Soils Technical Report

Powder River Gas
Coal Creek Plan of Development
November, 2004

Contents

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Soil Survey of Big Horn Country Area, Montana

Major field work for this soil survey was completed in the period 1962-70. Series names and descriptions were approved in 1970. Data in the soil survey refers to conditions in the area in 1971. This survey was made cooperatively by the Soil Conservation Service, (now Natural Resources Conservation Service), the Bureau of Indian Affairs, Missouri River Basin Investigations Project; and the Montana Agricultural Experiment Station.

Data used in this report uses National Soil Information System (NASIS) data combined with Soil Survey Geographic (SSURGO) data: The SSURGO data are the geographic component (GIS layer) for each soil survey unit. The NASIS data are Microsoft Access database files containing the attribute data related to the GIS polygon layer for each soil survey unit. The repository for this information is the Soil Data Mart at: http://soildatamart.nrcs.usda.gov/. The National NRCS NASIS home page is at: http://nasis.nrcs.usda.gov/.

Formation and Classification of the Soils

Formation of the Soils

Soil is developed by the action of soil-forming processes on material deposited or accumulated by geological forces. The characteristics of a soil at any given point depend on the physical and mineralogical composition of the parent material; the climate under which the soil material has accumulated and has existed since accumulation; the plant and animal life on and in the soil; topographic relief; and the length of time the forces of soil development have acted on the soil material.

All five of these factors are important in the genesis of each soil. Some have had more influence than other on a given soil. In this area, climate and parent material, based on geology, have had the greatest influence on soil forming processes and their present characteristics and are expanded upon later in this document.

Climate

Climate, an active force in the formation of soils, is determined mainly by temperature and precipitation. Erosion and alternate freezing and thawing break down rock into material in which soils form. Water and wind are active agents in transporting and separating weathered material. The weathered material is further broken down by chemical reactions such as solution and hydration. The precipitation and temperature affect the kind and amount of native vegetation that grows on the soil. Vegetation decays to produce organic matter that subsequently becomes part of the soil. Soils with cool temperatures and higher precipitation generally have a dark-colored surface layer. Soils with warm temperatures and lower precipitation generally have a light-colored surface layer. In this area, precipitation is 10 to 16 inches per year, and the mean annual temperature is 40 to 46 degrees F.

Living Organisms

Living organisms are active in the formation of soils. Organic matter is the main source of the dark color of the surface layer of soils. Fungi and algae are among the earliest inhabitants of the rock material that contribute to the decomposition of rock. As the rock decomposes, grasses, shrubs, and trees are able to grow and support animal life.

The kinds and amounts of plants and animals present largely determine the kinds and amount of organic matter added to the soil, and the manner in which this matter is incorporated into the mineral part of the soil. Roots, rodents, and insects penetrate the soil and influence its structure. Leaves, roots, and whole plants remain in the surface layer where they are changed to humus by micro-organisms, chemicals in the soil, and insects.

The native vegetation in this area consists of short and mid grasses, forbs, shrubs, and trees. Trees are commonly juniper with minor amounts of ponderosa pine. Big Sagebrush is the most common shrub and western wheatgrass, green needlegrass, bluebunch wheatgrass, and little bluestem are the most dominate grass species.

Common rodents are gophers, prairie dogs, badgers, rabbits, and field mice. Many of the pebbles and cobbles on the surface were brought up by burrowing rodents.

Topography

Topography is determined by the uplift of mountain masses and the resistance of bedrock and geologic formations to erosion by water and wind. In the eroded uplands of this area, runoff water has carved deep valleys into the bedrock. The rugged relief contrasts sharply with the smooth, low relief of the terraces and flood plains of the river valleys.

On the uplands the number, distinctness, and thickness of the soil horizons decreases as slope increases. Steep soils on which runoff is rapid have many characteristics similar to those of soils that formed in arid climates. Nearly level to moderately sloping soils that receive runoff water from soils above have many characteristics of soils that formed in a more humid climate. Erosion on steeper slopes removes surface material, and limits soil development.

Parent material

Many of the soils in this area formed in place over semiconsolidated sedimentary beds or shale. Some soils formed in alluvium and colluvium and were deposited in valleys and on bordering uplands. Soils take on the textural characteristics of the material they formed in. Some soils in the area have salt and sodium derived from the parent material. The salts and sodium make these soils saline, alkaline, or saline-alkaline, and limit the kind and amount of plants that can grow on them. The density of the parent rock and its mineral composition can limit the rate of weathering and the depth of soils.

Time

The changes that take place in a soil over a long period are called soil genesis. These changes give the soil distinct layers of horizons. The kinds and arrangement of these horizons are called soil morphology and are described in terms of color, texture, structure, consistence, thickness, and permeability.

Soils can be classified according to their approximate age, from young to mature. The age or maturity of a soil is generally indicated by the thickness and distinctness of the subsurface horizons, the content of the organic matter and clay, the depth to which soluble material is leached, and the form distribution of calcium carbonate and gypsum in the soil.

Classification of the Soils

The system of soil classification used by the National Cooperative Soil Survey has six categories (Soil Survey Staff, 1998). Beginning with the broadest, these categories are the order, suborder, great group, subgroup, family, and series. Classification is based on soil properties observed in the field or inferred from those observations or from laboratory measurements. The categories are defined in the following paragraphs.

ORDER. Twelve soil orders are recognized. The differences among orders reflect the dominant soil forming processes and the degree of soil formation. Each order is identified by a word ending in sol. An example is Entisol.

SUBORDER. Each order is divided into suborders primarily on the basis of properties that influence soil genesis and are important variables within the orders. The last syllable in the name of a suborder indicates the order. An example is Aquent (Aqu, meaning water, plus ent, from Entisol).

GREAT GROUP. Each suborder is divided into great groups on the basis of close similarities in kind, arrangement, and degree of development of pedogenic horizons; soil moisture and temperature regimes; and base status. Each great group is identified by the name of a suborder and by a prefix that indicates a property of the soil. An example is Fluvaquents (fluv, meaning flood plain, plus aquent, the suborder of the Entisols that has an aquic moisture regime).

SUBGROUP. Each great group has a typic subgroup. Other subgroups are intergrades or extragrades. The typic is the central concept of the great group; it is not necessarily the most extensive. Intergrades are transitions to other orders, suborders, or great groups. Extragrades have some properties that are not representative of the great group but do not indicate transitions to any other known kind of soil. Each subgroup is identified by one or more adjectives preceding the name of the great group but do not indicate transitions to any other known kind of soil. The adjective Typic identifies the subgroup that typifies the great group. An example is Typic Fluvaquents.

FAMILY. Families are established within a subgroup on the basis of physical and chemical properties and other characteristics that affect management. Generally, the properties are those of horizons below plow depth where there is much biological activity. Among the properties the characteristics considered are particle-size class, mineral content, temperature regime, thickness of the root zone, consistence, moisture equivalent, slope, and permanent cracks. A family name consists of the name of a subgroup preceded by terms that indicate soil properties. An example is fine-loamy, mixed, calcareous, frigid Typic Fluvaquents.

