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PHYSICAL PROPERTIES AND LABORATORY DATA FOR SOILS FORMED IN PLEISTOCENE TILLS AT BULL LAKE, DINWOODY LAKES, AND FREMONT LAKE, FREMONT AND SUBLETTE COUNTIES, WYOMING

by

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INTRODUCTION

This report contains selected physical properties and laboratory data for soils formed in Pleistocene tills in the Wind River Range at Bull Lake, Dinwoody Lakes, and Fremont Lake, Wyoming (figs. 1 and 2). Some of these soils will be visited and (or) discussed during the Friends of the Pleistocene Rocky Mountain Cell field trip on August 18-21, 1989.

Field work was conducted by the author in August 1972, August 1973, and July 1974, and with G.M. Richmond and R.A. Parnell, Jr. in July 1976. Physical properties and laboratory data for soil sites BL-1, BL-3, FL-1, FL-2, FL-4, and FL-6 are summarized from Shroba (1977).

The soils in this report were described according to the procedures of the Soil Conservation Service (Soil Survey Staff, 1951, 1975). The soil-horizon nomenclature is that of the Soil Conservation Service (Soil Survey Staff, 1951; Guthrie and Witty, 1982) combined with the C-horizon nomenclature of Birkeland (1984). Criteria used to distinguish stages of secondary carbonate morphology are described in Birkeland (1984, table A-4).

Soil properties are one of several major criteria that are commonly used to distinguish and correlate glacial deposits in the Rocky Mountains (Shroba and Birkeland, 1983; Richmond, 1986). The data presented in this report are intended to help provide a basis for comparing the soils and glacial deposits observed and discussed on the field trip with those in other areas of the Rocky Mountains.

ENVIRONMENTAL FACTORS

The deposits in which the soils are formed include tills of the Pinedale, Bull Lake, and Sacagawea Ridge Glaciations (Richmond, 1962, 1964, 1973, 1976, 1986, 1987; Richmond and Murphy, 1965). These tills typically consist of about 50-70 percent granule and larger material. They have a sandy loam matrix that has a calcium-carbonate content of about 10 percent or less. The rock fragments in the tills at Fremont Lake are chiefly granite and gneiss, whereas those in the tills at Bull Lake and Dinwoody Lakes also contain a significant amount of sandstone, limestone, and dolomite. Some of the soils near Fremont Lake have silt-enriched surface layers that may contain some eolian material. This material may be similar to the loess or reworked loess at site FL-3B (fig. 2) that has a silt loam texture and contains less than 0.5 percent calcium carbonate.

Age assignments for the glacial deposits in the Wind River Range, summarized in Richmond (1986; chart 1A), indicate that deposits of the Pinedale Glaciation are between 12 and 35 ka, deposits of the Bull Lake Glaciation are between 130 and 300 ka, and deposits of the Sacagawea Ridge Glaciation are between 350 and 610 ka. The loess or reworked loess at site FL-3B at Fremont Lake is in a closed depression formed in till of the Pinedale Glaciation. Radiocarbon age determinations reported by Sorenson (1987) for the Fremont Lake area suggest that the silty material at site FL-3B may have accumulated during the middle Holocene.

The three study areas have a semiarid climate. The Bull Lake area has a mean annual air temperature of about 6 ^{o}C and a mean annual precipitation of about 20 cm. The Fremont Lake area is cooler and slightly more moist than the Bull Lake area, and has mean annual values of about 2 ^{o}C and 30 cm, respectively (Shroba, 1977). The Dinwoody Lakes area has a climate similar to that of the Bull Lake area. The vegetation at and near the soil sites reflects the semiarid climate, and typically consists of short grasses and sagebrush.

The soil sites are on gentle slopes at or near moraine crests, except for site FL-3B which is on the floor of a closed depression. Elevation of the soil sites ranges from about 1,750 m at Bull Lake to 2,300 m at Fremont Lake.

LABORATORY METHODS

Particle-size analyses were performed on the less than 2-mm size fraction by the sieve and pipette methods. Samples for particle-size analyses were pretreated to remove organic matter and secondary carbonate. Particle-size classes are: sand, 2-0.05 mm; silt, 0.05-0.002 mm; total clay, less than 0.002 mm; and fine clay, less than 0.0005 mm. Calcium-carbonate content was determined by the Chittick method. Values for particle size analyses and calcium-carbonate content are expressed as weight percentages of the less than 2-mm size fraction.

