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REPORT ON

RESOURCE AND POTENTIAL RECLAMATION EVALUATION OF

NEWELL/28 STUDY SITE OTTER CREEK COALFIELD MONTANA 1978

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RESOURCE AND POTENTIAL RECLAMATION EVALUATION OF NEWELL/28 STUDY SITE OTTER CREEK COALFIELD, MONTANA

CONTENTS

PLATES

TABLES

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TABLES (cont.)

PHOTOGRAPHS

RESOURCE AND POTENTIAL RECLAMATION EVALUATION
OF
NEWELL/28 STUDY SITE
OTTER CREEK COALFIELD, MONTANA

INTRODUCTION

The nation's ever increasing need for energy has focused attention on the abundant low sulphur coal resources in the Western States, primarily the Rocky Mountain and the Northern Great Plains regions, due to the abundance, ease of extraction, and the quality of the coal present. It is the responsibility of the Bureau of Land Management to assist in meeting the nation's energy demands and, at the same time, provide for reclaiming surface mined lands.

Purpose

This study will provide data for developing reclamation objectives at a potential coal leasing area. The site was selected to determine if existing data collected for the nearby Otter Creek Study Site (EMRIA No.1) could be correlated or projected throughout the Otter Creek Coalfield.

Authority

This report is prepared in accordance with Section 4 of the Agreement between the Bureau of Land Management and the Bureau of Reclamation dated May 7, 1974.

Location

The Newell/28 Site is located in Powder River County, about 10 miles (16 km) southeast of Ashland, Montana. The site includes all of Section 28, T.4S., R.45 E. It is 1.2 miles (1.9 km) west of the Otter Creek East Study Site which was completed in 1976. Plate 1 shows the general location of all pre-1979 study sites in the Otter Creek Coalfield.

The Federal Government owns all coal deposits in the site. The surface is privately owned.

CLIMATE

The Newell 28 Study Site is in the Otter Creek geographical area which has a continental type climate. It is cold in the winter and warm in the summer. Large daily variations are common. Elevations at the site range from 3135 (956) to 3344 feet (1019 m). The Broadus weather station, at elevation 3030 feet (924 m), receives 14.2 inches (361 mm) average annual precipitation and Birney, at elevation 3190 feet (972 m), receives an average of 13.7 inches (348 mm) annually. Torrential rainstorms are common and unprotected soil surfaces may erode severely during these storms. These storms, though common, may not cover large areas. Hailstorms occasionally cross the area, but these weather extremes do not place the area in any particular type storm belt. About 53 percent of the precipitation falls as rain during the growing season. Growth of native grass is rapid during May and June which are the wettest months of the year. Precipitation data from the Otter weather station located 28 miles (45.2 km) southwest of this site follow:

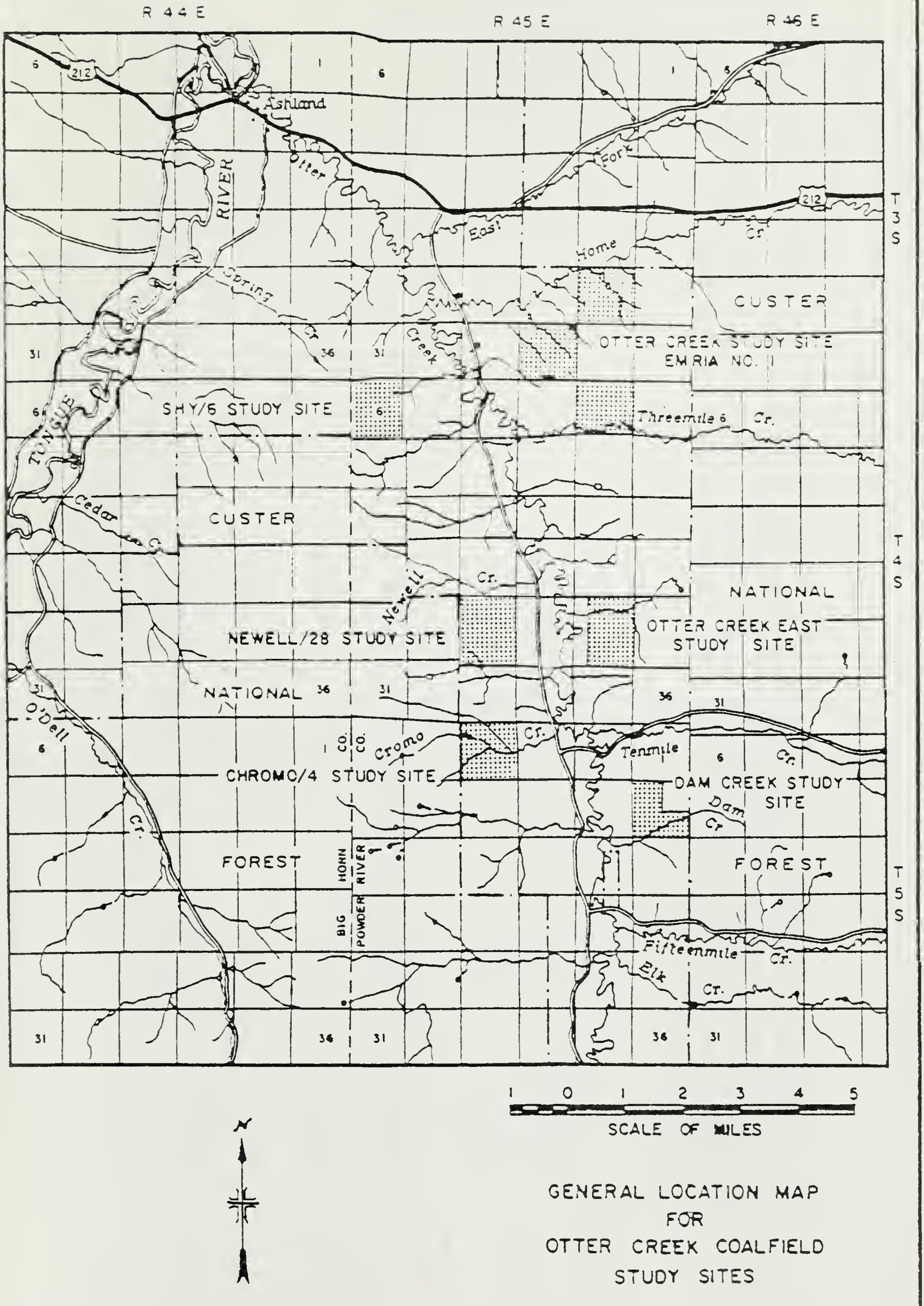
May	June	July	August	Sept.	Percent of Annual	Annual
2.51	3.30	1.32	1.26	1.69	53	19.1 1/ inches
63.8	83.8	33.5	32.0	42.9	53	485.1 millimeters

The elevation of the Otter station is 4000 feet (1219 m).

The frost-free period (32°F or 0°C) ranges from 108 days at Birney to 120 days at Broadus. The growing season for hardy grasses (28°F or -2.2°C) in average years begins May 10 at Birney and ends 131 days later on Sept. 19. Following the spring rains, July is hot, dry and windy with excessive evaporation and evapotranspiration rates. Humidity is low. During the months of June, July and August, about 32 days have a temperature of 74°F (23.3°C) or higher. Average monthly temperatures exceed 51°F (10.6°C) in May, June, July, August, September and October. July, with an average temperature of 74°F (23.3°C), is the hottest month and May and October, with 51°F (10.6°C), are the coolest growing season months.

The climate in the Otter Creek area in most years is suited for reclamation of surface mined land because the spring rains are generally adequate for establishing stands of native vegetation. The 13.7 (348) to 14.2 inches (361 mm) of precipitation received in average years meet the requirement of range vegetation which grows rapidly in the late spring and early summer. This moisture from natural precipitation is usually depleted by established native grasses in 6 to 8 weeks and the plants mature and become dormant. Consumptive use data in Table 1 show native grasses could use 22.5 inches (571 mm) of moisture if available; but it also shows that 13.9 inches (353 mm) or the average annual precipitation could be used by July 15. Table 1 prepared for the Otter Creek Study Site also represents the potential consumptive use in this site.

1/ The Otter station is several hundred feet higher than this study site. The apparent effect is an increase in the precipitation, especially during the nongrowing season.



GENERAL LOCATION MAP
FOR
OTTER CREEK COALFIELD
STUDY SITES

Multiply miles by 1.6093 to obtain kilometers

Table 1 - Potential Consumptive Use of Moisture and Available Moisture - Native Grasses 1/

Newell/28 Study Site

Month	Midpoint	Accumulative Days to Midpoint	Air Temp. (^{o}C)	Monthly Requirement Millimeters	Moisture Reserve Millimeters 2/	Precipitation Millimeters	Difference Millimeters 3/
May 4					+ 102.6		
	May 17	13	12.6	71.1		56.6	+ 88.1
June					+ 85.6		
	June 15	42	17.3	120.6		79.5	+ 47.0
July					+ 47.0		
	July 15	72	21.8	161.5		34.5	- 80.0 4/
August					- 80.0		
	August 15	103	21.0	140.2		27.4	- 192.8
Sept.					- 192.8		
	Sept. 13	131	14.6	77.5		30.5	- 239.8
Sept. 27		145					
				570.9		228.5	

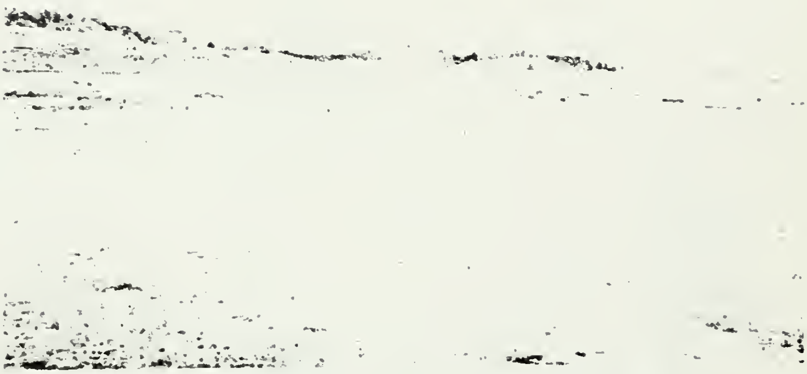
1/ Computed by Blaney-Criddle Method using the Broadus Weather Station - Latitude 45°26' N.
2/ Moisture Reserve = Summation of precipitation (Oct. to April) = 128.3 x 0.80 = 102.6 millimeters
3/ Difference = Moisture Reserve plus precipitation minus moisture use
4/ Natural precipitation during most years is inadequate to meet potential moisture needs. In average years, the plants use the available moisture by July 15 and mature and become dormant.

Reclamation of surface mined land is very difficult in areas that consistently receive 10 inches (254 mm) of precipitation or less each year. In this area, years that receive less than the average annual precipitation are not common. The Broadus station reported less than 10 inches (254 mm) only three times in the last 37 years and Birney only once in the last 21 years.

PHYSIOGRAPHY

The Newell/28 Study Site is in the unglaciated portion of the Great Plains Physiographic Province. Relief ranges from 3135 feet (956 m) in the eastern part of the section to 3344 feet (1019 m) on a bench in the western part of the study site. The topography, which is relatively flat along the major drainages, changes to rolling uplands dominated by narrow ridges with steep (20 to 35 percent) sideslopes in the western and southern parts of the study site. The branching dendritic drainage system is well developed in the weak sandstones and shales of the Fort Union Formation. Gene Creek, the only named tributary in the study site, crosses the SW¼ of the section. All drainage is tributary to Otter Creek which flows northwestward into the Tongue River. Photographs 1 through 3 show the typical terrain in the study area.

Photograph 1 - Newell/28 Study Site - Otter Creek Coalfield, Montana.
Panoramic view looking east from near the center of Section 28.
U. S. Bureau of Reclamation photograph 11/16/77



Photograph 2 - Newell/28 Study Site - Otter Creek Coalfield, Montana. View looking west into the study site. Photograph taken from trail in western half of Section 27.
U. S. Bureau of Reclamation photograph 11/16/77

Photograph 3 - Newell/28 Study Site - Otter Creek Coalfield, Montana. View looking west toward DH78-101 which is near the white U.S.G.S. well casing in the center of the photograph.
U. S. Bureau of Reclamation photograph 11/16/77

GEOLOGY

Regional Geology

The Newell/28 Study Site is in the northern part of the Powder River Basin in southeastern Montana. This basin, a part of the unglaciated portion of the Great Plains Physiographic Province, is about 225 miles (363 km) long, extending from the Yellowstone River in Montana to the North Platte River in Wyoming. It is about 90 miles (145 km) in width, bounded on the west by the Bighorn Mountains and on the east by the Black Hills. Structurally, the basin is an asymmetrical syncline with a northwestward trending axis. An estimated 18,000 feet (5486 m) of sediments overlie the basement complex in the deepest part of the basin north of Glenrock, Wyoming.