SERIES. The series consists of soils that have similar horizons in their profile. The horizons are similar in color, texture, structure, reaction, consistence, mineral and chemical composition, and arrangement in the profile. The texture of the surface layer or of the underlying material can differ within a series. An example is the Deephole series which is a fine-loamy, mixed, calcareous, frigid Typic Fluvaquent.

Classification of soils effected by this project are found in the Official Soils Description starting on page 36 of this document.

References

Soil Survey Staff, 1998, United States Department of Agriculture, Natural Resources Conservation Service, Keys to Soil Taxonomy.

Climate

The area has a modified continental climate and is subject to air masses from several sources. During winter the coldest weather comes from a few Artic air invasions, often supplanted in a few days later by warmer air from the Pacific – sometimes borne on Chinook winds. Spring and early summer are the wettest parts of the year. The heaviest rain is during storms from the Gulf of Mexico, mostly in May and June. Midsummer afternoon thunder storms occur about 25 to 35 days a year, often accompanied by hail and gusty winds. The tables below give temperature and precipitation recorded at nearby stations: Birney, Decker, and Kirby. Data is from the Western Regional Climate Center: http://www.wrcc.dri.edu/climsum.html.

BIRNEY, MONTANA (240819)

Period of Record: 11/13/1954 to 2/ 7/2001

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	33.1	40.4	49.7	61.5	71.6	80.8	89.5	88.5	76.6	64.1	45.0	36.0	61.4
Average Min. Temperature (F)	4.9	11.6	20.5	30.1	40.0	48.8	53.3	51.0	40.7	30.3	18.0	8.6	29.8
Average Total Precipitation (in.)	0.51	0.38	0.65	1.41	2.11	2.64	1.26	0.95	1.07	1.00	0.70	0.50	13.16
Average Total Snow Fall (in.)	6.9	5.4	3.3	3.2	0.2	0.0	0.0	0.0	0.3	0.6	3.6	6.5	30.0
Average Snow Depth (in.)	4	3	1	0	0	0	0	0	0	0	1	2	1

Percent of possible observations for period of record.
Max. Temp.: 95.5% Min. Temp.: 95.7% Precipitation: 95.4% Snowfall: 88.1% Snow Depth: 81.9%

DECKER 1 E, MONTANA (242266)

Period of Record: 4/ 1/1950 to 12/31/2003

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)					Insuff	icient	Data						
Average Min. Temperature (F)					Insuff	icient	Data						
Average Total Precipitation (in.)	0.48	0.34	0.63	1.32	1.92	2.21	1.12	0.88	1.07	0.85	0.61	0.50	11.92
Average Total Snow Fall (in.)	4.1	2.9	3.2	0.9	0.0	0.0	0.0	0.0	0.6	0.4	2.4	4.3	19.0
Average Snow Depth (in.)	0	0	0	0	0	0	0	0	0	0	0	0	0

Percent of possible observations for period of record.
Max. Temp.: 0.5% Min. Temp.: 0.5% Precipitation: 84.9% Snowfall: 68.8% Snow Depth: 44%

KIRBY 1 S, MONTANA (244701)

Period of Record: 11/7/1959 to 7/31/1975

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	33.3	39.4	45.3	56.1	66.6	76.5	86.9	86.5	72.7	62.3	46.6	37.0	59.1
Average Min. Temperature (F)	5.3	11.6	16.8	26.9	35.6	43.3	47.2	45.2	36.2	27.8	18.1	8.9	26.9
Average Total Precipitation (in.)	1.46	1.08	1.20	2.23	2.50	2.94	1.03	1.65	1.77	1.40	0.88	1.11	19.24
Average Total Snow Fall (in.)	17.6	16.6	11.3	9.9	0.7	0.1	0.0	0.0	1.6	1.5	6.6	14.6	80.6
Average Snow Depth (in.)	6	5	2	0	0	0	0	0	0	0	1	3	1

Percent of possible observations for period of record.
Max. Temp.: 99.3% Min. Temp.: 98.8% Precipitation: 99.4% Snowfall: 94.2% Snow Depth: 97.5%

Geology
The area lies within the Unglaciated Missouri Plateau section of the Northern Great Plains Province. The region is underlain by sedimentary rocks, predominantly sandstone, siltstone, and shale.

The terrain of the area is characterized by wide valleys and undulating to steep dissected uplands. Outcrops of sandstone or clinker form ridges and buttes. These topographical forms are local expressions of the hardness of strata and their differential resistance to erosion.

The Tongue River is the one major river in the area. Generally the river is bordered by wide alluvial terraces separated by low bedrock bluffs that are gently sloping to steep and several hundred feet higher than the terraces.

Upland surfaces show that a long period of down cutting has taken place to successionally lower the steam base level. Evidence of this erosion cycle are plateau like upland surfaces and river gravel found capping some upland areas. The terraces near the river are early Pleistocene in age, formed during the glacial epoch. The valley bottoms formed during and after the retreat of glacial ice from northern Montana. At the present time, the streams are in a cycle of down cutting.

Bare steep slopes of rugged badlands occur in isolated areas in the region. The badlands are most often formed in the soft erosive shale of the Lebo Member of the Fort Union Formation.

Structure
The area lies within the northern portion of the Powder River Basin. The Powder River Basin is a broad gentle syncline which extends from southeastern Montana to southeastern Wyoming. The northern part of the basin ends at a structure known as the Miles City Arch, which trends east-west south of Miles City. Strata dips from one to three degrees in the area though local displacement has resulted in dips up to 45 degrees. Faults are somewhat common in this area and are of relatively minor displacement, often covered by sediment and are not easily identifiable.

Geologic History
Permanent withdrawal of seas from the area began after the deposition of sediments forming the Pierre Shale. Broad regional uplift in central Montana is believed to have been the cause of the final withdrawal of the sea (Gill and Cobban, 1973). This final withdrawal of the Late Cretaceous sea is represented by the fine to medium grained sandstone deposits of the Fox Hills Sandstone. Vast amounts of erosional debris from the uplift were subsequently deposited in the region.

Compressional faulting, folding and uplift during the Laramide Orogeny of Late Cretaceous and Early Tertiary produced the structures of this region, although these were later accentuated and other structures were superposed upon them. The mountain ranges produced by the Laramide Orogeny did not project in the manner they do today, but were eroded about as rapidly as they were uplifted. By the end of the Eocene, erosion of the mountains and filling of adjacent basins had resulted in a fairly level topography. Regional altitudes remained low; floors of basins stood no more than 1,000 feet above sea level, and the intervening mountains projected only thousand feet higher. The climate was moist and semitropical; no mountain barriers to the west blocked moisture bearing winds from the Pacific Ocean (King, 1977).