Soil pH was determined with a pH test kit and a pH meter. Measurements determined with a test kit (soils at sites BL-1, BL-3, FL-1, FL-2, FL-4, and FL-6) are reported to a half of a pH unit, whereas those determined with a meter (soils at sites BL-2, BL-4, DL-1, FL-3A, FL-3B, and FL-5) are reported to a tenth of a pH unit. Equilibration time for the pH meter measurements was about 5 minutes.

SOILS DATA FOR THE BULL LAKE AREA

Soil site: BL-1
Location: Soil site is in a hand-dug pit in SW1/4SW1/4 sec. 16, T. 3 N., R. 2 W., Bull Lake East 7.5-min. topographic quadrangle
Parent material: Till of the Pinedale Glaciation
Map unit designation: Lower till of Pinedale Till (Richmond and Murphy, 1965)

[N, none observed; leaders, --, not determined]

Horizon	Depth (cm)	Munsell color (dry)	Stage of secondary carbonate	Particle size, percent				Calcium carbonate content, percent	pH
				sand	silt	clay			
						total	fine		
A	0-13	10YR 5/3	N	54.4	35.1	10.4	--	1.0	8
Bt	13-20	7.5YR 5/3	N	57.7	28.9	13.4	--	3.2	8
Bk1	20-53	2.5Y 7/2	I	66.4	26.3	7.3	--	18.3	8
Bk2	53-102	2.5Y 7/2	I	77.4	17.0	5.6	--	11.3	8
Ckn	102-112+	5Y 7.2	I-	69.2	24.3	6.5	--	10.4	8

Soil site: BL-2
Location: Soil site is in a road cut along U.S. 287 in NW1/4SW1/4 sec. 16, T. 3 N., R. 2 W., Bull Lake East 7.5-min. topographic quadrangle
Parent material: Till of the Pinedale Glaciation
Map unit designation: Lower till of Pinedale Till (Richmond and Murphy, 1965)

[N, none observed]

Horizon	Depth (cm)	Munsell color (dry)	Stage of secondary carbonate	Particle size, percent				Calcium carbonate content, percent	pH
				sand	silt	clay			
						total	fine		
A	0-2	10YR 6/3	I-	62.0	27.3	10.7	5.6	4.8	8.0
Bt	2-13	7.5YR 5/4	I-	60.2	23.3	16.5	12.2	3.7	8.1
Bk	13-70	10YR 8/1	I	64.4	24.2	11.4	7.3	13.3	8.3
Cn	70-200+	5Y 7.3	N	65.9	23.4	10.7	6.6	7.8	8.7

Soil site: BL-3
Location: Soil site is in a hand-dug pit in SE1/4SW1/4 sec. 24, T. 3 N., R. 3 W., Bull Lake East 7.5-min. topographic quadrangle
Parent material: Till of the Bull Lake Glaciation
Map unit designation: Lower till of Bull Lake Till (Richmond and Murphy, 1965)

[Leaders, --, not determined]

Horizon	Depth (cm)	Munsell color (dry)	Stage of secondary carbonate	Particle size, percent				Calcium carbonate content, percent	pH
				sand	silt	clay			
						total	fine		
Bt	0-22	7.5YR 5/3	I	48.0	34.3	17.7	--	0.9	7.5
Btk1	22-43	10YR 6/3	II	48.9	38.7	12.4	--	24.4	8
Btk2	43-73	10YR 7/3	II	49.7	40.0	10.3	--	18.1	8
Bk	73-106+	10YR 7/3	I	50.7	42.6	6.7	--	12.5	8

Soil site: BL-4
Location: Soil site is in a hand-dug pit in SE1/4NE1/4 sec. 11, T. 3 N., R. 3 W., Crowheart Butte 7.5-min. topographic quadrangle
Parent material: Till of the Bull Lake Glaciation
Map unit designation: Lower till of Bull Lake Till (G.M. Richmond, oral commun., 1976)