The geologic history of the area since Precambrian time includes periods of deposition, deformation, and erosion. During the Paleozoic and Mesozoic Eras, a sequence of carbonates, sandstones, and shales was deposited throughout Montana and Wyoming. Thickness of these sediments on the west side of the basin varies from 9,000 feet (2743 m) near Yellowtail Dam to 11,500 feet (3505 m) near Buffalo, Wyoming. About 6,500 feet (1981 m) of Paleozoic and Mesozoic sediments are present in the Black Hills area on the east side of the basin.

The area was relatively stable during these periods with deposition usually occurring in a marine environment. Deformation of strata began with the Laramide Revolution near the close of the Mesozoic Era (Late Cretaceous), at which time mountain masses such as the Bighorns and Black Hills were uplifted. Uplift continued throughout Paleocene and gradually ended in Eocene time. Materials stripped from the mountains were deposited in fans or sheets across the basin floors, gradually burying the flanks of the mountains in their own debris. By the middle of the Cenozoic Era, the basins were largely filled and the mountains peneplained. In Pliocene time, a broad regional uplift occured and continued intermittently into Pleistocene time. This uplift raised the previously developed peneplain surface to elevations of about 10,000 feet (3048 m) in the Bighorn Mountains. Streams rejuvenated by the uplift excavated the basins and exhumed the buried mountain masses.

Today, Precambrian rocks are exposed in the cores of the Black Hills and Bighorn Mountains. These rocks are surrounded by sediments of Paleozoic and Mesozoic Age. The central part of the basin is filled with Cenozoic (Tertiary) sediments.

Site Geology

Investigations

Previous geologic investigations have been conducted in the general area by the U. S. Geological Survey and the Montana Bureau of Mines and Geology. A list of relevant maps and publications follows:

1. U.S.G.S. Bulletin 1072-J - Reconnaissance Geology of the Birney-Broadus Coal Field, Rosebud and Powder River Counties, Montana.

2. U.S.G.S. Miscellaneous Field Studies Map MF-802 - Willow Crossing Quadrangle, Montana.

3. U.S.G.S. Miscellaneous Field Studies Map MF-807 - Fort Howes Quadrangle, Montana.

4. U.S.G.S. Miscellaneous Field Studies Map MF-814 - Browns Mountain Quadrangle, Montana.

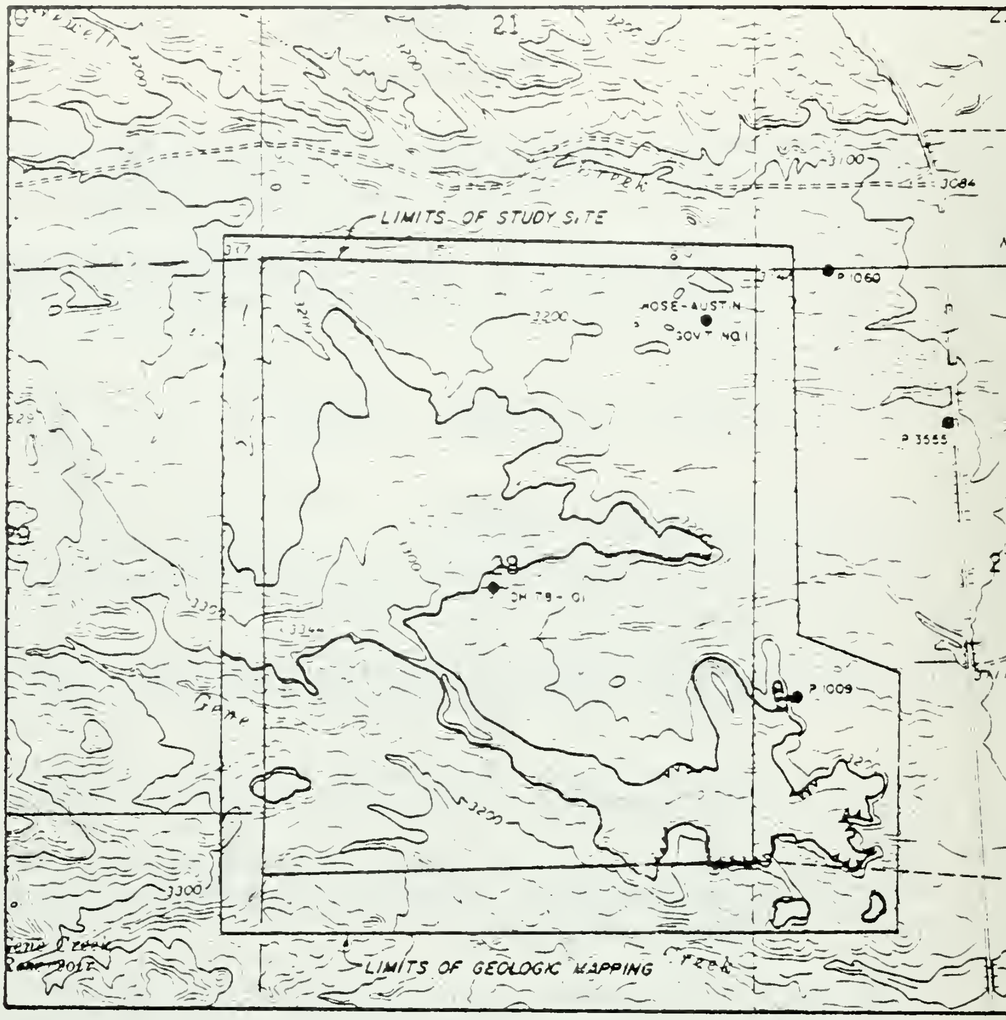
5. U.S.G.S. Miscellaneous Field Studies Map MF-817 - King Mountain Quadrangle, Montana.

6. Montana Bureau of Mines and Geology Bulletin 69 - Strippable Coal Deposits on State Land, Powder River County, Montana.

7. Montana Bureau of Mines and Geology Bulletin 91 - Quality and Reserves of Strippable Coal, Selected Deposits, Southeastern Montana.

Geologic investigations were conducted at the Newell/28 Study Site by the U. S. Bureau of Reclamation during May and June of 1978. Investigations included mapping the surface geology and drilling one core hole. Drill cores were tested by the U.S.B.R. Soils Laboratory for suitability in reconstructed profiles. Results of the tests are graphically shown on the geologic log. Detailed geologic mapping on a scale of 1 to 12,000 was done in the field on aerial photographs. The data were transferred to a topographic map and are shown on Plate 2. A detailed geologic log for Drill Hole 78-101 is included in this report (Plate 3).

Core drilling was performed using a Failing Model 314 rotary drill rig with an "H" series wire line core barrel. Water from Otter Creek was used as the drilling fluid. Test results conducted by the U.S.B.R. Soils Laboratory in Miles City, Montana, indicated that the total dissolved solids in the water supply was about 900 parts per million (900 mg/l).



EXPLANATION

PALEOCENE	(blank box)	FT UNION FORMATION (TONGUE RIVER MEMBER) - interbedded shale, siltstone, sandstone and coal
	(toothed line)	Coalbed burned at outcrop
	(heavy line)	3 to 4 ft of coal. The Sawyer Coalbed of McKay (Geologic Map of King Mountain quadrangle, Montana USGS Map MF-817) corresponds with the "F" Coalbed of the Otter Creek East Study Site and probably the "F" bed of the Dam Creek and Chromo/4 Study Sites and the "A" and "C" beds of the Otter Creek Study Site (EMRIA #1)
	(star symbol)	D.H. 78-101 USBR Drill hole
	(dot)	P 1060 Drill hole from U.S.G.S. Miscellaneous Field Studies Map MF-817

1000 0 1000 2000 3000

SCALE OF FEET
C.I. = 20'

NOTE
Elevations and distances measured in feet. Multiply feet by 0.3048 to obtain meters

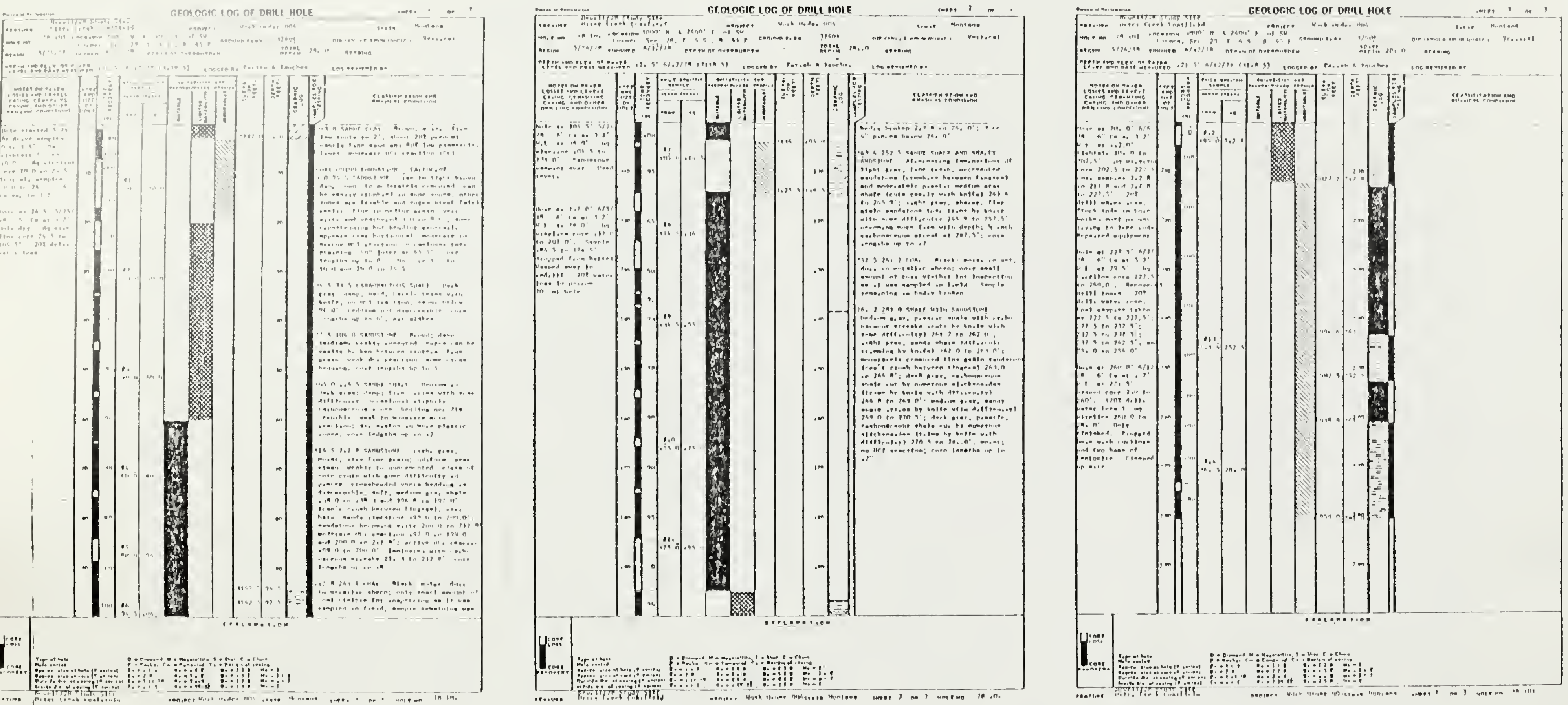
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

RESOURCE & POTENTIAL RECLAMATION EVALUATION
NEWELL/28 STUDY SITE
OTTER CREEK COALFIELD - MONTANA

GEOLOGIC AND INVESTIGATIONS MAP

GEOLOGY ______ SUBMITTED ______
DRAWN ______ RECOMMENDED ______
CHECKED ______ APPROVED ______

BILLINGS, MONTANA — JULY 1979 — 1305-600-153



UNITED STATES
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BUREAU OF RECLAMATION

NEWELL/2B STUDY SITE
OTTER CREEK COALFIELD-MONTANA

GEOLOGIC LOG OF DH 7B-101

1305-600-154

Stratigraphy

The Fort Union Formation of Paleocene Age underlies the entire area. It is divided into the Tullock, Lebo and Tongue River Members. The Tullock and Lebo Members are not discussed in this report as they are not exposed and were not encountered in drilling. Except for alluvium, only sediments in the lower part of the Tongue River Member are involved in the study area. The upper part of the Tongue River and younger rock have been stripped away by erosion. Brief descriptions of the Cenozoic sediments involved in the site follow:

Fort Union Formation (Paleocene)

Tongue River Member - pale olive to yellowish gray sandstone, siltstone, shale, carbonaceous shale and coal with thin lenticular calcareous or siliceous cemented concretions. Unweathered samples vary from light to dark gray in color. Poorly silicified, fragmented tree trunks and soft, calcareous shell fragments are common in zones. Sandstones, even though uncemented, tend to be resistant in outcrops. Shale and siltstone zones generally form slopes below sandstone ledges. Coal and carbonaceous beds are generally traceable over large areas. Conversely, correlation of clastic sediments over short distances is difficult due to variation in bedding thicknesses and lithologic changes. Tongue River sediments were deposited in a continental environment which included swamps conducive to the production of coalbeds. Thickness of this member varies from 1150 (351 m) to 1900 feet (579 m) in the Montana portion of the Powder River Basin.