Fort Union sediments were being deposited during the Paleocene as the Big Horn Mountains and Black Hills began to rise, and large volumes of sediment was transported into the swampy flood plain environment of the newly formed Powder River Basin. Outcrops of the Tullock and Lebo Members exhibit varied strata in the northeast part of the basin, which is indicative of lacustrine deposition. Deposition was irregular and in none of the area was deposition continuous. The intervals of nondeposition allowed limited erosion of sediments and is inferred from the abrupt truncation of cross bedding and channel depressions filled with sandstone that cut across coal and shale beds.   The upper Paleocene is represented by the Tongue River Member of the Fort Union Formation. This unit is alternating sandstone, siltstone, carbonaceous shale, coal, and clinker. Continental conditions prevailed with abundant accumulations of organic material in swamps, from which coal was later formed. Deposition was partly cyclic in nature and generally represented a period of alternating fluvial and lacustrine conditions (Balster, 1971).

During the early Eocene, strata in the basin and surrounding areas was strongly folded and faulted (Glaze and Keller, 1965), forming most of the present day structural features of southeastern Montana. The environment of deposition at this time was similar to that of the underlying Tongue River Member, with sediments that later formed shale, sandstone, and coal of the Wasatch Formation being deposited in an environment of fresh water lakes, stream channels, and swamps. During late Eocene time, uplift was renewed in the Black Hills (Robinson et al, 1964) and the basin tilted westward, creating an asymmetrical structure with the deepest part on the west side adjacent to the Big Horn Mountains.

Following the Black Hills uplift, erosion created a mature landscape of reduced relief over much of the area. During Oligocene and Miocene time, the area was buried by tuffaceous debris from increased volcanic activity to the west (Glaze and Keller, 1965). Erosional debris from the Rocky Mountains also formed extensive deposits across the eastern Montana plains. Only the highest mountain ranges were left unburied. These deposits are present today only as isolated remnants of the original broad sheets of sediment.

Near the end of Pliocene time, regional uplift occurred, with many of the structures in the area, such as the Miles City Arch, becoming more prominent. This uplift caused streams to be rejuvenated, uncovering buried mountains and re-excavating basins. Erosion continued until Pleistocene time and produced much of the present landscape (Glaze and Keller, 1965).

The transition to a more arid climate in late Tertiary resulted in part from a world wide change toward cooler, more arid conditions, which proceeded the Pleistocene ice ages. In part it was the result of the higher mountains to the west, which produced a rain shadow over the plains country. By Pliocene time the climate of the Great Plains was apparently as arid as that of the present (King, 1977).

Dramatic fluctuations in climate during the Pleistocene initiated a series of glacial periods which extensively modified Montana's landscape and surficial geology. Continental ice sheets smoothed the northern plains with glacial scouring and deposition of till and outwash. Ice sheets blocked north flowing rivers and streams, resulting in glacial lakes and forcing drainages to flow to the east. During the Pleistocene, deposition of continental debris was restricted to sites associated with glaciation, eolian features in areas of low relief, alluvial deposits along streams, and lacustrine sediments in low lying areas. Erosion has removed most of the Pleistocene deposits from the area. More recent deposition has been alluvial deposition on flood plains, some eolian deposits, and limited amounts of lacustrine sediments.

Bedrock Geology

Bedrock exposed in the area is of sedimentary origin and ranges in age from Tertiary to Recent. The area is predominately covered by the Fort Union Formation and its members. Near the state line, the Wasatch Formation caps much of the uplands. Western volcanism during this time contributed large volumes of ash that was incorporated into the formations as they were deposited. Surficial deposits of terrace gravel and alluvium deposits ranging in age from Oligocene to Holocene form a thin mantle over the eroded bedrock along streams.

The Fort Union Formation of the early Tertiary Period, Paleocene Epoch contains variable floodplain sediments deposited in an area of low relief with an abundance of ponds and swamps. Sandy beds are river channel deposits and finer textured beds are floodplain and levee deposits with coal forming in swampy areas. This formation is more than 2,000 feet thick and is divided into three members, a basal member known as the Tullock, followed by the Lebo, and an upper member called the Tongue River. The Tullock and Tongue River Members are very similar in composition except that the Tongue River contains thicker, greater number, and more persistent coal seams and clinker beds. The Lebo Member is an easily distinguished dark gray shale in contrast to the yellowish colors of the other two members, and is finer textured, commonly forming a badland topography. Resistance of the sandstones is related to cementing agents. Dark yellowish brown weathering brown calcareous sandstones are more resistant ridge formers than noncalcareous light gray sandstones. The Formation covers much of the adjacent region except for near the southern state line.

The Tullock Member consists of interbedded fine grained light yellow sandstone and siltstone, medium gray to light gray sandy or silty shale, and thin but persistent coal beds which grade upward to light gray carbonaceous shale. Some more resistant sandstones form low ledges and much of the sandstone and shale is calcareous.

The Lebo Member consists of predominantly dark gray alkaline shale with thin interbeds of thin, fine grained sandstone or sandy shale lenses. The most distinguishing characteristics of the Lebo are its dark color, barren surface, and ferriginous concretions. Its color and the predominance of clay distinguish the Lebo from the prevailing yellow and red sandy Tongue River Member that overlies it. The bottom of the Lebo is a distinctive marker bed known as the Big Dirty which contains coal in mineable thickness and quality. In addition to this seam, thin layers of non commercial coal are associated with carbonaceous shale in other sections of the Lebo Member. Siderite and calcareous concretions are common and weather to small reddish brown fragments covering outcrop slopes. Lebo outcrops are usually treeless and support sparse vegetation.

The Tongue River Member is the thickest of the Fort Union members and consists of soft interbedded light yellow to light gray fine to medium grained, thick bedded to massive locally crossbedded lenticular sandstones, and siltstone. It commonly contains light buff to light gray shale, siltstone, and shale, and brown to black carbonaceous shale, coal seams and clinker beds. Most sandstones are soft and weakly cemented by calcium carbonate, some sandstones are more resistant, capping buttes and ridges in dissected areas. Shallow coal seams have been extensively burned in the Tongue River Member, baking the overlying sediments into reddish clinker. Because of the resistance of clinker to erosion, these areas show more relief and tend to develop rugged topography. Most sandstone grades into siltstones and shale within short distances, though some persist laterally. Gypsum crystals and powdery sulfur are found along bedding plains in some carbonaceous shale.

The Wasatch Formation of the early Tertiary Period, Eocene Epoch is the youngest bedrock formation in the area. It consists of yellowish gray to light gray siltstone and medium to coarse grained, massive, or cross bedded sandstone interbedded with medium gray shale, brown carbonaceous shale , coal and associated clinker. The formation typically weathers light gray to tan.

Quaternary Alluvium can be found along valley of the Tongue Rivers as well as its tributaries. Most of the alluvium consists of clay, silt, sand, and local lenses of gravel. Gravel consists of clinker fragments on many smaller streams. The composition is dependent on the type of bedrock from which the alluvium developed. Where the Lebo Member is exposed, the alluvium is predominantly silty with a small amount of sand and no gravel. Where streams cross the Tongue River Member and Wasatch Formation, alluvium is sandy and contains more gravel.