Horizon	Depth (cm)	Munsell color (dry)	Stage of secondary carbonate	Particle size, percent				Calcium carbonate content, percent	pH
				sand	silt	clay			
						total	fine		
A	0-2	10YR 5/3	I	59.9	28.6	11.5	5.9	1.0	7.1
Bt	2-11	7.5YR 5/3	I	52.8	30.7	16.5	7.9	6.1	7.4
Bk	11-49	10YR 8/1	II	63.6	25.4	11.0	6.5	18.3	7.8
Ckn	49-110+	5Y 7/2	I	62.0	30.3	7.7	2.6	8.4	8.2

SOILS DATA FOR THE DINWOODY LAKES AREA

Soil site:	DL-1
Location:	Soil site is in a hand-dug pit in SE1/4NE1/4 sec. 27, T. 5 N., R. 5 W., Wilderness 7.5-min. topographic quadrangle
Parent material:	Till of the Sacagawea Ridge Glaciation
Map unit designation:	Outer moraine of the Sacagawea Ridge Till (G.M. Richmond, oral commun., 1976)

[N, none observed]

Horizon	Depth (cm)	Munsell color (dry)	Stage of secondary carbonate	Particle size, percent				Calcium carbonate content, percent	pH
				sand	silt	clay			
						total	fine		
A	0-3	10YR 5/3	I-	79.6	12.6	7.8	5.0	1.5	7.7
Bw	3-12	10YR 6/4	I-	73.3	15.9	10.8	8.0	5.5	7.8
Bk1	12-86	7.5YR 8/2	II+	71.7	18.8	9.5	5.1	33.2	8.5
Bk2	86-126	10YR 8/4	I-	73.8	17.4	8.8	6.0	24.1	9.0
Bk3	126-187	10YR 7/4	I-	68.3	23.9	7.8	5.4	20.2	9.0
Cox	187-202+	10YR 7/3	N	71.8	22.0	6.2	3.8	13.3	9.0

SOILS DATA FOR THE FREMONT LAKE AREA

Soil site:	FL-1
Location:	Soil site is in a road cut along County Road 23-111 in SW1/4SW1/4 sec. 24, T. 34 N., R. 109 W., Fremont Lake South 7.5-min. topographic quadrangle
Parent material:	Till of the Pinedale Glaciation
Map unit designation:	Middle till of Pinedale Glaciation (Richmond, 1973) Pinedale end moraine 4 (Richmond, 1987)

[N, none observed; leaders, --, not determined]

Horizon	Depth (cm)	Munsell color (dry)	Stage of secondary carbonate	Particle size, percent				Calcium carbonate content, percent	pH
				sand	silt	clay			
						total	fine		
A	0-15	10YR 5/3	N	68.8	26.0	5.2	--	<0.1	7.5
2Bw	15-66	10YR 6/3	N	54.4	38.9	6.6	--	0.1	7
3Cox	66-91	2.5Y 6/3	N	66.5	29.7	3.8	--	0.3	8
3Cn1	91-122	2.5Y 6/2	N	69.7	27.7	2.6	--	<0.1	8
3Cn2	122-153+	2.5Y 6/2	N	64.9	32.4	2.7	--	<0.1	8

Soil site: FL-2
Location: Soil site is in a road cut along County Road 23-111 in SE1/4NW1/4 sec. 26, T. 34 N., R. 109 W., Fremont Lake South 7.5-min. topographic quadrangle
Parent material: Till of the Pinedale Glaciation
Map unit designation: Lower till of Pinedale Glaciation (Richmond, 1973)
Pinedale end moraine 1 (Richmond, 1987)

[N, none observed; leaders, --, not determined]

Horizon	Depth (cm)	Munsell color (dry)	Stage of secondary carbonate	Particle size, percent				Calcium carbonate content, percent[1]	pH
				sand	silt	clay			
						total	fine		
A	0-4	10YR 5/2	N	65.3	30.4	4.3	--	--	7.5
Bt	4-26	10YR 4/3	N	64.9	26.5	8.6	--	--	7.5
Cox1	26-40	10YR 5/3	N	66.6	29.6	4.8	--	--	7.5
Cox2	40-60	2.5Y 6/3	N	67.2	28.6	4.2	--	--	7.5
Cox3	60-134	2.5Y 6/3	N	74.0	23.5	2.5	--	--	--
Cn	134-214+	2.5Y 7/2	N	68.5	29.6	1.9	--	--	--

[1]The calcium carbonate content of the entire profile is estimated to be less than 0.5 percent.

