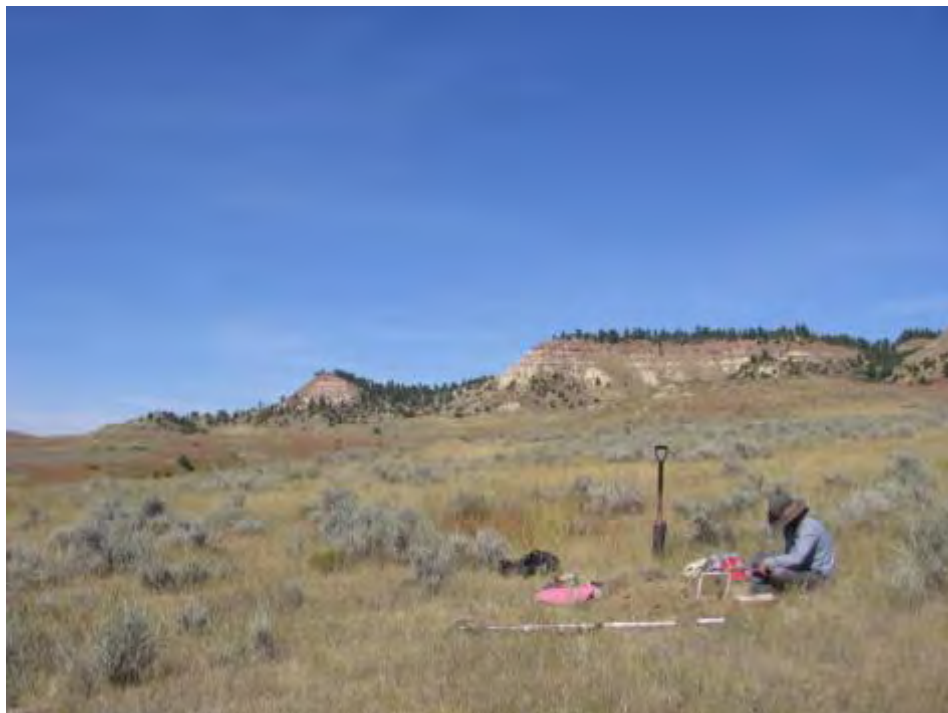
**Sample Site CB-159: Nihill Series  
Pit View**



**Sample Site CB-167: Twilight Series  
Landscape View**



**Sample Site CB-167: Twilight Series  
Pit View**



**Sample Site LB-09: Delpoint Series  
Landscape View**



**Sample Site LB-09: Delpoint Series  
Soil Profile View**



**Sample Site LB-18: Cabba Series  
Landscape View**





**Sample Site LB-21: Cabba Series  
Landscape View**



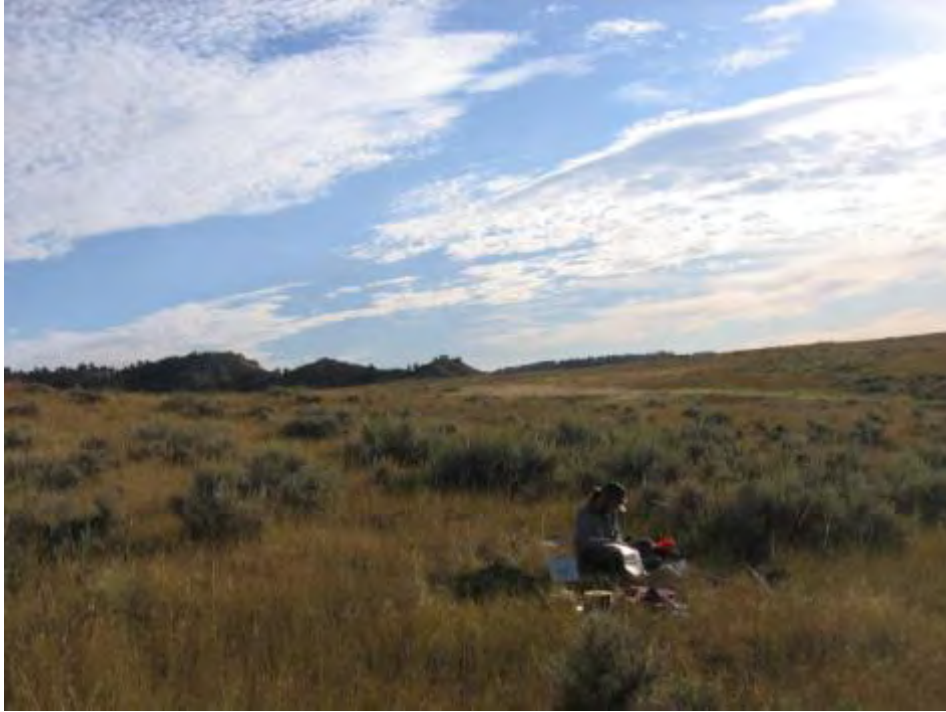
**Sample Site LB-21: Cabba Series  
Soil Profile View**



**Sample Site LB-24: Blacksheep Series  
Landscape View**



**Sample Site LB-24: Blacksheep Series  
Pit View**

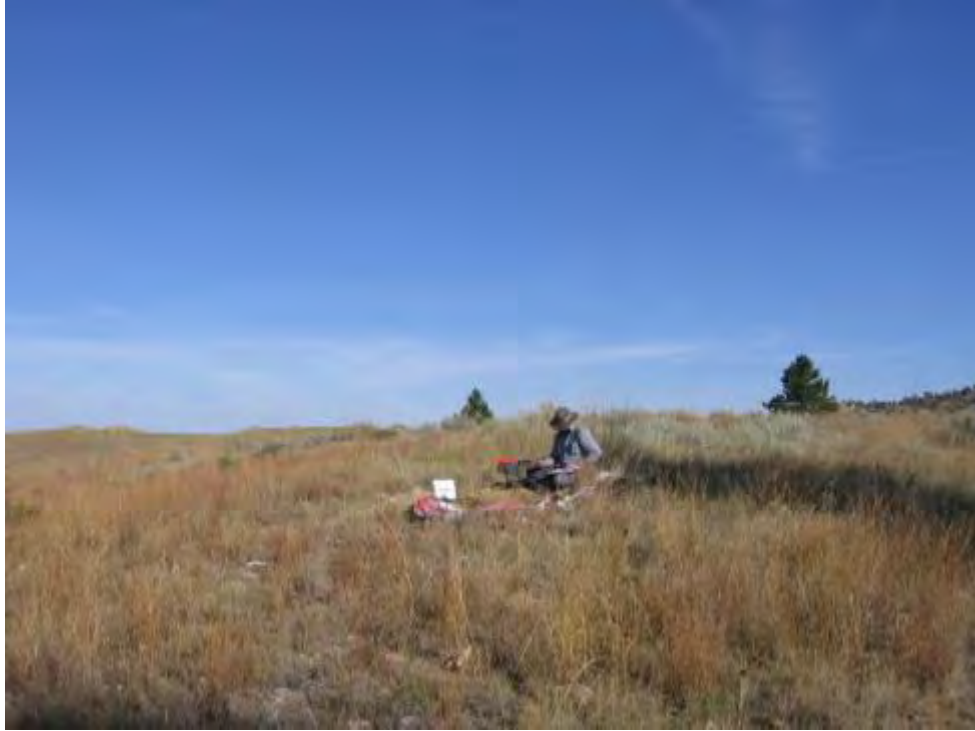


**Sample Site LB-33: Midway Series  
Landscape View**



**Sample Site LB-33: Midway Series  
Soil Profile View**

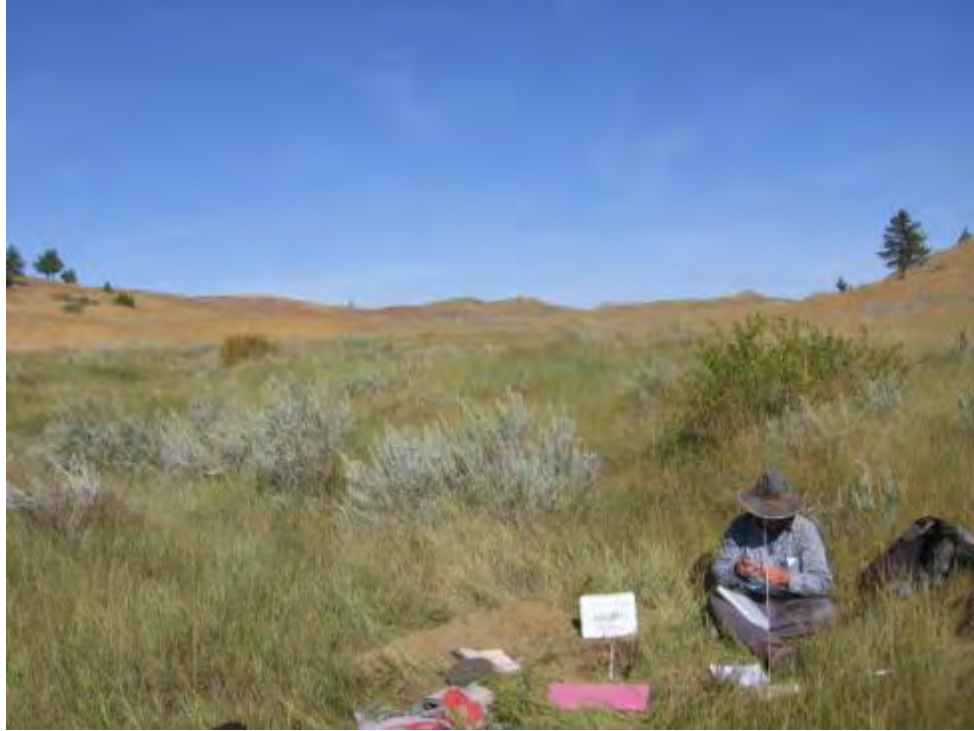




**Sample Site LB-38: Cabba Series  
Landscape View**



**Sample Site LB-38: Cabba Series  
Soil Profile View**



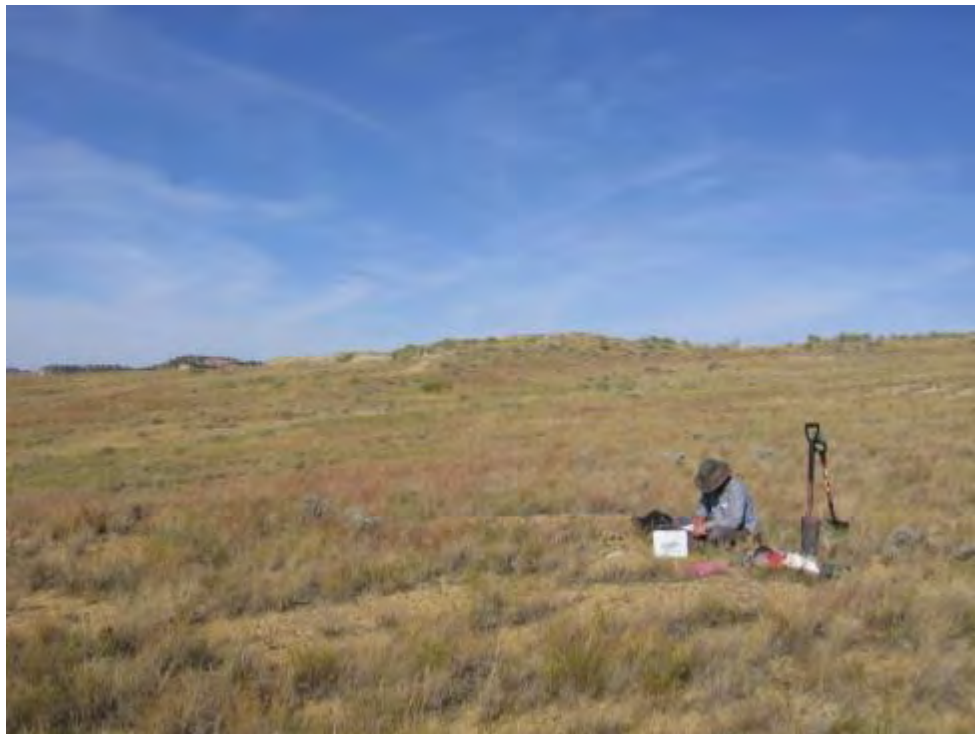
**Sample Site LB-41: Haverson Series  
Landscape View**



**Sample Site LB-41: Haverson Series  
Soil Profile View**



**Sample Site LB-58: Hydro Series  
Landscape View**



**Sample Site LB-67: Cabbart Series  
Landscape View**





**Sample Site LB-79: Midway Series  
Landscape View**



**Sample Site LB-79: Midway Series  
Pit View**



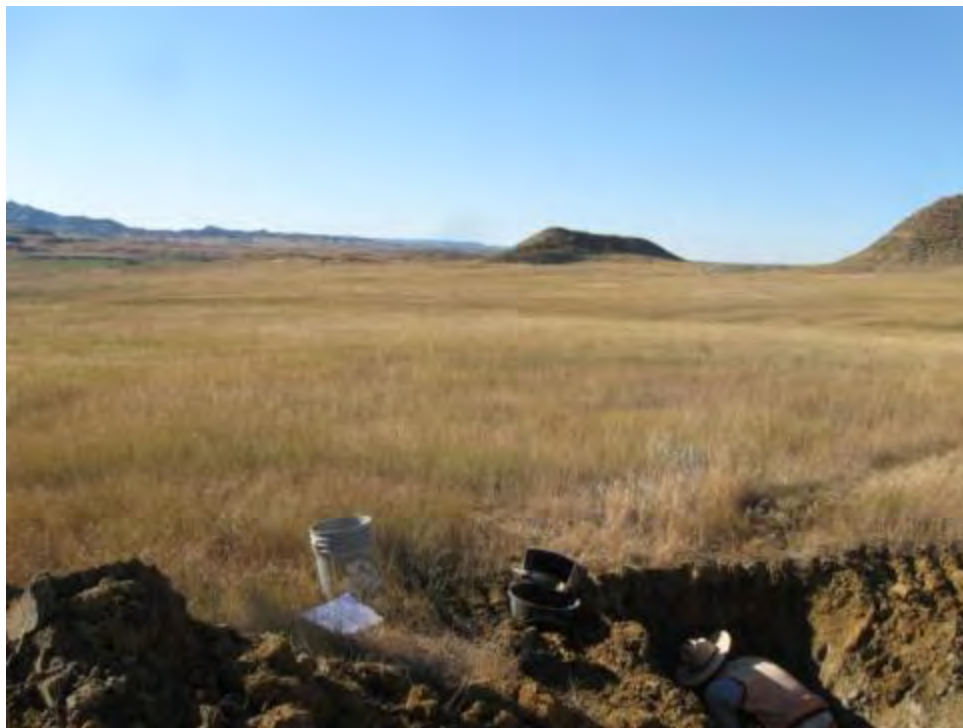
**Sample Site LB-85: Fort Collins Series  
Landscape View**



**Sample Site LB-85: Fort Collins Series  
Pit View**



**Sample Site LB-91: Delpoint Series  
Landscape View**



**Sample Site LB-96: Arvada Series  
Landscape View**

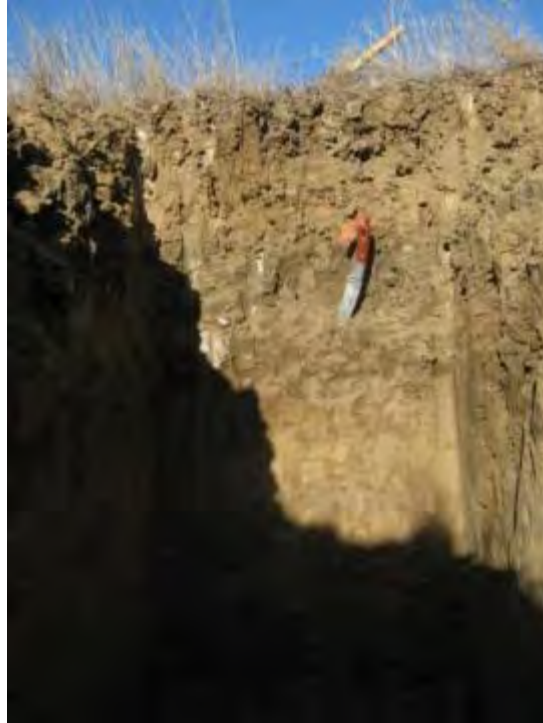




**Sample Site LB-99: Fort Collins Series  
Landscape View**



**Sample Site LB-102: Hydro Series  
Landscape View**



**Sample Site LB-102: Hydro Series  
Pit View**



**Sample Site LB-111: Delpoint Series  
Landscape View**

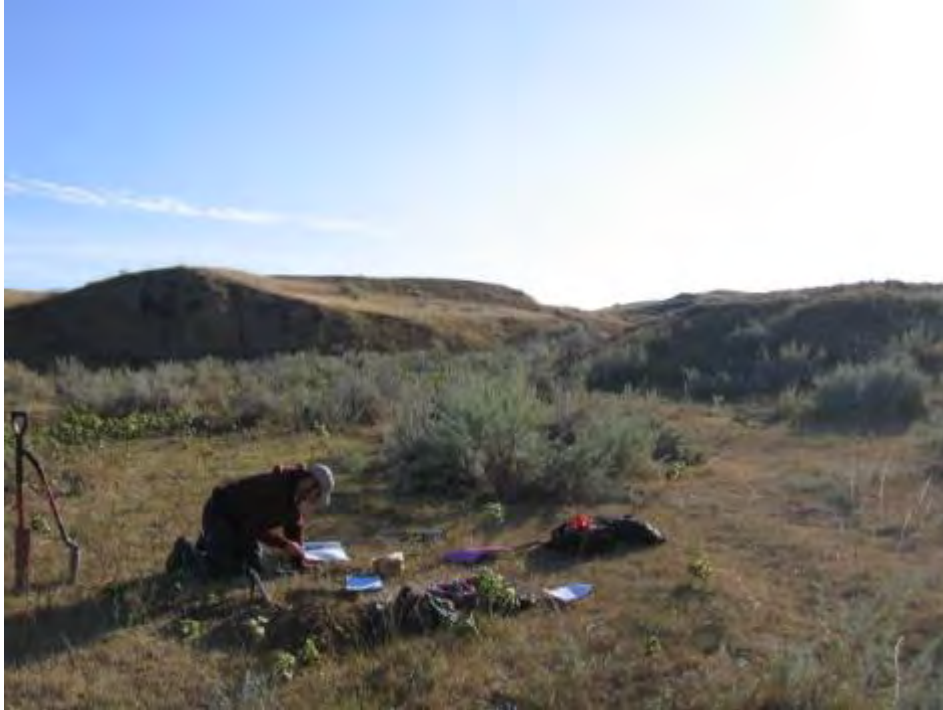




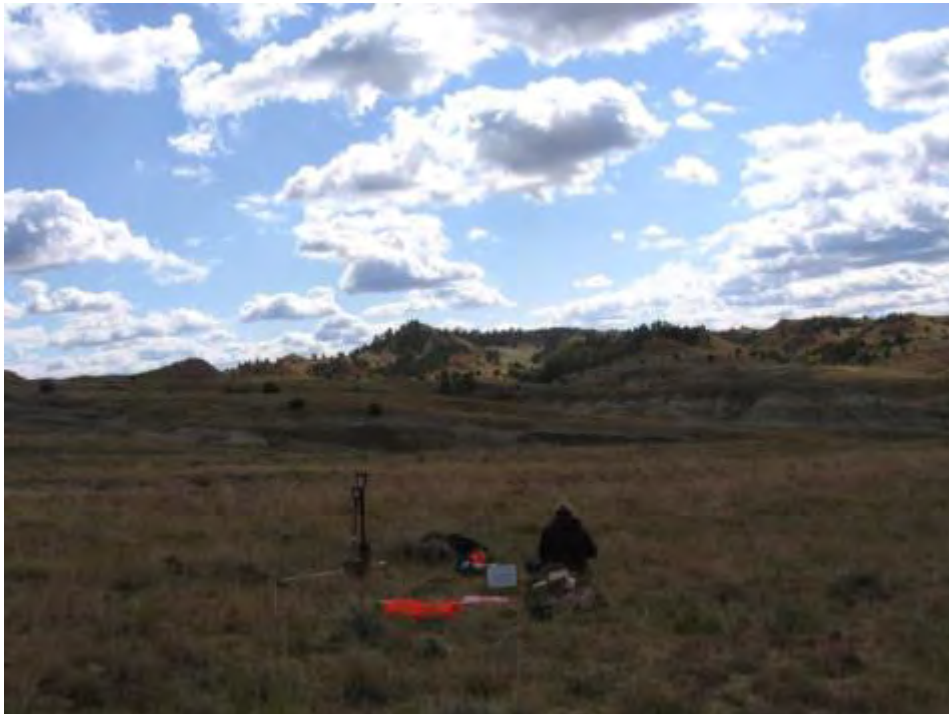
**Sample Site LB-111: Delpoint Series  
Soil Profile View**