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Component Legend
Powder River Gas – Coal Creek Plan of Development

Big Horn County Area, Montana

NASIS Distribution Generation Date: 8/14/2003

Map Unit Symbol and Map Unit Name	% Comp-	Component	Component Kind	Slope Low	Slope RV	Slope High
Kg: KIM LOAM, 4 TO 15 PERCENT SLOPES	85	KIM	Series	4	10	15
THn: THEDALUND-WIBAUX STONY LOAMS, HILLY	45	THEDALUND	Series	15	30	45
	30	WIBAUX	Series	15	30	45
	15	ROCK OUTCROP	Miscellaneous area	---	---	---
THo: THEDALUND-WIBAUX COMPLEX, VERY STEEP	45	THEDALUND	Series	35	53	70
	30	WIBAUX	Series	35	53	70
	20	ROCK OUTCROP	Miscellaneous area	---	---	---

Mapunit Descriptions
Powder River Gas – Coal Creek Plan of Development

Big Horn County Area, Montana

NASIS Distribution Generation Date: 8/14/2003

Note, data applies to the entire extent of the mapunit within the survey area. Mapunit and soil properties for a specific parcel of land may vary somewhat and should be determined by on-site investigation.

Kg - KIM LOAM, 4 TO 15 PERCENT SLOPES

Mean annual precipitation: 12 to 14 inches
Mean annual temperature: 37 to 45 degrees F
Frost-free period: 110 to 125 days

KIM and similar soils

Extent: about 85 percent of the unit
Landform(s):
Slope gradient: 4 to 15 percent
Parent material:
Restrictive feature(s): none
Seasonal high water table: greater than 60 inches
Flooding hazard: none
Ponding Hazard: none

Soil loss tolerance (T factor): 5
Wind erodibility group (WEG): 4L
Wind erodibility index (WEI): 86
Land capability class, non-irrigated: 4e
Drainage class: well drained
Hydric soil: no
Hydrologic group: B
Potential frost action: moderate

Representative soil profile:		*Texture*	*Permeability*	*Available Water Capacity*	*pH*	*Kw*	*Kf*
H1 --	0 to 4 in		moderate	0.6 to 0.7 in	7.9 to 8.4	.37	.37
H2 --	4 to 65 in		moderate	9.8 to 11.0 in	7.9 to 8.4	.37	

Minor Components

THn - THEDALUND-WIBAUX STONY LOAMS, HILLY

Mean annual precipitation: 12 to 14 inches
Mean annual temperature: 39 to 45 degrees F
Frost-free period: 110 to 125 days

THEDALUND and similar soils

Extent: about 45 percent of the unit
Landform(s):
Slope gradient: 15 to 45 percent
Parent material:
Restrictive feature(s): bedrock (paralithic) at 20 to 40 inches
Seasonal high water table: greater than 60 inches
Flooding hazard: none
Ponding Hazard: none

Soil loss tolerance (T factor): 3
Wind erodibility group (WEG): 6
Wind erodibility index (WEI): 48
Land capability class, non-irrigated: 6e
Drainage class: well drained
Hydric soil: no
Hydrologic group: C
Potential frost action: moderate

Representative soil profile:	*Texture*	*Permeability*	*Available Water Capacity*	*pH*	*Kw*	*Kf*
H1 -- 0 to 2 in		moderate	0.2 to 0.3 in	7.4 to 7.8	.24	.37
H2 -- 2 to 14 in		moderate	2.1 to 2.3 in	7.4 to 7.8	.37	
H3 -- 14 to 28 in		moderate	2.3 to 2.6 in	7.4 to 8.4	.37	
H4 -- 28 to 60 in		impermeable				

WIBAUX and similar soils

Extent: about 30 percent of the unit
Landform(s):
Slope gradient: 15 to 45 percent
Parent material:
Restrictive feature(s): none
Seasonal high water table: greater than 60 inches
Flooding hazard: none
Ponding Hazard: none

Soil loss tolerance (T factor): 2
Wind erodibility group (WEG): 5
Wind erodibility index (WEI): 56
Land capability class, non-irrigated: 7e
Drainage class: well drained
Hydric soil: no
Hydrologic group: A
Potential frost action: low

Representative soil profile:	*Texture*	*Permeability*	*Available Water Capacity*	*pH*	*Kw*	*Kf*
H1 -- 0 to 4 in		moderately rapid	0.4 to 0.5 in	7.4 to 8.4	.20	.37
H2 -- 4 to 12 in		rapid	0.3 to 0.5 in	7.9 to 8.4	.05	
H3 -- 12 to 60 in		very rapid	0.0 to 0.5 in	7.9 to 8.4	.02	

ROCK OUTCROP

Extent: about 15 percent of the unit
Landform(s):
Slope gradient:
Parent material:
Restrictive feature(s): none
Seasonal high water table: greater than 60 inches
Flooding hazard: none
Ponding Hazard: none

Soil loss tolerance (T factor):
Wind erodibility group (WEG):
Wind erodibility index (WEI):
Land capability class, non-irrigated:
Drainage class:
Hydric soil: no
Hydrologic group:
Potential frost action:

Representative soil profile:	*Texture*	*Permeability*	*Available Water Capacity*	*pH*	*Kw*	*Kf*
none						

Minor Components

THo - THEDALUND-WIBAUX COMPLEX, VERY STEEP

Mean annual precipitation: 12 to 14 inches
Mean annual temperature: 39 to 45 degrees F
Frost-free period: 110 to 125 days

THEDALUND and similar soils

Extent: about 45 percent of the unit
Landform(s):
Slope gradient: 35 to 70 percent
Parent material:
Restrictive feature(s): bedrock (paralithic) at 20 to 40 inches
Seasonal high water table: greater than 60 inches
Flooding hazard: none
Ponding Hazard: none

Soil loss tolerance (T factor): 3
Wind erodibility group (WEG): 6
Wind erodibility index (WEI): 48
Land capability class, non-irrigated: 7e
Drainage class: well drained
Hydric soil: no
Hydrologic group: C
Potential frost action: moderate

Representative soil profile:	*Texture*	*Permeability*	*Available Water Capacity*	*pH*	*Kw*	*Kf*
H1 -- 0 to 2 in		moderate	0.1 to 0.2 in	7.4 to 7.8	.15	.37
H2 -- 2 to 14 in		moderate	2.1 to 2.3 in	7.4 to 7.8	.37	
H3 -- 14 to 28 in		moderate	2.3 to 2.6 in	7.4 to 8.4	.37	
H4 -- 28 to 60 in		impermeable				

WIBAUX and similar soils

Extent: about 30 percent of the unit
Landform(s):
Slope gradient: 35 to 70 percent
Parent material:
Restrictive feature(s): none
Seasonal high water table: greater than 60 inches
Flooding hazard: none
Ponding Hazard: none

Soil loss tolerance (T factor): 2
Wind erodibility group (WEG): 5
Wind erodibility index (WEI): 56
Land capability class, non-irrigated: 7e
Drainage class: well drained
Hydric soil: no
Hydrologic group: A
Potential frost action: low

Representative soil profile:	*Texture*	*Permeability*	*Available Water Capacity*	*pH*	*Kw*	*Kf*
H1 -- 0 to 4 in		moderately rapid	0.4 to 0.5 in	7.4 to 8.4	.20	.37
H2 -- 4 to 12 in		rapid	0.3 to 0.5 in	7.9 to 8.4	.05	
H3 -- 12 to 60 in		very rapid	0.0 to 0.5 in	7.9 to 8.4	.02	