Soil site: FL-3A
Location: Soil site is in a hand-dug pit in NW1/4NE1/4 sec. 20, T. 34 N., R. 108 W., Fremont Lake South 7.5-min. topographic quadrangle
Parent material: Till of the Pinedale Glaciation and probably some eolian material in the uppermost horizon
Map unit designation: Lower till of Pinedale Glaciation (Richmond, 1973)
Pinedale end moraine 1 (Richmond, 1987)

[N, none observed]

Horizon[1]	Depth (cm)	Munsell color (dry)	Stage of secondary carbonate	Particle size, percent				Calcium carbonate content, percent	pH
				sand	silt	clay			
						total	fine		
A	0-8	10YR 5/3	N	56.3	29.5	14.2	9.2	0.2	6.4
2Bw1	8-17	10YR 5/3	N	64.5	20.1	15.4	12.0	0.3	6.4
2Bw2	17-38	10YR 5/4	N	66.4	20.5	13.2	9.0	0.3	6.6
2Cox	38-95	10YR 6/3	I-	71.3	18.8	9.9	6.3	0.2	7.2
2Cn1	95-145	5Y 6/3	I-	69.5	20.0	10.5	5.0	1.2	8.2
2Cn2	145-195+	5Y 6/3	I-	69.9	19.2	10.9	7.3	0.8	8.7

[1]The Cn horizon was arbitrarily subdivided into two subhorizons.

Soil site: FL-3B
Location: Soil site is at an auger hole about 75 m west of soil site FL-3A in NW1/4NE1/4 sec. 20, T. 34 N., R. 108 W., Fremont Lake South 7.5-min. topographic quadrangle
Parent material: Loess or reworked loess
Map unit designation: Lower till of Pinedale Glaciation (Richmond, 1973)
Pinedale end moraine 1 (Richmond, 1987)

[N, none observed; leaders, --, not determined]

Horizon	Depth (cm)	Munsell color (dry)	Stage of secondary carbonate	Particle size, percent				Calcium carbonate content, percent	pH
				sand	silt	clay			
						total	fine		
--	0-25	--	--	--	--	--	--	--	--
Cn1	25-52	10YR 4/2	N	--	--	--	--	--	--
Cn2	52-72	10YR 5/2	N	12.4	64.8	22.8	14.5	0.2	6.1
Cn3	72-87	10YR 7/1	N	19.1	59.7	21.2	13.4	0.4	6.0
Cox[1]	87-105	10YR 4/8	N	--	--	--	--	--	--

[1]Horizon contains some 7.5YR 5/8 (dry) mottles and numerous carbonized rootlets.

Soil site: FL-4
Location: Soil site is in a road cut along County Road 23-111 in SE1/4NW1/4 sec. 26, T. 34 N., R. 109 W., Fremont Lake South 7.5-min. topographic quadrangle
Parent material: Till of the Bull Lake Glaciation(?)
Map unit designation: Inner moraine of upper till of Bull Lake Glaciation (Richmond, 1973)
Bull Lake end moraine IV (Richmond, 1987)

[N, none observed; leaders, --, not determined]

Horizon	Depth (cm)	Munsell color (dry)	Stage of secondary carbonate	Particle size, percent				Calcium carbonate content, percent	pH
				sand	silt	clay			
						total	fine		
A	0-18	10YR 4/2	N	64.7	24.0	11.3	--	0.1	7
Bt	18-33	10YR 5/3	N	69.8	19.1	11.1	--	0.1	7
Cox1	33-66	10YR 6/3	N	72.7	22.3	5.0	--	1.0	8
Cox2	66-102	2.5Y 6/3	N	70.6	23.3	6.1	--	0.6	8
Cox3	102-127+	2.5Y 6/3	N	76.9	19.8	3.3	--	0.5	8

Soil site: FL-5
Location: Soil site is in a hand-dug pit in SW1/4NE1/4 sec. 20, T. 34 N., R. 108 W., Fremont Lake South 7.5-min. topographic quadrangle
Parent material: Till of the Bull Lake Glaciation and probably some eolian material in the upper two horizons
Map unit designation: Inner moraine of upper till of Bull Lake Glaciation (Richmond, 1973)
Bull Lake end moraine V (Richmond, 1987)