One striking feature in the Tongue River Member is the resistant clinker zones that cap ridges or armor valley walls. The clinker, which is fused or baked rock, was produced by the burning of underlying coalbeds along their outcrops. In places where the heat was sufficiently intense, the clinker has been fused to a dark gray, lightweight rock similar in appearance to vesicular basalt. Near the outer edge of thermal metamorphism, the rock is disoriented, baked and red to orange in color. Alteration of the overlying material is roughly proportional to the original thickness of coal that has burned. A coalbed 20 feet (6 m) thick will produce clinker zones 40 to 60 feet (12 to 18 m) thick. The clinker is highly permeable and locally supplies water for springs and wells.

Except for minor alteration of sediments along the Sawyer coalbed (Plate 2), clinker deposits do not occur in the study site.

Only the Knoblock coalbed is of economic significance at the Newell/28 Study Site. It thins and splits into several benches southward from the Otter Creek Study Site, EMRIA No. 1. At the Otter Creek Study Site the coalbed averages about 61 feet (18.6 m) thick. At the Otter Creek East Site, a distance of 3 to 4 miles (4.8 to 6.4 km) southward, it splits into an upper and lower bench, 45 and 17 feet (13.7 and 5.2 m) thick, respectively. Across the valley, a mile (1.6 km) west of the Otter Creek East Site, at the Newell/28 Study Site, the Knoblock is also split into two benches. The upper averages about 38 feet (11.6 m) thick and the lower about

13.5 feet (4.1 m) thick. At the Chromo/4 Site, about a mile (1.6 km) south of the Newell/28 Study Site, the Knoblock splits into five main benches. In descending order, they are about 6, 26, 7, 2 and 10 feet (1.8, 7.9, 2.1, 0.6, and 3.1 m) thick. At the Dam Creek Site, about 2.5 miles (4 km) southeast of the Chromo/4 Study Site, the upper bench of the Knoblock coal is about 24 feet (7.3 m) thick and geologic data in the Montana Bureau of Mines and Geology Bulletin 91 indicate that lower benches of the Knoblock are insignificant. Plate 1 shows the locations of all study sites along Otter Creek.

Alluvium(Holocene)- deposits of clay, silt, sand and gravel that cover valley floors of Otter Creek and its tributaries. Gravels are generally composed of clinker or hard shale and sandstone fragments. The deposits are up to 20 feet (6.1 m) thick.

Structure

Sediments at the Newell/28 Study Site and in the surrounding Otter Creek Coalfield are generally flat lying with minor folding evident on the surface and on subsurface contour maps constructed using drill hole information. Some of the structural irregularities may be of a depositional nature while others may be due to differential compaction of the underlying strata.

Small local faults exist in the area as indicated by slickensides encountered in the drill core. They are generally restricted to weak, plastic, carbonaceous shales immediately above or below coalbeds. Displacement along the fractures could not be determined but probably does not exceed 5 feet (1.5 m). No faulting was observed during surface mapping.

Paleontology

Occasional poorly silicified tree fragments and pieces of unidentified calcareous shells were found on the surface area. However, nothing of significance was observed.

Engineering Geology

Engineering property tests were not conducted on bedrock samples from the Newell/28 Study Site. However, physical properties of these sediments should be similar to the results obtained for Fort Union samples at the Otter Creek Study Site (EMRIA)Report No. 1) by the U. S. Geological Survey. Shear strengths of the materials are low, especially in a saturated condition. Slides could easily develop adjacent to high walls in surface mines, namely along beds of weak, plastic, carbonaceous shales, which are typically cut by inherent slickensides. Adequate drainage should be insured to relieve porewater pressures in the overburden as mine excavations progress.

Saturated alluvial deposits and uncemented siltstones and fine grain sandstones will readily erode and flow into excavations. This problem is occasionally encountered in drilling when the walls of holes continue to collapse and slough. Depth of excavation below the water table will be limited until these materials are unwatered.

Excavation slopes will vary considerably between mine sites and will depend upon exposure time, moisture conditions, materials types and depth of cut. Detailed engineering studies of the overburden will be required at each location for use in determination of designed slopes.

Studies conducted at the Otter Creek Study Site indicate that disturbed overburden (spoil banks and piles) should have slopes not greater than 4 to 1 with berms of 50 to 100 feet (15.2 to 30.5 m) in width designed on the slope surface.

Coal Resources

Coal Analyses

The proximate, ultimate, Btu and sulfur forms analyses were completed by Northern Testing Laboratories in Billings, Montana, on one composite sample (DH78-101 at depths 212.8-243.4 and 251.0-261.2 feet) (64.9-74.2 and 76.5-79.6 m) from the study site. Test results are shown on Table 2. Results indicate that the coal is of Subbituminous C rank with heat value of 8790 Btu as received. The ash and sulfur content as received is 5.35 and 0.20 percent, respectively.

Estimation of Coal Resources

The term "coal resources" is defined as the estimated quantity of coal that is currently or potenially economically mineable. Resource estimates have been prepared for the Newell/28 Study Site using standard procedures and are presented on Table 3.

The quantities shown are categorized as demonstrated resources and are the sum of measured and indicated resources. They contain coal for which estimates of rank, quality and quantity are known and coal for which estimates have been at least partly computed using reasonable geologic projections.

Table 3 shows coal reserves for the Knoblock coalbed which at the Newell/28 Study Site is divided into two beds - the upper, and lower coalbeds. Quantities for each coalbed are shown separately.

Most of the study site is covered with less than 200 feet (61 m) of overburden above the Upper Knoblock. Table 3 divides the coal reserves of the Upper Knoblock coalbed into quantities covered by set ranges of overburden thicknesses. The interburden between the Upper and Lower Knoblock coalbeds averages about 7 feet (2.1 m) thick at the study site and quantities and stripping ratios have been figured separately for it. Structure and overburden thickness contours for the Knoblock coalbed are shown on Plate 4.

LAND CLASSIFICATION

Land classification is a systematic appraisal of lands for a specific purpose. In this classification, lands were grouped in classes 1, 2, 3 or 6 based on their physical and chemical properties that related to their use for plant media in reclaiming surface mined land. Specifications are on Table 4.

Description of the Land

The principal natural land bodies consist of residual and colluvial soils. There are small tracts of alluvial soil along natural drains. Within each soil type there is a range of physical and chemical properties. Alluvial soils are the most uniform and residual soils are the most diverse. The principal land condition represented by each soil group is described separately.

Alluvial Soils

The soils in this site are along the channels of small intermittent upland natural drains. Surface gradients range from 0 to 6 percent. The vegetative cover is largely mid and short grasses with scattered big sage and a few forbes.

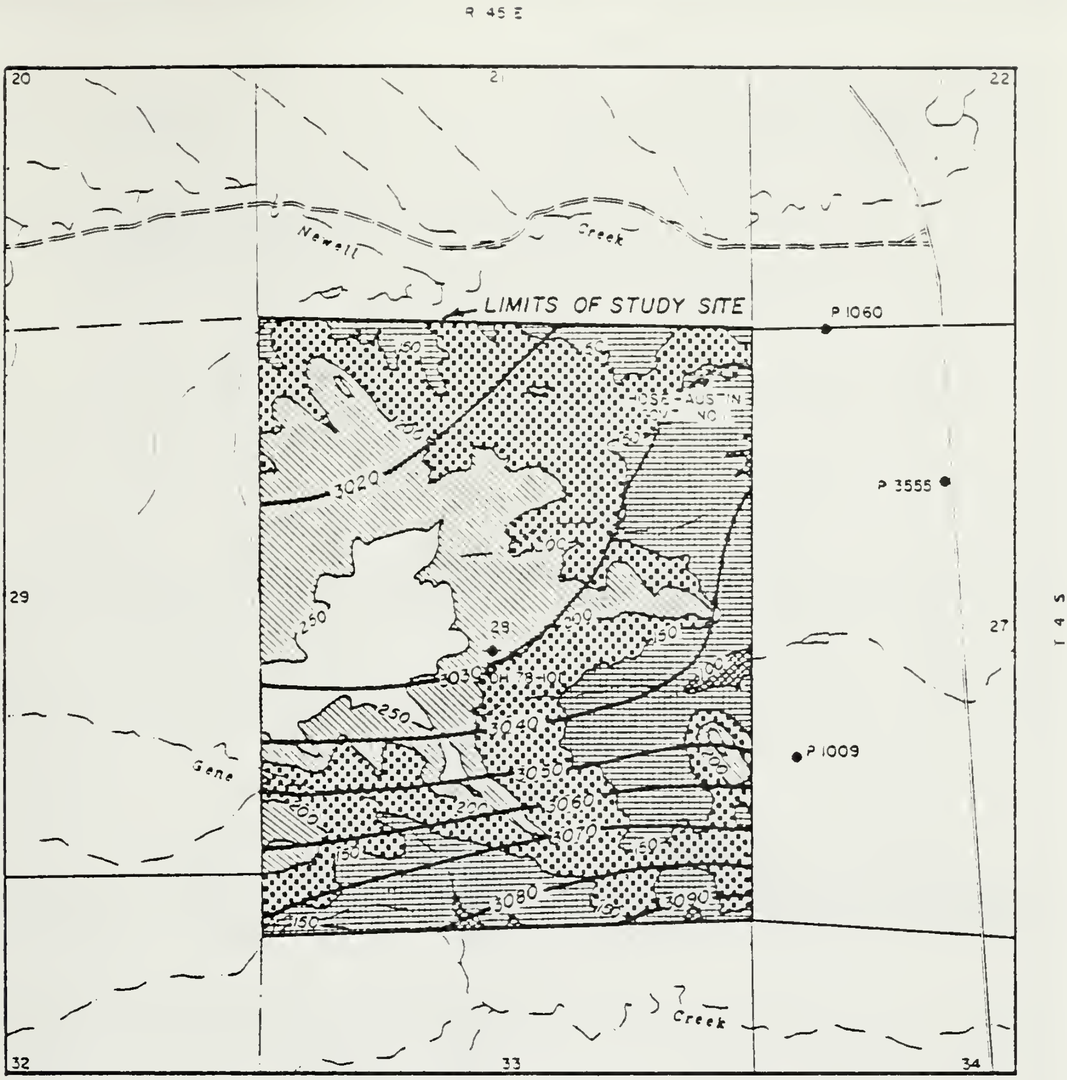
Weakly developed loamy soil profiles are most common. This material is permeable, retains up to 2 inches (51 mm) of water per foot (.3 m), is well drained and is relatively stable. Precipitation enters and moves through this soil readily; therefore surface runoff is minimal. Channel erosion is moderate. The vertical water movement has usually leached the soluble salts below 24 inches (.61 m). Free carbonates occur just below the surface layer and the subhorizons are often saline and may be gypsiferous.

These soils are well suited for use as plant media; however they occupy only a small total acreage in this study site.

Colluvial Soils

The colluvial soils are on footslopes and fans in the upland. They have developed under a mid and short grass plant association that has a moderate amount of big sage and forbes. Slope gradients range from 4 to 15 percent. Short steep slopes of 35% are common along natural drains.

Loamy and fine loamy soil profiles with moderate development are most common. The physical and chemical properties of the surface few inches are similar to the alluvial soils. The lower horizons and substrata have retained many of the physical and chemical properties of the parent material. This material is usually fine textured, slowly permeable and saline. It retains about 2 inches (51 mm) of available water per foot (.3 m).Surface runoff and erosion are in part slope dependent and range from low to moderate.



EXPLANATION

OVERBURDEN ABOVE KNOBLOCK COALBED

- 50 to 100 Feet
- 100 to 150 Feet
- 150 to 200 Feet
- 200 to 250 Feet
- Over 250 Feet
- —3050— Structure contour on top of Knoblock Coalbed.
- —50— Contour showing depth to top of Knoblock Coalbed.
- OH 78-101 ✦ USBR Drill hole
- P 1009 ● Drill hole from USGS Miscellaneous Field Studies Map MF-817

NOTE

Thicknesses and distances measured in feet. Multiply feet by 0.3048 to obtain meters.