**Sample Site LB-124: Hesper Series  
Landscape View**



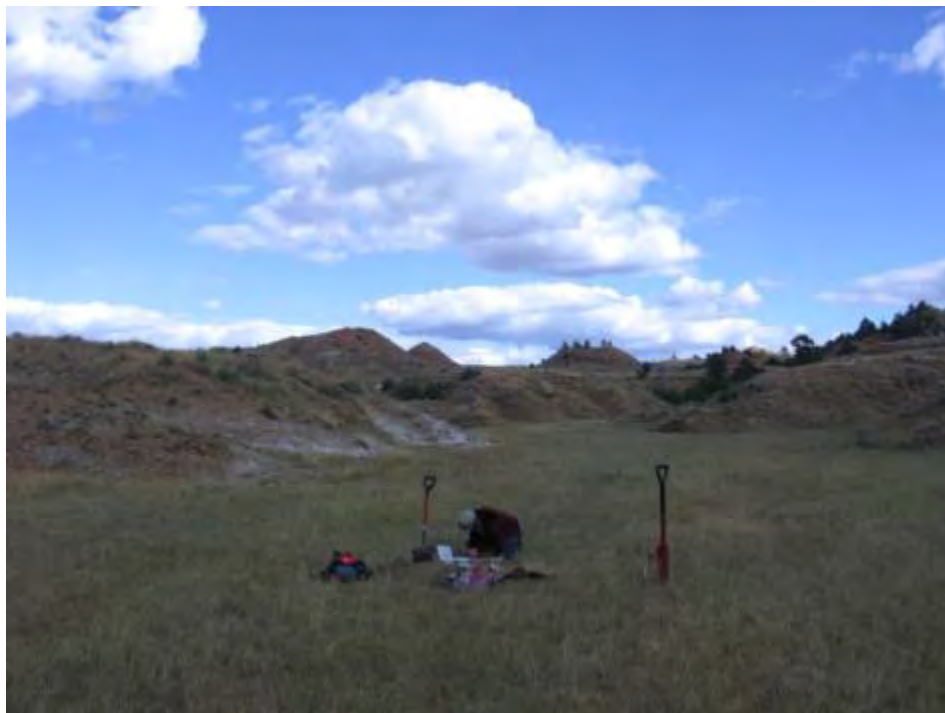
**Sample Site LB-129: Havre Series  
Landscape View**



**Sample Site LB-136: Midway Series  
Landscape View**



**Sample Site LB-136: Midway Series  
Soil Profile View**



**Sample Site LB-137: Midway Series  
Landscape View**





**Sample Site LB-137: Midway Series  
Soil Profile View**



**Sample Site LB-142: Blacksheep Series  
Landscape View**



**Sample Site LB-137: Midway Series  
Soil Profile View**



**Sample Site RU-01: Ringling Series  
Landscape View**





**Sample Site DP-01: Nihill Series  
Landscape View**



**Sample Site 12-02: Relan Series**



**Sample Site 12-03: Blacksheep Series**



**Sample Site 12-04: Havre Series**



**Sample Site 12-07: Midway Series**

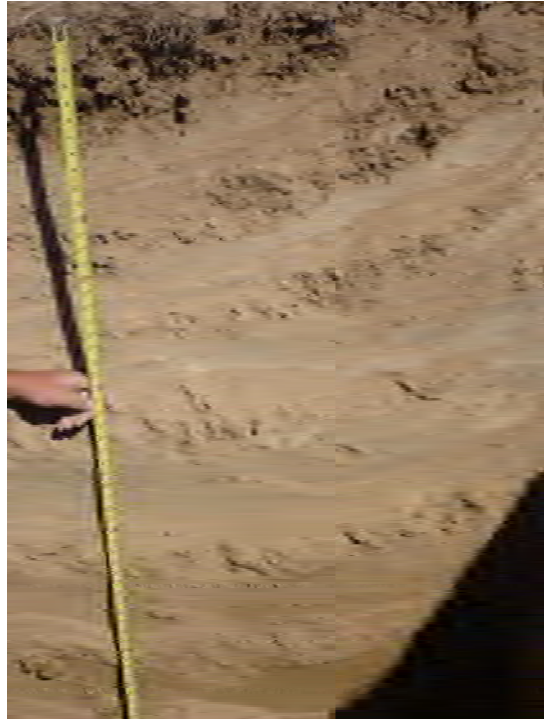




**Sample Site 12-09: Twilight Series**



**Sample Site SS 12-13: McRae Series  
Landscape View**



**Sample Site SS 12-13: McRae Series  
Pit View**



**Sample Site SS 12-14: Haverson Series  
Landscape View**





**Sample Site SS 12-14: Haverson Series  
Pit View**



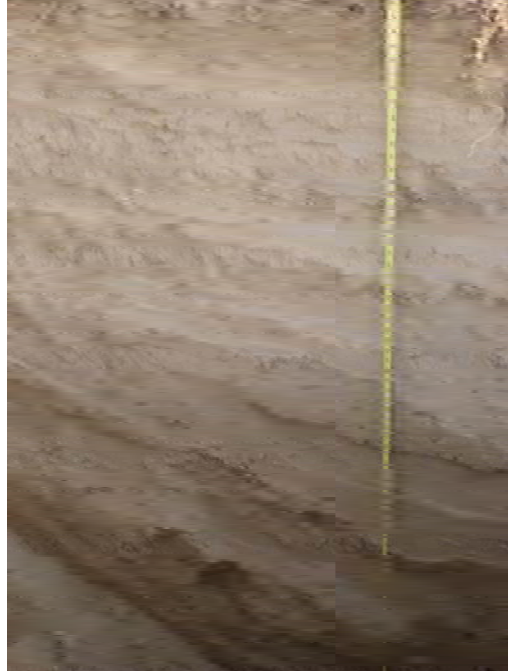
**Sample Site 12-17: McRaeSeries  
Landscape View**



**Sample Site 12-21: Farland Series  
Landscape View**



**Sample Site SS 12-22: McRae Series  
Landscape View**



**Sample Site SS 12-22: McRae Series  
Pit View**



**Sample Site 12-23: Relan Series  
Landscape View**





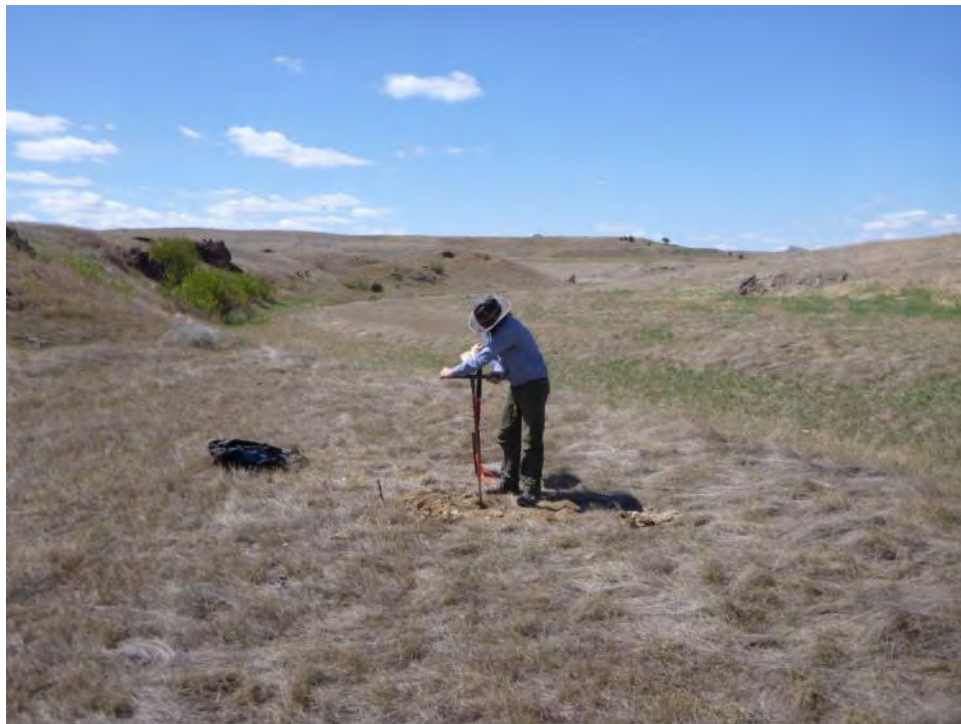
**Sample Site SS 12-24: Haverson Series  
Landscape View**



**Sample Site SS 12-24: Haverson Series  
Pit View**



**Sample Site SS 12-25: Heldt Series  
Landscape View**



**Sample Site 12-28: Nihill Series**





**Sample Site 12-29: Ringling Series  
Landscape View**



**Sample Site SS 12-31: Saline Overflow  
Landscape View**



**Sample Site SS 12-32: Saline Overflow  
Landscape View**



**Sample Site SS 12-35: Haverson Series  
Landscape View**



**Sample Site SS 12-36: Barvon Series  
Landscape View**



**Sample Site SS 12-36: Barvon Series  
Pit View**





**Sample Site SS 12-37: Haverson Series  
Landscape View**



**Sample Site SS 12-37: Haverson Series  
Pit View**

**APPENDIX D**  
**NRCS SOIL SERIES DESCRIPTIONS**



LOCATION ARVADA

WY+CO KS MT NE SD

Established Series  
MCS/JWW/CJH  
12/2003

## ARVADA SERIES

The Arvada series consists of very deep, well drained soils formed in alluvium and colluvium derived from sodic shale. Arvada soils are on alluvial fans, fan remnants, fan terraces and hillslopes. Slopes are 0 to 25 percent. The mean annual precipitation is about 12 inches, and the mean annual air temperature is about 46 degrees F.

**TAXONOMIC CLASS:** Fine, smectitic, mesic Ustertic Natrargids

**TYPICAL PEDON:** Arvada fine sandy loam-rangeland. (Colors are for dry soil unless otherwise stated)

**E**--0 to 4 inches; light gray (10YR 7/2) fine sandy loam, grayish brown (10YR 5/2) moist; moderate very thin platy structure parting to moderate very fine granular; soft, very friable, nonsticky and nonplastic; many fine and very fine roots; slightly alkaline (pH 7.8); abrupt smooth boundary. (0 to 8 inches thick)

**B<sub>tn</sub>**--4 to 14 inches; brown (10YR 5/3) clay, brown (10YR 4/3) moist; moderate medium columnar structure parting to moderate medium angular blocky; extremely hard, firm, sticky and very plastic; common medium roots; many prominent clay films on faces of peds and in root channels; very strongly alkaline (pH 9.2); ESP is 20 percent; clear smooth boundary. (3 to 14 inches thick)

**B<sub>tkn</sub>**--14 to 20 inches; brown (10YR 5/3) clay loam, brown (10YR 4/3) moist; weak medium subangular blocky structure; extremely hard, firm, sticky and very plastic; few faint clay films on faces of peds and in root channels; strongly effervescent, few fine segregations of calcium carbonate in thin seams and streaks; strongly alkaline (pH 9.0); 20 percent exchangeable sodium; gradual smooth boundary. (0 to 17 inches thick)

**B<sub>kny</sub>**--20 to 60 inches; light yellowish brown (2.5Y 6/3) clay loam, light olive brown (2.5Y 5/3) moist; massive; hard, friable, sticky and plastic; violently effervescent, common medium soft masses of calcium carbonate and gypsum as crystals in thin seams and as filaments or threads; strongly alkaline (pH 8.8); 20 percent exchangeable sodium.

**TYPE LOCATION:** Sheridan County, Wyoming; 650 feet south and 200 feet west of the northeast corner of sec. 29, T. 55 N., R. 78 W. 44 degrees 43 minutes 7 seconds north latitude and 106 degrees 15 minutes 54 seconds west longitude.

**RANGE IN CHARACTERISTICS:** Depth to effervescent material ranges from 0 to 19 inches. Depth to layers with greater than 15 percent exchangeable sodium is 4 to 10 inches. The depth to the base of the B<sub>t</sub> horizon is 15 inches or more. A thin A horizon occurs in some pedons. A light colored platy E horizon is generally present but is absent in some pedons. Gravel is typically less than 5 percent but ranges from 0 to 15 percent. The moisture control section is usually dry for 60 consecutive days during the 90 day period following the summer solstice. The mean annual soil temperature is 47 to 53 degrees F., and the soil temperature at a depth of 20 inches is 41 degrees F. or more for 175 to 195 days. The soil has an aridic moisture regime that borders on ustic.

The E and A horizons have hue of 10YR, 2.5Y or 5Y, value of 4 to 7, 4 or 5 moist, and chroma of 2 to 4.

Texture is fine sandy loam, loam, silt loam, clay loam or very fine sandy loam. Reaction ranges from neutral through strongly alkaline. EC ranges from 0 to 4 mmhos/cm.

The Btn horizon has hue of 7.5YR, 10YR, 2.5Y or 5Y, value of 4 to 6 dry, 4 or 5 moist, and chroma of 2 to 4. Texture is clay, clay loam, silty clay or silty clay loam and has 35 to 60 percent clay, 10 to 50 percent silt, and 5 to 45 percent sand. This horizon is strongly alkaline or very strongly alkaline (pH 8.8 to 10.0), has 15 to 34 percent exchangeable sodium, and an EC of 4 to 16 mmhos/cm. Some pedons when buffered by gypsum are moderately alkaline. The Btkn horizon, when present, has a calcium carbonate equivalent of 3 to 12 percent and an exchangeable sodium percent of 10 to 30. A thin Bt horizon is present above the Btn in some pedons. Some pedons have a Btkny horizon.

The Bkny horizon has hue of 7.5YR, 10YR or 2.5Y, value of 5 or 6 dry, 4 or 5 moist. Textures are clay, clay loam, silty clay or silty clay loam. Reaction ranges from strongly alkaline or very strongly alkaline (pH 8.6 to 10.0). This horizon contains 4 to 15 percent calcium carbonate equivalent. Some pedons when buffered by gypsum are moderately alkaline. Exchangeable sodium typically ranges from 10 to 30 percent but decreases with increasing depth. Electrical conductivity is 4 to 16 mmhos/cm. Some pedons have a C horizon.

Some pedons have a C horizon below 40 inches. It has properties similar to those of the Bkny horizon.

**COMPETING SERIES:** There are no competing series.

**GEOGRAPHIC SETTING:** The Arvada soils are on alluvial fans, fan remnants, terraces and hillslopes. The soils formed in moderately fine textured alluvium and colluvium derived from sedimentary rocks. Slopes range from 0 to 25 percent. Elevations range from 2,600 to 6,000 feet. The average annual precipitation is about 12 inches but ranges from 9 to 14 inches with about half the precipitation occurring during April, May, and early June. The mean annual air temperature is about 43 to 53 degrees F., and the mean summer temperature is 63 degrees F. The frost-free season is estimated to range from 100 to 160 days.

**GEOGRAPHICALLY ASSOCIATED SOILS:** These are the [Absted](#), [Bidman](#), [Parmleed](#), [Renohill](#) and [Ulm](#) soils. Absted soils have less than 15 percent sodium in the upper part of the argillic horizon. Bidman, Parmleed, Renohill and Ulm soils lack natric horizons.

**DRAINAGE AND PERMEABILITY:** Well drained; high or very high runoff; very slow permeability.

**USE AND VEGETATION:** Rangeland and wildlife habitat. Native vegetation is alkali sacaton, Gardner saltbush, western wheatgrass, and scattered greasewood.

**DISTRIBUTION AND EXTENT:** Eastern Wyoming, eastern Colorado and parts of adjacent states. The series is extensive.

**MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE:** Bismarck, North Dakota

**SERIES ESTABLISHED:** Sheridan County, Wyoming; 1932.

**REMARKS:** Diagnostic horizons and features recognized in this pedon are: Albic horizon - 0 to 4 inches (E)

Natric horizon - 4 to 20 inches (Btn, Btkn)

**SIR-** WY1130

**LRR-** G

U.S.A.

LOCATION BARVON

MT

Established Series

CJH

11/2002

## BARVON SERIES

The Barvon series consists of moderately deep, well drained soils that formed in residuum derived from weakly consolidated interbedded sandy and silty sedimentary beds and semiconsolidated shale. These soils are on sedimentary plains and hills. Slopes are 2 to 70 percent. Mean annual precipitation is about 14 inches, and mean annual air temperature is about 43 degrees F.

**TAXONOMIC CLASS:** Fine-loamy, mixed, superactive, frigid Entic Haplustolls

**TYPICAL PEDON:** Barvon loam, woodland. (Colors are for dry soil unless otherwise noted)

**Oi**--0 to 0.5 inch; pine needles, grass, twigs and leaves.

**Oe**--0.5 to 0.75 inch; decomposed pine needles, grasses and leaves mixed with mineral soil (Combined O horizons 0 to 2 inches thick)

**A1**--0.75 to 4.75 inches; dark grayish brown (10YR 4/2) loam, very dark grayish brown (10YR 3/2) moist; weak fine granular structure; soft, friable, slightly sticky and nonplastic; many very fine roots; many krotovinas; soil mass noncalcareous, but some pebbles lime-coated on lower sides; less than 1 percent pebbles; neutral (pH 7.0); clear smooth boundary.

**A2**--4.75 to 14.75 inches; grayish brown (10YR 5/2) and brown (10YR 5/3) loam, very dark grayish brown (10YR 3/2) moist; weak medium subangular blocky structure; soft, very friable, sticky and slightly plastic; common very fine roots; many very fine and common fine tubular pores; many large krotovinas; few fine masses of lime; slightly effervescent; some pebbles lime coated on lower sides; less than 1 percent pebbles; slightly alkaline (pH 7.6); clear wavy boundary. (Combined A horizons 7 to 16 inches thick)

**Bk1**--14.75 to 24.75 inches; pale brown (10YR 6/3) light clay loam, brown (10YR 4/3) moist; weak medium subangular blocky structure; slightly hard, friable, sticky and plastic; few very fine and medium roots; common fine and medium tubular pores; many large krotovinas; strongly effervescent; common seams and threads of segregated lime; moderately alkaline (pH 8.2); gradual wavy boundary.

**Bk2**--24.75 to 34.75 inches; light yellowish brown (2.5Y 6/4) clay loam, light olive brown (2.5Y 5/4) moist; massive; slightly hard, friable, sticky and slightly plastic; few very fine roots; common fine and medium tubular pores; strongly effervescent; common seams and threads of segregated lime; moderately alkaline (pH 8.2); gradual wavy boundary. (Combined Bk horizons 12 to 24 inches thick)

**Cr1**--34.75 to 42.75 inches; light gray (5Y 7/2) weakly consolidated sandy sedimentary beds, light olive gray (5Y 6/2) moist; few very fine roots along fracture planes; strongly effervescent; moderately alkaline (pH 8.2); clear boundary.

**Cr2**--42.75 to 60 inches; stratified weakly consolidated silty sedimentary beds and semi-consolidated shale.

**TYPE LOCATION:** Powder River County, Montana; NE 1/4 of sec. 17, T. 3 S., R. 47 E.

**RANGE IN CHARACTERISTICS:**

Soil temperature - 42 to 47 degrees F.

Mollic epipedon thickness - 7 to 16 inches.

Control section - 20 to 30 percent clay and 0 to 10 percent flat angular pebbles.

Depth to bedrock - 20 to 40 inches.

Depth to K horizon - 7 to 16 inches.

**A horizon:**

Hue: 10YR

Value: 4 or 5 dry; 2 or 3 moist

Chroma: 2 or 3

Texture, less than 2 mm: loam or silt loam

Clay content: 20 to 27 percent

Rock fragments: 0 to 5 percent pebbles

Reaction: pH 6.6 to 7.8

Some pedons have a light colored Bw horizon in place of the A2 horizon. When present it extends to a depth of less than 10 inches.

**Bk horizons:**

Hue: 10YR or 2.5Y

Value: 5 to 7 dry; 4 to 6 moist

Chroma: 2 to 4

Texture, less than 2 mm: loam or clay loam

Clay content: 20 to 30 percent

Rock fragments: 0 to 10 percent flat angular pebbles

Calcium Carbonate Equivalent: 5 to 15 percent

Reaction: pH 7.4 to 8.4

**Cr horizon:**

Hue: 10YR, 2.5Y or 5Y

Value: 6 to 8 dry; 5 or 6 moist

Chroma: 2 to 6

Texture, less than 2 mm: weakly consolidated sandy or silty sedimentary beds or semi-consolidated shale that texture to loamy fine sand to light silty clay

**COMPETING SERIES:** There are the [Coulterg](#), [Mavreeso](#) and [Rottulee](#) series.

Coulterg: do not have a paralithic contact at depths of 20 to 40 inches.

Mavreeso: have hue of 7.5YR or redder.

Rottulee: have limestone bedrock at 20 to 40 inches.

**GEOGRAPHIC SETTING:**

Landform - sedimentary plains and hills.

Elevation - 2,300 to 4,500 feet.

**Slope-** 2 to 70 percent.



Parent material - residuum derived from weakly consolidated sandy and silty sedimentary beds and semiconsolidated shale.

Climate - long, cold winters; moist springs; and warm summers.

Mean annual precipitation - 12 to 20 inches.

Mean annual air temperature - 40 to 45 degrees F.

Frost-free period - 100 to 135 days.