[N, none observed]

Horizon	Depth (cm)	Munsell color (dry)	Stage of secondary carbonate	Particle size, percent				Calcium carbonate content, percent	pH
				sand	silt	clay			
						total	fine		
A	0-13	10YR 4/3	N	56.9	29.8	13.3	8.9	0.3	7.0
Bw	13-39	7.5YR 4/4	N	63.1	25.8	11.1	7.4	0.3	6.8
2Cox1	39-92	10YR 6/4	N	75.5	19.3	5.2	3.1	0.4	6.8
2Cox2	92-156	10YR 6/3	N	74.0	20.9	5.1	2.9	0.2	7.4
2Cn	156-178+	2.5Y 7/2	N	71.9	23.7	4.4	2.9	0.4	7.4

Soil site: FL-6
Location: Soil site is in a road cut along County Road 23-111 in SW1/4NW1/4 sec. 34, T. 34 N., R. 109 W., Pinedale 7.5-min. topographic quadrangle
Parent material: Till of the Bull Lake Glaciation
Map unit designation: Lower till of Bull Lake Glaciation (Richmond, 1973)
Bull Lake end moraine I (Richmond, 1987)

[N, none observed; leaders, --, not determined]

Horizon	Depth (cm)	Munsell color (dry)	Stage of secondary carbonate	Particle size, percent				Calcium carbonate content, percent	pH
				sand	silt	clay			
						total	fine		
A	0-5	10YR 5/3	N	62.9	28.3	8.8	--	--	7
Bt	5-48	10YR 5/3	N	51.2	30.5	18.3	--	0.4	8
Bk	48-119	10YR 8/1	II	59.1	31.1	9.8	--	26.6	8
Cox	119-260+	2.5Y 7/3	N	56.0	32.1	11.9	--	1.9	8

DISCUSSION

Soils formed in tills of the Pinedale and Bull Lake Glaciations at Bull Lake and Fremont Lake are described in reports by Richmond (1962, 1964, 1976, 1986, 1987), Murphy and Richmond (1965), Richmond and Murphy (1965), Shroba (1977), Mahaney (1978), Shroba and Birkeland (1983), Sorenson (1986). The soils data presented in this report (summarized in table 1) indicate that (1) the Bt horizons of the post-Pinedale and post-Bull Lakes soils at Bull Lake are similar in thickness, color, and maximum clay content, and they tend to be thinner, redder, and slightly more clayey than Bt horizons of similar age at Fremont Lake, (2) the post-Sacagawea Ridge soil at Dinwoody Lakes lacks a Bt horizon probably due to erosion; however, it has a Bk horizon that contains more calcium carbonate than the Bk or C horizons of the younger soils at Bull Lake and Fremont Lake, (3) the post-Pinedale and the post-Bull Lake soils at Fremont Lake display variable amounts of Bw and Bt horizon development, probably due in part to differences in soil ages and differences in the clay content of the parent materials, and (4) much of the clay increase in the Bw and Bt horizons tends to be fine clay. The similarity in the degree of development of some of the post-Bull Lake soils to that of the post-Pinedale soils at Bull Lake and Fremont Lake lends support to Richmond's evidence for local erosion of the post-Bull Lake soil as well as to his suggestion that the youngest Bull Lake moraine in these areas could be as young as early Wisconsin (Richmond, 1986, 1987).

Table 1.--Summary of selected soil properties

[P, Pinedale; B, Bull Lake; S, Sacagawea Ridge; leaders, --, not determined]