1000 0 1000 2000 3000

SCALE OF FEET

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UNITED STATES
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RESOURCE & POTENTIAL RECLAMATION EVALUATION

NEWELL/28 STUDY SITE
OTTER CREEK COALFIELD-MONTANA

OVERBURDEN THICKNESS MAP KNOBLOCK COALBED

GEOLOGY L. PARISH ______ SUBMITTED ______
DRAWN ______ RECOMMENDED ______
CHECKED ______ APPROVED ______

BILLINGS, MONTANA AUGUST 1978 1305-600-155

Report of Coal Analysis
Newell/23

Report to BUREAU OF RECLAMATION
P O BOX 2553
BILLINGS MT 59103

Date July 27, 1978
Job Number 61-11--1
Sheet 1 of 1

Sample Identification.

On June 28, 1978, this coal sample was delivered to our laboratory, with instructions to perform the following analyses.

TEST RESULTS:

Drill Hole: 78-101
Area : Otter Creek Coal Field

Study Site: Newell 23
Depth, ft.: 212 3 - 2-3.4 & 251.0 - 261.2
Formation : --
Lab No. : 15160

Proximate	As Rec'd	Air Dry	Oven Dry
% Moisture	26.39	22.62	0.00
% Ash	5.35	5.63	7.27
% Volatile	29.51	31.02	40.09
% Fixed Carbon	38.75	40.73	52.64
Total	100.00	100.00	100.00

Sulfur Forms	As Rec'd	Air Dry	Oven Dry
Pyritic Sulfur	0.02	0.02	0.03
Sulfate Sulfur	0.02	0.02	0.03
Organic Sulfur	0.16	0.17	0.21
Total Sulfur	0.20	0.21	0.27

	As Rec'd	Air Dry	Oven Dry
% Sulfur	0.20	0.21	0.27
BTU, per pound	8,790	9,240	11,942
BTU, per pound, ash, moisture free			12,878

Note:
Multiply feet by 0.3048 to obtain meters
Multiply Btu/pound x 1.80 to obtain Kilogram-calories/kilogram

Ultimate	As Rec'd	Air Dry	Oven Dry
% Carbon	43.67	45.91	59.33
% Hydrogen**	6.59	6.36	4.95
% Nitrogen	0.81	0.85	1.10
% Oxygen**	43.38	41.04	27.08
% Ash	5.35	5.63	7.27
% Sulfur	0.20	0.21	0.27
Total	100.00	100.00	100.00

**Includes total moisture content in accordance with ASTM D3176

Certified ______

RESOURCE AND POTENTIAL RECLAMATION EVALUATION
OF
NEWELL/28 STUDY SITE
OTTER CREEK COALFIELD
SECTION 28, T. 4 S., R. 45 E.

COAL RESERVES, OVERBURDEN AND INTERBURDEN VOLUMES AND RATIOS, ACRES AND TONS PER ACRE

UPPER KNOBLOCK COALBED 1/

Thickness of Overburden Ft.	Measured and Indicated Reserves Million Tons	Overburden Million Cubic Yards	Overburden Ratio Cubic Yards Per Ton	Acres	Tons Per Acre
50-100	0.41	0.92	2.24	6	68,333
100-150	11.80	36.49	3.09	174	67,816
150-200	16.07	66.91	4.16	237	67,806
200-250	11.19	59.89	5.35	165	67,818
250+	3.93	24.33	6.19	58	67,759
	Total 43.40	Total 188.54	Average 4.34 2/	Total 640	Average 67,906

LOWER KNOBLOCK COALBED 3/

Average Thickness of Interburden Between Upper and Lower Knoblock Coalbeds	Measured and Indicated Reserves Million Tons	Interburden Between Upper and Lower Knoblock Coalbeds Million Cubic Yards	Interburden Ratio Cubic Yards Per Ton	Acres	Tons Per Acre
7.1	15.18	7.33	0.48	640	23,718

FOOTNOTES:

1/ Upper Knoblock Coalbed of Newell/28 Study Site probably corresponds with Upper and Middle Knoblock Coalbeds of the Chromo/4 Study Site. It averages about 18.3 feet thick.

2/ The average shown is a weighted average based on the number of acres per individual ratio.

3/ Lower Knoblock Coalbed averages about 13.4 feet thick.

NOTES:

Thickness of coal, overburden, and interburden based on data from U.S.B.R. Drill Hole DH78-101 and Drill Holes Hose-Austin Govt. No. 1, P1060, P3555, and P1009 as shown on sheets 1 and 2 of U.S.G.S. Miscellaneous Field Studies Map MF-817 and Plates 2 and 3 of this report.

English to Metric Conversions

Multiply	By	To Obtain
Feet	0.3048	Meter
Acre	0.4047	Hectare
Ton	0.9072	Tonne
Cubic Yard	0.7646	Cubic Meter

LAND CLASSIFICATION SPECIFICATIONS - SURFACE MINE RECLAMATION
Suitability of Overburden for Revegetation of Surface-Mined Areas
BLM/BR Cooperative Program EMRIA

Newell/28 Study Site

Table
United States
Dept. of the Interior
Bureau of Reclamation
July 1977

Overburden Characteristics	Symbols: Basic Subclass	Symbols: Inform. & Defic.	Class 1	Class 2	Class 3
SOILS AND/OR BEDROCK	s				
Textures			Sandy loams to clay loams.	Sandy loam to silty clay loam.	Loamy sand to clay.
Coarse		v		Sandy loams sufficiently coarse to slightly reduce productivity, moisture retention and may increase erosiveness slightly.	Loamy sand in sufficient quantity to moderately reduce productivity and moisture retention, and may increase erosiveness moderately.
Fine		h		Profile should have sufficient material for top dressing; clayey type materials that are moderately permeable should be placed below .25 m in the reconstructed profile	Profile should have sufficent material for top dressing; placement of clay in reconstructed profile; permeable .25 m plus; slowly permeable .75 m plus.
Depth		d	1 m of overburden that is suitable for plant media.	.5 m of overburden that is suitable for plant media.	.25 m of overburden that is suitable for plant media.
Sodicity		a	SAR not to exceed 9.0 in clay textured material but may be 20.0 in loam sand. Values may be higher if compensated by adequate gypsum.		
Salinity (m^3/cm)		s	Overburden with characteristics (chemical and physical) capable of producing an expected electrical conductivity at equilibrium with the natural precipitation must be readily available as follows.		
			Less than 4 m^3/cm	Less than 8 m^5/cm except the surface .25 m must be 4 m^3/cm	Less than 12 except the surface .25 m must be 4 m^3/cm
Available Water Holding Capacity		q	38 mm/.3m foot of overburden	.25 mm/.3m of overburden	.19 mm/.3m of overburden
Hydraulic Conductivity		p	Adequate to provide a well drained and aerated root zone and an infiltration rate adequate to prevent serious erosion.	Slightly restricted; movement of drainage water and aeration in the lower root zone will be reduced. Infiltration rate may be reduced and erosion hazard increase slightly.	Restricted in the lower root zone and internal drainage may limit choice of plant species. Restricted infiltration may create serious but controllable erosion hazard.
Indurated Sandstone: Stones and cobble		x	Permissible stone in overburden that may be stockpiled and reused as surface soil 0 to .25 m 5%.	Permissible stone in overburden that may be stockpiled and reused as surface soil 0 to .25 m 10%.	Permissible stone in overburden that may be stockpiled and reused as surface soil 0 to .25 m 20%.
Weatherability 1/			Will break down readily upon exposure to the weather.	May require short period to break down upon exposure.	May require extended period to break down.
Erodibility		e	Slight.	Moderate, controllable with average management.	Severe but controllable with above average management and selective placement of overburden.
TOPOGRAPHY 2/	t				
Slope		g	Permissible surface gradient g - 0 to 12% with smooth slopes.	Permissible surface gradient g - 0 - 20%.	Permissible surface gradient g - 0 - 35%.
Indurated Sandstone: Massive and lenticular		r	None.	1 to 5% of area.	5 to 20% of area.
Cover		c	Not applicable.		
DRAINAGE	d		(Present drainage conditions, surface and subsurface) are not a factor in this classification because of the anticipated land disturbance during mining. All soil properties evaluated to classify the land were also considered in evaluating material that may be placed in the subsurface drainage zone, but this evaluation did not affect the land classes.		
Class 6			Areas delineated in this class generally lack suitable material for stripping and stockpiling for surface use. One or a combination of the following deficiencies may result in the use of this class: (1) insufficient surface soil and bedrock of suitable quality at or near the surface; (2) topography which prevents general stripping and stockpiling; (3) rocklands with large amounts of massive indurated sandstone; (4) toxic overburden (soil and bedrock) on or near the surface. Reclamation of these lands will require material from outside the delineated area, from deep geologic strata, or special treatment of available material.		

1/ Applicable only to unweathered bedrock material.
2/ Not applicable to unweathered bedrock material.

The upper 12 (.3) to 18 inches (.45 m) of soil are well suited for plant media. This material may be placed at or near the surface of reconstructed profiles. Lower horizons are best suited for use below the surface layer.

Residual Soils

In this site the shallow residual soils are on narrow ridges, knobs and steep eroded slopes. The vegetative cover is variable and reflects the interaction of slowly permeable soils, slope gradient and the resultant erosion. Mid and short grasses are most common, but the number of forbes and salt tolerant sedges and shrubs is high. Slope gradients range from 4 to over 35 percent. The rate of erosion is usually high.

Soil profile development is minimal and the physical and chemical properties below the surface 2 (51) to 5 inches (127 mm) are similar to the underlying Fort Union Formation. This subsurface material is fine textured, slowly permeable, commonly saline and sodic, silty to clayey shale.

A composite of the surface 6 inches (152 mm), the approximate minimum stripping depth, will be fair-to-good for use as plant media. Raw shale exposures and rock outcrops are included in this soil type.

Description of Classes

Class 1 land has no major soil and/or topographic limitations. Topographically, this land is well suited for stripping and stockpiling good quality overburden for use as plant media. The physical and chemical properties of this material make it suitable for use at or near the surface of reconstructed profiles. Land in this class is usually a good source of topdressing material. Excess material may be used in tracts with insufficient good quality plant media.

Class 2 land has few soil and topographic limitations. Topographically this land can be stripped and stockpiled without special practices. The suitability of this material for use as plant media is reduced because of texture, permeability, salinity or quantity. Class 2 land has sufficient material for reclamation, but is only a fair-to-poor source of borrow material.

Class 3 land is limited by topography and soils. Special measures such as selective stripping and borrowing topdressing material for localized tracts will be required. Most Class 3 land will have sufficient suitable overburden for reclamation. However, the reclamation potential will be lower because of quantity, texture, permeability, salinity or sodicity. A high level of management will be required for optimum reclamation through revegetation.

Class 6 land does not have sufficient suitable overburden for reclamation. Material must be borrowed or the available material modified for optimum results. The topography and land conditions also limit stripping.

Steep eroded slopes, bluff-forming sandstone and rock outcrops are common. However, selective stripping of the best material will reduce the amount of borrow required.

Methods and Procedures

The chemical and physical properties of soil profiles were evaluated in typical land areas and the land classes were delineated on photographs. Most profiles were sampled for testing in the soil laboratory. After the laboratory tests were completed, the land classes were finalized on reproducible drawings.

Standard laboratory procedures for pH, conductivity (salts), water movement, and soil stability were performed on all samples. Trace elements and heavy metals were determined on the bedrock cores.

Typical profile descriptions are recorded on Tables 6 and 8. Erosion conditions are shown on Tables 5 and 7. Tables 5 through 8 are in the Appendix.

Results of Classification

Class 1 land occurs on 34 percent of the study site. This loamy textured material is of good quality and will be easily stripped and stockpiled.