ROCK OUTCROP

Extent: about 20 percent of the unit
Landform(s):
Slope gradient:
Parent material:
Restrictive feature(s): none
Seasonal high water table: greater than 60 inches
Flooding hazard: none
Ponding Hazard: none

Soil loss tolerance (T factor):
Wind erodibility group (WEG):
Wind erodibility index (WEI):
Land capability class, non-irrigated:
Drainage class:
Hydric soil: no
Hydrologic group:
Potential frost action:

Representative soil profile:	*Texture*	*Permeability*	*Available Water Capacity*	*pH*	*Kw*	*Kf*
none						

Minor Components

Prime and Important Farmland
Powder River Gas – Coal Creek Plan of Development

Big Horn County Area, Montana

NASIS Distribution Generation Date: 8/14/2003

Only the soils considered prime or important farmland are listed. Urban or built-up areas of the soils listed are not considered prime farmland. If a soil is prime or important farmland only under certain conditions, the conditions are specified in parenthesis after the soil name.

Map Symbol	Soil Name

There is no prime or important farmland in this area of development.

Chemical Properties of the Soils
Powder River Gas – Coal Creek Plan of Development

Big Horn County Area, Montana

NASIS Distribution Generation Date: 8/14/2003

Absence of an entry indicates that data were not estimated.

Map Symbol and Soil Name	Depth	Cation Exchange Capacity	Effective Cation Exchange Capacity	Soil Reaction	Calcium Carbon-ate	Gypsum	Salinity	Sodium Adsorp-tion Ratio
	In	meq/100 g	meq/100 g	pH	Pct	Pct	mmhos/cm	
Kg:								
KIM	0-4	15-20	---	7.9 - 8.4	5-10	---	0.0	0
	4-65	10-15	---	7.9 - 8.4	5-15	---	0.0-2.0	0
THn:								
THEDALUND	0-2	15-20	---	7.4 - 7.8	---	---	0.0-2.0	---
	2-14	10-15	---	7.4 - 7.8	1-10	---	0.0-2.0	---
	14-28	5.0-10	---	7.4 - 8.4	5-15	---	0.0-2.0	---
	28-60	---	---	---	---	---	---	---
WIBAUX	0-4	10-15	---	7.4 - 8.4	---	---	0.0-2.0	---
	4-12	5.0-10	---	7.9 - 8.4	5-15	---	0.0-2.0	---
	12-60	0.0-1.0	---	7.9 - 8.4	---	---	0.0-2.0	---
ROCK OUTCROP	---	---	---	---	---	---	---	---
THo:								
THEDALUND	0-2	15-20	---	7.4 - 7.8	---	---	0.0-2.0	---
	2-14	10-15	---	7.4 - 7.8	1-10	---	0.0-2.0	---
	14-28	5.0-10	---	7.4 - 8.4	5-15	---	0.0-2.0	---
	28-60	---	---	---	---	---	---	---
WIBAUX	0-4	10-15	---	7.4 - 8.4	---	---	0.0-2.0	---
	4-12	5.0-10	---	7.9 - 8.4	5-15	---	0.0-2.0	---
	12-60	0.0-1.0	---	7.9 - 8.4	---	---	0.0-2.0	---
ROCK OUTCROP	---	---	---	---	---	---	---	---

Physical Properties of the Soils
Powder River Gas – Coal Creek Plan of Development

Big Horn County Area, Montana

NASIS Distribution Generation Date: 8/14/2003

Entries under "Erosion Factors--T" apply to the entire profile. Entries under "Wind Erodibility Group" and "Wind Erodibility Index" apply only to the surface layer. Absence of an entry indicates that data were not estimated.

Map Symbol and Soil Name	Depth	Sand	Silt	Clay	Moist Bulk Density	Permeability (Ksat)	Available Water Capacity	Linear Extensi-bility	Organic Matter	Erosion Factors Kw	Erosion Factors Kf	Erosion Factors T	Wind Erodi-bility Group	Wind Erodi-bility Index
	In	Pct	Pct	Pct	g/cc	In/Hr	In/In	Pct	Pct					
Kg:														
KIM	0-4	---	---	18-27	1.10-1.30	0.6-2	0.16-0.18	0.0-2.9	1.0-2.0	.37	.37	5	4L	86
	4-65	---	---	18-30	1.40-1.60	0.6-2	0.16-0.18	0.0-2.9	0.5-1.0	.37	---			
THn:														
THEDALUND	0-2	---	---	18-27	1.15-1.35	0.6-2	0.12-0.14	3.0-5.9	1.0-3.0	.24	.37	3	6	48
	2-14	---	---	18-27	1.25-1.45	0.6-2	0.17-0.19	3.0-5.9	0.5-1.0	.37	---			
	14-28	---	---	18-27	1.30-1.50	0.6-2	0.17-0.19	3.0-5.9	0.0-0.5	.37	---			
	28-60	---	---	---	---	---	---	---	---	---	---			
WIBAUX	0-4	---	---	10-22	1.20-1.40	2-6	0.09-0.13	0.0-2.9	1.0-2.0	.20	.37	2	5	56
	4-12	---	---	10-22	1.25-1.45	6-20	0.04-0.06	0.0-2.9	0.5-1.0	.05	---			
	12-60	---	---	0-1	1.50-1.70	20	0.00-0.01	0.0-2.9	0.0-0.5	.02	---			
ROCK OUTCROP	---	---	---	---	---	---	---	---	---	---	---	---	---	---
THo:														
THEDALUND	0-2	---	---	18-27	1.15-1.35	0.6-2	0.07-0.09	0.0-2.9	1.0-3.0	.15	.37	3	6	48
	2-14	---	---	18-27	1.25-1.45	0.6-2	0.17-0.19	3.0-5.9	0.5-1.0	.37	---			
	14-28	---	---	18-27	1.30-1.50	0.6-2	0.17-0.19	3.0-5.9	0.0-0.5	.37	---			
	28-60	---	---	---	---	---	---	---	---	---	---			
WIBAUX	0-4	---	---	10-22	1.20-1.40	2-6	0.10-0.13	0.0-2.9	1.0-2.0	.20	.37	2	5	56
	4-12	---	---	10-22	1.25-1.45	6-20	0.04-0.06	0.0-2.9	0.5-1.0	.05	---			
	12-60	---	---	0-1	1.50-1.70	20	0.00-0.01	0.0-2.9	0.0-0.5	.02	---			
ROCK OUTCROP	---	---	---	---	---	---	---	---	---	---	---	---	---	---

Rutting Hazard
Powder River Gas – Coal Creek Plan of Development

Big Horn County Area, Montana

NASIS Distribution Generation Date: 8/14/2003

The information in this table indicates the dominant soil condition, but does not eliminate the need for onsite investigation. The numbers in the value column range from 0.01 to 1.00. The larger the value, the greater the potential limitation. Limiting features in this report are limited to the top 5 limitations. Additional limitations may exist.