Soil site	Age of till parent material[1]	Horizon of maximum clay accumulation					Maximum percentage of calcium carbonate in Bk or Cox horizon	Cn or lower part of Cox horizon		
		Designation	Thickness (cm)	Munsell color (dry)	Maximum percentage of clay			Clay percentage		Calcium carbonate, percentage
					total	fine		total	fine	
BL-1	P	Bt	7	7.5YR 5/3	13.4	--	18.3	6.5	--	10.4
BL-2	P	Bt	11	7.5YR 5/4	16.5	12.2	13.3	10.7	6.6	7.8
BL-3	B	Bt	22	7.5YR 5/3	17.7	--	24.4	--	--	--
BL-4	B	Bt	9	7.5YR 5/3	16.5	7.9	18.3	7.7	2.6	8.4
DL-1	S	Bw	9	10YR 6/4	10.8	8.0	33.2	<6.2	<3.8	<13.3
FL-1	P	Bw	41	10YR 6/3	6.6	--	3.8	2.7	--	<0.1
FL-2	P	Bt	22	10YR 4/3	8.6	--	<0.5	1.9	--	<0.5
FL-3A	P	2Bw	30	10YR 5/4	[2]13.9	[2]9.9	0.2	[2]10.7	[2]6.2	[2]1.0
FL-4	B	Bt	15	10YR 5/3	11.1	--	1.0	3.3	--	0.5
FL-5	B	Bw	26	7.5YR 4/4	11.1	7.4	0.4	4.4	2.9	0.4
FL-6	B	Bt	43	10YR 5/3	18.3	--	26.6	11.9	--	1.9

[1]The age of the till parent material is based on the map-unit designations of Richmond (1973, oral commun., 1989) and Richmond and Murphy (1965).

[2]Weighted mean of two samples.

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REFERENCES

Birkeland, P.W., 1984, Soils and geomorphology: New York, Oxford University Press, 372 p.

Guthrie, R.L., and Witty, J.E., 1982, New designations for soil horizons and layers and the new Soil Survey Manual: Soil Science Society of America Journal, v. 46, p. 443-444.

Mahaney, W.C., 1978, Late Quaternary stratigraphy and soils in the Wind River Mountains, western Wyoming, in Mahaney, W.C., ed., Quaternary soils: Norwich, England, Geo Abstracts, p. 223-264.

Murphy, J.F., and Richmond, G.M., 1965, Geologic map of the Bull Lake West quadrangle, Fremont County, Wyoming: U.S. Geological Survey Geologic Quadrangle Map GQ-432, scale 1:24,000.

Richmond, G.M., 1962a, Three pre-Bull Lake tills in the Wind River Mountains, Wyoming: U.S. Geological Survey Professional Paper 450-D, p. D132-D136.

_____1964, Three pre-Bull Lake tills in the Wind River Mountains, Wyoming--A reinterpretation: U.S. Geological Survey Professional Paper 501-D, p. D104-D109.

_____1973, Geologic map of the Fremont Lake South quadrangle, Sublette County, Wyoming: U.S. Geological Survey Geologic Quadrangle Map GQ-1138, scale 1:24,000.

_____1976, Pleistocene stratigraphy and chronology in the mountains of western Wyoming, in Mahaney, W.C., ed., Quaternary Stratigraphy of North America: Stroudsburg, Pennsylvania, Dowden, Hutchinson, and Ross, p. 353-379.

_____1986, Stratigraphy and correlation of glacial deposits of the Rocky Mountains, the Colorado Plateau, and the ranges of the Great Basin, in Sibrava, V., Bowen, D.Q., and Richmond, G.M., eds., Quaternary glaciations in the northern hemisphere: Quaternary Science Reviews, v. 5, p. 99-127.

_____1987, Type Pinedale Till in the Fremont Lake area, Wind River Range, Wyoming: Geological Society of America, Centennial Field Guide No. 2, Rocky Mountain Section, p. 201-204.

Richmond, G.M., and Murphy, J.F., 1965, Geologic map of the Bull Lake East quadrangle, Fremont County, Wyoming: U.S. Geological Survey Geologic Quadrangle Map GQ-431, scale 1:24,000.

Shroba, R.R., 1977, Soil development in Quaternary tills, rock-glacier deposits, and taluses, Southern and Central Rocky Mountains: Boulder, University of Colorado, Ph.D. thesis, 424 p.

Shroba, R.R., and Birkeland, P.W., 1983, Trends in late-Quaternary soil development in the Rocky Mountains and Sierra Nevada of the western United States, in Porter, S.C., ed., Late-Quaternary environments of the United States, v. 1, The Late Pleistocene: Minneapolis, University of Minnesota Press, p. 145-156.

Soil Survey Staff, 1951, Soil survey manual: U.S. Department of Agriculture Handbook No. 18, 503 p.