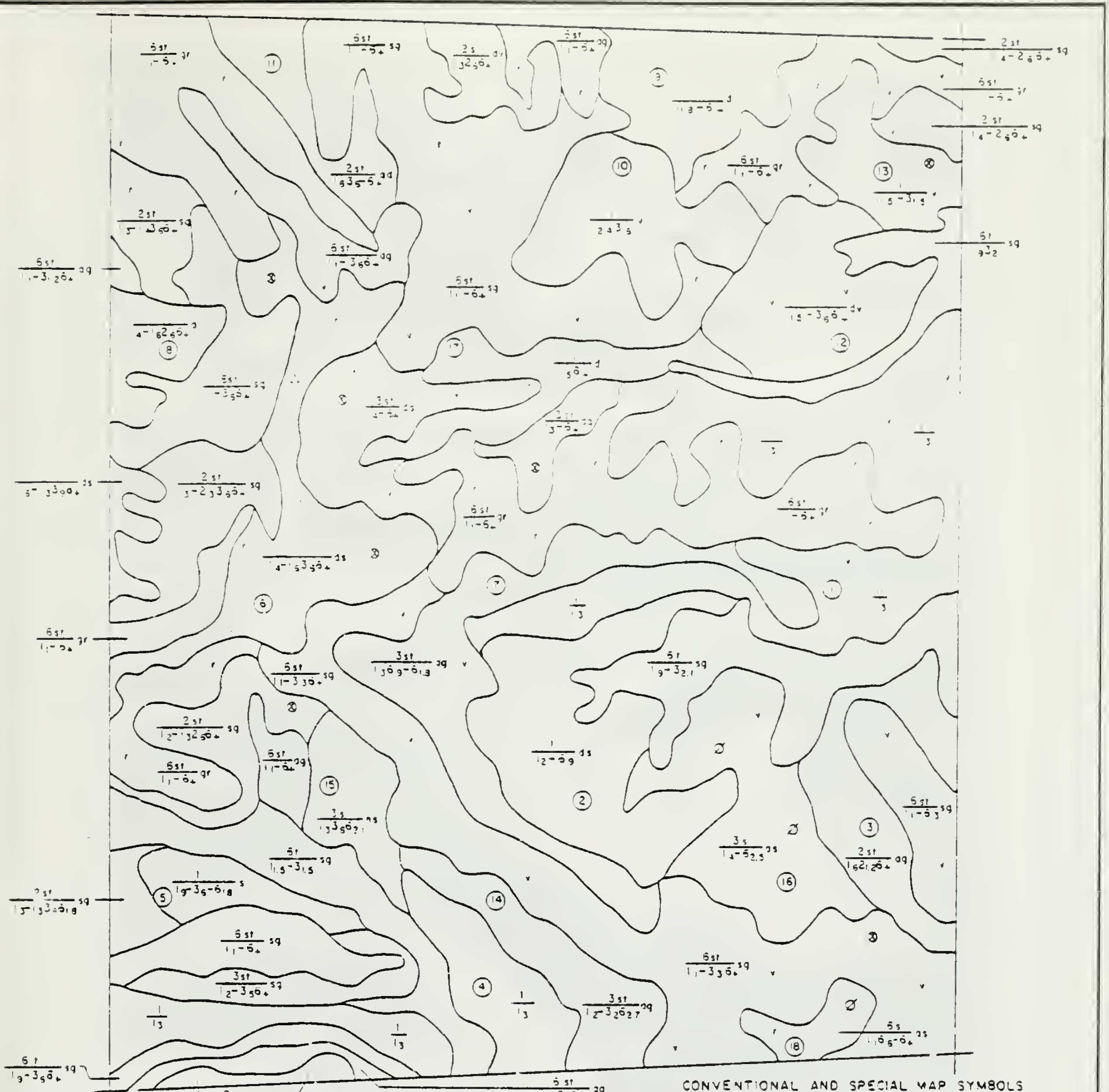
Class 2 land makes up only 12 percent of this site. The major soil deficiencies are salinity and permeability. Sodium and rock are the other deficiencies.

Class 3 land occurs on 15 percent of the area. Soil deficiencies are sodicity, salinity and permeability. Some slick spots and rock and shale outcrops are included in this class. Some borrow will be required, but resurfacing material is adequate in most tracts.

Class 6 land represents 39 percent of the site. Small inclusions of good soil occur, and they merit selective stripping where possible. About 1 percent of the area is in class 6t. The soil is of good quality, but topographically very difficult to strip. The location and areal distribution of the land classes are shown on Plate 5. This drawing also shows the soil and topographic deficiencies.

Results of the screenable tests in the soil laboratory are recorded on Table 9 in the Appendix.

Plate 6 shows the location and the approximate depth of the topsoiling material and Plate 7 shows location, depth and soil deficiencies of subsoil material.



SOIL PROFILE NOTES

PROFILE REPRESENTS 1.5 METERS DEPTH

(3) SOIL PROFILE NUMBER

- 2.8 EC mmhos/cm Sat Ext
- 8.4 pH 1:5 Soil water Suspension
- 8.0 pH Soil-$CaCl_2$ Suspension
- 65 Hydraulic Conductivity - in./hr. (Disturbed Sample)
- 24 Settling Volume

SOIL PROFILE SYMBOLS

Cb	Cobble
Gr	Gravel
S	Sand
LS	Loamy Sand
SL	Sandy Loam
L	Loam
SiL	Silt Loam
SCL	Sandy Clay Loam
CL	Clay Loam
SiCL	Silty Clay Loam
SC	Sandy Clay
C	Clay
SiC	Silty Clay
Sh	Shale
Ss	Sandstone
F	Fine
Lt	Light
M	Medium
H	Heavy

INFORMATIVE SYMBOLS

OVERBURDEN DEFICIENCIES (for plant media)

- a Salinity
- s Sodicity
- n Clay (very fine texture)
- r Coarse (very sandy texture)
- p Restricted permeability
- q Available moisture capacity
- d Depth of suitable overburden
- x Stoniness

TOPOGRAPHIC DEFICIENCIES

- g Slope (including gradient and complexity)
- r Massive lenticular sandstone and or Glacial eratics
- c Cover

LAND CLASSIFICATION SYMBOLS

LAND CLASS — 3st — Plant media deficiency; Topographic deficiency

ag — Informative symbols

SURFACE LAYER: Quality; Depth (meters)

SECOND LAYER: Quality; Depth (meters)

GEOLOGIC MATERIAL: Quality; Depth (meters)

Divides soil material and nonsoil material

CONVENTIONAL AND SPECIAL MAP SYMBOLS

LAND FEATURES

- Blowout
- Clay spot
- Gravelly spot
- Gumbo, slick or scaby spot (sodic)
- Dumps and similar nonsoil areas
- Rock outcrop (includes shale and sandstone)
- Baked rock - clinker (local name scoria)
- Slide or slip (tips point upslope)
- Stony spot, very stony spot
- Greasewood
- Soil profile (check)

WATER FEATURES

- Marsh or swamp
- Spring
- Well artesian
- Well, irrigation
- Wet spot

PITS

- Gravel
- Mine

DAMS

- Medium or small

Section 28, T. 4 S. - R. 45 E.

250 0 250 500

SCALE OF METERS

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

RESOURCE & POTENTIAL RECLAMATION EVALUATION

NEWELL/28 SITE
OTTER CREEK COALFIELD-MONTANA

SEMI-DETAILED LAND CLASSIFICATION

LANDS H. B. WARD	SUBMITTED
DRAWN L. E. ALLSOP	RECOMMENDED
CHECKED	APPROVED
BILLINGS, MONTANA MARCH 1978	1305-600-156

EXPLANATION

DEPTH OF TOPSOILING MATERIAL

MATERIAL FOR USE ON OR NEAR THE SURFACE

Depth	ACRES
0 - 0.1 m	285.6
0.1 - 0.2 m	160.2
0.2 - 0.3 m	84.7
0.3 - 0.4 m	101.3
0.4 - 1.0 m	8.2

TOTAL ADDITIONAL SUITABLE MATERIAL
(.6) 1/

1/ Material over the amount indicated by the zip-a-tone symbols. Best use below 0.1 meters.

Section 28, T. 4 S. - R. 45 E.

250 0 250 500 750
SCALE OF METERS

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
RESOURCE & POTENTIAL RECLAMATION EVALUATION

NEWELL/28 SITE
OTTER CREEK COAL FIELD - MONTANA
TOPSOILING MATERIAL

LANDS H. B. WARD SUBMITTED
DRAWN L. E. ALLSOP RECOMMENDED
CHECKED APPROVED

BILLINGS, MONTANA MARCH, 1978 1305-600-157

EXPLANATION

MATERIAL SUITABLE FOR SUBSURFACE PLACEMENT

QUALITY OF MATERIAL

- Good
- Fair
- Poor
- NS (Not Suitable)
- Material to 3 meters is suitable for use at or near the surface.

DEPTH TO MATERIAL FOR SUBSURFACE PLACEMENT 6'[1]

NOTE

Usable material for subsurface, as used in this report includes that portion of the overburden (soil mantle and bedrock) that should be placed[1] below the primary plant root zone in reconstructed profiles. It contains no known toxic elements but may be clayey, sandy or highly saline. However, the soluble salts will leach from material subjected to downward movement of natural precipitation.

[1] Unless modified by leaching, mixing or other measures.

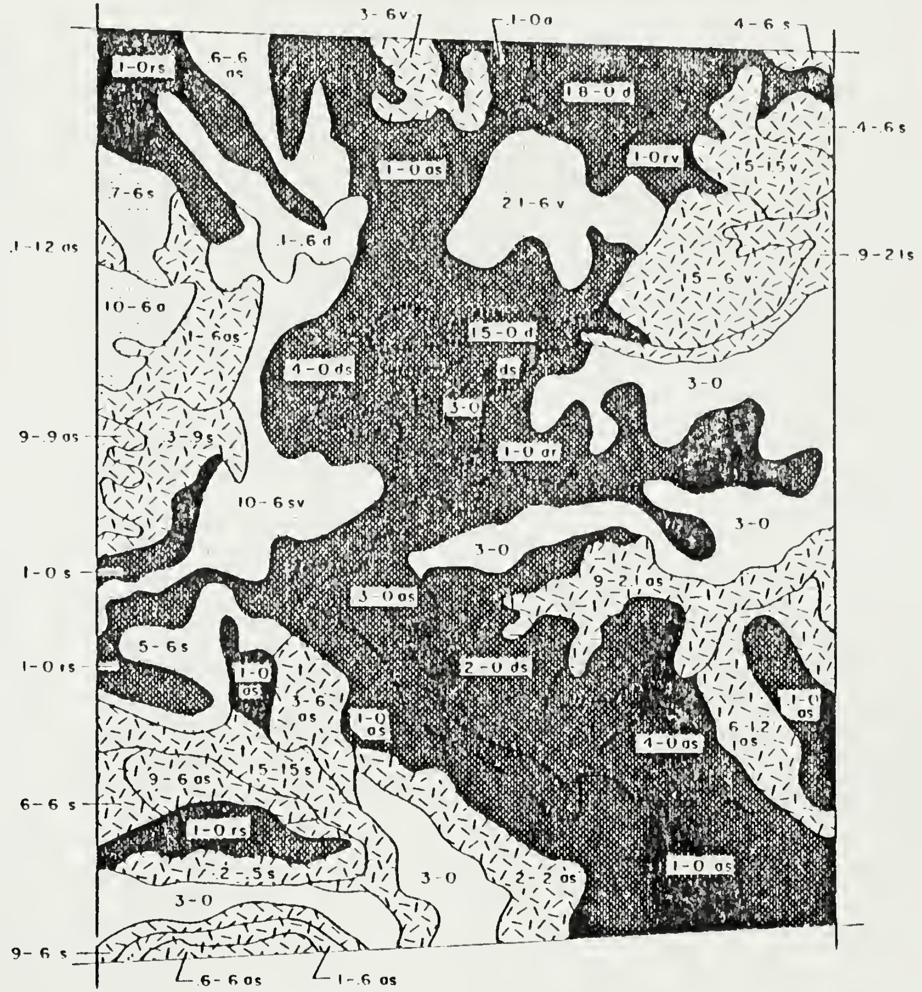
INFORMATIVE SYMBOLS

OVERBURDEN DEFICIENCIES
(for plant media)

- a Salinity
- s Sodicity
- h Clay (very fine texture)
- v Coarse (very sandy texture)
- p Restricted permeability
- q Available moisture capacity
- d Depth of suitable overburden
- x Stoniness

TOPOGRAPHIC DEFICIENCIES

- g Slope (including gradient and complexity)
- r Massive lenticular sandstone and/or Glacial erratics
- c Cover



Section 28, T.4 S.-R 45 E.

250 0 250 500 750
SCALE OF METERS

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
RESOURCE & POTENTIAL RECLAMATION EVALUATION
NEWELL/28 SITE
OTTER CREEK COAL FIELD-MONTANA
SUBSURFACE MATERIAL

LANDS H. B. WARD	SUBMITTED
DRAWN L.F. ALLSOP	RECOMMENDED
CHECKED	APPROVED
BILLINGS, MONTANA	MARCH, 1978

1305-600-158

Soil Inventory

The Powder River Area soil survey data are shown on Plate 8.