**GEOGRAPHICALLY ASSOCIATED SOILS:** These are the [Arnegard](#), [Bitton](#), [Cabba](#), [Campspass](#), [Farland](#), [Lamedeer](#) and [Ringling](#) soils. Arnegard soils occur at the base of slopes or in beds of drainage valleys and have a mollic epipedon 20 inches or more thick. Bitton and Lamedeer sils have a loamy-skeletal particle-size control section and lack a Cr horizon. Cabba soils lack a mollic epipedon and have weakly consolidated sedimentary beds at depths of less than 20 inches. Campspass soils have an argillic horizon with more than 35 percent clay. Farland soils lack a Cr horizon and have an argillic horizon. Ringling soils have fragmental material at depths of less than 20 inches.

**DRAINAGE AND PERMEABILITY:** Well drained; moderate permeability.

**USE AND VEGETATION:** Barvon soils are used mainly for woodland. Potential native vegetation is mainly ponderosa pine with a canopy cover of 30 to 50 percent. The understory is mainly bluebunch wheatgrass, Idaho fescue, common snowberry, common chokecherry and Oregon-grape.

**DISTRIBUTION AND EXTENT:** Barvon soils are of moderate extent in southeastern Montana.

**MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE:** Bismarck, North Dakota

**SERIES ESTABLISHED:** Powder River County (Powder River Area), Montana, 1972.

**REMARKS:** Soil Interpretations Record: MT0260, MT1135.

Diagnostic horizons and features recognized in this pedon are: mollic epipedon - from the mineral soil surface to 14 inches (A1 and A2 horizons); horizons of secondary carbonate accumulation - from 143/4 to 343/4 inches (Bk1 and Bk2 horizons); a paralithic contact at 343/4 inches (Cr horizon); particle-size control section - from 103/4 to 343/4 inches.

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National Cooperative Soil Survey  
U.S.A.

LOCATION BLACKSHEEP MT

Established Series  
SGV-CJH  
04/2003

## BLACKSHEEP SERIES

The Blacksheep series consists of shallow, well drained soils that formed in residuum, alluvium or colluvium from sandstone. Blacksheep soils are on sedimentary plains, ridges, escarpments and hills. The mean annual precipitation is about 13 inches, and the mean annual air temperature is about 44 degrees F. Slopes are 2 to 50 percent.

**TAXONOMIC CLASS:** Loamy, mixed, superactive, calcareous, frigid, shallow Aridic Ustorthents

**TYPICAL PEDON:** Blacksheep fine sandy loam, in rangeland. (Colors are for dry soil unless otherwise noted)

**A**--0 to 6 inches; brown (10YR 5/3) fine sandy loam, brown (10YR 4/3) moist; weak medium granular structure; soft, very friable, nonsticky and nonplastic; common fine and very fine roots; common very fine tubular pores; slightly alkaline (pH 7.4); clear smooth boundary. (3 to 6 inches thick)

**Bk**--6 to 16 inches; light gray (2.5Y 7/2) very fine sandy loam, grayish brown (2.5Y 5/2) moist; weak medium prismatic structure parting to weak fine subangular blocky; soft, very friable, nonsticky and nonplastic; common very fine and fine roots; common very fine and few fine tubular pores; few medium masses of lime; violently effervescent; moderately alkaline (pH 8.4); clear smooth boundary. (5 to 14 inches thick)

**Cr**--16 to 60 inches; light gray (10YR 7/2) semiconsolidated sandstone; strongly effervescent; moderately alkaline (pH 8.2).

**TYPE LOCATION:** Custer County, Montana; 1,500 feet north and 1,200 feet east of the SW corner of sec. 32, T. 2 N., R. 46 E.

### **RANGE IN CHARACTERISTICS:**

Soil temperature - 43 to 47 degrees F.

Moisture control section - between 8 inches and the paralithic contact; dry in all parts between four-tenths and five-tenths of the cumulative days per year when the soil temperature at a depth of 20 inches is 41 degrees F. or higher.

A horizon - Hue: 2.5Y, 7.5YR or 10YR

Value: 5, 6 or 7 dry; 4 or 5 moist

Chroma: 2 to 4

Texture: fine sandy loam, sandy loam or very fine sandy loam

Clay content: 5 to 15 percent

Rock fragments: 0 to 35 percent; 0 to 15 percent cobbles, and 0 to 20 percent pebbles

Reaction: pH 7.4 to 8.4

Bk horizon - Hue: 2.5Y, 7.5YR or 10YR

Value: 5, 6 or 7 dry; 4 to 6 moist

Chroma: 2, 3 or 4

Texture: very fine sandy loam, fine sandy loam or sandy loam

Clay content: 5 to 18 percent

Rock fragments: 0 to 35 percent; 0 to 15 percent cobbles, and 0 to 20 percent pebbles

Calcium carbonate equivalent: 5 to 10 percent

Reaction: pH 7.4 to 9.0

### **COMPETING SERIES:**

[Cabbart](#) (MT) - has more than 18 percent clay in the particle-size control section; formed in materials derived from silt and loam bedrock.

### **GEOGRAPHIC SETTING:**

Landform - sedimentary plains, ridges, escarpments and hills.

Elevation - 2,000 to 6,200 feet.

**Slope**- 2 to 50 percent.

Parent material - residuum or colluvium from sandstone.

Climate - long, cold winters; moist springs; warm summers.

Mean annual precipitation - 10 to 16 inches.

Mean annual air temperature - 39 to 45 degrees F.

Frost-free period - 95 to 135 days.

**GEOGRAPHICALLY ASSOCIATED SOILS:** These are the competing [Cabbart](#) soils on similar landscape positions.

**DRAINAGE AND PERMEABILITY:** Well drained; moderately rapid permeability. Runoff is very low to medium depending on slope.

**USE AND VEGETATION:** Blacksheep soils are used mainly for rangeland, with limited use as forest land. Potential native vegetation is mainly Wyoming big sagebrush, bluebunch wheatgrass, needleandthread, Sandberg bluegrass, Indian ricegrass, threadleaf sedge, and fringed sagewort. Forest vegetation is mainly ponderosa pine. Dense stands are mainly on north slopes but trees can occur on all aspects.

**DISTRIBUTION AND EXTENT:** Blacksheep soils are of large extent on the sedimentary uplands of eastern and central Montana, and northeastern Wyoming.

**MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE:** Bismarck, North Dakota

**SERIES ESTABLISHED:** Hill County, Montana, 1994.

**REMARKS:** Soil interpretation record: MT1470, MT1612.

Diagnostic horizons and features recognized in this pedon are: ochric epipedon - the zone from the soil surface of the soil to a depth of 7 inches (after mixing) (A and Bk horizon); horizon of calcium carbonate accumulation - the zone from 6 to 16 inches (Bk horizon); particle-size control section - the zone from 10 to 16 inches (Bk horizon); paralithic contact of sandstone - at 16 inches (Cr horizon).

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National Cooperative Soil Survey  
U.S.A.

LOCATION CABBA

MT+ND SD UT

Established Series  
Rev. NRS-JAL-CJH  
2/97

## CABBA SERIES

The Cabba series consists of shallow, well drained soils that formed in residuum or colluvium derived from semiconsolidated, loamy sedimentary beds. These soils are on hills, escarpments, and sedimentary plains. Slopes are 2 to 70 percent. Mean annual precipitation is about 16 inches, and mean annual air temperature is about 43 degrees F.

**TAXONOMIC CLASS:** Loamy, mixed, superactive, calcareous, frigid, shallow Typic Ustorthents

**TYPICAL PEDON:** Cabba loam in rangeland. (Colors are for dry soil unless otherwise noted)

**A**--0 to 3 inches; grayish brown (2.5Y 5/2) loam, dark grayish brown (2.5Y 4/2) moist; moderate fine granular structure; soft, very friable, slightly sticky and slightly plastic; many very fine and fine roots; slightly effervescent; slightly alkaline (pH 7.6); clear smooth boundary. (3 to 4 inches thick)

**Bk1**--3 to 8 inches; light brownish gray (2.5Y 6/2) loam, dark grayish brown (2.5Y 4/2) moist; weak fine and medium subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; many very fine and fine roots; many very fine pores; common fine masses of lime; strongly effervescent; slightly alkaline (pH 7.8); clear wavy boundary.

**Bk2**--8 to 15 inches; pale brown (10YR 6/3) clay loam, brown (10YR 5/3) moist; strong thin platy structure; hard, friable, slightly sticky and slightly plastic; common very fine and fine roots; common very fine pores; common fine masses of lime; strongly effervescent; moderately alkaline; (pH 8.0); clear wavy boundary. (Combined Bk horizons 7 to 18 inches thick)

**Cr**--15 to 60 inches; pale brown (10YR 6/3) semiconsolidated sedimentary beds consisting of interbedded sandstone and shale, brown (10YR 5/3) moist; few very fine and fine roots in vertical cracks in upper part; strongly effervescent; moderately alkaline (pH 8.2).

**TYPE LOCATION:** Chouteau County, Montana; 2,100 feet north and 1,000 feet east of the SW corner of sec. 15, T. 21 N., R. 9 E.

### **RANGE IN CHARACTERISTICS:**

Soil temperature - 41 to 47 degrees F.

Moisture control section - between 4 to 12 inches or to the paralithic contact.

Rock fragments - 0 to 35 percent in the particle-size control section.

Particle-size control section - 20 to 35 percent clay, 0 to 35 rock fragments.

Individual horizons may have as much as 45 percent rock fragments with less than 15 percent lithic fragments.



Depth to Cr horizon - 10 to 20 inches.

The chromas of 1 are lithochromic.

Soil phases - stony, gravelly; PE greater than 31. The hard rock fragments in the stony and gravelly phases are mainly surficial deposits.

A horizon - Hue: 10YR or 2.5Y

Value: 3, 4, 5, or 6 dry; 3 or 4 moist

Chroma: 1, 2, 3, or 4

Texture: fine sandy loam, loam, silt loam, clay loam, or silty clay loam

Clay content: 10 to 35 percent

Rock fragments: 0 to 60 percent--0 to 40 percent stones, cobbles, boulders; 0 to 30 percent pebbles or channers

Rock fragments, surface cover: 0.01 to 0.1 percent stones

**EC:** 0 to 4 mmhos/cm

Effervescence: none to violently

Calcium carbonate equivalent: 0 to 10 percent

Reaction: pH 6.6 to 9.0

Bk horizons - Hue: 10YR, 2.5Y, or 5Y

Value: 5, 6, 7, or 8 dry; 4, 5, 6, or 7 moist

Chroma; 1, 2, 3, 4, or 6

Texture: loam, silt loam, clay loam, or silty clay loam

Clay content: 18 to 35 percent

Structure: massive thin platy, subangular blocky or prismatic

Rock fragments: 0 to 35 percent--0 to 5 percent cobbles, 0 to 30 percent pebbles or channers

Calcium carbonate equivalent: 2 to 15 percent

**EC:** 0 to 8 mmhos/cm

Reaction: pH 7.4 to 9.0

Effervescence: slight to violently

Cr horizon: This horizon consists of interbedded layers of silt, sand, and clay or a mixture of the three. They crush to loam, silt loam, very fine sandy loam, clay loam, or silty clay loam. Some layers are harder than others, but all are considered rippable or soft and are readily dug with power tools.

Reaction: pH 7.4 to 8.4

**COMPETING SERIES:**

[Abac](#) (MT) - has hues of 5YR and redder.

[Cohagen](#) (ND) - has a coarse-loamy particle-size control section.

[Wiggler](#) (UT) - has its precipitation evenly distributed throughout the year; moisture control section is not frozen during winter and is dry in some part for 60 to 75 days in winter; does not have accumulation of secondary carbonates.

**GEOGRAPHIC SETTING:**

Landform - sedimentary plains; escarpments; hills.

Elevation - 1,600 to 6,800 feet.

**Slope**- 2 to 70 percent.

Parent material - formed in residuum from semiconsolidated loamy sedimentary beds or in colluvium over the beds.

Climate - cool with long, cold winters; moist springs; warm, dry summers.

Mean annual precipitation - 12 to 19 inches. Some areas receive less than 14 inches of precipitation and have cooler temperatures and lower evaporation.

Mean annual air temperature - 37 to 45 degrees F.

Frost-free period - 70 to 135 days.

**DRAINAGE AND PERMEABILITY:** Well drained. Moderate permeability. Runoff is very low to high depending on slope.

**USE AND VEGETATION:** Used as rangeland. The potential native vegetation is mainly little bluestem, western wheatgrass, needleandthread, prairie sandreed, bluebunch wheatgrass, green needlegrass, plains muhly, forbs, and shrubs.

**DISTRIBUTION AND EXTENT:** Widely distributed in central and eastern Montana and in western North Dakota. Cabba soils are of moderate extent.

**MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE:** Bismarck, North Dakota

**SERIES ESTABLISHED:** Granite County, Montana, 1969.

**REMARKS:** Soil interpretation records: MT0048, MT0253, MT0254, MT0463, MT0686.

Diagnostic horizons and features recognized in this pedon are: ochric epipedon - the zone from the soil surface of the soil to a depth of 7 inches (A and Bk1 horizons); particle size-control section - the zone from 10 to 15 inches (Bk2 horizon); paralithic contact - at a depth of 15 inches (Cr horizon). Cabba soils have a frigid temperature regime and an ustic moisture regime.

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National Cooperative Soil Survey  
U.S.A.

LOCATION CABBART

MT+ND SD

Established Series

CJH

04/2002

# CABBART SERIES

The Cabbart series consists of shallow, well drained soils that formed in material derived from semiconsolidated loamy sedimentary beds at depths of 10 to 20 inches. These soils are on hills, ridges, escarpments, and sedimentary plains. Slopes are 2 to 75 percent. Mean annual precipitation is about 12 inches, and mean annual air temperature is about 43 degrees F.

**TAXONOMIC CLASS:** Loamy, mixed, superactive, calcareous, frigid, shallow Aridic Ustorthents

**TYPICAL PEDON:** Cabbart loam, grassland. (Colors are for dry soil unless otherwise noted)

**A**--0 to 3 inches; light brownish gray (2.5Y 6/2) loam, dark grayish brown (2.5Y 4/2) moist; weak fine granular structure; slightly hard, very friable, slightly sticky and slightly plastic; many fine roots and pores; strongly effervescent; moderately alkaline (pH 8.4); clear wavy boundary. (1 to 4 inches thick)

**Bk1**--3 to 7 inches; light brownish gray (2.5Y 6/2) loam, grayish brown (2.5Y 5/2) moist; weak medium prismatic structure; hard, very friable, slightly sticky and slightly plastic; many fine roots and pores; few fine masses of lime; strongly effervescent; moderately alkaline (pH 8.4); clear wavy boundary.

**Bk2**--7 to 16 inches; pale yellow (2.5Y 7/4) loam, light yellowish brown (2.5Y 6/4) moist; weak coarse prismatic structure; hard, very friable, slightly sticky and slightly plastic; many fine roots and pores; common fine masses of lime; strongly effervescent; moderately alkaline (8.4); clear wavy boundary. (Combined Bk horizons 9 to 18 inches thick)

**BC**--16 to 18 inches; pale yellow (2.5Y 7/4) loam, light yellowish brown (2.5Y 6/4) moist; weak coarse prismatic structure; very hard, friable, slightly sticky and slightly plastic; many fine roots and pores; disseminated lime; strongly effervescent; moderately alkaline (pH 8.4); clear wavy boundary. (0 to 8 inches thick)

**Cr**--18 to 60 inches; pale yellow (5Y 7/4) semiconsolidated loamy sedimentary beds that crush to loam; few widely spaced vertical cracks in upper 4 to 6 inches with roots; root mat at contact of beds.

**TYPE LOCATION:** Cascade County, Montana; about 2,450 feet east and 1,200 feet north of SW corner of sec. 7, T. 20 N., R. 3 W.

## RANGE IN CHARACTERISTICS:

Soil temperature - 42 to 47 degrees F. Allow soil temperature to range to 42 degrees F in MLRA 44.

Moisture control section - between 4 to 12 inches or to the paralithic contact; dry in all parts between four-tenths and five-tenths of the cumulative days per year when the soil temperature at a depth of 20 inches is 41 degrees F.

Depth to Cr horizon - 10 to 20 inches.

A C horizon is allowed; individual soil horizons may have up to 45 percent coarse fragments with only 15 percent lithic fragments.

Soil phases - gravelly; PE less than 31; south; moist; high ppt; cool.

A horizon - Hue: 10YR, 2.5Y, or 5Y

Value: 5, 6, or 7 dry; 3, 4, or 5 moist

Chroma: 2, 3, or 4

Texture: loam, silt loam, clay loam, very fine sandy loam, fine sandy loam, sandy loam

Clay content: 10 to 35 percent

Rock fragments: 0 to 60 percent hard fragments--0 to 20 percent cobbles, 0 to 50 percent pebbles

Electrical Conductivity: 0 to 4 mmhos/cm

Calcium carbonate equivalent: 1 to 10 percent

Reaction: pH 7.4 to 9.0

Bk horizons - Hue: 10YR, 2.5Y, or 5Y

Value: 5, 6, 7, or 8 dry; 3, 4, 5, or 6 moist

Chroma: 2, 3, or 4

Texture: loam, clay loam, silt loam, silty clay loam

Clay content: 18 to 35 percent

Structure: massive, prismatic, or blocky

Rock fragments: 0 to 45 percent--0 to 15 percent hard pebbles, 0 to 45 percent soft pebbles

Electrical conductivity: 0 to 8 mmhos/cm

**SAR:** 0 to 10

Calcium carbonate equivalent: 5 to 25 percent

Reaction: pH 7.4 to 9.0

BC horizon - Hue: 10YR, 2.5Y, or 5Y

Value: 5, 6, 7, or 8 dry; 4, 5, or 6 moist

Chroma: 3 or 4

Texture: loam, clay loam, silt loam, silty clay loam

Clay content: 18 to 35 percent



Rock fragments: 0 to 45 percent--0 to 15 percent hard pebbles; 0 to 45 percent soft pebbles

Electrical conductivity: 0 to 8 mmhos/cm

**SAR:** 0 to 10

Gypsum: 0 to 5 percent

Calcium carbonate equivalent: 5 to 25 percent

Reaction: pH 7.4 to 9.0

**COMPETING SERIES:**

[Blacksheep](#) (MT) - has less than 18 percent clay in the particle-size control section; formed in materials derived from sandstone bedrock.

**GEOGRAPHIC SETTING:**

Landform - hills; escarpments; ridges; sedimentary plains; strath terraces.

Elevations - 1,900 to 5,400 feet. Allow elevation to range to 6500 feet in MLRA 44.

**Slopes-** 2 to 75 percent.

Parent material - materials derived from semiconsolidated loamy sedimentary beds of Cretaceous and/or Tertiary age.

Climate - long, cold winters; moist springs; warm summers.

Mean annual precipitation - 10 to 16 inches of which approximately three-quarters falls during the growing season.

Mean annual air temperature - 39 to 45 degrees F. Allow MAAT to range to 38 degrees F in MLRA 44.

Frost-free period - 95 to 135 days. Allow frost-free period to range to 90 days in MLRA 44.

**GEOGRAPHICALLY ASSOCIATED SOILS:** These are the Arikara, Cambeth, Lonna, and Yawdim soils. Delpoint and Cambeth soils are on slideslopes below the Cabbart. They have soft bedrock at depths of 20 to 40 inches. The Arikara and Lonna soils are very deep. Arikara soils are on side slopes and Lonna soils are on fans. Yawdim soils are found on similar landscapes as Cabbart soils. They are fine textured.

**DRAINAGE AND PERMEABILITY:** Well drained; moderate permeability.

**USE AND VEGETATION:** Mainly in range, but small areas are farmed to small grains. The potential native vegetation is western wheatgrass, bluebunch wheatgrass, green needlegrass, plains reedgrass, little bluestem, needleandthread, blue grama, dryland sedges, and forbs. Some area have low density stands of ponderosa pine and Rocky Mountain juniper.

**DISTRIBUTION AND EXTENT:** Eastern Montana and western North Dakota. The series is extensive.

**MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE:** Bismarck, North Dakota

**SERIES ESTABLISHED:** Cascade County, Montana, 1969.

**REMARKS:** Soil interpretation records: MT0050, MT0870, MT7008.

Diagnostic horizons and features recognized in this pedon are: ochric epipedon - the zone from the surface of the soil to a depth of 7 inches (A and Bk1 horizons); lime accumulation - the zone from 3 to 16 inches (Bk1 and Bk2 horizons); paralithic contact - at 18 inches (Cr horizon); particle-size control section - the zone from 10 to 18 inches (Bk2 and BC horizons). Cabbart soils have an ustic moisture regime bordering on aridic.

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National Cooperative Soil Survey  
U.S.A.

LOCATION CUSHMAN

WY+MT SD

Established Series  
CAP/GFK/CJH  
05/2002

## CUSHMAN SERIES

The Cushman series consists of well drained soils that are moderately deep to bedrock. These soils formed in slopewash alluvium and residuum from interbedded shales and siltstone and fine-grained argillaceous sandstone. Cushman soils are on buttes, fan remnants, hills, piedmonts, ridges and terraces. Slopes are 0 to 20 percent. The mean annual precipitation is about 13 inches, and the mean annual air temperature is about 45 degrees F.