Map Symbol and Soil Name	Pct of Map Unit	Soil Rutting Hazard: Rating Class and Limiting Features	Value
Kg:			
Kim	85	Severe	
		Strength	1.00
THn:			
Thedalund	45	Severe	
		Strength	1.00
Wibaux	30	Severe	
		Strength	1.00
Rock Outcrop	15	Not Rated	
THo:			
Thedalund	45	Severe	
		Strength	1.00
Wibaux	30	Severe	
		Strength	1.00
Rock Outcrop	20	Not Rated	

Definitions

Drainage class:

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

Hydric soil:

A hydric soil is a soil that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part. Hydric soils along with hydrophytic vegetation and wetland hydrology are used to define wetlands.

The current criteria for generating a list of hydric soils in the Federal Register, February 24, 1995, volume 60, number 37, page 10349. The reference for field identification of hydric soils is Field Indicators of Hydric Soils of the United States, Fall 1996.

Hydrologic group:

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

The soils in the United States are placed into four groups A, B, C, and D, and three dual classes, A/D, B/D, and C/D. Definitions of the classes are as follows:

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

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

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

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

Dual hydrologic groups, A/D, B/D, and C/D, are given for certain wet soils that can be adequately drained. The first letter applies to the drained condition, the second to the undrained. Only soils that are rated D in their natural condition are assigned to dual classes.

Land capability class, non-irrigated:

Land capability classification shows, in a general way, the suitability of soils for most kinds of field crops.

Crops that require special management are excluded. The soils are grouped according to their limitations for field crops, the risk of damage if they are used for crops, and the way they respond to management. The criteria used in grouping the soils do not include major and generally expensive landforming that would change slope, depth, or other characteristics of the soils, nor do they include possible but unlikely major reclamation projects. Capability classification is not a substitute for interpretations that show suitability and limitations of groups of soils for rangeland, for woodland, and for engineering purposes.

In the capability system, soils are generally grouped at three levels -- capability class, subclass, and unit. Only class and subclass are included in this dataset.

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

Class I soils have few limitations that restrict their use.

Class II soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.

Class III soils have severe limitations that reduce the choice of plants or that require special conservation practices, or both.

Class IV soils have very severe limitations that reduce the choice of plants or that require very careful management, or both.

Land capability classification shows, in a general way, the suitability of soils for most kinds of field crops. Crops that require special management are excluded. The soils are grouped according to their limitations for field crops, the risk of damage if they are used for crops, and the way they respond to management. The criteria used in grouping the soils do not include major and generally expensive landforming that would change slope, depth, or other characteristics of the soils, nor do they include possible but unlikely major reclamation projects. Capability classification is not a substitute for interpretations that show suitability and limitations of groups of soils for rangeland, for woodland, and for engineering purposes.

In the capability system, soils are generally grouped at three levels -- capability class, subclass, and unit. Only class and subclass are included in this dataset.

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

In class I there are no subclasses because the soils of this class have few limitations. Class V contains only the subclasses indicated by w, s, or c because the soils in class V are subject to little or no erosion. They have other limitations that restrict their use to pasture, rangeland, woodland, wildlife habitat, or recreation.

Prime and important farmland
Farmland Classification identifies soils as prime farmland, farmland of statewide importance, or farmland of local importance. Farmland classification identifies the location and extent of the most suitable land for

producing 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.

Permeability

Soil permeability is the quality of the soil that enables water or air to move through it. Historically soil survey has used permeability as term for saturated hydraulic conductivity (Ksat). Saturated hydraulic conductivity is measured as the amount of water that would move vertically through a unit area of saturated soil in unit time under hydraulic gradient. Ksat is expressed as micrometers per second.

Permeability classes for Ksat values are: very rapid 141 - 705, rapid 42 - 141, moderately rapid 14 - 42, moderate 4 - 14, moderately slow 1.4 - 4, slow 0.42 - 1.4, very slow 0.01 - 0.42, impermeable 0.00 - 0.01.

K factor

Soil erodibility factors K factor - whole (Kw) and K factor - rock free (Kf) are erodibility factors which quantify the susceptibility of soil detachment by water. These erodibility factors predict the long-term average soil loss, which results from sheet and rill erosion under various alternative combinations of crop systems and conservation techniques. K factor - whole considers the whole soil, and K factor - rock free considers only the fine-earth fraction, which is the material < 2.0 mm in diameter.

Prime or important farmland

Farmland Classification identifies map units as prime farmland, farmland of statewide importance, or farmland of local importance. Farmland classification identifies the location and extent of the most suitable land for producing 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.

T factor (Soil loss tolerance):

The T factor is the soil loss tolerance. It is defined as the maximum amount of erosion in tons per acre per year at which the quality of a soil as a medium for plant growth can be maintained. This quality of the soil to be maintained is threefold in focus. It includes maintaining (1) the surface soil as a seedbed for plants, (2) the atmosphere-soil interface to allow the entry of air and water into the soil and still protect the underlying soil from wind and water erosion, and (3) the total soil volume as a reservoir for water and plant nutrients, which is preserved by minimizing soil loss.

Soil loss tolerance “T” is assigned according to properties of root limiting subsurface soil layers. The designation of a limiting layer implies that the material above the layer has more favorable plant growth properties. As limiting or less favorable soil layers become closer to the surface, the relative ability of a soil to maintain its productivity through natural and managed processes decreases.

WEG (Wind erodibility group) and WEI (Wind erodibility index):

Wind Erodibility Group (WEG) is a grouping of soils that have similar properties affecting their resistance to soil blowing in cultivated areas. The groups indicate the susceptibility to blowing. The Wind Erodibility Index (WEI), used in the wind erosion equation, is assigned using the wind erodibility groups.

Official Soil Descriptions

Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture.
Official Soil Series Descriptions
Available URL: http://soils.usda.gov/soils/technical/classification/osd/index.html

LOCATION KIM CO+KS MT NM WY
Established Series
Rev. AJC/GB/PRF
01/2000

KIM SERIES

The Kim series consists of very deep, moderately permeable, well drained soils that formed in alluvium and mixed eolian and alluvial material derived from sandstone and shale. Kim soils are on alluvial fans below escarpments of sedimentary rock and uplands. Slopes are 0 to 20 percent. The mean annual precipitation is about 13 inches and the mean annual temperature is about 51 degrees F.

TAXONOMIC CLASS: Fine-loamy, mixed, active, calcareous, mesic Ustic Torriorthents

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

A--0 to 6 inches; grayish brown (10YR 5/2) loam, dark grayish brown (10YR 4/2) moist; moderate very fine granular structure; soft, very friable; strongly effervescent; moderately alkaline (pH 8.0); clear smooth boundary. (4 to 8 inches thick)

AC--6 to 14 inches; grayish brown (10YR 5/2) clay loam, dark grayish brown (10YR 4/2) moist; weak medium prismatic structure parting to weak medium subangular blocky; hard, very friable, plastic; violently effervescent; moderately alkaline (pH 8.0); clear wavy boundary. (6 to 10 inches thick)

C--14 to 60 inches; pale brown (10YR 6/3) clay loam, brown (10YR 5/3) moist; massive; hard, very friable; 5 percent sandstone fragments; some visible calcium carbonate occurring as small soft masses; violently effervescent; moderately alkaline (pH 8.0).