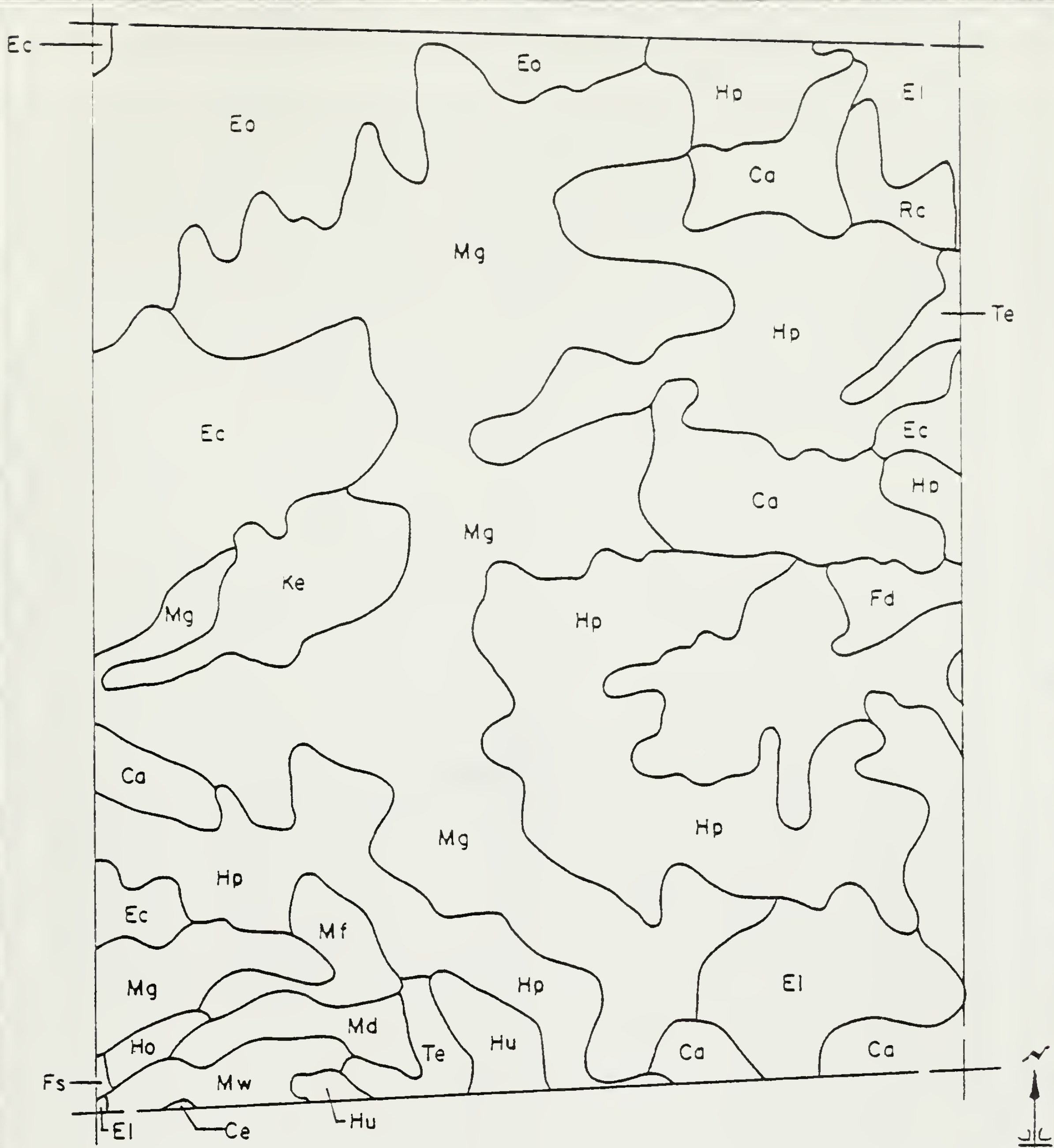
Reclamation Potential

The land conditions in this site are adequate for reclaiming this land if the site is surface mined. The soil and topographic conditions are best suited for returning the site to range. Adding borrow material to class 6s and 6st tracts is necessary for satisfactory reclamation. However, profile enhancement and increased production under post-mining conditions, though limited, are possible.

To achieve maximum or optimum productivity levels under post-mining conditions, the following measures should be considered and used where applicable: (1) Add borrow material to some class 3s and 3st tracts, (2) Class 6 land must receive additional topdressing material, and (3) strip and stockpile all suitable overburden for topdressing reshaped spoils. The quantity of this material would be determined by the post-mining goals of optimum or maximum productivity. Another measure that should be considered and used where applicable, is the reduction of slopes, especially those that are moderately steep and face to the south or southwest.

Regardless of the goal selected, the mining plan should also provide for the use of current approved land preparation and planting methods. Plant species, that are compatible with the land conditions, should be selected from an approved list.

It may be possible to develop a small field (10 to 20 acres or 4.05 to 8.10 ha) suitable for small grain production in each quarter section. The good quality material may be used to improve class 6 areas for the production of range forage.



SOIL SERIES		SLOPE - %
Ca	Cabba association	15 - 50
Ce	Cushman-Elso silt loams	4 - 8
Ec	Elso silt loam	8 - 15
El	Elso silt loam	15 - 45
Eo	Elso - Ocean Lake association	15 - 45
Fd	Farland silt loam	0 - 2
Fs	Fort Collins silt loam	4 - 8
Ho	Hesper silty clay loam	2 - 4
Hp	Hesper silty clay loam	4 - 8
Hu	Hydro silty clay loam	2 - 4
Ke	Keiser silty clay loam	2 - 4
Md	Mc Rae silt loam	2 - 4
Mf	Midway silty clay loam	2 - 8
Mg	Midway - Elso association	8 - 35
Mw	Midway and Elso rocky soils	35 - 75
Rc	Rapelje silt loam	2 - 8
Te	Terrace escarpments	

Section 28, T. 4 S. - R. 45 E.

250 0 250 500 750

SCALE OF METERS

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

RESOURCE & POTENTIAL RECLAMATION EVALUATION

NEWELL/28 SITE
OTTER CREEK COAL FIELD-MONTANA

SOIL SURVEY MAP

LANDS H. B. WARD SUBMITTED
DRAWN L.E. ALLSOP RECOMMENDED
CHECKED APPROVED

BILLINGS, MONTANA APRIL, 1978 1305-600-159

APPENDIX

Form 7310–12
(May 1973)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

By | Date 11/1/78
Location (D) Sect 28., T 4 S., R 45 E
Treatment affecting the SSF

DETERMINATION OF EROSION CONDITION CLASS
SOIL SURFACE FACTORS (SSF)

SOIL MOVEMENT*	No visual evidence of movement 0 1 2 3	Some movement of soil particles 4 5	Moderate movement of soil is visible and recent. Slight terracing generally less than 1" in height. 6 7 (8)	Occurs with each event. Soil and debris deposited against minor obstructions. 9 10 11	Subsoil exposed over much of area, may have embryonic dunes and wind scoured depressions 12 13 14
SURFACE LITTER*	Accumulating in place 0 1 2 3	May show slight movement 4 5 6	Moderate movement is apparent, deposited against obstacles 7 (8)	Extreme movement apparent, large and numerous deposits against obstacles 9 10 11	Very little remaining *(use care on low productive sites)* 12 13 14
SURFACE ROCK*	If present, the distribution of fragments show no movement caused by wind or water 0 1 2	If present, coarse fragments have a truncated appearance or spotty distribution caused by wind or water 3 4 5	If present, fragments have a poorly developed distribution pattern caused by wind or water 6 7 8	If present, surface rock or fragments exhibit some movement and accumulation of smaller fragments behind obstacles (9) 10 11	If present, surface rock or fragments are dissected by rills and gullies or are already washed away 12 13 14
PEDESTALLING*	No visual evidence of pedestalling 0 1 2 3	Slight pedestalling, in flow patterns 4 5 6	Small rock and plant pedestals occurring in flow patterns 7 8 (9)	Rocks and plants on pedestals generally evident, plant roots exposed 10 11	Most rocks and plants pedestalled and roots exposed 12 13 14
FLOW PATTERNS*	No visual evidence of flow patterns 0 1 2 3	Deposition of particles may be in evidence 4 5 6	Well defined, small, and few with intermittent deposits 7 8 9	Flow patterns contain silt and sand deposits and alluvial fans 10 11 12	Flow patterns are numerous and readily noticeable. May have large barren fan deposits 13 14 15
RILLS	No visual evidence of rills 0 1 2 3	Some rills in evidence at infrequent intervals over 10' 4 5 6	Rills ½" to 6" deep occur in exposed places at approximately 10' intervals 7 8 9	Rills ½" to 6" deep occur in exposed area at intervals of 5 to 10' 10 (11) 12	May be present at 3" to 6" deep at intervals less than 5' 13 14
GULLIES	May be present in stable condition. Vegetation on channel bed and side slopes 0 1 2 3	A few gullies in evidence which show little bed or slope erosion. Some vegetation is present on slopes. 4 5 6	Gullies are well developed with active erosion along less than 10% of their length. Some vegetation may be present. 7 8 (9)	Gullies are numerous and well developed with active erosion along 10 to 50% of their lengths or a few well developed gullies with active erosion along more than 50% of their length 10 11 12	Sharply incised gullies cover most of the area and over 50% are actively eroding 13 14 15
SITUATION	TOTAL		[illegible]		

Erosion Condition Classes: Stable 0–20; Slight 21–40; Moderate 41–60; Critical 61–80; Severe 81–100

(Instructions on reverse)

Table 5

Table 6

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

VEGETATION–SOIL DESCRIPTION

1. State	2. District	3. Planning Unit	4. Vegetation–Soil Unit	5. Soil Map Symbol	6. Surname	7. Date
--	--	--	---- / ----	---		11 mo 78 yr

8. Area	9. County	10. Location	11. Photo No.	12. Writeup No.	13. File No.	14. Parent Rock
--	---	Sec. 28, T. 4S, R 45E	----	---	---	Sandstone

15. Formation Name	16. Surface Conditions (percent)	17. Land Conditions	18. Landform
Fort Union	Stone -- Rock --	Alkaline Mod. Saline Mod. Water table	Residual

19. Slope (percent)	20. Aspect	21. Elevation	22. Present Erosion	23. Hydrologic Group
4-8% [ ] Single [✓] Complex	E	912 m	Mod- Type Gully SSF 63 Class Critical	B

24. Precipitation (in)	25. Temperature	26. Frost-free	27. Drainage Class	28. Infiltration	29. Percolation	30. ERD	31. AWC
12-16" 1st, 2nd, 3rd, 4th	-- Air -- Soil	Days 100 > 28°	Excessive	Slow	Slow	-- m	.05 cm per .3 m

32. HORIZON	33. THICKNESS	34. COLOR DRY/MOIST MATRIX	MOTTLING	35. TEXTURE	36. STRUCTURE	37. CONSISTENCY DRY MOIST	38. CLAY FILMS	39. ROOTS	40. STONES % VOL.	41. REACTION (pH)	42. BOUNDARY
A_1	0-.10	(D) 10YR 6/2 (M) " 4/2		SiL	m1gr/ f1gr	(D) so (M) vfr	—	2f	—	—	g
B_2	.10-.25	(D) 10YR 5/3 (M) " 4/2		CL	m2pr/ m2bk	(D) sh (M) fr	2n	2f	—	es	g
B_{3ca}	.25-.35	(D) 10YR 6/3 (M) " 5/3		CL	m2pr/ m2bk	(D) sh (M) fr	—	2f	—	es	g
Cca	.35-.46	(D) 10YR 6/2 (M) " 5/2		CL	c1bk/ m1bk	(D) h (M) fr	—	—	—	es	g
C_2	.46-.76	(D) 10YR 6/2 (M) " 5/2		CL	Massive	(D) h (M) fr	—	—	—	es	g
C	.76+	(D) 10YR 6/2 (M) " 5/2		CL	"	"	—	—	—	es	

.35-.46 threads common with few lime nodules
.46-.76 salt crystals
.76+ soft sandstone material

(Instructions inside back cover)

(D) W 1/4 Corner

Form 7310-9a (December 1970)

Table 7

Form 7310-12
(May 1973)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

By | Date 11/18
Location (C) Sec 28, T4S, R35E
Treatment affecting the SSF

DETERMINATION OF EROSION CONDITION CLASS
SOIL SURFACE FACTORS (SSF)