**TAXONOMIC CLASS:** Fine-loamy, mixed, superactive, mesic Ustic Haplargids

**TYPICAL PEDON:** Cushman very fine sandy loam-on south facing slope of about 3 percent under native grass vegetation. (Colors are for dry soil unless otherwise stated)

**A**--0 to 2 inches; light brownish gray (10YR 6/2) very fine sandy loam, dark brown (10YR 3/3) moist; moderate medium granular structure; soft, friable, slightly sticky and slightly plastic; common very fine, fine, and few medium roots; slightly alkaline (pH 7.6); clear smooth boundary. (2 to 6 inches thick)

**Bt1**--2 to 8 inches; brown (10YR 5/3) clay loam, dark yellowish brown (10YR 3/4) moist; weak medium prismatic structure parting to moderate medium subangular blocky; slightly hard, friable, moderately sticky and moderately plastic; common very fine, fine and few medium roots; few faint clay films on faces of peds and lining pores; moderately alkaline (pH 7.9); clear smooth boundary.

**Bt2**--8 to 14 inches; yellowish brown (10YR 5/4) clay loam, dark yellowish brown (10YR 4/4) moist; moderate coarse prismatic structure parting to strong medium angular blocky; hard, firm, moderately sticky and moderately plastic; few fine, medium and coarse roots; common distinct clay films on faces of peds, lining pores and root channels; slightly alkaline (pH 7.8); clear wavy boundary. (Combined Bt horizons 8 to 20 inches thick)

**Btk**--14 to 21 inches; pale brown (10YR 6/3) clay loam, yellowish brown (10YR 5/4) moist; moderate coarse prismatic structure parting to moderate fine and very fine subangular blocky; hard, firm, moderately sticky and moderately plastic; few fine roots; few faint clay films on faces of peds; strongly effervescent; calcium carbonate on faces of peds and in pores as common distinct irregularly shaped filaments and masses; moderately alkaline (pH 8.2); clear smooth boundary. (0 to 11 inches thick)

**Bk**--21 to 32 inches; very pale brown (10YR 8/2) loam, pale brown (10YR 6/3) moist; weak coarse subangular blocky structure; slightly hard, friable, moderately sticky and moderately plastic; violently effervescent; calcium carbonate as common prominent irregularly shaped, masses and many fine filaments; moderately alkaline (pH 8.4); clear smooth boundary. (7 to 15 inches thick)

**Cr**--32 to 60 inches; soft, thickly stratified gray and brown calcareous shale; reaction of crushed fragments strongly alkaline; these shales extend to depths greater than 10 feet.

**TYPE LOCATION:** Sheridan County, Wyoming; SE1/4, NE1/4 of sec. 2, T. 57 N., R. 84 W. 44 degrees 56 minutes 53 seconds north latitude and 106 degrees 56 minutes 52 seconds west longitude.

**RANGE IN CHARACTERISTICS:** Depth to a paralithic contact and bedrock is typically about 28 to 32 inches but ranges from 20 to 40 inches. Depth to continuous horizons of carbonate accumulation is 7 to 26 inches. Depth to the base of the argillic horizon ranges from 10 to 26 inches. Rock fragments range from 0 to 15 percent and are soft shale channers or semirounded sandstone pebbles. The soil is dry in the moisture control section more than half the time cumulative that the soil temperature at a depth of 20 inches is 41 degrees F., which occurs about April 21-27, and is dry in all parts of the moisture control section for at least 60 consecutive days from July 15 to October 25 and for at least 90 cumulative days during this period. The mean annual soil temperature is 47 to 53 degrees F., and the soil temperature at a depth of 20 inches is 41 degrees F. or more for 175 to 192 days. EC ranges from 0 to 2 mmhos throughout.

The A horizon has hue of 10YR or 2.5Y, value of 4 to 6 dry, 3 to 5 moist, and chroma of 2 to 4. Reaction is neutral or slightly alkaline.

The Bt horizon has hue of 10YR or 2.5Y, value of 4 to 6 dry, 3 to 5 moist, and chroma of 2 to 4. Texture of the Bt is clay loam or loam with 20 to 35 percent clay and more than 15 percent but less than 35 percent fine sand or coarser. Reaction is neutral to moderately alkaline.

The Btk horizon has hue of 10YR or 2.5Y, value of 5 to 7 dry, 4 to 6 moist, and chroma of 2 to 4. Texture is loam or clay loam with 20 to 35 percent clay. Reaction is moderately alkaline or strongly alkaline. Calcium carbonate ranges from 3 to 12 percent.

The Bk horizon has hue of 10YR and 2.5Y, value of 6 to 8 dry, 4 to 6 moist, and chroma of 2 to 4. Texture is loam or clay loam with 20 to 30 percent total clay of which about 2 to 4 percent is carbonate clay. Reaction is typically moderately alkaline but may be strongly alkaline when sodic shales are present. Calcium carbonate equivalent is 5 to 15 percent, but some horizons may exceed 15 percent but are discontinuous or too thin to be considered as a calcic.

The Cr is weakly consolidated sedimentary rock. It is primarily calcareous shale; but siltstone or thinly interbedded fine grained argillaceous sandstone is common. The rock is typically moderately alkaline or strongly alkaline when crushed, but slightly alkaline or neutral shales are not uncommon.

**COMPETING SERIES:** These are the [Balon](#), [Blancot](#), [Bowbac](#), [Buckle](#), [Cambria](#), [Cerrillos](#), [Decolney](#), [Doakum](#), [Forkwood](#), [Gapmesa](#), [Hagerman](#), [Hagerwest](#), [Los Alamos](#), [Mentmore](#), [Oelop](#), [Olney](#), [Palacid](#), [Penistaja](#), [Pokeman](#), [Potts](#), [Pugsley](#), [Quagwa](#), [Redpen](#), [Spangler](#), [Spenlo](#), [Sundance](#) and [Teckla](#) series. It is assumed the [Gaddes](#) and [Yenlo](#) are competing pending an update of the classification. Balon, Blancot, Buckle, Cambria, Cerrillos, Decolney, Doakum, Forkwood, Los Alamos, Mentmore, Oelop, Olney, Palacid, Penistaja, Potts, Quagwa, Redpen, Spenlo, Sundance, Teckla and Yenlo soils are deeper than 40 inches to any bedrock. Gaddes, Gapmesa, Hagerman, Hagerwest and [Progresso](#) soils have lithic contacts between 20 and 40 inches. Bowbac and Pugsley soils have more than 35 percent fine sand or coarser in the particle-size control section. Pugsley soils are also noncalcareous throughout. Pokeman soils have redder hue and have a paralithic contact to gypsum or alabaster at 20 to 40 inches. Spangler soils are noncalcareous throughout and lack a Bk horizon.

**GEOGRAPHIC SETTING:** Cushman soils are on buttes, fan remnants fan piedmonts, hills and ridges. Slopes range from 0 to 20 percent. The soils formed in moderately fine textured slopewash alluvium and residuum. Surface erosion is common in overgrazed areas, and some thin eolian deposits overlie these soils in some areas. Elevations are 3,500 to 6,000 feet. The mean annual precipitation is 13 inches and ranges from 10 to 14 inches with over half of the annual precipitation falling in April, May, and June and less than one inch falling in each month of July, August, September and October. The mean annual temperature is 43 to 51 degrees F. The frost-free season is about 105 to 130 days depending upon elevation, aspect, and air drainage.

**GEOGRAPHICALLY ASSOCIATED SOILS:** These are the competing [Bowbac](#), [Cambria](#) and [Forkwood](#)

soils and the [Absted](#), [Hiland](#), [Shingle](#) and [Theedle](#) soils. Absted soils have natric horizons. Hiland soils have more than 35 percent fine sand and coarser in the particle-size control section. Shingle soils are shallow and Theedle soils do not have an argillic horizon.

**DRAINAGE AND PERMEABILITY:** Well drained; medium runoff; moderate permeability.

**USE AND VEGETATION:** Rangeland and wildlife habitat. Native vegetation is variable but western wheatgrass, needleandthread, big sagebrush, and blue grama are typical.

**DISTRIBUTION AND EXTENT:** Central and northern Wyoming and northeastern Colorado. The series is extensive.

**MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE:** Bismarck, North Dakota

**SERIES ESTABLISHED:** Big Horn County, Montana; 1941.

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

Ochric epipedon - 0 to 2 inches (A)

Argillic horizon - 2 to 21 inches (Bt1,Bt2,Btk)

Paralithic contact - 32 inches (Cr)

**SIR-** WY1136

**LRR-** G

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National Cooperative Soil Survey  
U.S.A.



LOCATION DELPOINT

MT+WY

Established Series

CJH-GFB

04/2002

## DELPOINT SERIES

The Delpoint series consists of moderately deep, well drained soils that formed in alluvium, colluvium, or residuum derived from semiconsolidated loamy sedimentary beds or in till over the sedimentary beds. These soils are on sedimentary plains, hills, ridges, strath terraces or escarpments. Slopes are 0 to 70 percent. Mean annual precipitation is about 12 inches and mean annual air temperature is about 42 degrees F.

**TAXONOMIC CLASS:** Fine-loamy, mixed, superactive, frigid Aridic Haplustepts

**TYPICAL PEDON:** Delpoint loam, in grassland. (Colors are for dry soil unless otherwise noted)

**A**--0 to 3 inches; grayish brown (10YR 5/2) loam, dark grayish brown (2.5Y 4/2) moist; moderate very thin platy structure parting to weak very fine granular; slightly hard, very friable, sticky and plastic; many fine and very fine roots; many fine pores; slightly effervescent; moderately alkaline (pH 8.0); clear smooth boundary. (2 to 5 inches thick)

**Bw**--3 to 17 inches; light brownish gray (2.5Y 6/2) loam, grayish brown (2.5Y 5/2) moist; weak coarse prismatic structure parting to moderate medium blocky; hard, very friable, sticky and plastic; many fine and very fine roots; many fine and very fine pores; slightly effervescent; moderately alkaline (pH 8.2); clear wavy boundary. (6 to 15 inches thick)

**Bk**--17 to 28 inches; light gray (2.5Y 7/2) loam, grayish brown (2.5Y 5/2) moist; weak coarse prismatic structure; hard, very friable, sticky and plastic; common fine and very fine roots; many fine and very fine pores; strongly effervescent; disseminated lime; common fine masses and threads of lime; strongly alkaline (pH 8.5); gradual wavy boundary. (10 to 20 inches thick)

**Cr**--28 to 60 inches; light gray (2.5Y 7/2) semiconsolidated sedimentary beds that crush to a loam, grayish brown (2.5Y 5/2) moist; common medium reddish brown (5YR 5/4) mottles; few roots in fractures and between plates; strongly effervescent; strongly alkaline (pH 8.8).

**TYPE LOCATION:** Cascade County, Montana; 330 feet east and 900 feet south of the SW 1/4 corner of sec. 18, T. 20 N., R. 3 W.

### RANGE IN CHARACTERISTICS:

Soil temperature - 42 to 47 degrees F. Range mean annual soil temperature to 40 degrees in MLRA 40.

Moisture control section - between 4 and 12 inches; dry in all parts between four tenths and five tenths of the cumulative days per year when the soil temperature at a depth of 20 inches is higher than 41 degrees F.

Depth to Bk horizon - 10 to 20 inches.

Depth to bedrock - 20 to 40 inches.

Soil phase - cool; calcareous (more than 5 percent lime); stony.

A horizon - Hue: 10YR or 2.5Y

Value: 5 or 6 dry; 3, 4, or 5 moist

Chroma: 2, 3, or 4

Texture: loam, clay loam, silt loam, or very fine sandy loam

Clay content: 10 to 35 percent

Rock fragments: 0 to 5 percent pebbles, total rock fragment percentage ranges to 20 percent in the stony and gravelly phases.

Effervescence: None to strongly

Reaction: pH 6.6 to 8.4

When mixed to 7 inches the surface will not meet the requirements for a mollic epipedon.

Bw horizon - Hue: 10YR, 2.5Y, or 5Y

Value: 5, 6, or 7 dry; 4 or 5 moist

Chroma: 2, 3, or 4

Texture: loam, clay loam, or silty clay loam

Clay content: 18 to 35 percent clay

Rock fragments: 0 to 15 percent pebbles

Effervescence: none to violently

Reaction: pH 6.6 to 9.0

Bk horizon - Hue: 10YR, 2.5Y, or 5Y

Value: 5, 6, or 7 dry; 4, 5, or 6 moist

Chroma: 2, 3, or 4

Texture: loam, sandy loam, clay loam, or silty clay loam

Clay content: 18 to 35 percent clay

Rock fragments: 0 to 15 percent pebbles

Calcium carbonate equivalent: 5 to 30 percent. There is not more than a 5 percent difference in calcium carbonate equivalent or by volume of secondary carbonates in the underlying horizon of material to meet the

requirements of a calcic horizon.

Effervescence: strongly or violently

Reaction: pH 6.6 to 9.0

#### **COMPETING SERIES:**

[Cooecreek](#) (CO) - does not have a paralithic contact at depths of 20 to 40 inches and has hue redder than 10YR throughout.

[Coopers](#) (MT) - has hues redder than 10YR throughout the soil.

[Spinekop](#) (MT) - does not have a paralithic contact at depths of 20 to 40 inches.

[Trudau](#) (MT) - does not have a paralithic contact at depths of 20 to 40 inches.

[Yamacall](#) (MT) - does not have a paralithic contact at depths of 20 to 40 inches.

#### **GEOGRAPHIC SETTING:**

Landform - sedimentary plains; strath terraces; ridges; escarpments; and hills.

Elevation - 2,200 to 5,500 feet. Range elevation to 6200 feet in MLRA 44.

**Slope**- 0 to 70 percent.

Parent material - alluvium, colluvium, or residuum derived from semiconsolidated loamy sedimentary beds or in till over the sedimentary beds.

Climate - long, cold winters; moist springs; warm summers.

Mean annual precipitation - 10 to 16 inches, most of which falls as snow and springs rain.

Mean annual air temperature - 39 to 45 degrees F. Range mean annual air temperature to 38 degrees in MLRA 44.

Frost-free period - 90 to 135 days.

**GEOGRAPHICALLY ASSOCIATED SOILS:** These are the competing [Yamacall](#) soils and the [Abor](#), [Cabbart](#), [Kremlin](#), [Rothiemay](#), and [Yawdim](#) soils. The Abor soils are found on similar landscapes as the Delpoint soils. They are fine textured and have a calcic horizon within 40 cm. The Cabbart and Yawdim soils have soft bedrock between 10 and 20 inches. They are on summits and shoulder slopes above the Delpoint soils. Kremlin, Rothiemay, and Yamacall soils are very deep and are on alluvial fans and terraces below the Delpoint soils.

**DRAINAGE AND PERMEABILITY:** Well drained; moderate permeability.

**USE AND VEGETATION:** Delpoint soils are used for nonirrigated cropland and range. Potential native vegetation is western wheatgrass, green needlegrass, needleandthread, bluebunch wheatgrass, forbs, and shrubs.

**DISTRIBUTION AND EXTENT:** Eastern part of Montana and possibly in adjacent states. Delpoint is extensive.

**MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE:** Bismarck, North Dakota

**SERIES ESTABLISHED:** Cascade County, Montana, 1976.

**REMARKS:** Soil interpretation records: MT0271, MT0776.

Diagnostic horizons and features recognized in this pedon are: ochric epipedon - from 0 to 7 inches (A, Bw horizons); cambic horizon - from 3 to 17 inches (Bw horizon); horizon of lime accumulation - from 17 to 28 inches (Bk horizon); paralithic contact - at a depth of 28 inches (Cr horizon); particle-size control section - from 10 to 28 inches (Bw and Bk horizons).

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National Cooperative Soil Survey  
U.S.A.

LOCATION FARLAND

ND+MT SD

Established Series

Rev. CJH

10/98

## FARLAND SERIES

The Farland series consists of very deep, well drained soils that formed in stratified alluvium on terraces, valley foot slopes and fans on uplands. Permeability is moderate or moderately slow. Slope ranges from 0 to 20 percent. Mean annual precipitation is about 14 inches, and mean annual temperature is about 42 degrees F.

**TAXONOMIC CLASS:** Fine-silty, mixed, superactive, frigid Typic Argiustolls

**TYPICAL PEDON:** Farland silt loam on an east-facing 1 percent slope in native grassland. (Colors are for dry soil unless otherwise stated. When described, the soil was moist to 13 inches and dry below.)

**A**--0 to 4 inches; dark grayish brown (10YR 4/2) silt loam, very dark brown (10YR 2/2) moist; weak medium and fine prismatic and fine subangular blocky structure parting to moderate fine granular; slightly hard, friable; many roots; many fine pores; neutral; gradual wavy boundary. (3 to 12 inches thick)

**Bt1**--4 to 11 inches; grayish brown (10YR 5/2) silty clay loam, very dark grayish brown (10YR 3/2) moist; moderate medium and fine prismatic structure parting to strong medium and fine angular blocky; hard, friable; many roots; common fine pores; faint clay films on faces of peds; neutral; clear wavy boundary.

**Bt2**--11 to 18 inches; grayish brown (2.5Y 5/2) silty clay loam, dark grayish brown (2.5Y 4/2) moist; moderate medium and fine prismatic structure parting to strong medium and fine subangular blocky; hard, friable; common roots; common fine pores; faint patchy clay films; neutral; gradual wavy boundary. (Combined Bt horizons 6 to 22 inches thick)

**Bk1**--18 to 25 inches; light yellowish brown (2.5Y 6/4) silt loam, grayish brown (2.5Y 5/2) moist; weak coarse prismatic and moderate coarse subangular blocky structure; hard, friable; few roots; common fine pores; strong effervescence; slightly alkaline; clear wavy boundary.

**Bk2**--25 to 34 inches; light yellowish brown (2.5Y 6/4) loam, light olive brown (2.5Y 5/4) moist; weak coarse prismatic and moderate coarse and medium subangular blocky structure; friable; few roots; few fine pores; violent effervescence; common coarse masses of carbonates; moderately alkaline; gradual boundary. (Combined Bk horizons 7 to 35 inches thick)

**C**--34 to 60 inches; light brownish gray (2.5Y 6/2) stratified silt loam, loam and silty clay loam, olive brown (2.5Y 4/4) moist; weak coarse to fine subangular blocky structure parting to weak thin platy; friable; few roots; few fine pores; strong effervescence; moderately alkaline.

**TYPE LOCATION:** Stark County, North Dakota; about 10 miles east of Richardton; 1,490 feet north and 1,200 feet west of southeast corner, sec. 1, T. 139 N., R. 91 W.

**RANGE IN CHARACTERISTICS:** Depth to carbonates ranges from 8 to 30 inches. Depth to contrasting material in the substratum is more than 40 inches. Thickness of the mollic epipedon ranges from 7 to 16 inches.



The A horizon has hue of 10YR, value of 4 or 5 and 2 or 3 moist, and chroma of 2 or 3. It is loam, silt loam or clay loam. It is slightly acid to slightly alkaline.

The Bt horizon has hue of 10YR or 2.5Y, value of 4 to 6 and 3 or 4 moist, and chroma of 2 to 4. It is silty clay loam or clay loam having a clay content which averages between 27 and 35 percent. It is neutral or slightly alkaline. Structure ranges from moderate to strong prismatic which parts to strong or moderate angular or subangular blocks. Peds have faint continuous or patchy clay films. Some pedons have a Btk horizon.

The Bk horizon has hue of 10YR, 2.5Y, or 5Y, value of 5 to 7 and 3 to 5 moist, and chroma of 2 to 4. It is loam, silt loam or silty clay loam. It is slightly alkaline or moderately alkaline. Carbonates are disseminated and in masses. Some pedons have a BCK horizon.

The C horizon has hue of 2.5Y or 5Y, value of 5 or 6 and 4 moist, and chroma of 2 to 4. It typically is loam, silt loam or silty clay loam alluvium, and less commonly stratified silty clay to very fine sand. It is slightly alkaline or moderately alkaline.

**COMPETING SERIES:** These are the [Hanaker](#), [Jekley](#), [Morton](#) and [Xavier](#) series. Hanaker soils have a moderately alkaline Bt horizon. Jekley and Morton soils have bedrock within depths of 40 inches. In addition, Jekley soils occur at elevations above 7,700 feet. Xavier soils are less than 12 inches to the base of the Bt horizon.

**GEOGRAPHIC SETTING:** Farland soils are on level to moderately steep terraces, foot slopes of stream valleys and fans on uplands. Slope gradients commonly average between 1 and 6 percent, but range from 0 to 20 percent. The soils formed in stratified alluvium of mixed mineralogy. The mean annual temperature ranges from 39 to 45 degrees F, and mean annual precipitation from 13 to 18 inches. Most of the precipitation comes in the spring and summer.

**GEOGRAPHICALLY ASSOCIATED SOILS:** These are the competing [Morton](#) soils and the [Belfield](#), [Manning](#), [Parshall](#), [Regent](#), [Savage](#), [Sen](#), [Shambo](#), [Stady](#), [Straw](#) and [Vebar](#) soils. Belfield, Manning, Parshall, Savage, Shambo, Stady and Straw soils on adjacent terraces and the Morton, Regent, Sen and Vebar soils on adjacent uplands. Belfield soils have a natric horizon. Manning and Stady soils have gravelly 2C horizons at depths of less than 40 inches. Parshall and Straw soils have a mollic epipedon more than 16 inches thick. In addition, Parshall soils are coarse-loamy and Straw soils are fine-loamy. Regent and Vebar soils are moderately deep to paralithic beds. In addition Regent soils are fine and Vebar soils are coarse-loamy. Savage soils are fine. Sen soils do not have argillic horizons. Shambo soils do not have an argillic horizon and are fine-loamy.