TYPE LOCATION: Bent County, Colorado; 50 feet west and .85 mile south of the northwest corner of Sec. 3, T. 26 S., R. 52 W.

RANGE IN CHARACTERISTICS: Mean annual soil temperature ranges from 49 to 58 degrees F., and mean summer soil temperature ranges from 59 to 78 degrees F. The surface 15 inches has approximately .8 percent organic matter and the sand/clay ratio ranges from 1 to about 3. The particle-size control section is typically loam, sandy clay loam, or light clay loam, and less commonly in the lower part a fine sandy loam. It has 18 to 35 percent clay, 20 to 55 percent silt, and 15 to 60 percent sand, with more than 15 percent but less than 45 percent being fine or coarser sand. Rock fragments are typically less than 10 percent and range from 0 to 15 percent. Exchangeable sodium percentage is usually less than 3 and is less than 15 in any layer as thick as 4 inches. This soil is not dry in all parts of the moisture control section for more than one-half the time that the soil temperature is above 41 degrees F. (225 to 235 days) and is not dry for 45 consecutive days following July 15.

A horizon
Hue: 5Y through 7.5YR
Value: 5 through 7 dry, 3 through 6 moist
Chroma: 2 through 4
Structure: granular structure, but has subangular blocky structure in some pedons.
Consistence: soft to slightly hard
Carbonates: In some pedons it is leached to depths of 2 to 8 inches.

Reaction: slightly alkaline or moderately alkaline (pH 7.6 to 8.2)
When the surface horizons have value as dark as 5 dry and 3 moist they contain less than 1 percent organic carbon, or they are thin enough that if mixed to depth of 7 inches the soil has an ochric epipedon.

C horizon:
Hue: 5Y through 7.5YR
Value: 6 or 7 dry, 4 through 6 moist
Chroma: 2 through 6
Reaction: moderately to strongly alkaline (pH 8.0 to 8.6)
Calcium carbonate equivalent: 1 to 14 percent
Calcium carbonate: soft masses occurs at any depths in this horizon, but it should not be concentrated into a consistent horizon of secondary carbonate accumulation.

COMPETING SERIES: These are the El Rancho, Kishona, Mikim, Neville, Paradox, Pojoaque, Shavano, Sixmile, Thedalund, Theedle, and (T) Tsosie series. Shavano, Sixmile, Thedalund, and Theedle soils have bedrock at some point above a depth of 40 inches. El Rancho, Neville, and Pojoaque soils have hue of 5YR or redder. Kishona soils have cooler annual soil temperature and have moisture control sections that are dry more than one-half the time, cumulative, that the soil temperature at 20 inches is above 41 degrees F. Kishona soils are also dry in all parts of the moisture control section for at least 60 consecutive days following July 16. Mikim and Paradox soils are dry in some parts of the moisture control section for 15 consecutive days from May 15 to July 15 when the soil temperature at 20 inches is greater than 41 degrees F. In addition, Paradox soils have hues of 5YR and redder. Tsosie soils are dry in all parts of the soil moisture control section from April 15 to July 1.

GEOGRAPHIC SETTING:
Slope: 0 to 20 percent
Landform: alluvial fans usually below escarpments of sedimentary rock
Landscape: uplands
Parent material: parent sediments derived from a variety of rocks, including sandstone, shale, and similar materials.
Mean annual precipitation: 11 to 14 inches, with peak periods of precipitation occurring during the spring and early summer.
Mean annual temperature: 47 to 53 degrees F.
Mean annual summer temperature is 74 degrees F.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Shingle soils and the competing Thedalund soils. The three series often form a toposequence. Shingle soils have bedrock at depths of 10 to 20 inches.

DRAINAGE AND PERMEABILITY:
Drainage: Well
Runoff: low to high
Permeability: moderate

USE AND VEGETATION: These soils are used principally as native pastureland; however, they are used as dry or irrigated cropland in some localities. Native vegetation typically consists of short grasses, of which blue grama predominates.

DISTRIBUTION AND EXTENT: Eastern Colorado, southeastern Wyoming, and northeastern New Mexico in MLRA 69. The series is of moderate extent.

MLRA OFFICE RESPONSIBLE: Salina, Kansas

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

REMARKS: Diagnostic features include an ochric epipedon and free lime carbonate at 7 to 20 inches. Last updated by the state 2/94.
Updated by the MLRA Office-5 on 1/12/2000 to update the parent materials in the first paragraph and to move to a semi-tab format.

National Cooperative Soil Survey
U.S.A.

LOCATION THEDALUND CO+MT UT WY
Established Series
GB
11/98

THEDALUND SERIES

The Thedalund series consists of moderately deep, well drained, moderately permeable soils formed in thick calcareous alluvial materials derived from sedimentary rock. Thedalund soils are on hills and ridges and have slopes of 0 to 30 percent. The mean annual precipitation is about 15 inches and mean annual temperature is about 49 degrees F.

TAXONOMIC CLASS: Fine-loamy, mixed, superactive, calcareous, mesic Ustic Torriorthents

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

A--0 to 2 inches; light brownish gray (10YR 6/2) clay loam, dark grayish brown (10YR 4/2) moist; moderate very fine granular structure; soft, friable; strongly effervescent; moderately alkaline; gradual wavy boundary. (3 to 6 inches thick)

AC--4 to 8 inches; light yellowish brown (2.5Y 6/3) light clay loam, olive brown (2.5Y 4/3) moist; weak medium and fine subangular blocky structure parting to moderate fine granular; strongly effervescent; moderately alkaline; gradual wavy boundary. (3 to 6 inches thick)

C--8 to 30 inches; pale yellow (2.5Y 7/3) light clay loam, light yellowish brown (2.5Y 6/3) moist; massive; hard, very friable; few small concretions of secondary calcium carbonate; strongly effervescent; moderately alkaline; gradual wavy boundary. (12 to 28 inches thick)

Cr--30 inches; soft shale and interbedded soft sandstone and siltstone.

TYPE LOCATION: Arapahoe County, Colorado; 1,400 feet north and 200 feet east of the SW corner of Sec. 7, T. 4 S., R. 57 W.

RANGE IN CHARACTERISTICS: Mean annual soil temperature ranges from 47 to 58 degrees F. and mean summer soil temperature ranges from 59 to 79 degrees F. Normally, these soils are calcareous throughout but they are leached for a few inches in some pedons. Some visible secondary calcium carbonate occurs inconsistently and at variable depths. The particle size control section is generally loam or light clay loam, but clay ranges from 18 to 35 percent, silt from 20 to 55 percent and sand from 15 to 50 percent with more than 15 percent but less than 35 percent fine or coarser sand. Rock fragments range from 0 to 15 percent by volume. Depth to bedrock ranges from 20 to 40 inches.
The A horizon has hue of 5Y through 7.5YR, value of 5 through 7, 3 through 5 moist, and chroma of 2 through 4. The horizon is usually granular but has subangular blocky structure in some pedons. It is soft or slightly hard. It is mildly alkaline or strongly alkaline (pH 7.8 to 8.5).