SOIL MOVEMENT*	No visual evidence of movement 0 1 2 3	Some movement of soil particles 4 (5)	Moderate movement of soil is visible and recent. Slight terracing generally less than 1" in height. 6 7 8	Occurs with each event. Soil and debris deposited against minor obstructions. 9 10 11	Subsoil exposed over much of area, may have embryonic dunes and wind scoured depressions 12 13 14
SURFACE LITTER*	Accumulating in place 0 1 2 3	May show slight movement 4 5 6	Moderate movement is apparent, deposited against obstacles 7 (8)	Extreme movement apparent, large and numerous deposits against obstacles 9 10 11	Very little remaining *(use care on low productive sites)* 12 13 14
SURFACE ROCK*	If present, the distribution of fragments show no movement caused by wind or water 0 1 2	If present, coarse fragments have a truncated appearance or spotty distribution caused by wind or water 3 4 (5)	If present, fragments have a poorly developed distribution pattern caused by wind or water 6 7 8	If present, surface rock or fragments exhibit same movement and accumulation of smaller fragments behind obstacles 9 10 11	If present, surface rock or fragments are dissected by rills and gullies or are already washed away 12 13 14
PEDESTALLING*	No visual evidence of pedestalling 0 1 2 3	Slight pedestalling, in flow patterns 4 5 (6)	Small rock and plant pedestals occurring in flow patterns 7 8 9	Rocks and plants on pedestals generally evident, plant roots exposed 10 11	Most rocks and plants pedestalled and roots exposed 12 13 14
FLOW PATTERNS*	No visual evidence of flow patterns 0 1 2 3	Deposition of particles may be in evidence 4 5 6	Well defined, small, and few with intermittent deposits (7) 8 9	Flow patterns contain silt and sand deposits and alluvial fans 10 11 12	Flow patterns are numerous and readily noticeable. May have large barren fan deposits 13 14 15
RILLS	No visual evidence of rills 0 1 2 3	Some rills in evidence at infrequent intervals over 10' 4 (5) 6	Rills ½" to 6" deep occur in exposed places at approximately 10' intervals 7 8 9	Rills ½" to 6" deep occur in exposed area at intervals of 5 to 10' 10 11 12	May be present at 3" to 6" deep at intervals less than 5' 13 14
GULLIES	May be present in stable condition. Vegetation on channel bed and side slopes 0 1 2 (3)	A few gullies in evidence which show little bed or slope erosion. Some vegetation is present on slopes. 4 5 6	Gullies are well developed with active erosion along less than 10% of their length. Some vegetation may be present. 7 8 9	Gullies are numerous and well developed with active erosion along 10 to 50% of their lengths or a few well developed gullies with active erosion along more than 50% of their length 10 11 12	Sharply incised gullies cover most of the area and over 50% are actively eroding 13 14 15
SITUATION	TOTAL	(39)			

Erosion Condition Classes: Stable 0–20; Slight 21–40; Moderate 41–60; Critical 61–80; Severe 81–100

(Instructions on reverse)

Table 8

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

VEGETATION–SOIL DESCRIPTION

1. State: Mont	2. District: 02	3. Planning Unit 08	4. Vegetation–Soil Unit: ---------- / -------	5. Soil Map Symbol ----	6. Surname ----------	7. Date 11 mo '18 yr
8. Area: 78	9. County: P. River	10. Location Sec. 28, T. 4 S, R. 45 E	11. Photo No. ----------	12. Writeup No. ----	13. File No. ----	14. Parent Rock: Sandstone
15. Formation Name: Fort Union	16. Surface Conditions (percent) Stone -- Rock --	17. Land Conditions Alkaline — Saline — Water table ---				18. Landform: Colluvial
19. Slope (percent) 2-4% [ ] Single [✓] Complex	20. Aspect: E	21. Elevation: 960 m	22. Present Erosion: Slight; Type: Rills; SSF 39; Class: Slight			23. Hydrologic Group: B
24. Precipitation (in) 12-16" 1st, 2nd, 3rd, 4th	25. Temperature -- Air -- Soil	26. Frost-free Days 100 -> 28°	27. Drainage Class: Well	28. Infiltration: moderate	29. Percolation: moderate	30. ERD: .91 m; 31. AWC: .05 m per .3 m

32. HORIZON	33. THICKNESS m	34. COLOR (DRY / MOIST) MATRIX	MOTTLING	35. TEXTURE	36. STRUCTURE	37. CONSISTENCY DRY MOIST	38. CLAY FILMS	39. ROOTS	40. STONES % VOL.	41. REACTION (pH)	42. BOUNDARY
A_1	0-.12	(D) 10YR 5/2 (M) " 4/2		FSL	m 1 gr / f 1 gr	(D) so (M) vfr	—	2f	—	—	g
AB	.12-.40	(D) 10YR 6/3 (M) " 5/3		FSL >	c 1 bk / m 1 bk	(D) sh (M) fr	—	2f	—	e	g
B_2	.40-.76	(D) 10YR 6/4 (M) " 5/4		L	c 2 pr / c 2 bk	(D) sh (M) fr	1 m	2f	—	es	g
C_{ca}	.76-.91	(D) 10YR 7/4 (M) " 6/3		< L	c 1 pr / c 1 bk	(D) sh (M) fr	—	1f	—	es	g
C_2	.91-1.5	—		FSL	Massive	(D) sh (M) fr	—	—	—	es	g

FSL to 2.7 meters becoming IIC-LFS to 3 meters. Description is underlain by sandy shale at depths of more than 1.5 meters. Soil is derived from and over softly consolidated sandy shales & sandstone.

(Instructions inside back cover)

(C) 1200'S., 600'E. of N1/4 Cor.

Form 7310-9a (December 1970)

UNITED STATES - DEPARTMENT OF THE INTERIOR - BUREAU OF RECLAMATION - UPPER MISSOURI REGION

SOIL LABORATORY - MILES CITY, MONTANA

UNIT NEWELL/28 PROJECT ______

SOIL SCIENTIST [illegible] LOCATION- SECTION 21 T. 55 R 45 E DATE 11/77

LAB NO.	PROFILE NO.	DEPTH	TEXTURE		pH		SET. VOL. ml	EC		FRAG. HYD. COND.		SODIUM ABSORPTION RATIO			GYP. REQ. me/100g	PARTICLE SIZE PERCENTAGE			HCL	%
		METERS	FIELD	LAB	1-5	$CaCl_2$		1-5	SAT. EXT.	8 hr in./hr	24 hr in./hr	TSC me/l	Ca+Mg me/l	SAR		SAND	SILT	CLAY		gr
1	[illegible]	0-.30	VFSL		8.3		22	0.75 0.10		1.44	4.36								+	
	107	.30-.61	L		8.6	7.6	19	0.75 0.10		0.31	0.33								"	
	[illegible]	.61-1.2	FSL		9.0	7.7	17	0.75 0.10		0.60	0.84								"	
	[illegible]	1.2-1.8	FSL		8.9	7.7	18	1.4 0.18		0.84	1.32								"	11
	[illegible]	1.8-2.4	FSL		8.8	7.8	19	2.5 0.32		0.40	0.44								"	
	[illegible]	2.4-3.0	FSL		8.7	7.7	17	2.6 0.33		0.72	1.12								"	14
2	112	0-.30	L		8.2		25	0.75 0.10		3.15	8.00+								--	
	113	.30-.76	L		8.4		24	0.90 0.12		0.36	0.36								+-	
	[illegible]	.76-1.4	CL		8.9	7.8	22	1.2 0.16		0.22	0.22								+-	
	115	1.4-2.0	CL		9.2	7.9	26	1.8 0.22		0.20	0.18								+-	

Table 9
(Sheet 1 of 8)

UNITED STATES - DEPARTMENT OF THE INTERIOR - BUREAU OF RECLAMATION - UPPER MISSOURI REGION

SOIL LABORATORY - MILES CITY, MONTANA

UNIT NEWELL/28 PROJECT ____

SOIL SCIENTIST ____ LOCATION- SECTION 28 T. 53 R. 4 E DATE 11/..

LAB NO.	PROFILE NO.	DEPTH METERS	TEXTURE FIELD	TEXTURE LAB	pH 1-5	pH $CaCl_2$	SET. VOL. ml	EC 1-5	EC SAT. EXT.	FRAG. HYD. COND. 8 hr in/hr	FRAG. HYD. COND. 24 hr in/hr	SODIUM ABSORPTION RATIO TSC me/l	SODIUM ABSORPTION RATIO Ca+Mg me/l	SODIUM ABSORPTION RATIO SAR	GYP. REQ. me/100g	PARTICLE SIZE PERCENTAGE SAND	PARTICLE SIZE PERCENTAGE SILT	PARTICLE SIZE PERCENTAGE CLAY	HCL	%
3	116	0-.30	CL		8.3		24	0.75 0.10		3.80	8.00+								[illegible]	
	117	.30-.76	CL		8.5		23	0.90 0.12		0.52	0.84								[illegible]	
	118	.76-1.4	>CL		9.6	8.1	70	2.6 0.32		0.00	0.00	26.0	3.2	17.3	-1.0				[illegible]	
	119	1.4-2.0	>CL		9.7	8.3	105	3.6 0.46		0.00	0.00								[illegible]	
4	120	0-.30	CL		8.0		25	0.90 0.12		0.38	0.48								[illegible]	
	121	.30-1.1	CL		8.7	7.7	21	0.90 0.12		0.22	0.32								[illegible]	
	122	1.1-1.7	>FSL		9.0	7.9	18	1.0 0.13		0.96	2.32								[illegible]	
	123	1.7-2.1	L		8.8	7.8	18	1.2 0.16		1.08	2.40								[illegible]	
	124	2.1-2.7	CL		8.7	7.8	20	1.2 0.16		0.50	0.76								[illegible]	
	125	2.7-3.0	CL		8.6	7.7	24	1.0 0.13		0.38	0.56								[illegible]	

Table 9
(Sheet 2 of 8)

UNITED STATES - DEPARTMENT OF THE INTERIOR - BUREAU OF RECLAMATION - UPPER MISSOURI REGION

SOIL LABORATORY - MILES CITY, MONTANA

UNIT NEWELL/28 PROJECT

SOIL SCIENTIST LOCATION - SECTION 28 T. 5S R. 45E DATE 11/77

LAB NO.	PROFILE NO.	DEPTH	TEXTURE		pH		SET. VOL. ml	EC		FRAG HYD. COND.		SODIUM ABSORPTION RATIO			GYP. REQ. me/100g	PARTICLE SIZE PERCENTAGE			HCL	%
		METERS	FIELD	LAB	1-5	$CaCl_2$		1-5	SAT. EXT	8 hr in./hr	24 hr in./hr	TSC me/l	Ca+Mg me/l	SAR		SAND	SILT	CLAY		
5	126	0-.46	L		8.2		22	0.75 / 0.10		8.00+	8.00+								∴	
	127	.46-.91	CL		9.1	7.7	24	1.0 / 0.13		0.92	0.80								∴	
	128	.91-1.4	CL		9.0	8.0	39	4.8 / 0.65	9.0	0.80	1.68	90.0	45.5	9.3	-2.4				∴	
	129	1.4-2.0	CL		8.4		42	9.6 / 1.70	13.0	TR	0.04								∴	
	130	2.0-2.6	CL		8.7	8.3	60	6.80 / 1.00	10.0	0.00	0.02								∴	
	131	2.6-3.0	CL		9.2	8.4	100	6.20 / 0.87	6.0	0.00	0.00								∴	
6	132	0-.46	L		8.2		25	1.20 / 0.16		1.80	3.12								∴	42
	133	.46-.91	L		8.6	7.9	20	2.40 / 0.30		0.18	0.20								#	31
	134	.91-1.4	FSL		8.8	8.1	17	3.00 / 0.38		1.84	2.80								#	

DOUBLE LINES INDICATE SOIL-BEDROCK CONTACT

UNITED STATES - DEPARTMENT OF THE INTERIOR - BUREAU OF RECLAMATION - UPPER MISSOURI REGION

SOIL LABORATORY - MILES CITY, MONTANA

UNIT NEWELL/28 PROJECT

SOIL SCIENTIST LOCATION- SECTION 29 T. 5S R 45E DATE 11/77

LAB NO.	PROFILE NO.	DEPTH	TEXTURE		pH		SET. VOL. ml	EC		FRAG. HYD. COND.		SODIUM ABSORPTION RATIO			GYP. REQ. me/100g	PARTICLE SIZE PERCENTAGE			HCL	%
		METERS	FIELD	LAB	1-5	CaCl2		1-5	SAT. EXT.	8 hr in./hr	24 hr in./hr	TSC me/l	Ca+Mg me/l	SAR		SAND	SILT	CLAY		
7	135	0-.30	CL		9.0	7.9	26	1.80 0.33		0.25	0.28								+	
	136	.30-.76	CL		8.8	8.3	96	6.40 0.90	8.5	0.00	0.00								++	
	[illegible]	.76-1.2	CL		8.6	8.5	50	12.0 2.[illegible]	16.0	0.09	0.11	160.0	63.5	12.2	-2.0				++	
	138	1.2-1.8	CL		8.9	8.6	70	10.00 1.80	13.0	0.00	0.00								++	
	139	1.8-2.4	CL		8.9	8.3	60	9.40 1.60	12.0	0.00	0.00								++	
	140	2.4-3.0	CL		8.3	8.4	55	11.00 2.00	12.0	0.06	0.07								++	
8	141	0-.46	CL		8.1		26	1.40 0.18		1.88	8.00+								+	
	142	.46-1.1	CL		7.4		33	1.20 0.16		0.24	0.28								-	
	143	1.1-1.5	CL		9.1		33	3.20 0.40	2.1	0.12	0.14	21.0	7.2	7.3					+	54
	144	1.5-2.1	[illegible]		9.2	8.2	45	2.40 0.30		0.05	0.04								++	
9	145	0-.30	VFSL		8.3		20	1.00 0.13		1.56	2.52								++	
	146	.30-.91	VFSL		9.2	8.2	18	1.00 0.13		0.38	0.52								++	
	147	.91-1.2	VFSL		9.1	8.1	21	[illegible] 0.12		0.30	0.34								.	
	148	1.2-1.8	VFSL		9.1	8.0	21	0.75 0.10		0.60	0.92									