**DRAINAGE AND PERMEABILITY:** Well drained. Runoff is slow or medium. Permeability is moderate or moderately slow.

**USE AND VEGETATION:** Cultivated areas are used for growing small grains, flax, corn, hay and pasture. Some areas are irrigated for production of alfalfa, beans, corn and sugar beets. Native vegetation is needleandthread, green needlegrass, western wheatgrass and blue grama.

**DISTRIBUTION AND EXTENT:** Western North Dakota, eastern Montana and northwestern South Dakota. The series is of large extent.

**MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE:** Bismarck, North Dakota

**SERIES ESTABLISHED:** McKenzie County, North Dakota, 1932.

**REMARKS:** Diagnostic horizons and features recognized in this pedon are: mollic epipedon - zone from the surface of the soil to a depth of 11 inches (A and Bt1 horizons); argillic horizon - zone from 4 to 18 inches

(Bt1 and Bt2 horizons).

**ADDITIONAL DATA:** S58ND-45-13, and S58ND-45-20 on pp. 88-91 of Soil Survey Investigation Report No. 2.

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National Cooperative Soil Survey  
U.S.A.

LOCATION FORT COLLINS

CO+MT WY

Established Series

Rev. GB/LLC

11/2005

# FORT COLLINS SERIES

The Fort Collins series consists of very deep, well drained soils that formed in mixed eolian sediments and alluvium. Fort Collins soils are on terraces, hills, plains, and alluvial fans and have slopes of 0 to 10 percent. The mean annual precipitation is about 38 centimeters (5 inches) and the mean annual temperature is about 8 degrees C. (47 degrees F.)

**TAXONOMIC CLASS:** Fine-loamy, mixed, superactive, mesic Aridic Haplustalfs

**TYPICAL PEDON:** Fort Collins loam - grassland. (Colors are for dry soil unless otherwise noted).

**A**--0 to 13 centimeters (0 to 5 inches); light brownish gray (10YR 6/2) loam, dark grayish brown (10YR 4/2) moist; moderate fine granular structure; soft, very friable; neutral (pH 7.2); clear smooth boundary. (8 to 15 centimeters (3 to 6 inches) thick)

**BA**--13 to 20 centimeters (5 to 8 inches); light brownish gray (10YR 6/2) loam, dark grayish brown (10YR 4/2) moist; moderate fine subangular blocky structure parting to fine granular; hard, very friable; few faint clay films on faces of peds; neutral (pH 7.2); clear smooth boundary. (8 to 10 centimeters (3 to 4 inches) thick)

**Bt**--20 to 46 centimeters (8 to 18 inches); brown (10YR 5/3) heavy loam, brown (10YR 4/3) moist; moderate medium prismatic structure parting to moderate fine subangular blocks; very hard, very friable; common distinct clay films on faces of peds, and as coatings in root channels and pores; slightly alkaline (pH 7.6); gradual smooth boundary. (13 to 30 centimeters (5 to 12 inches) thick)

**Bck**--46 to 61 centimeters (18 to 24 inches); pale brown (10YR 6/3) loam, brown (10YR 5/3) moist; weak medium subangular blocky structure; hard, very friable; few faint clay films on faces of peds; few faint clay films in some root channels; some visible secondary calcium carbonate occurring mostly as concretions; strongly effervescent; moderately alkaline (pH 8.0); gradual smooth boundary. (10 to 25 centimeters (4 to 10 inches) thick)

**Ck**--61 to 152 centimeters (24 to 60 inches); pale brown (10YR 6/3) loam, brown (10YR 5/3) moist; massive; hard, very friable; visible calcium carbonate occurring as concretions and in thin seams and streaks; violently effervescent; moderately alkaline (pH 8.2); gradual smooth boundary.

**TYPE LOCATION:** Larimer County, Colorado; approximately 1 block north of LaPorte Avenue on North Shields Street, and 152 meters (500 feet) west of North Shields Street in Sec. 11, T. 7 N., R. 69 W.

## RANGE IN CHARACTERISTICS:

Mean annual soil temperature: 8 to 13 degrees C. (47 to 55 degrees F.)

Mean summer soil temperature: 15 to 22 degrees C. (59 to 72 degrees F.)

Depth to the base of the Bt: 28 to 76 centimeters (11 to 30 inches)

Depth to calcareous material: 20 to 51 centimeters (8 to 20 inches)

Organic carbon upper 38 centimeters (15 inches): ranges from .6 to 2 percent (weighted average .8 percent)  
Average sand/clay ratio: 1 to 3  
Base saturation: 90 to 100 percent  
Rock fragments: 0 to 15 percent, (typically less than 5 percent)  
Moisture control section: not dry in all part for more than 1/2 of the time that the soil temperature is above 5 degrees C. (41 degrees F.) (moist in some or all parts during May and June)  
Moisture control section: not dry for 45 consecutive days following July 15.

A horizon:

Hue: 10YR or 2.5Y

Value: 5 to 7, 3 to 5 moist

Chroma: 2 or 3

When the value of the surface horizon is as dark as 5 dry and 3 moist the horizon must be thin enough so that if the soil is mixed to 7 inches it will have an ochric epipedon or it must contain less than 1 percent organic matter. Structure: usually granular but may be weak subangular blocky

Firmness: soft or slightly hard

Reaction: neutral to slightly alkaline.

Bt horizon:

Hue: 2.5Y to 7.5YR

Value: 5 to 7, 4 or 5 moist

Chroma: 2 to 4

Texture: loam or clay loam

Clay content: 18 to 35 percent

Silt content: 20 to 50 percent

Sand content: 20 to 50 percent (more than 15 percent but less than 35 percent being fine sand or coarser)

Structure: prismatic but subangular blocky in some pedons

Reaction: neutral or slightly alkaline.

Bk or C horizon:

Hue: 2.5Y or 10YR

Value: 6 or 7, 5 or 6 moist

Chroma: 2 to 6

Reaction: moderately alkaline or strongly alkaline

Calcium carbonate equivalent: 5 to 15 percent

Textures: loam or clay loam and less commonly sandy clay loam.

**COMPETING SERIES:** These are the [Arnor](#), [Arwite](#), [Augustine](#), [Bigbow](#), [Bosonoak](#), [Carri](#), [Celacy](#), [Celavar](#), [Dalhart](#), [Deekay](#), [Dermala](#), [Elwop](#), [Evpark](#), [Flugle](#), [Gateson](#), [Goesling](#), [Iwela](#), [Lykorly](#), [Navajita](#), [Nyjack](#), [Oldwolf](#), [Olnest](#), [Orlie](#), [Parkelei](#), [Pinitos](#), [Rauzi](#), [Ribera](#), [Rockybutte](#), [Stoneham](#), [Toluca](#) and [Wagonhound](#) series.

Arnor and Rauzi soils are redder hues and Arnor soils contain 15 to 30 percent rock fragments.

Augustine, Dalhart, Goesling, & Pinitos soils have thicker argillic layers with the base of the Bt in excess of 56 centimeters (22 inches).

Augustine soils may have a calcic horizon below 102 centimeters (40 inches).

Arwite, Deekay and Wagonhound soils are dry for 45 consecutive days in July through September.

Bosonoak soils have secondary carbonates in the surface.

Carri, Celacy, Celavar, Elwop, Evpark, Gateson, Nyjack, Oldwolf, and Ribera soils have a lithic or paralithic contact above 102 centimeters (40 inches).

Flugle soils have greater than 35 percent fine sand and coarser in the particle size control section.

Iwela soils have a lithologic discontinuity of stones at 66 centimeters (26 inches) and the moisture control section is dry in [may](#) and June.

Lykorly soils have up to 25 centimeters (10 inches) of overburden over a lithologic discontinuity with additional clay content and have a moisture control section that is dry in May and June.

Navajita soils have a 5 to 10 percent pararock fragments.

Orlie and Parkelei soils are dry in most parts of the moisture control section in May and June when the soil temperature at 51 centimeters (20 inches) is greater than 5 degrees C. (41 degrees F.)

Pinitos and Ribera soils have moisture control sections that are dry in May and June.

Olneft and Rockybutte soils may have rock fragments through out the profile.

Stoneham soils have less than 15 percent fine sand or coarser.

Toluca soils are noncalcareous above 25 centimeters (10 inches).

**GEOGRAPHIC SETTING:**

Parent materials: alluvium (may be modified by a thin mantle of eolian deposits)

Landscape: terraces, hills, plains, or alluvial fans

Slopes: 0 to 10 percent

Mean annual precipitation: 33 to 43 centimeters (13 to 17 inches)

Mean annual temperature: 7 to 12 degree C. (45 to 53 degrees F.)

Mean summer temperature: 14 to 21 degrees C. (57 to 70 degrees F.)

**GEOGRAPHICALLY ASSOCIATED SOILS:** These are the competing [Stoneham](#) and [Olneft](#) soils.

**DRAINAGE AND SATURATED HYDRAULIC CONDUCTIVITY:**

Drainage: well drained

Runoff: medium

Saturated Hydraulic Conductivity: moderately high

**USE AND VEGETATION:** These soils are used as native pastureland and as dry and irrigated cropland.

Principal irrigated crops are small grains, alfalfa, corn, sorghums, and sugar beets.

Dryland crops are limited primarily to winter wheat.

Native vegetation is blue grama grass, wheatgrass and some buffalo grass.

**DISTRIBUTION AND EXTENT:** Eastern Colorado, Montana, and Wyoming. The series is of large extent.  
MLRA 67

**MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE:** Salina, Kansas

**SERIES ESTABLISHED:** The Greeley Area, Colorado, 1904.

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

Argillic horizon: 20 to 46 centimeters (8 to 18 inches)

This series is changed in class from Ustollic Haplargids to Aridic Haplustalfs due to update and revision of higher moisture levels in the moisture control section.

Last updated by the state 3/94.

10/2005 JCR LM Changed to semitab format, added metric conversion and changed permeability to saturated hydraulic conductivity.

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National Cooperative Soil Survey  
U.S.A.



LOCATION HAVERSON

CO+MT NE NM SD UT WY

Established Series

AJC/JEB/CJH

12/2002

## HAVERSON SERIES

The Haverson series consists of very deep, well drained soils that formed in alluvium from mixed sources. Haverson soils are on floodplains and low terraces and have slopes of 0 to 9 percent. The mean annual precipitation is about 15 inches and the mean annual air temperature is about 49 degrees F.

**TAXONOMIC CLASS:** Fine-loamy, mixed, superactive, calcareous, mesic Aridic Ustifluents

**TYPICAL PEDON:** Haverson loam - grassland. (Colors are for dry soil unless otherwise noted)

**A1**--0 to 3 inches; pale brown (10YR 6/3) loam, dark brown (10YR 3/3) moist; strong fine granular structure; slightly hard, very friable; violently effervescent; slightly alkaline (pH 7.8); clear smooth boundary. (2 to 6 inches thick)

**A2**--3 to 6 inches; pale brown (10YR 6/3) loam, dark brown (10YR 3/3) moist; weak fine and medium granular structure; hard, friable; strongly effervescent; slightly alkaline (pH 7.8); abrupt smooth boundary. (2 to 6 inches thick)

**A3**--6 to 12 inches; light brownish gray (10YR 6/2) loam, dark grayish brown (10YR 4/2) moist; weak coarse subangular blocky structure; very hard, friable; strongly effervescent; slightly alkaline (pH 7.8); clear smooth boundary. (4 to 8 inches thick)

**C1**--12 to 32 inches; pale brown (10YR 6/3) very fine sandy loam that has thin strata of loam, brown (10YR 4/3) moist; massive; hard, friable; strongly effervescent; slightly alkaline (pH 7.8); gradual smooth boundary. (16 to 24 inches thick)

**C2**--32 to 60 inches; pale brown (10YR 6/3) loam that has thin lenses of sandy loam and very fine sandy loam, brown (10YR 4/3) moist; massive; slightly hard, very friable; few fine irregularly shaped masses and seams of lime; strongly effervescent; moderately alkaline (pH 8.4)

**TYPE LOCATION:** Weld County, Colorado; approximately 1,320 feet south and 1,320 feet east of the northwest corner of Sec. 36, T. 10 N., R 64 W.

**RANGE IN CHARACTERISTICS:** Mean annual soil temperature ranges from 47 to 55 degrees F. and mean summer soil temperature ranges from 59 to 78 degrees F. Organic carbon ranges from 0.5 to 2.0 percent in the surface horizon but decreases irregularly with depth. The particle-size control section is stratified with strata ranging from sandy loam to clay loam, but averaging approximately loam. On a weighted average basis, clay ranges from 18 to 35 percent, silt from 10 to 50 percent, and sand from 20 to 60 percent with more than 15 percent but less than 35 percent being fine or coarser sand. Rock fragments are generally less than 5 percent and range from 0 to 20 percent. Some visible calcium carbonate may occur at any depth in these soils, but it is not concentrated into any consistent horizon of accumulation. This soil is not dry in all parts of the moisture control section for more than one-half the time the soil temperature is above 41 degrees F. (195 to 210 days) and is not dry for 45 consecutive days following July 15.

The A horizon has hue of 2.5Y or 10YR, value of 4 to 6 dry, 3 to 5 moist and chroma of 2 or 3. When the value of the surface horizon is as dark as 5 dry and 3 moist, the horizon is thin enough so that if mixed to 7 inches it is too light colored or contains too little organic carbon to qualify as a mollic epipedon or are finely stratified. The A horizon usually has granular primary structure but it has subangular blocky structure in some pedons. It is soft or slightly hard. It is neutral through moderately alkaline.

The C horizon has hue of 2.5Y, 10YR or 7.5YR, value of 5 or 6 dry, 4 or 5 moist and chroma of 2 or 3. It is slightly alkaline to very strongly alkaline. It has from less-than-one to about 15 percent calcium carbonate equivalent, which differs erratically from stratum to stratum.

**COMPETING SERIES:** These are the [Aparejo](#), [Hickman](#), [Hysham](#), [Ramper](#) and [Rockypoint](#) series (it is assumed Hickman soils are competing pending and update of the classification). Aparejo, Hickman and Ramper soils are driest during [May](#) and June in the moisture control section. In addition Aparejo soils have hues of 5YR and redder. Hysham soils have very strongly alkaline surface horizons and typically have Bt horizons with columnar structure. Rockypoint soils are dry from July through September.

**GEOGRAPHIC SETTING:** The Haverson soils are on floodplains and low terraces of major rivers. Slope is 0 to 9 percent. The soils formed in highly stratified, calcareous, recent alluvium derived from mixed sources. At the type location the average annual precipitation is 14 to 18 inches with peak periods of precipitation occurring during the early spring and summer. The mean annual air temperature ranges from 47 to 52 degrees F. and the mean summer temperature is 77 degrees F. The frost-free season is 125 to 180 days.

**GEOGRAPHICALLY ASSOCIATED SOILS:** These are the [Bankard](#) and [Glenberg](#) soils. Bankard and Glenberg soils have less than 18 percent clay in the series control section.

**DRAINAGE AND PERMEABILITY:** Well drained; runoff is negligible to medium depending on slope; moderate permeability.

**USE AND VEGETATION:** These soils are used as native pastureland, dry farm land or irrigated cropland. Native vegetation is mixed grasses, cottonwoods and brush.

**DISTRIBUTION AND EXTENT:** Eastern Colorado and Wyoming, northeastern New Mexico and adjacent states. This soil is of large extent.

**MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE:** Bismarck, North Dakota

**SERIES ESTABLISHED:** Prowers County, Colorado, 1965.

**REMARKS:** Classification was changed from Ustic Torrifluents to Aridic Ustifluents and the type location moved from Prowers County to Weld County, Colorado in 3/94.

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National Cooperative Soil Survey  
U.S.A.

LOCATION HAVRE

MT+ND SD UT WY

Established Series  
GFB-CJH-JAL  
06/2000

## HAVRE SERIES

The Havre series consists of very deep, well drained soils that formed in stratified, calcareous, loamy alluvium. These soils are on flood plains, alluvial fans and stream terraces. Slopes are 0 to 6 percent. Mean annual precipitation is about 12 inches. Mean annual air temperature is about 43 degrees F.

**TAXONOMIC CLASS:** Fine-loamy, mixed, superactive, calcareous, frigid Aridic Ustifluvents

**TYPICAL PEDON:** Havre loam, in cropland (colors are for dry soil unless otherwise noted).

**Ap**--0 to 8 inches; grayish brown (10YR 5/2) loam, dark grayish brown (10YR 4/2) moist; weak granular structure; soft, very friable, slightly sticky and slightly plastic; many fine and very fine roots; strongly effervescent; moderately alkaline (pH 7.9); abrupt wavy boundary. (4 to 10 inches thick)

**C1**--8 to 36 inches; light brownish gray (2.5Y 6/2) loam consisting of thin strata of fine sandy loam, silt loam, and clay loam, dark grayish brown (2.5Y 4/2) moist; massive; slightly hard, very friable, slightly sticky and slightly plastic; common fine roots; common to many medium and fine pores; strongly effervescent; moderately alkaline (pH 8.2); clear wavy boundary. (18 to 30 inches thick)

**C2**--36 to 60 inches; light brownish gray (2.5Y 6/2) loam consisting of thin strata of clay loam, fine sandy loam, and silt loam, dark grayish brown (2.5Y 4/2) moist; massive; slightly hard, very friable, slightly sticky and nonplastic; few fine and very fine roots; common medium and fine pores; strongly effervescent; moderately alkaline (pH 8.2).

**TYPE LOCATION:** Blaine County, Montana; 1,050 feet north and 2,640 feet east of SW corner of sec. 33, T. 32 N., R. 23 E.

### **RANGE IN CHARACTERISTICS:**

Soil temperature - 40 to 47 degrees F.

Moisture control section - between 4 and 12 inches; dry in all parts between four-tenths and five-tenths of the cumulative days per year when the soil temperature at a depth of 20 inches is 41 degrees F or higher.

Some pedons have a 2 to 5 inch horizon of weak prismatic or subangular blocky structure above a depth of 10 inches.

Soil phases - moderately wet, saline; flooded, PE greater than 31; cool; flooded, cool; moderately wet; clayey surface; flooded, clayey surface; clayey substratum; warm; saline.

Ap horizon - Hue: 10YR or 2.5Y

Value: 5 or 6 dry; 4 or 5 moist

Chroma: 2 or 3

Texture: loam, fine sandy loam, silt loam, clay loam, silty clay loam, clay or silty clay

Clay content: 10 to 55 percent

Calcium carbonate equivalent: 1 to 10 percent

Effervescence: none to strongly

**EC:** 0 to 8 mmhos/cm; saline phase is 4 to 16 mmhos/cm

**SAR:** 0 to 4

Reaction: pH 6.1 to 9.0

Some pedons have a thin A horizon that has a value of 4 dry and 3 moist and does not meet the requirement for a mollic epipedon after mixing to 7 inches.

C1 horizon - Hue: 10YR, 2.5Y, or 5Y

Value: 5 or 6 dry; 4 or 5 moist

Chroma: 2 or 3

Texture: loam, silt loam, sandy clay loam or clay loam which consist of strata of silt loam, fine sandy loam, very fine sandy loam, silty clay loam, and clay loam

Clay content: 18 to 35 percent

Calcium carbonate equivalent: 1 to 10 percent

Effervescence: slight or strongly

**EC:** 0 to 16 mmhos/cm; saline phase is 4 to 16 mmhos/cm

**SAR:** 0 to 13

Reaction: pH 7.4 to 9.0

Some pedons have 15 to 60 percent coarse fragments below a depth of 40 inches.

C2 horizon - Hue: 10YR, 2.5Y, or 5Y

Value: 5, 6 or 7 dry; 4 or 5 moist

Chroma: 2 or 3

Texture: loam, silt loam, sandy clay loam or clay loam which consist of strata of silt loam, fine sandy loam, very fine sandy loam, silty clay loam, and clay loam

Clay content: 18 to 35 percent

Calcium carbonate equivalent: 1 to 10 percent

Effervescence: slight or strongly

**EC:** 0 to 16 mmhos/cm; saline phase is 4 to 16 mmhos/cm

**SAR:** 0 to 13

Reaction: pH 7.4 to 9.0

**COMPETING SERIES:**

[Bullhook](#) (MT) - has an SAR greater than 13 below the surface 10 inches; has concentration of gypsum at depths of 5 to 15 inches.

**GEOGRAPHIC SETTING:**

Landform - flood plains; alluvial fans; stream terraces.

Elevation - 1,900 to 6,000 feet in Montana; ranges to 7,300 feet in Utah.

**Slope-** 0 to 6 percent.

Parent material - stratified calcareous loamy alluvium.

Climate - long, cold winters; moist springs; warm summers.

Mean annual precipitation - 10 to 16 inches, most of which falls during spring and the early part of summer.