The C horizon has hue of 5Y through 7.5YR. It is loam or clay loam with more than 18 percent clay. It is moderately alkaline or strongly alkaline (pH 8.0 to 8.6) and contains 1 to 5 percent calcium carbonate equivalent.

COMPETING SERIES: These are the El Rancho, Kim, Kishona, Neville, Pojoaque, Shavano, and Sixmile series. El Rancho, Kim, Kishona, Neville, and Pojoaque soils lack a paralithic contact at a depth of less than 40 inches. Also El Rancho, Neville and Pojoaque soils have hue of 5YR or redder. Shavano soils have a lithic contact between a depth of 20 and 40 inches, Sixmile soils have hue of 5YR or redder.

GEOGRAPHIC SETTING: Thedalund soils are on hills and ridges. Slopes range from 0 to 30 percent. The soils formed in thick calcareous alluvial fan materials derived from sedimentary rock. At the type location the average annual precipitation is 15 inches with peak periods of precipitation in the spring and early summer months. Mean annual temperature is 49 degrees F., mean summer temperature is 69 degrees F.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the competing Kim soils and the Shingle soils. Shingle soils have bedrock at a depth of 20 inches or less.

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

USE AND VEGETATION: They are used as native pastureland or as irrigated or dry cropland. Native vegetation is blue grama, sage, and cactus.

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

MLRA OFFICE RESPONSIBLE: Bismarck, North Dakota

SERIES ESTABLISHED: Arapahoe County, Colorado, 1965.

National Cooperative Soil Survey
U.S.A.

LOCATION WIBAUX WY+MT

Established Series
CAP
02/2000

WIBAUX SERIES

The Wibaux series consists of very deep, well drained soils formed in colluvium and alluvium derived from porcelanite. Wibaux soils are on hillslopes, knolls and ridges. Slopes range from 0 to 75 percent. The mean annual precipitation is about 15 inches, and the mean annual temperature is about 46 degrees F.

TAXONOMIC CLASS: Loamy-skeletal over fragmental, mixed, superactive, nonacid, mesic Ustic Torriorthents

TYPICAL PEDON: Wibaux channery fine sandy loam, on a 4 percent north facing slope - utilized as range land. (Colors are for dry soils unless otherwise stated)

A--0 to 3 inches; reddish brown (5YR 5/4) channery fine sandy loam, reddish brown (5YR 4/4) moist; weak fine granular structure; soft, very friable, nonsticky and nonplastic; noneffervescent; 25 percent angular scoria channers; slightly alkaline; clear wavy boundary. (3 to 6 inches thick)

C--3 to 16 inches; reddish brown (5YR 5/4) very channery loam, reddish brown (5YR 4/4) moist; massive; soft, friable, slightly sticky and slightly plastic; noneffervescent; 55 percent angular scoria channers; slightly alkaline; clear wavy boundary. (4 to 17 inches thick)

2C--16 to 60 inches; fractured porcelanite.

TYPE LOCATION: Campbell County, Wyoming; about 1600 feet west and 150 feet south of the northeast corner of Sec. 14, T 41 N, R 70 W.; USGS Piney Canyon SW, WY topographic quadrangle; lat. 43 degrees 32 minutes 3 seconds N. and long. 105 degrees 12 minutes 42 seconds W.

RANGE IN CHARACTERISTICS: Depth to the fragmental substrata ranges from 7 to 20 inches. These soils typically are noncalcareous throughout the loamy-skeletal part of the control section but some pedons have carbonates within 6 inches. The fragmental materials in some pedons are inconsistently calcareous. The weighted average organic carbon content of the surface 15 inches or that portion of the solum above the fragmental beds ranges from approximately 0.4 to 1.0 percent. Conductivity is typically less than 2 mmhos/cm and exchangeable sodium percentage is normally less than 3 percent. The mean annual soil temperature ranges from 47 to 53 degrees F. The soil temperature at 20 inches is 41 degrees F. or higher for 175 to 210 days. The fragmental material contains interstices ranging from 2 mm to over 2 cm in diameter. These are devoid of any fine earth material.

The A horizon has hue of 5YR, 7.5YR or 10YR, value of 5 to 7 and 3 to 6 moist, and chroma of 2 to 6. When the value of the A horizon is as dark as 5 and 3 moist, the horizon is too thin or contains too little organic matter to be a mollic epipedon. Texture is loam or fine sandy loam, or channery or very channery analogues of these textures. Rock fragments range from 5 to 40 percent, with 0 to 5 percent flagstone. Reaction is neutral or slightly alkaline. Some pedons have an AC horizon.

The C horizon has hue of 2.5YR, 5YR, 7.5YR or 10YR, value of 4 to 7 and 3 to 6 moist, and chroma of 2 to 8. Texture is very channery or extremely channery loam or fine sandy loam. Rock fragments range from 35 to 90 percent, with 0 to 15 percent flagstones and 0 to 5 percent stones. Reaction is neutral to slightly alkaline. Moderately alkaline reactions may occur where baked shale is sodic.

The 2C horizon consists of fractured and/or folded porcelanite beds. A soil matrix is uncommon but when present is less than 5 percent. Colors of the rock are quite variable but commonly have 10R or 2.5YR hue. Hues of 5Y have been recorded in some areas.

COMPETING SERIES: There are no competing soils.

GEOGRAPHIC SETTING: The Wibaux series occurs on hillslopes, knolls and the crests and shoulders of ridges. Slopes range from 0 to 75 percent. The soil is developing in thin mantels of medium to moderately fine textured, noncalcareous, channery materials weathered principally from porcelanite beds. The average annual precipitation ranges from 10 to 14 inches with peak periods of precipitation occurring in April, May and June. The mean annual temperature is 46 degrees F., and the mean summer temperature is 65 degrees F. Elevation is 3,500 to 5,800 feet. The frost-free season is 105 to 130 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Lawver, Shingle, Taluce, Teckla, Theedle and Turnercrest soils. Lawver and Teckla soils occur on uplands and footslopes. They have argillic horizons. Shingle, Taluce, Theedle and Turnercrest occur on similar landscape positions as Wibaux soils lack fragmental discontinuities. Redhills soils are moderately deep to fractured porcelanite.

DRAINAGE AND PERMEABILITY: Well to somewhat excessively drained; runoff is medium; permeability is moderate over very rapid.

USE AND VEGETATION: They are used as native rangeland. Native vegetation includes sage, prairie junegrass, Sandberg bluegrass and needleandthread. Some areas have ponderosa pine and juniper.

DISTRIBUTION AND EXTENT: Wyoming, Montana and South Dakota. The series is of moderate extent.

MLRA OFFICE RESPONSIBLE: Bismarck, North Dakota.

SERIES ESTABLISHED: Campbell County, Wyoming; 1940.

Ochric epipedon - 3 inches (A horizon)

Fragmental discontinuity - 16 inches (top of 2C horizon)

Ustic subgroup of the aridic moisture regime.

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