UNITED STATES - DEPARTMENT OF THE INTERIOR - BUREAU OF RECLAMATION - UPPER MISSOURI REGION

SOIL LABORATORY - MILES CITY, MONTANA

UNIT NEWELL/28 PROJECT ______

SOIL SCIENTIST [illegible] LOCATION- SECTION 28 T. 5S R. 8 5E DATE 11/77

Table 9 (Sheet 5 of 8)

LAB NO.	PROFILE NO.	DEPTH METERS	TEXTURE FIELD	TEXTURE LAB	pH 1-5	pH $CaCl_2$	SET. VOL. ml	EC 1-5	EC SAT. EXT	FRAG. HYD. COND. 8 hr in./hr	FRAG. HYD. COND. 24 hr in./hr	SODIUM ABSORPTION RATIO TSC me/l	Ca+Mg me/l	SAR	GYP. REQ. me/100g	PARTICLE SIZE PERCENTAGE SAND	SILT	CLAY	HCL	%
10	149	0-.46	L		8.4		21	0.75 0.10		3.00	5.28								+	
	150	.46-.91	CL		9.0	8.0	19	0.90 0.12		0.52	0.84								++	
	151	.91-1.5	FSL		9.4	8.2	16	1.40 0.18		2.08	3.44								++	
	152	1.5-2.1	FSL		9.3	8.3	17	3.00 0.38		0.96	2.24								++	
	153	2.1-2.7	FSL		9.2	8.3	17	2.80 0.34		1.60	2.56								++	
	154	2.7-3.0	[illegible]		9.0	8.2	18	3.60 0.46		3.04	3.28								++	24
11	155	0-.46	CL		8.5		25	0.90 0.12		1.76	5.20								+	
	156	.46-.76	CL		8.8	7.9	21	1.00 0.13		0.33	0.26								++	
	157	.76-1.1	>CL		9.0	8.2	31	3.40 0.44	3.6	0.09	0.08	36.0	20.6	4.8					++	
12	158	0-.46	CL		8.0		22	0.75 0.10		1.20	3.72								+	
	159	.46-1.1	CL		9.3	8.2	23	1.80 0.22		0.28	0.39								++	
	160	1.1-1.5	SCL		9.4	8.3	21	3.00 0.38		0.21	0.26								++	13
	161	1.5-1.8	FSL		9.0	8.2	19	4.00 0.52	8.0	0.36	0.88								+	[illegible]

Table 9
(Sheet 6 of 8)

UNITED STATES - DEPARTMENT OF THE INTERIOR - BUREAU OF RECLAMATION - UPPER MISSOURI REGION

SOIL LABORATORY - MILES CITY, MONTANA

UNIT NEWELL/28 PROJECT ______

SOIL SCIENTIST [illegible] LOCATION- SECTION 28 T. 4 R. 45 DATE 11/77

LAB NO.	PROFILE NO.	DEPTH	TEXTURE		pH		SET. VOL. ml	EC		FRAG. HYD. COND.		SODIUM ABSORPTION RATIO			GYP. REQ. me/100g	PARTICLE SIZE PERCENTAGE			HCL	%
		METERS	FIELD	LAB	1-5	$CaCl_2$		1-5	SAT. EXT.	8 hr in./hr	24 hr in./hr	TSC me/l	Ca Mg me/l	SAR		SAND	SILT	CLAY		
13	235	0-.30	L		6.3	5.7	19	4.00 0.52	5.1	1.53	2.40								+	
	236	.30-.91	L		8.2		17	2.80 0.34		0.80	0.80								+	
	237	.91-1.5	FSL		8.6	7.5	16	1.80 0.22		1.20	1.16								+	
	238	1.5-2.1	LFS		8.8	7.6	16	2.00 0.25		2.40	3.80								+	
	239	2.1-2.6	LFS		8.9	7.6	16	2.40 0.30		2.00	3.04								+	
	240	2.6-3.0	FS		9.0	7.6	17	2.50 0.31		1.68	2.80								+	
14	241	0-.30	SCL		8.3		27	4.00 0.52	4.5	0.08	0.05								++	
	242	3.0-.61	SCL		8.0		30	16.00 3.60	27.0	0.10	0.10	270.0	142.5	15.2	-18.8				++	
	243	.61-.91	SCL		8.2		28	20.00 6.75	27.0	0.04	0.03								+	
	244	.91-1.5	>CL		8.4		23	20.00 6.75	30.0	0.02	0.01								+	
	245	1.5-2.1	>CL		7.7		35	20.00 9.00	38.0	TR	0.00								++	
	246	2.1-2.7	>CL		7.1		60	20.00 6.75	40.0	TR	TR								+	
	247	2.7-3.0	>CL		7.0		60	18.00 4.70	40.0	0.00	TR									

UNITED STATES - DEPARTMENT OF THE INTERIOR - BUREAU OF RECLAMATION - UPPER MISSOURI REGION

SOIL LABORATORY - MILES CITY, MONTANA

UNIT NEWELL/28 PROJECT ______

SOIL SCIENTIST ______ LOCATION- SECTION 28 T. 1 R. 45 DATE 11/76

LAB NO.	PROFILE NO.	DEPTH METERS	TEXTURE FIELD	TEXTURE LAB	pH 1-5	pH CaCl2	SET. VOL. ml	EC 1-5	EC SAT. EXT	FRAG. HYD. COND. 8 hr in./hr	FRAG. HYD. COND. 24 hr in./hr	SODIUM ABSORPTION RATIO TSC me/l	Ca+Mg me/l	SAR	GYP. REQ. me/100g	PARTICLE SIZE PERCENTAGE SAND	SILT	CLAY	HCL	%
15	248	0-.30	CL		7.3		25	3.80 / 0.50		0.44	1.00								+	
	249	.30-.91	>CL	CL	8.3		23	3.90 / 0.50		0.09	0.06					26	36	38	+	
	250	.91-1.4	>CL		8.9	8.4	26	10.00 / 1.80	14.0	0.00	0.01								+	
	251	1.4-1.8	>CL		9.0	8.5	26	10.40 / 1.65	19.5	0.03	0.01								+	
	252	1.8-2.4	>CL		8.8	8.5	28	12.00 / 2.20	20.0	0.30	0.26								+	
	253	2.4-3.0	CL		8.8	8.5	30	10.40 / 1.65	20.0	0.23	0.18								+	
16	254	0-.46	CL		8.9	7.9	32	3.60 / 0.46		0.26	0.28								+	
	255	.46-1.1	>CL/C	[illegible]	7.8		60	14.00 / 2.30	20.0	0.00	0.00								—	
	256	1.1-1.5	>CL/C	[illegible]	5.8	5.6	70	14.00 / 2.30	20.0	0.00	0.00	Slightly Acid							—	
	257	1.5-2.0	>CL/C	[illegible]	6.4	5.7	50	12.00 / 2.30	18.0	0.00	TR								—	
	258	2.0-2.6	CL		6.0	5.6	39	11.00 / 2.00	19.0	0.00	0.00								—	
	259	2.6-3.0	CL		5.3	5.2	27	12.00 / [illegible]	20.0	0.34	0.40								—	
17	263	0-.30	L		8.3		21	1.00 / 0.13		1.56	3.39								L	
	264	.30-1.5	<L		9.1	7.9	23	2.00 / 0.24		0.21	0.33								L	

MISSOURI SOURIS PROJECTS OFFICE
SOIL AND WATER LABORATORY
BUREAU OF RECLAMATION
BISMARCK, NORTH DAKOTA
SOIL ANALYSIS DATA SHEET

Date Received 7-21-78
Date Reported 8-28-78

DH 78-101

AREA Newell/28 Study Site INVESTIGATOR: Tom Fiechtl SECTION: 28 TOWNSHIP 43 RANGE 45E

Boring Number: DRILL HOLE 78-101

Laboratory Number	Sack Number	Depth in feet	Text Field	Frag. Hyd. Cond. 2 Hr. in./Hr.	6 Hr. in./Hr.	24 Hr. in./Hr.	Sed. Vol. ml	pH P @ 2 1:5	Milligram Per Liter B	Cd	Cu	Fe	Hg	Mn	Pb	Se	Zn	EC @ 25C	SAR	M.R. % 15 BAR	Particle Size Percentage VCo 2-1 (mm)	Co. 1-.5 (mm)	Med. .5-.25 (mm)	F .25-.10 (mm)	VF .10-.05 (mm)	Sand 2 (mm)	Silt .050 (mm)	Clay .002 (mm)	Lab Text Class
11,904	1	0'-20'		0.04	0.09	0.09	28.	8.8	0.3	0.02	5.8	184		13.0	50			4.7	12	9.2						23.4	51.5	22.1	SiL
5	2	20'-40'		0.37	0.41	0.41	20	9.2	0.0	0.02	0.4	36.4		2.2	2.0			6.4	2.5	3.4	1.3	3.6	3.2	42.7	22.8	78.6	15.2	6.2	LFS
6	3	40'-60'		0.59	0.39	0.39	19.	9.1	0.0	0.02	0.6	26.8		4.8	7.0			1.5		3.4	0.3	1.8	2.1	31.6	41.2	77.0	16.6	6.4	LFS
7	4	60'-80'		0.33	0.33	0.32	20.	8.9	0.0	0.02	0.6	26.4		4.8	7.3			1.3	1.1	5.0	1.7	2.4	1.9	50.6	16.0	72.5	18.7	8.8	FSL
8	5	80'-94½'		0.26	0.26	0.26	20.	8.9	0.0	0.02	0.2	24.2		4.4	4.4			1.7		4.3	0.8	1.8	15.1	45.6	12.7	76.0	15.3	8.2	FSL
9	6	94½'-104½'		0.18	0.18	0.18	23.	8.9	0.0	0.02	1.0	33.7		8.0	3.2			1.3	6.4	5.5	0.5	0.8	0.8	17.3	51.1	66.5	21.9	11.6	VFSL
10	7	104½'-114½'		*	0.04	0.02	27.	8.1	0.2	0.10	2.2	22		20.4	7.0			2.0		10.9						26	51.3	23.1	[illegible]
11,911	8	114½'-131'		0.20	0.20	0.24	19.	8.3												5.9	0.3	1.1	0.9	38.6	29.5	70.4	21.2	8.4	FSL
									0.0	0.06	0.8	76		7.2	6.6	...		2.3	12										
11,888	9	134½'-155'		1.85	1.89	1.93	17.	8.8	0.0	0.02	0.2	58		2.8	2.2	0.00065		2.1	19	4.18	0.1	0.8	0.8	67.4	19.8	88.9	5.7	5.4	FS
9	10	155'-175'		1.77	1.77	1.81	17.	8.3	0.0	0.02	0.2	58		2.8	2.0	0.00014		2.5	.	4.52	0.1	0.6	1.0	62.4	23.2	87.3	7.5	5.2	LFS
90	11	175'-185'		2.20	2.17	2.05	17.	8.0	0.0	0.04	0.2	56		2.4	2.0	0.00050		2.6	2.8	4.32	0.1	0.6	1.7	63.3	21.8	87.7	5.2	5.1	FS
1	12	185'-202'		0.13	0.11	0.17	18.	8.8	0.0	0.04	1.4	46		7.6	16.8	0.0013		3.0		6.43	1.5	1.1	0.8	30.6	32.7	66.7	26.2	7.1	VFSL
2	13	202'-220'		* ½	* ¾	*	36	9.2	0.1	0.10	2.4	58		3.0	7.3	0.0024		2.8	24	11.66						28.6	58.1	13.3	SiL
11,893	14	220'-231'		* ⅓	* ⅓	* ¼	131	9.2	0.1	0.12	11.2	92		2.4	11.4	0.0049		6.4		22.02						5.8	44.6	49.6	SiC

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