Mean annual air temperature - 38 to 45 degrees F.

Frost-free period - 90 to 135 days.

**DRAINAGE AND PERMEABILITY:** Well drained; moderate permeability.

**USE AND VEGETATION:** Havre soils are mainly used for irrigated and nonirrigated crops. The potential native vegetation is bluebunch wheatgrass, western wheatgrass, green needlegrass, needleandthread, forbs, and shrubs.

**DISTRIBUTION AND EXTENT:** Havre soils are extensive in the plains area of Montana and in the states of Colorado, North Dakota, Nebraska, South Dakota, Utah, and Wyoming.

**MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE:** Bismarck, North Dakota

**SERIES ESTABLISHED:** Milk River Area, Montana, 1928.

**REMARKS:** Soil interpretation records: MT0072, MT0181, MT0188, MT0256, MT0744, MT0745, MT0773, MT0777, MT0778, MT0816, MT0860, MT1009.

Diagnostic horizons and features recognized in this pedon are: ochric epipedon - from 0 to 8 inches (Ap horizon); stratified soil material (C1, C2 horizons); particle-size control section - from 10 inches to 40 inches (C1, C2 horizons). Havre soils have a frigid temperature regime and an aridic moisture regime bordering on ustic.

**ADDITIONAL DATA:** S51MT-85-3, S50MT-85-3, S51MT-85-6, S51MT-85-7, S51MT-43-3.



LOCATION HELDT

WY+CO MT

Established Series  
Rev. PSD/MS/JW  
04/2003

## HELDT SERIES

The Heldt series consists of very deep, moderately well drained, moderately slow to slowly permeable soils that formed in fine textured alluvium on fans, terraces, and piedmonts. Slopes are 0 to 25 percent. The mean annual precipitation is about 13 inches, and the mean annual temperature is about 48 degrees F.

**TAXONOMIC CLASS:** Fine, smectitic, mesic Ustertic Haplocambids

**TYPICAL PEDON:** Heldt silty clay loam-on a nearly level alluvial terrace under native vegetation. (Colors are for dry soil unless otherwise stated.)

**A--**0 to 6 inches; light brownish gray (2.5Y 6/2) silty clay loam, grayish brown (2.5Y 5/2) moist; strong very fine granular structure; soft, very friable, sticky and plastic; slightly effervescent, calcium carbonate disseminated; moderately alkaline (pH 8.2); clear smooth boundary. (5 to 10 inches thick)

**Bw--**6 to 40 inches; light brownish gray (2.5Y 6/2) silty clay, grayish brown (2.5Y 5/2) moist; moderate coarse prismatic structure parting to moderate coarse angular blocky; extremely hard, friable, very sticky and very plastic; common distinct slickensides; slightly effervescent, calcium carbonate occurs as few prominent seams; strongly alkaline (pH 8.5); gradual wavy boundary. (15 to 40 inches thick)

**Bk--**40 to 60 inches; light gray (2.5Y 7/2) silty clay, grayish brown (2.5Y 5/2) moist; few distinct reddish brown (5YR 5/4) redox concentrations; massive, extremely hard, firm, very sticky and very plastic; strongly effervescent, calcium carbonate occurs as common prominent soft masses and seams; few distinct gypsum crystals; moderately alkaline (pH 8.3); gradual smooth boundary. (6 to 12 inches thick)

**TYPE LOCATION:** Goshen County, Wyoming; 517 feet east and 187 feet north of the east abutment of the bridge over Cherry Creek on the road to Veteran, SW1/4, SE1/4, SW1/4 of sec. 25, T. 24 N., R. 62 W. 42 degrees 1 minute 2 seconds north latitude and 104 degrees 15 minutes 32 seconds west longitude.

**RANGE IN CHARACTERISTICS:** Organic content of the A1 horizon averages .6 to 2 percent and decreases uniformly with depth. Conductivity typically ranges from 0 to about 12 millimhos in the upper 40 inches. The soils are usually calcareous throughout, but depth to calcareous material ranges from 0 to 15 inches. Exchangeable sodium percentage usually ranges from less than 1 to 5 percent in the upper part of the control section but commonly increases with increasing depth. The particle size control section is usually clay or silty clay but ranges in clay from 35 to 50 percent, in silt from 10 to 50 percent, and in sand from 10 to 45 percent. Coarse fragments are typically less than 5 percent but range from 0 to 15 percent. Cracks more than .4 inch wide and 12 inches long occur in the upper 20 inches when the soils are dry. The soil is dry in the moisture control section more than half the time cumulative that the soil temperature at a depth of 20 inches is 41 degrees F. and is never moist in some or all parts for as long as 60 consecutive days when the soil temperature at a depth of 20 inches is 41 degrees F., which occurs about April 21-27, but is dry in all parts of the moisture control section for at least 60 consecutive days from July 15 to October 25 and for at least 90 cumulative days during this period. The mean annual soil temperature is 47 to 53 degrees F., and the soil temperature at a depth of 20 inches is 41 degrees F. or more for 175 to 192 days.

The A horizon has hue of 5Y through 7.5YR, value of 5 through 7 dry, 3 through 6 moist, and chroma of 1 through 4. Surface horizons having value as dark as 5 dry and 3 moist are too thin or contain too little organic matter to be mollic epipedons. Reaction is mildly alkaline through strongly alkaline.

The Bw horizon has hue of 5Y through 7.5YR, value of 5 through 7 dry, 4 through 6 moist, and chroma of 2 through 5. It is usually clay or silty clay but is silty clay loam in some pedons. Reaction is moderately alkaline or strongly alkaline.

The Bk or C horizon has hue of 5Y through 7.5YR, value of 5 through 7 dry, 4 through 6 moist, and chroma of 2 through 5. Reaction is moderately or strongly alkaline. It has 3 to 10 percent calcium carbonate equivalent.

**COMPETING SERIES:** These are the [Denby](#), [Dominguez](#), [Littlenan](#), and [Lockerby](#) series. The Denby soils do not contain visible carbonates within the soil profile. The Dominguez soils have hue of 5YR or redder. The Littlenan and Lockerby soils are underlain by shale at depths of 20 to 40 inches and, in addition, the Lockerby soils do not have a cambic horizon.

**GEOGRAPHIC SETTING:** The Heldt soils are on fan remnants terraces, hillslopes and alluvial fans. Slopes range from 0 to 25 percent. The soils formed in fine textured alluvial sediments derived primarily from sedimentary rock. The average annual precipitation is 10 to 15 inches with over half falling in the months of April, May, and June. The average annual temperature is 44 to 48 degrees F. The frost-free season is 110 to 140 days.

**GEOGRAPHICALLY ASSOCIATED SOILS:** These are the [Orella](#) and [Samday](#) soils. Orella and Samday soils have bedrock at depths of less than 20 inches.

**DRAINAGE AND PERMEABILITY:** Well or moderately well drained; slow or very slow runoff; slow to moderately slow permeability.

**USE AND VEGETATION:** These soils are used principally as native pastureland, although they may be tilled to both dryland and irrigated crops in some localities. Native vegetation is primarily western wheatgrass, green needlegrass, blue grama, and basin wildrye.

**DISTRIBUTION AND EXTENT:** Central and northern Wyoming, southern Montana, and northern Colorado. The series is of moderate extent.

**MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE:** Salina, Kansas

**SERIES ESTABLISHED:** Big Horn County (Big Horn Area), Montana; 1970.

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

Ochric epipedon - 0 to 6 inches (A)

Cambic horizon - 6 to 40 inches (Bw)

**SIR-** WY1141

**LRR-** G

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National Cooperative Soil Survey  
U.S.A.

LOCATION HESPER

MT

Established Series  
Rev. RLM/CAM  
02/98

## HESPER SERIES

The Hesper series is a member of the fine, montmorillonitic, mesic family of Ustollic Haplargids. Typically, these soils have grayish brown silt loam A1 horizons less than 5 inches thick, brown heavy silty clay loam B2t horizons that have strong fine prismatic and blocky structure, and C horizons of olive silt loam that has distinct accumulation of calcium carbonate.

**TAXONOMIC CLASS:** Fine, smectitic, mesic Aridic Haplustalfs

**TYPICAL PEDON:** Hesper silty clay loam - native grass. (Colors are for dry soil unless otherwise noted.)

**A1**--0 to 2 inches; grayish brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) moist; weak thin platy structure parting to weak very fine crumb structure; soft, very friable, slightly sticky; common bleached silt and very fine sand-size particles; moderately acid (pH 5.8); abrupt boundary. (2 to 5 inches thick.)

**B2t**--2 to 11 inches; brown (10YR 4/3) to (10YR 5/3) crushed heavy silty clay loam, dark brown (10YR 3/3) moist, brown (10YR 4/3) crushed moist; strong fine and medium prismatic structure separating easily to strong fine and very fine subangular blocky structure; very hard, friable, sticky, plastic; moderately thick continuous clay films coating and bridging mineral grains and partly filling many pores; neutral (pH 7.0); clear boundary. (8 to 12 inches thick.)

**B3**--11 to 16 inches; dark grayish brown (10YR 4/2), light olive brown (2.5Y 5/3) crushed, silty clay loam, very dark grayish brown (10YR 3/2) moist, olive brown (2.5Y 4/3) crushed moist, strong medium prismatic structure separating to strong fine subangular blocky structure; hard, friable, sticky, plastic; moderately thick and continuous clay films coating and bridging mineral grains; mildly alkaline (pH 7.7); gradual wavy boundary. (2 to 5 inches thick.)

**Clca**--16 to 20 inches; light olive brown (2.5Y 5/3) light silty clay loam, olive brown (2.5Y 4/2) moist; moderate medium and fine blocky structure; hard, friable, sticky, slightly plastic; moderate effervescence; common white nodules of lime; moderately alkaline (pH 8.3); gradual boundary.

**C2ca**--20 to 44 inches; pale olive (5Y 6/3) heavy silt loam, olive gray (5Y 4/2) moist; blocky structure; hard, very friable, slightly sticky, slightly plastic; moderate effervescence; many soft white nodules of lime; moderately alkaline (pH 8.3); gradual boundary.

**C3**--44 to 60 inches; olive (5Y 5/3) very fine sandy loam, olive (5Y 4/3) moist; blocky structure; soft, very friable, slightly sticky; moderate effervescence, few seams of lime; moderately alkaline (pH 8.3).

**TYPE LOCATION:** Yellowstone County, Montana; just east of road near fence corner in northwestern part of SE 1/4 NW 1/4 sec. 33, T. 2 N., R. 29 E.

**RANGE IN CHARACTERISTICS:** Hesper soils are usually dry between depths of 4 and 12 inches when soil temperature is warmer than 41 degrees F., but they are not dry in all parts above 12 inches for more than half the time during this period. Mean annual soil temperature ranges from 47 degrees to 50 degrees F.

Thickness of solum ranges from 10 to 20 inches. Most pedons have Ap horizons 5 to 8 inches thick of silty clay loam. The color hue ranges from 2.5Y through 7.5YR throughout the soil. The A1 horizon has value of more than 5 dry and more than 3 moist and chroma of 2 or 3. These values are one-half to one unit more than those of coatings in the upper part of the B2 horizon. Clear uncoated silt and fine sand grains are abundant in the A horizon. The B horizon has chroma of 2 through 4. The finest texture is in the upper 3 to 5 inches of the B2t horizon, starting at depths of 2 to 5 inches below the surface. These layers contain between 35 and 50 percent clay. In plowed soils they are mixed in the Ap horizon. The B2t horizon remaining beneath the Ap horizon ranges from 35 to 45 percent clay and contains 2 to 8 percent more clay than the Ap horizon. Distinct clay films are on faces of peds in the B2 horizon, and many pores are partially filled with clay. The Cca horizon contains less than 15 percent CaCO<sub>3</sub> equivalent but has accumulations of secondary lime. The C horizon is silt loam that contains less than 15 percent fine and coarser sand. Some pedons have IIC horizons of contrasting texture below depths of 40 inches.

**COMPETING SERIES:** Similar and related soils are in the [Baca](#), [Bew](#), [Big Horn](#), [Fort Collins](#), [Hinman](#), [Renohill](#), [Thurlow](#), and [Ulm](#) series. The Baca soils have A and B1 horizons 5 to 10 inches thick above the B2t horizon and a more gradual increase in amount of clay from the A to the B horizon. The Bew soils have 50 to 60 percent clay in their argillic horizon. The Big Horn soils have more than 10 percent more clay in the upper part of the B2t horizon than in the Ap horizon. The Fort Collins soils have less than 35 percent clay and more than 15 percent fine and coarser sand in the B2t horizon. The Hinman soils have calcareous sola. The Renohill soils have soft rock at depths between 20 and 40 inches. The Thurlow and Ulm soils have more than 15 percent fine and coarser sand in their argillic horizons and C horizons; and the Ulm soils, in addition, have 5 to 10 inches of A and B1 horizon above the B2t horizon.

**SETTING:** Hesper soils are on upland plains and on terraces. They formed in uniform calcareous silt loam. The climate is cool semiarid. Mean annual temperature ranges from 45 degrees to 48 degrees F., mean summer temperature from 64 degrees to 67 degrees F., and mean winter temperature from 0 to 28 degrees F. Mean annual precipitation ranges from 10 to 14 inches and about 8 inches falls from April through August.

**PRINCIPAL ASSOCIATED SOILS:** These are the competing Fort Collins and Thurlow soils, and the Keiser and Wanetta soils. Keiser soils have sola less than 10 inches thick. The Wanetta soils have IIC horizons of loose sand and gravel at depths of 20 to 40 inches.

**DRAINAGE AND PERMEABILITY:** Well drained. The B horizon is moderately permeable.

**USE AND VEGETATION:** Used primarily for cropland, both irrigated and nonirrigated. A few areas are still in native vegetation of western wheatgrass, needle-and-thread, blue grass, prairie Junegrass, and big sagebrush.

**DISTRIBUTION AND EXTENT:** Southeastern Montana. The soil is extensive.

**MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE:** Bismarck, North Dakota

**SERIES ESTABLISHED:** Treasure County, Montana, 1963.

**REMARKS:** Hesper series was formerly classified in the Brown great soil group.

OSD scanned by SSQA. Last revised by state on 4/68.

LOCATION HYDRO

MT

Established Series

CJH-JHS

12/2003

## HYDRO SERIES

The Hydro series consists of very deep, well drained soils on terraces and footslopes. Slopes are 0 to 15 percent. Mean annual precipitation is about 13 inches and mean annual air temperature is about 48 F.

**TAXONOMIC CLASS:** Fine, smectitic, frigid Aridic Glossic Natrustalfs

**TYPICAL PEDON:** Hydro loam - grassland. (Colors are for dry soil unless otherwise noted)

**A--**0 to 1 inches; dark grayish brown (2.5Y 4/2) loam, very dark grayish brown (2.5Y 3/2) moist; moderate thin platy structure that separates to moderate very fine granules; slightly hard, very friable, slightly sticky, slightly plastic; many very fine roots and tubular pores; slightly acid (pH 6.2); clear boundary. (1 to 3 inches thick)

**E--**1 to 4 inches; light gray (2.5Y 7/2) on top of plates and light brownish gray (2.5Y 6/2) on bottom of plates, loam, grayish brown (2.5Y 5/2) and dark grayish brown (2.5Y 4/2) crushing to dark grayish brown (2.5Y 4/2) moist; very thin platy structure; slightly hard, very friable, slightly sticky, slightly plastic; many very fine roots and tubular pores; surfaces of plates have a continuous coating of uncoated mineral grains on top and undersides; slightly acid (pH 6.2); clear boundary. (2 to 4 inches thick)

**EB--**4 to 11 inches; light gray (2.5Y 7/2) on top of plates and light brownish gray (2.5Y 6/2) on underside of plates, light clay loam, dark grayish brown (2.5Y 4/2) moist; moderate coarse prismatic structure that separates to strong very thin plates in upper part and strong very fine blocks in lower part; slightly hard, very friable, slightly sticky, slightly plastic; many very fine roots and tubular pores; plates have continuous thick frosting of uncoated mineral grains on top and undersides, blocks have thin coating of uncoated silt grains; slightly acid (pH 6.3); clear boundary. (4 to 8 inches thick)

**Btn--**11 to 21 inches; pale brown (10YR 6/3) light clay, light olive brown (2.5Y 5/3) moist; brown (10YR 4/3) coating on peds; moderate medium prismatic structure that separates to strong fine and very fine blocks; extremely hard, firm, sticky, plastic; common very fine roots, mainly between prisms; faint continuous clay films; few stained sand grains; moderately alkaline (pH 8.0); clear boundary. (6 to 10 inches thick)

**Btkn--**21 to 31 inches; light olive brown (2.5Y 5/3) heavy clay loam, olive brown (2.5Y 4/3) moist; weak medium and coarse prismatic structure that separates to moderate medium blocks; very hard, friable, sticky, plastic; few roots; faint patchy clay films; moderate effervescence with common lime nodules; moderately alkaline (pH 8.4); clear boundary. (5 to 15 inches thick)

**Bk--**31 to 36 inches; light olive brown (2.5Y 5/3) heavy clay loam, olive brown (2.5Y 4/3) moist; weak coarse blocky structure; very hard, friable, sticky, plastic; few roots; moderate effervescence with common soft lime nodules and few nests and seams of gypsum in lower part; moderately alkaline (pH 8.4).

**Bky--**36 to 51 inches; light olive brown (2.5Y 5/3) clay loam, olive brown (2.5Y 4/3) moist; weak coarse blocky structure; hard, friable, sticky, plastic; very few roots; moderate effervescence with few soft lime segregations and with common segregations of gypsum in seams and nests of crystals; moderately alkaline



(pH 8.2); gradual boundary. (0 to 20 inches thick)

**BC--**51 to 60 inches; light olive brown (2.5Y 5/3) clay loam, olive brown (2.5Y 4/3) moist; weak coarse blocky structure; hard, friable, sticky, plastic; moderate effervescence; moderately alkaline (pH 8.2).

**TYPE LOCATION:** Powder River County, Montana; 200 feet east and 1,200 feet north of S1/4 corner of section 11; T9S, R53E.

**RANGE IN CHARACTERISTICS:**

Soil Temperature: 48 to 50 degrees F.

Depth to Bk horizon: 12 to 18 inches

Depth to gypsum or other visible salts: more than 30 inches

Combined thickness of A, E and EB horizons: 5 to 10 inches

Notes: Some pedons have a C Horizon.

A horizon:

Hue: 2.5Y, 10YR or 7.5YR

Value: 4 or 5 and 3 or 4 moist (Ap horizons have values of more than 5 dry and 4 or more moist)

Chroma: 2

Texture: loam or silt loam

Clay Content: 18 to 27 percent

Rock Fragments: 0

Reaction: 6.1 to 6.5

E horizon:

Hue: 2.5Y, 10YR or 7.5YR

Value: 6 or 7 and 4 or 5 moist

Chroma: 2

Texture: loam or silt loam

Clay Content: 18 to 27 percent

Rock Fragments: 0

Reaction: 6.1 to 6.5

EB horizon:

Hue: 2.5Y, 10YR or 7.5YR

Value: 6 or 7 and 4 or 5 moist

Chroma: 2

Texture: loam or clay loam

Clay Content: 20 to 35 percent

Rock Fragments: 0

Reaction: 6.1 to 6.5

EC: 4 to 8 mmhos/cm

SAR: 0 to 5

Notes: The coating on the plates and prisms shows many clear uncoated grains with chroma of 1 or 2 and value of 5 or greater. The broken and crushed surfaces have one unit stronger chroma.

Btn horizon:

Hue: 2.5Y, 10YR or 7.5YR

Value: 5 or 6 and 4 or 5 moist

Chroma: 3

Texture: clay loam or clay  
Clay Content: 38 to 45 percent  
Rock Fragments: 0  
Reaction: 7.4 to 8.4  
EC: 4 to 8 mmhos/cm  
SAR: 5 to 15 (where the SAR is less than 13.5, the Na plus Mg is more than the Ca plus H.

Btkn horizon:  
Hue: 2.5Y, 10YR or 7.5YR  
Value: 5 or 6 and 4 or 5 moist  
Chroma: 2 or 3  
Texture: clay loam or clay  
Clay Content: 35 to 45 percent  
Rock Fragments: 0  
Reaction: 7.9 to 8.4  
EC: 4 to 16 mmhos/cm  
SAR: 15 to 25

Bk horizon:  
Hue: 2.5Y, 10YR or 7.5YR  
Value: 5 or 6 and 4 or 5 moist  
Chroma: 2 or 3  
Texture: clay loam  
Clay Content: 27 to 35 percent  
Rock Fragments: 0  
Reaction: 7.9 to 8.4  
EC: 4 to 16 mmhos/cm  
SAR: 15 to 30

Bky and BC horizons:  
Hue: 2.5Y, 10YR or 7.5YR  
Value: 5 or 6 and 4 or 5 moist  
Chroma: 2 or 3  
Texture: loam or clay loam  
Clay Content: 18 to 35 percent  
Rock Fragments: 0  
Reaction: 7.9 to 8.4  
EC: 4 to 16 mmhos/cm  
SAR: 15 to 30

**COMPETING SERIES:** These are the [Talag](#) series. Talag soils have more than 45 percent clay in the Btn horizons.

**GEOGRAPHIC SETTING:** The Hydro soils are on nearly level to sloping terraces and footslopes. They formed in very deep transported calcareous loam or clay loam materials of mixed rock origin. The climate is cool semiarid with mean annual air temperature ranging from 45 to 48 degrees F., mean summer air temperature of 65 to 70 degrees F., a frost-free period of 95 to 150 days, and a mean annual precipitation of 10 to 15 inches with 8 to 10 inches of warm season rainfall. Frost-free period is 100 to 150 days.

**GEOGRAPHICALLY ASSOCIATED SOILS:** These were the [Arvada](#), [Fort Collins](#), [Thurlow](#) and [Cushman](#) soils (when previously classified as mesic). Arvada soils do not have EB horizons and have an ESP of more than 15 in the Bt horizon. The Fort Collins, Thurlow and Cushman soils do not have E horizons, have

prismatic or blocky structured Bt horizons with neutral or moderately alkaline reaction, and have an ESP of less than 7 in any part of the Bt horizon.

**DRAINAGE AND PERMEABILITY:** Well-drained; slow permeability.

**USE AND VEGETATION:** Used for irrigated and nonirrigated cropland and for rangeland. Large areas still have western wheatgrass, prairie junegrass, blue grama, and silver sagebrush.

**DISTRIBUTION AND EXTENT:** An extensive soil occurring in small areas widely distributed throughout the eastern and northern plains of Montana.

**MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE:** Bismarck, North Dakota

**SERIES ESTABLISHED:** Big Horn County (Big Horn Area), Montana, 1970.

**REMARKS:** Diagnostic horizons and features recognized in this pedon: ochric epipedon - the zone from the surface of the soil to a depth of 4 inches (A and E horizons); glossic horizon - the zone from 4 to 11 inches (EB horizon); natric horizon - the zone from 11 to 31 inches (Btn and Btkn horizons).

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National Cooperative Soil Survey  
U.S.A.

LOCATION MCRAE

MT+WY

Established Series

Rev. CAM

10/98

## MCRAE SERIES

Typically, McRae soils have light brownish gray loam Ap horizons, grayish brown loam B2 horizons and pale olive calcareous loam C horizons with slight segregation of lime in the upper part.

**TAXONOMIC CLASS:** Fine-loamy, mixed, superactive, mesic Aridic Haplustepts

**TYPICAL PEDON:** McRae loam - cultivated. (Colors are for dry soil unless otherwise noted.)

**Ap**--0 to 5 inches; light brownish gray (2.5Y 6/2) loam, dark grayish brown (2.5Y 4/2) moist; coatings on granules of grayish brown (2.5Y 5/2) dry and very dark grayish brown (2.5Y 3/2) moist; weak medium granular structure; slightly hard, very friable, slightly sticky, nonplastic; abrupt boundary.

**B2**--5 to 11 inches; grayish brown (2.5Y 5/2) loam, dark grayish brown (2.5Y 4/2) moist; coatings on peds of dark grayish brown (2.5Y 4/2), very dark grayish brown (2.5Y 3/2) moist; moderate medium prismatic structure; hard, very friable, slightly sticky, slightly plastic; thin patchy clay films; clear boundary. (6 to 9 inches thick)

**C1ca**--11 to 34 inches; pale olive (5Y 6/3) loam, olive (5Y 5/3) moist; very weak coarse prismatic structure in upper part, becoming massive and stratified in lower part; hard, friable, slightly sticky, slightly plastic; moderate effervescence with few seams and soft nodules of segregated lime; gradual boundary. (20 to 30 inches thick)

**C2**--34 to 60 inches; pale olive (5Y 6/3) loam, olive (5Y 5/3) moist; massive; slightly hard, friable, slightly sticky, slightly plastic; moderate effervescence.

**TYPE LOCATION:** Yellowstone County, Montana; 1,350 feet south and 330 feet east of W1/4 corner sec. 19, T.4N., R.33E.

**RANGE IN CHARACTERISTICS:** The McRae soils are usually dry between depths of 4 and 12 inches but are not dry in all parts above 12 inches for more than half the time that soil temperature at 20 inches is more than 41 degrees F. The mean annual soil temperature is about 48 degrees F. The solum is 11 to 14 inches thick. The soil between depths of 10 and 40 inches is loam or light clay loam with 18 to 30 percent clay and more than 15 percent fine and coarser sands. The soil is moderately or strongly alkaline. Conductivity of the saturation extract ranges from 1 to 3 millimhos per cm. These soils are generally nonsaline. The Ap and B2 horizons are noncalcareous or weakly calcareous. Hue is 10YR through 5Y.

The Ap horizon has value of 5 or 6 dry and 3.5 through 5 moist. Its granules are coated one-half to one unit of value darker.

The B2 horizon has dry and moist value of the crushed soil the same as in the Ap horizon, and has coated colors one-half unit darker. The chroma is 2 or 3.

The C horizon has value of 5 or 4 moist. It has less than 5 percent mottles of segregated lime and has an

estimated 8 to 12 percent CaCO<sub>3</sub> equivalent.

**COMPETING SERIES:** These are the [Edgar](#) and [Menoken](#) series. Edgar soils have a prominent horizon of lime accumulation with dry value of 7 or more. Menoken soils have less than 15 percent fine and coarser sand in the 10- to 40-inch control section.

**GEOGRAPHIC SETTING:** McRae soils are on terraces of rivers and streams, alluvial fans in valleys, and footslopes in the uplands. They formed in calcareous loam alluvium from soils developed over sedimentary rocks. The mineralogy of the alluvium is mixed. The climate is semiarid with a mean annual precipitation of 8 to 14 inches and mean annual temperature of 45 to 50 degrees F.

**GEOGRAPHICALLY ASSOCIATED SOILS:** These are the [Bainville](#), [Cushman](#), Elso, [Fort Collins](#), [Havre](#), and [Midway](#) soils. Bainville, Cushman, Elso and Midway soils are on the uplands occupying hills and ridges, and the Fort Collins and Havre soils are in valleys. Bainville, Cushman, Elso and Midway soils have shale bedrock at depths ranging shallower than 40 inches, and Cushman and Fort Collins soils have Bt horizons. Havre soils occur on river and stream flood plains and have no horizonation.

**DRAINAGE AND PERMEABILITY:** Well-drained; moderate permeability; slow to medium runoff.

**USE AND VEGETATION:** Principally used for irrigated cropland. Used also for rangeland. Principal native vegetation is mixed short and mid grasses and forbs.

**DISTRIBUTION AND EXTENT:** Southeastern Montana where they are moderately extensive.

**MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE:** Bismarck, North Dakota

**SERIES ESTABLISHED:** Treasure County, Montana, 1961.

**REMARKS:** The McRae soils were formerly classified as Brown soils.

OSD scanned by SSQA. Last revised by state on 6/71.

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National Cooperative Soil Survey  
U.S.A.



LOCATION MIDWAY

CO+KS MT SD ND WY

Established Series

CJH

04/2004

## MIDWAY SERIES

The Midway series consists of shallow, well drained soils that formed in residuum and slope alluvium from calcareous platy, clayey shale. Midway soils are on ridge crests, mesas, plains, and hills in shale bedrock uplands. Slopes range from 0 to 40 percent. Mean annual precipitation is about 13 inches and mean annual air temperature is about 50 degrees F.

**TAXONOMIC CLASS:** Clayey, smectitic, calcareous, mesic, shallow Ustic Torriorthents

**TYPICAL PEDON:** Midway clay - grassland. (Colors are for dry soil unless otherwise noted)

**A--**0 to 3 inches; light brownish gray (2.5Y 6/2) clay, dark grayish brown (2.5Y 4/2) moist; moderate very fine granular structure; hard, friable, strongly effervescent; slightly alkaline; clear smooth boundary. (3 to 8 inches thick)

**C--**3 to 12 inches; light yellowish brown (2.5Y 6/4) clay, light olive brown (2.5Y 5/4) moist; weak fine subangular blocky structure; hard, firm; strongly effervescent; few, fine, and medium clusters of gypsum; moderately alkaline; clear smooth boundary. (7 to 12 inches thick)

**Cr--**12 to 24 inches; light yellowish brown (2.5Y 6/4) partially weathered, platy, clay shale, light olive brown (2.5Y 5/4) moist; massive; hard, very firm; strongly effervescent; few fine nests of gypsum; strongly alkaline.

**TYPE LOCATION:** Boulder County, Colorado; about 2 miles northwest of Niwot, Colorado; 1,220 feet south and 400 feet east of center of Sec. 14, T. 2 N., R. 70 W.

### **RANGE IN CHARACTERISTICS:**

Midway soils are usually dry unless irrigated.

Mean annual soil temperature ranges from 47 to 52 degrees F.

Depth to paralithic contact: 10 to 20 inches, but is as shallow as 6 inches in some pedons.

Gravel and channery size shale parafragments above the Cr horizon range from 0 to 80 percent.

A horizon:

Hue: 5Y to 10YR

Value: 4 to 6 dry, 3 to 5 moist

Chroma: 2 to 4

Texture: clay or clay loam

Reaction: neutral to moderately alkaline

C horizon: (AC is present in some pedons)

Hue: 5Y to 10YR

Value: 5 or 6 dry,

Chroma: 2 to 4

Texture: silty clay loam, silty clay, clay loam or clay

Clay content: 35 to 45 percent

Silt content: 20 to 50 percent silt

Sand content: less than 10 percent sand coarser than very fine sand

Reaction: slightly alkaline to strongly alkaline

**COMPETING SERIES:** These are the [Cannonville](#), [Danko](#), [Orella](#), [Samday](#) and [Zyme](#) series.

Cannonville and Zyme soils: have moisture control sections that are dry for 15 consecutive days from [May 15](#) to July 15 when the soil temperature at 20 inches is greater than 41 degrees F.

Danko soils: have hue of 7.5YR or redder.

Orella soils have 38 to 65 percent clay in the particle-size control section.

Samday soils are dry for 90 cumulative days or 60 consecutive days from July 15 to October 25.

**GEOGRAPHIC SETTING:**

Landform: crests of ridges, mesas, plains and hills in shale bedrock uplands.

Slopes: 0 to 40 percent

Parent material: slope alluvium and residuum from calcareous platy shale high in smectitic type clay

Mean annual precipitation: 10 to 16 inches, about 13 inches at the type location.

Mean annual air temperature is 45 to 53 degrees F.

Frost free period: 100 to 160 days.

**GEOGRAPHICALLY ASSOCIATED SOILS:** These are the [Gaynor](#), [Shingle](#) and [Renohill](#) soils.

Gaynor soils have a paralithic contact above 40 inches.

Shingle soils have less clay in their particle-size control section.

Renohill soils have an argillic horizon, and a paralithic contact at depths of 20 to 40 inches.

**DRAINAGE AND PERMEABILITY:** Well drained. Runoff is low to very high depending on slope.

Permeability is very slow or slow.

**USE AND VEGETATION:** Principally native range with associations of short grasses or forbs, prairie junegrass, silver sage, threadleaf sage, western wheatgrass and rabbitbrush.

**DISTRIBUTION AND EXTENT:** Colorado, Wyoming, Montana, South Dakota, North Dakota, Kansas.

LRR E, G, and H; MLRA 49, 67, 69, 72. The series is of moderate extent.

**MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE:** Salina, Kansas

**SERIES ESTABLISHED:** Central Montana Reconnaissance, Montana, 1943.

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

Ochric epipedon: the zone from 0 to 3 inches. (A horizon)

Paralithic contact - at 12 inches (top of the Cr horizon).

Differentia with the Orella series needs to be better defined.

Series updated from 7/87 to 2/94 for use on the Kit Carson County, Colorado, final correlation. CJH

Geographic Setting: Revised MAP to 13 inches at the type location and ranged the MAP from 8 to 14 inches.

CJH

Added, "Diagnostic features include a paralithic contact at 12 inches. Last updated by the state 2/94. CJH

11/21/96 CJH

1. Allowed clay texture in range of A horizon.
2. Range dry value in C horizon to 5 or 6 and chroma to 3 or 4.
3. Add descriptive material to Cr horizon.
4. Change mineralogy to smectitic

7/9/97 CJH

1. Range precipitation from 10 to 16 inches.

12/24/2002 CJH

1. Allow chroma of 2 in C horizon.
2. Allow slightly alkaline reaction in C horizon.
3. Allow very slowly permeable.
4. Update competing series section.

3/22/04 CJH Transfer responsibility to Kansas MO.

4/2004 WAW Change to semi-tabular format, update distribution and extent.

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National Cooperative Soil Survey  
U.S.A.

LOCATION NIHILL

WY+MT NE SD

Established Series  
Rev. P JL/PSD/MS  
11/98

## NIHILL SERIES

The Nihill series consists of very deep, well drained soils formed in gravelly alluvium from mixed sources. They are on late Pleistocene terraces and terrace remnants. Slopes range from 0 to 80 percent. The mean annual precipitation is about 16 inches, and the mean annual temperature is about 46 degrees F.

**TAXONOMIC CLASS:** Loamy-skeletal, mixed, superactive, calcareous, mesic Ustic Torriorthents

**TYPICAL PEDON:** Nihill gravelly loam-rangeland. (Colors are for dry soil unless otherwise stated.)

**A**--0 to 5 inches; dark brown (10YR 4/3) gravelly loam, very dark grayish brown (10YR 3/2) moist; weak very fine granular structure; soft, very friable, nonsticky and nonplastic; common fine and very fine roots; strongly effervescent, calcium carbonate disseminated and as thin crusts on some rock fragments; 20 percent pebbles; slightly alkaline (pH 7.4); clear wavy boundary. (0 to 7 inches thick)

**Bk1**--5 to 29 inches; light yellowish brown (10YR 6/4) very gravelly clay loam, yellowish brown (10YR 5/4) moist; massive; slightly hard, very friable, slightly sticky and slightly plastic; few very fine roots; violently effervescent, calcium carbonate and as few thin and moderately thick coatings on some rock fragments; 60 percent pebbles; moderately alkaline (pH 8.4); diffuse wavy boundary. (10 to 30 inches thick)

**Bk2**--29 to 60 inches; very pale brown (10YR 7/3) very gravelly sandy clay loam, light yellowish brown (10YR 6/4) moist; massive; slightly hard, friable, slightly sticky and nonplastic; violently effervescent, calcium carbonate as few thin discontinuous crusts on rock fragments; 60 percent pebbles; moderately alkaline (pH 8.3).

**TYPE LOCATION:** Sheridan County, Wyoming; in the SE1/4, SW1/4 of sec. 32, T. 57 N., R. 86 W. Dayton South Quadrangle 44 degrees 51 minutes 57 seconds north latitude and 107 degrees 16 minutes 7 seconds west longitude.

**RANGE IN CHARACTERISTICS:** The Nihill soils typically contain free carbonates throughout but are leached free of carbonates in the upper few inches in some pedons. The mean annual soil temperature ranges from 47 to 54 degrees F. The particle-size control section has a matrix texture of clay loam, sandy clay loam, or sandy loam with 15 to 35 percent clay. Rock fragments, typically rounded pebbles, range from 35 to 70 percent. There is typically less than 5 percent larger than 3 inches.

The A horizon has hue of 10YR or 2.5Y, value of 4 through 6 dry, 3 through 5 moist, and chroma of 2 through 4. Rock fragments range from 10 to 45 percent pebbles and 0 to 5 percent cobbles. It is slightly alkaline or moderately alkaline.

The Bk or C horizons have hue of 10YR or 2.5Y, value of 5 through 8 dry, 4 through 7 moist, and chroma of 2 through 4. Rock fragments range from 35 to 70 percent pebbles and 0 to 5 percent cobbles. Calcium carbonate equivalent ranges from 2 to 14 percent. It is slightly alkaline through strongly alkaline.

**COMPETING SERIES:** This is the [Chilton](#) series which has hue of 7.5YR or 5YR in the control section.

**GEOGRAPHIC SETTING:** Nihill soils are on late Pleistocene terraces and terrace remnants. They formed in calcareous gravelly alluvium from mixed sources. Slopes are 0 to 80 percent. Elevations range from 2,600 to 6,800 feet. The mean annual precipitation is about 16 inches but ranges from 10 to 19 inches with about half falling as snow or rain in April, May, and early June. The mean annual temperature is about 46 degrees F., but ranges from 44 to 50 degrees F. The frost-free season is estimated to range from 105 to 130 days.

**GEOGRAPHICALLY ASSOCIATED SOILS:** These are the [Butche](#), [Hesper](#), [Keiser](#), [Shingle](#), and [Wanetta](#) series. Butche soils have a lithic contact at less than 20 inches. Hesper, Keiser, and Wanetta soils have argillic horizons and are nonskeletal. Shingle soils are shallow to weakly consolidated bedrock.

**DRAINAGE AND PERMEABILITY:** Well drained to somewhat excessively drained; medium to high runoff depending on slope; moderate permeability.

**USE AND VEGETATION:** Rangeland and wildlife habitat. Native vegetation consists of western wheatgrass, needleandthread, blue grama, and in some areas bluebunch wheatgrass.

**DISTRIBUTION AND EXTENT:** North central and eastern Wyoming, South Dakota, and Colorado. The series is extensive.

**MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE:** Bismarck, North Dakota

**SERIES ESTABLISHED:** Treasure County, Montana; 1961.

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

Ochric epipedon - 0 to 5 inches (A)

**MLRR-** G

**SIR's-** WY0136, WY0431, WY1267

The type location is moved from Montana to Wyoming as per agreement reached in 1981.

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National Cooperative Soil Survey  
U.S.A.



LOCATION RELAN

MT

Established Series  
Rev. CAM/JLP  
10/98

## RELAN SERIES

Typically, Relan soils have brown grading to dark brown gravelly loam A1 horizons and pinkish gray, calcareous, gravelly loam C horizons with segregations of lime in the upper part.

**TAXONOMIC CLASS:** Coarse-loamy, mixed, superactive, frigid Typic Haplustolls

**TYPICAL PEDON:** Relan gravelly loam - native grass cover. (Colors are for dry soil unless otherwise noted.)

**A11**--0 to 8 inches; brown (7.5YR 5/2) gravelly loam, dark brown (7.5YR 3/2) moist; weak fine blocks that separate to weak fine crumb structure; soft, friable, nonsticky, nonplastic; many very fine roots and fine interstitial pores; common fine "scoria" fragments that give dark reddish brown color to rubbed moist soils; neutral (pH 7.4); gradual boundary.

**A12**--8 to 13 inches; dark brown (7.5YR 4/2) gravelly loam, dark brown (7.5YR 3/3) moist; weak fine crumb structure; soft, friable, nonsticky, nonplastic; many very fine roots and fine interstitial pores; common fine "scoria" fragments that give dark reddish brown color to rubbed moist soil; noncalcareous; mildly alkaline (pH 7.6); clear wavy boundary. (A1 horizon is 8 to 18 inches thick)

**C1ca**--13 to 26 inches; pinkish gray (7.5YR 6/4) gravelly light loam, brown (7.5YR 5/4) moist; massive; slightly hard, friable, nonsticky, nonplastic; common very fine roots and fine tubular pores; common fine "scoria" fragments; strongly calcareous with fine segregations of lime; moderately alkaline (pH 8.4); gradual boundary. (10 to 20 inches thick)

**C2**--26 to 30 inches; pinkish gray (7.5YR 6/4) gravelly fine sandy loam, dark brown (7.5YR 4/4) moist; massive; soft, very friable, nonsticky, nonplastic; common very fine roots and fine tubular pores; numerous fine "scoria" fragments; strongly calcareous; strongly alkaline (pH 8.6); gradual boundary.

**C3**--30 to 62 inches; pinkish gray (7.5YR 6/4) gravelly light loam that consists of stratified sand silt, loam and small gravel in place; dark brown (7.5YR 4/4) moist; soft, very friable, nonsticky, nonplastic; few very fine roots and common fine tubular pores; strongly calcareous; strongly alkaline (pH 8.6).

**TYPE LOCATION:** Powder River County, Montana; 1,200 feet north and 800 feet west of SE corner sec. 12, T.4S., R.50E.

**RANGE IN CHARACTERISTICS:** Mean annual soil temperature is 44 to 47 degrees F. and the average summer temperature is 60 to 64 degrees F. Average texture of the 10- to 40-inch section is loam or sandy loam with 7 to 18 percent clay, more than 15 percent fine and coarser sand and 15 to 30 percent fine gravel of porcelanite fragments. The hue is 7.5YR and redder with chroma of 2 through 4. The Ap and A1 horizons have value of 4 or 5 dry. The Cca horizon is weak with few to many segregations of thread and film lime and a CaCO<sub>3</sub> content of 8 to 12 percent. Loose porcelanite beds occur at depths greater than 40 inches.

**COMPETING SERIES:** These are the Bass, [Bitterroot](#), Groveland, [Hopley](#), Kalispell, [Manning](#), [Panguitch](#),

[Tally](#), [Twin Creek](#), [Vebar](#), and [Victor](#) series. Bass, Groveland and Kalispell soils have udic summer moisture regime and have moist value of 2 in the A1 horizons. Bass, Manning and Victor soils have very gravelly sandy substrata below depth of about 30 inches. Also, Bass soils have considerable mica from included granitic rock fragments. Bitterroot and Vebar soils have paralithic contacts with sandstone at depths of 20 to 40 inches. Hopley soils have hue yellower than 7.5YR. Panguitch soils have cambic horizons and are deeper than 18 inches to the Cca horizons. Tally and Vebar soils have fine sandy loam pedons. Twin Creek soils have 18 to 27 percent clay in the 10- to 40-inch section.

**GEOGRAPHIC SETTING:** The Relan soils are on terraces and alluvial fans and on floors of swales in the uplands. The parent material is of mixed mineral origin, consisting of local transported materials from red porcelanite beds and soils developed over these beds. The climate is cool semiarid with mean annual temperature colder than 45 degrees F. and mean summer temperature warmer than 65 degrees F. Mean annual precipitation is 15 to 19 inches with 9 to 12 inches falling during May to September.

**GEOGRAPHICALLY ASSOCIATED SOILS:** These are the Dillinger, [Fergus](#), [Ringling](#), and [Searing](#) soils, and the competing [Twin Creek](#) soils. Dillinger soils have mollic epipedons thicker than 20 inches. Fergus soils have an argillic horizon. Ringling soils have red porcelanite beds at depths shallower than 20 inches. Searing soils have porcelanite beds at depths of 20 to 40 inches.

**DRAINAGE AND PERMEABILITY:** Well-drained; moderate permeability.

**USE AND VEGETATION:** Used for native grass range and or dryland crop production. Native vegetation is mid grasses and sagebrush - needle-and-thread, green needlegrass, blue grama and western wheatgrass.

**DISTRIBUTION AND EXTENT:** Relan soils occur throughout eastern Montana where they are inextensive.

**MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE:** Bismarck, North Dakota

**SERIES ESTABLISHED:** Powder River County (Powder River Area), Montana, 1972.

**REMARKS:** The Relan soils were formerly classified as Chestnut soils.

OSD scanned by SSQA. Last revised by state on 2/72.

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National Cooperative Soil Survey  
U.S.A.

LOCATION REMMIT

CO+MT UT

Established Series  
MLP/GB  
02/98

## REMMIT SERIES

The Remmit series consists of very deep, well drained soils formed in wind reworked alluvium derived from sandstone sediments. Remmit soils are on terraces, fans and uplands on plains. Slopes range from 0 to 15 percent. The mean annual precipitation is about 12 inches, and the mean annual temperature is about 47 degrees F.

**TAXONOMIC CLASS:** Coarse-loamy, mixed, superactive, mesic Ustic Haplocambids

**TYPICAL PEDON:** Remmit fine sandy loam, 0 to 2 percent slopes. (Colors are for dry soil unless otherwise noted.)

**A--**0 to 4 inches; brown (10YR 5/3) fine sandy loam, dark brown (10YR 3/3) moist; moderate fine granular structure; soft, very friable, slightly sticky and slightly plastic; neutral (pH 6.5); abrupt smooth boundary. (2 to 5 inches thick)

**Bt1--**4 to 7 inches; pale brown (10YR 6/3) sandy loam, dark brown (10YR 3/3) moist; weak medium subangular blocky parting to moderate fine subangular blocky structure; hard, friable, slightly sticky and slightly plastic; 1 to 4 percent thin, patchy argillans around pores; neutral (pH 6.8), clear smooth boundary. (2 to 5 inches thick)

**Bt2--**7 to 16 inches; pale brown (10YR 6/3) sandy loam, brown (10YR 4/3) moist; strong fine prismatic parting to moderate fine and medium subangular blocky structure; hard, firm, slightly sticky and slightly plastic; 3 to 8 percent thin, patchy argillans in and around pores; moderately alkaline (pH 8.0); clear wavy boundary. (1 to 8 inches thick)

**Bt3--**16 to 22 inches; light yellowish brown (10YR 6/4) sandy loam, dark yellowish brown (10YR 4/4) moist; weak coarse prismatic parting to weak medium subangular blocky structure; hard, friable, slightly sticky and slightly plastic; 1 to 3 percent thin argillans in pores; moderately alkaline (pH 8.1); clear wavy boundary. (0 to 5 inches thick)

**Bk1--**22 to 33 inches; very pale brown (10YR 7/4) sandy loam, yellowish brown (10YR 5/4) moist; weak coarse prismatic parting to weak medium subangular blocky structure; hard, friable, slightly sticky and slightly plastic; strongly effervescent, few visible calcium carbonates as fine filaments filling old pores; moderately alkaline (pH 8.1); gradual wavy boundary. (3 to 8 inches thick)

**Bk2--**33 to 47 inches; very pale brown (10YR 7/3) sandy loam, light yellowish brown (10YR 6/4) moist; weak medium prismatic structure; slightly hard, friable, nonsticky and nonplastic; violently effervescent, common visible calcium carbonate as fine filaments, streaks and coatings on ped faces; moderately alkaline (pH 8.3); clear smooth boundary. (0 to 7 inches thick)

**2Bk3--**47 to 64 inches; very pale brown (10YR 8/3) loam, light yellowish brown (10YR 6/4) moist; weak coarse prismatic structure; slightly hard, friable, slightly sticky and slightly plastic; violently effervescent, common visible calcium carbonate as filaments, filled pores and blotches; moderately alkaline (pH 8.3) clear

wavy boundary. (0 to 9 inches thick)

**2Bk4**--64 to 77 inches; very pale brown (10YR 8/3) loam, pale brown (10YR 6/3) moist; massive; soft, very friable, slightly sticky and slightly plastic; violently effervescent, common visible, calcium carbonate visible as filled pores and filaments, moderately alkaline (pH 8.3). (0 to 12 inches thick)

**TYPE LOCATION:** Weld County, Colorado; 1,580 feet north and 2,050 feet west of the southeast corner of Sec. 2, T. 2 N., R. 66W. 104 degrees, 44 minutes, 30 seconds west longitude; 40 degrees, 51 minutes, 21 seconds north latitude.

**RANGE IN CHARACTERISTICS:** The mean annual soil temperature is 47 to 52 degrees F. The control section contains less than 15 percent gravel which usually occurs in lag lines. The 10 to 40 inch particle-size control section has 10 to 18 percent clay, and 45 to 55 percent fine sand and coarser. The weighted average of organic carbon in the upper 10 inches is 0.5 to 1.0 percent. Depth to calcareous soil material ranges from 8 to 15 inches. Depth to the lithologic discontinuity is greater than 40 inches.

The A horizon has a hue of 10YR, value of 5 to 6 dry, 3 through 5 moist, and chroma of 2 through 4. Reaction is neutral.

The Bt horizons have hues of 10YR or 2.5Y, value of 5 through 7 dry, 4 through 6 moist, chromas of 3 through 6. Texture is sandy loam. Clay films may be observable on surfaces of peds and in pores. Reaction is mildly alkaline or moderately alkaline.

The Bk horizons have hues of 10YR or 2.5Y, values of 5 through 8 dry, 4 through 7 moist. Texture is loam or sandy loam.

**COMPETING SERIES:** These are the [Begay](#) (UT), [Ignacio](#) (NM) [Parida](#) (NM), [Sandspring](#) T(AZ), and [Turnback](#) (WY) series. Begay soils have hues redder than 7.5YR in the Bw, Bk and c subsoils. Ignacio soils have a lithic contact at 20 to 40 inch depths. The Parida soils average more than 15 percent coarse fragments in the particle-size control section. The Turnback soils have a paralithic contact at 20 to 40 inches depths.

**GEOGRAPHIC SETTING:** Remmit soils are on plains and wind reworked terraces. Slopes range from 0 to 15 percent. The soils formed in wind reworked sandstone sediments. The mean annual precipitation is 10 to 14 inches. The mean annual air temperature ranges from 45 to 53 degrees F.

**GEOGRAPHICALLY ASSOCIATED SOILS:** These are the [Olney](#), [Owlcreek](#)(t), [vona](#) and [Zigweld](#) soils. Olney and vona soils have argillic subsoils. Owlcreek soils have mollic epipedons and dark colored buried subsoils. Zigweld soils have 18 to 35 percent clay in the particle-size control section.

**DRAINAGE AND PERMEABILITY:** Well drained or somewhat excessively drained, moderately rapid permeability.

**USE AND VEGETATION:** These soils are used for native range and limited nonirrigated cropland acreage. Vegetation is shortgrass prairie with some mid-grasses, buffalograss, blue grama, western wheatgrass, greens needlegrass, red threeawn and snakeweed.

**DISTRIBUTION AND EXTENT:** Remmit soils are in northeastern Colorado. This series is of small extent.

**MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE:** Bismarck, North Dakota

**SERIES ESTABLISHED:** Powder River County (Powder River Area), Montana, 1972.

**REMARKS:** The responsibility for the series and the type location has been transferred from Powder River

County Montana to Weld County Colorado. Laboratory sampling (1991) [sample 91P5247-5254] confirmed this soil as a coarse-loamy Ustollic Camborthid with some oriented clay argillians in the subsoil which are not qualifying for an argillic horizon. The Cambic horizon ranges from 4 to 22 inches. Last updated by the state 12/91.

OSD scanned by SSQA. Last revised by state on 12/91.

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National Cooperative Soil Survey  
U.S.A.



LOCATION RINGLING

MT+ND WY

Established Series

CJH

06/2003

## RINGLING SERIES

The Ringling series consists of very deep, excessively drained soils that formed in materials derived from burned shale, burned sandstone, argillite or from porcelanite. They are 12 to 20 inches deep over fragmental material. These soils are on sedimentary plains and hills. Slopes are 2 to 90 percent. Mean annual precipitation is about 16 inches, and mean annual air temperature is about 42 degrees F.

**TAXONOMIC CLASS:** Loamy-skeletal over fragmental, mixed, superactive, frigid Typic Haplustolls

**TYPICAL PEDON:** Ringling channery loam, in woodland. (Colors are for dry soil unless otherwise noted)

**Oi**--0 to 2 inches; partly decomposed pine needles and twigs.

**A**--2 to 7 inches; reddish brown (5YR 4/3) channery loam, dark reddish brown (5YR 3/3) moist; weak fine granular structure; soft, friable, nonsticky and nonplastic; common medium fine and very fine roots; 30 percent channers; slightly alkaline (pH 7.4); clear smooth boundary. (3 to 14 inches thick)

**Bw**--7 to 19 inches; reddish brown (5YR 4/4) very channery loam, dark reddish brown (2.5YR 3/4) moist; weak very fine subangular blocky structure; soft, friable, nonsticky and nonplastic; common medium, fine, and very fine roots; 50 percent channers and 5 percent flagstones; slightly alkaline (pH 7.4); clear smooth boundary. (5 to 15 inches thick)

**2Ck**--19 to 44 inches; pale red (10R 6/3) highly fractured baked sandstone and shale with less than 5 percent fine material in the voids; few medium, fine, and very fine roots along faces of fragments mainly in the upper part; lime casts on rock fragments mainly in the upper part; gradual wavy boundary.

**2C**--44 to 62 inches; pale red (10R 6/3) highly fractured baked sandstone; less than 3 percent fine material in the voids.

**TYPE LOCATION:** Rosebud County, Montana; 2600 feet west and 700 feet south of the northeast corner of sec. 22, T. 3 S., R. 42E.

### RANGE IN CHARACTERISTICS:

Soil temperature - 41 to 47 degrees F.

Moisture control section - approximately between the depths of 8 and 24 inches

Mollic epipedon thickness - 7 to 14 inches thick

Depth to fragmental material - 12 to 20 inches

A horizon - Hue: 7.5YR, 5YR, 2.5YR or 10R

Value: 4 or 5 dry; 2 or 3 moist

Chroma: 2 or 3

Clay content: 10 to 25 percent

Rock fragments: 10 to 80 percent--0 to 15 percent flagstones, 10 to 65 percent channers or shale

Reaction: pH 6.6 to 7.8

Bw horizon - Hue: 7.5YR, 5YR, 2.5YR or 10R

Value: 4 or 5 dry, 3 or 4 moist

Chroma: 2, 3 or 4

Clay content: 10 to 25 percent

Rock fragments: 35 to 80 percent--5 to 25 percent flagstones, 30 to 55 percent channers and shale

Reaction: pH 6.6 to 7.8

2Ck horizon -

Clay content: 0 to 5 percent

Rock fragments: 95 to 100 percent--90 to 95 percent flagstones, 5 to 10 percent channers and shale

Calcium carbonate equivalent: 5 to 10 percent

Reaction: pH 6.6 to 8.4

2C horizon -

Clay content: 0 to 5 percent

Rock fragments: 95 to 100 percent--90 to 95 percent flagstones, 5 to 10 percent channers and shale

Reaction: pH 6.6 to 8.4

**COMPETING SERIES:** There are no competing series

**GEOGRAPHIC SETTING:**

Landform - sedimentary plains and hills

Elevation - 2,000 to 4,800 feet

**Slope-** 2 to 90 percent

Parent material - material derived from argillite, porcelanite, or from burned shale or burned sandstone

Climate - long, cold winters; moist springs; warm summers.

Mean annual precipitation - 13 to 19 inches much of which falls as snow and as rain in spring, early summer and late fall.

Mean annual air temperature - 39 to 45 degrees F.

Frost-free period - 90 to 135 days.

**GEOGRAPHICALLY ASSOCIATED SOILS:** These are the [Brandenburg](#), [Dogtooth](#), [Janesburg](#) and [Searing](#) soils. Brandenburg soils occur higher on the landscape. They do not have a mollic epipedon. Dogtooth, Janesburg and Searing soils occur lower on the landscape. Dogtooth and Janesburg soils have a natric horizon. Searing soils have shattered porcelanite at depths of 20 to 40 inches.

**DRAINAGE AND PERMEABILITY:** Excessively drained; permeability is moderately rapid above the fragmental material and rapid in the fragmental material.

**USE AND VEGETATION:** Ringling soils are used mainly as rangeland. Some limited use as forest land. The potential native vegetation is mainly Bluebunch wheatgrass, little bluestem, needleandthread, western wheatgrass, rough fescue, shrubs and forbs. The forest vegetation is mainly ponderosa pine. Dense stands are mainly on the north slopes but trees can occur on all aspects.

**DISTRIBUTION AND EXTENT:** Ringling soils are of moderate extent on eastern Montana and western North Dakota.

**MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE:** Bismarck, North Dakota

**SERIES ESTABLISHED:** Reconnaissance Soil Survey of Central Montana, 1946.

**REMARKS:** Soil Interpretations Record: MT0016 and MT1100.

Diagnostic horizons and features recognized in this pedon are: mollic epipedon - from the top of the mineral soil surface (2 inches) to 9 inches after mixing (A and Bw horizons); cambic horizon - from 9 to 19 inches (Bw horizon); fragmental material - from 19 to 62 inches (2Ck and 2C horizons); particle-size control section - from 12 to 42 inches (Bw and 2Ck horizons).

Ringling soils have a frigid temperature regime and an ustic moisture regime.

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National Cooperative Soil Survey  
U.S.A.

LOCATION TWILIGHT

SD+MT

Established Series

PRJ-KEC-CJH

04/2002

## TWILIGHT SERIES

The Twilight series consists of moderately deep, well drained soils formed in alluvium or eolian over residuum, or residuum weathered from soft sandstone on hills and ridges on uplands. Permeability is moderate or moderately rapid. Slopes range from 2 to 45 percent. Mean annual precipitation is about 14 inches, and mean annual air temperature is about 44 degrees F.

**TAXONOMIC CLASS:** Coarse-loamy, mixed, superactive, frigid Haplocalcidic Haplustepts

**TYPICAL PEDON:** Twilight fine sandy loam - on an east-facing slope of 6 percent in native grass. When described the soil was dry throughout. (Colors are for dry soil unless otherwise stated).

**A**--0 to 4 inches; brown (10YR 5/3) fine sandy loam, dark grayish brown (10YR 4/2) moist; weak fine granular structure; hard, very friable; many fine roots; neutral; clear smooth boundary. (3 to 6 inches thick)

**Bw1**--4 to 10 inches; brown (10YR 5/3) fine sandy loam, brown (10YR 4/3) moist; weak coarse and very coarse prismatic structure; slightly hard; very friable; many fine roots; neutral; clear wavy boundary.

**Bw2**--10 to 16 inches; light brownish gray (2.5Y 6/2) fine sandy loam, grayish brown (2.5Y 5/2) moist; weak very coarse prismatic structure; slightly hard, very friable; common fine roots; slightly alkaline; clear wavy boundary. (Combined Bw horizons is 7 to 20 inches thick)

**Bk**--16 to 28 inches; light gray (2.5Y 7/2) fine sandy loam, grayish brown (2.5Y 5/2) moist; weak coarse subangular blocky; slightly hard, very friable; few fine roots; few fine accumulations of carbonate; strong effervescence; moderately alkaline; gradual wavy boundary. (6 to 15 inches thick.)

**Cr**--28 to 60 inches; white (2.5Y 8/1) weakly cemented sandstone, light brownish gray (2.5Y 6/2) moist; strong effervescence; moderately alkaline.

**TYPE LOCATION:** Butte County, South Dakota; about 1 mile north and 8 miles east of Hoover; 1,700 feet east and 1,200 feet south of northwest corner, sec. 1, T. 13 N., R. 8 E.

**RANGE IN CHARACTERISTICS:** The depth to soft sandstone bedrock ranges from 20 to 40 inches. The depth to carbonates typically ranges from 10 to 20 inches. Some pedons are leached of carbonates to the bedrock and are considered similar inclusions. Rock fragments range from 0 to 5 percent throughout.

The A horizon has hue of 10YR or 2.5Y, value of 4 or 5 and 3 or 4 moist, and chroma of 2 or 3. Pedons that have color value as dark or darker than value 5.5 dry and 3.5 moist, have an A horizon less than 4 inches thick. It typically is fine sandy loam but includes sandy loam. It ranges from slightly acid to slightly alkaline.

The Bw horizon has hue of 10YR or 2.5Y, value of 5 or 6 and 4 or 5 moist, and chroma of 2 to 4. It is fine sandy loam or sandy loam. It ranges from slightly acid to slightly alkaline.

The Bk horizon has hue of 10YR or 2.5Y hue, value of 5 to 7 and 4 to 6 moist, and chroma of 1 to 4. It is fine sandy loam or sandy loam. Layers of loamy sand textures 6 inches or less in thickness are allowed. It has disseminated and few or common accumulations of carbonate. It ranges from neutral to moderately alkaline.

Some pedons have a BC or C horizon that has color of the Bk horizon. They typically are fine sandy loam but some pedons are sandy loam or loamy fine sand.

The Cr horizon is typically soft sandstone but it is interbedded with soft siltstone, clay shale and lignite in some pedons. Some layers do not have carbonates.

**COMPETING SERIES:** These are the [Busby](#) and [Haxby](#) series. Busby soils do not have soft bedrock within depths of 40 inches. Haxby soils do not have a cambic horizon.

**GEOGRAPHIC SETTING:** Twilight soils are on gently sloping to hilly upland hills and ridges. Surfaces are plane to convex. Slope gradients range from 2 to 45 percent. The Twilight soils formed in alluvium or eolian over residuum, or residuum weathered from soft sandstone bedrock. Mean annual air temperature ranges from 40 to 45 degrees F, and mean annual precipitation from 10 to 16 inches. Growing season is about 95 to 130 days; average growing season precipitation ranges from 10 to 12 inches; and growing degree days are about 2500 to 2800.

**GEOGRAPHICALLY ASSOCIATED SOILS:** These are the [Assinniboine](#), [Blackhall](#), [Bullock](#), [Chinook](#), [Parchin](#), [Marmarth](#) and [Sorum](#) soils. Assinniboine and Chinook soils are on similar to less sloping landscapes. Assinniboine and Chinook soils have a mollic epipedon. In addition, Assinniboine and Chinook soils do not have bedrock within depths of 40 inches and Assinniboine soils have a fine-loamy argillic horizon. Blackhall soils are on the steeper parts of the landscape and have soft sandstone at depths less than 20 inches. Bullock, Parchin and Sorum soils have a natric horizon and typically are below the Twilight soils on less steep landscapes. Marmarth soils have a fine-loamy control section and are on less sloping parts of the landscape.

**DRAINAGE AND PERMEABILITY:** Well drained. Surface runoff is medium to very high. Permeability is moderate or moderately rapid.

**USE AND VEGETATION:** Used mainly as rangeland. Some areas are used for cropland. Principal native vegetation is prairie sandreed, little bluestem, needleandthread, western wheatgrass, bluebunch wheatgrass, indian ricegrass, plains muhly, skunkbush sumac, sand bluestem, sagebrush, sedges and forbs.

**DISTRIBUTION AND EXTENT:** Northwestern South Dakota and eastern Montana and possibly southwestern North Dakota. The soil is of moderate extent.

**MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE:** Bismarck, North Dakota

**SERIES ESTABLISHED:** Butte County, South Dakota, 1970.

**REMARKS:** Diagnostic horizons and feature recognized in the pedon are: ochric epipedon - the zone from the surface horizon to about 4 inches (A horizon); cambic horizon - the zone from about 4 to 16 inches (Bw1 and Bw2 horizon); calcic horizon - the zone from 16 to 28 inches (Bk horizon).