_____1975, Soil taxonomy: U.S. Department of Agriculture Handbook No. 436, 754 p.

Sorenson, C.J., 1986, Soils map of the Fremont Lake South quadrangle, Sublette County, Wyoming: U.S. Geological Survey Miscellaneous Investigations Series Map I-1800, scale 1:24,000.

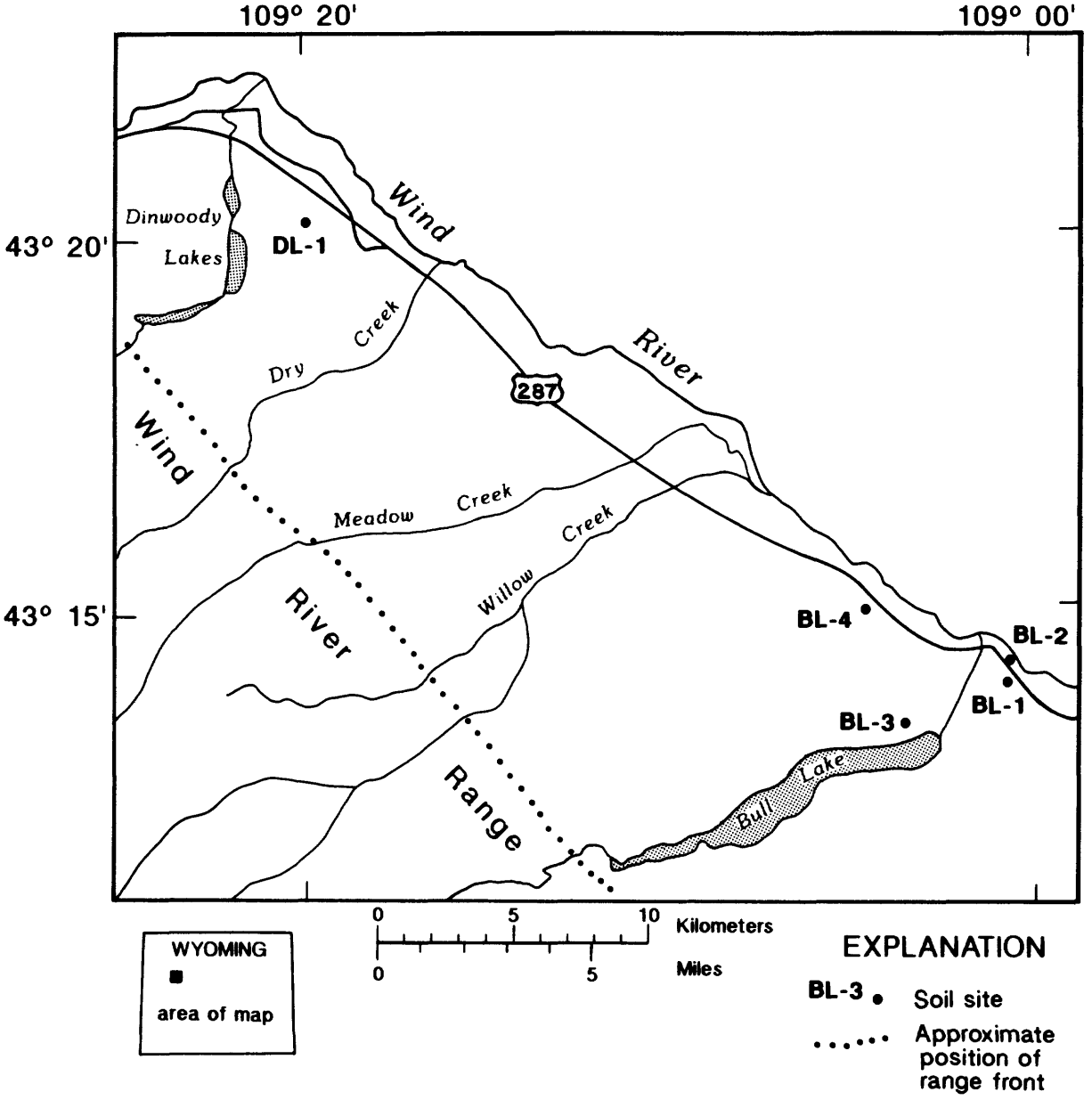

Figure 1.--Map showing the locations of soil sites at Bull Lake and Dinwoody Lakes, Fremont County, Wyoming

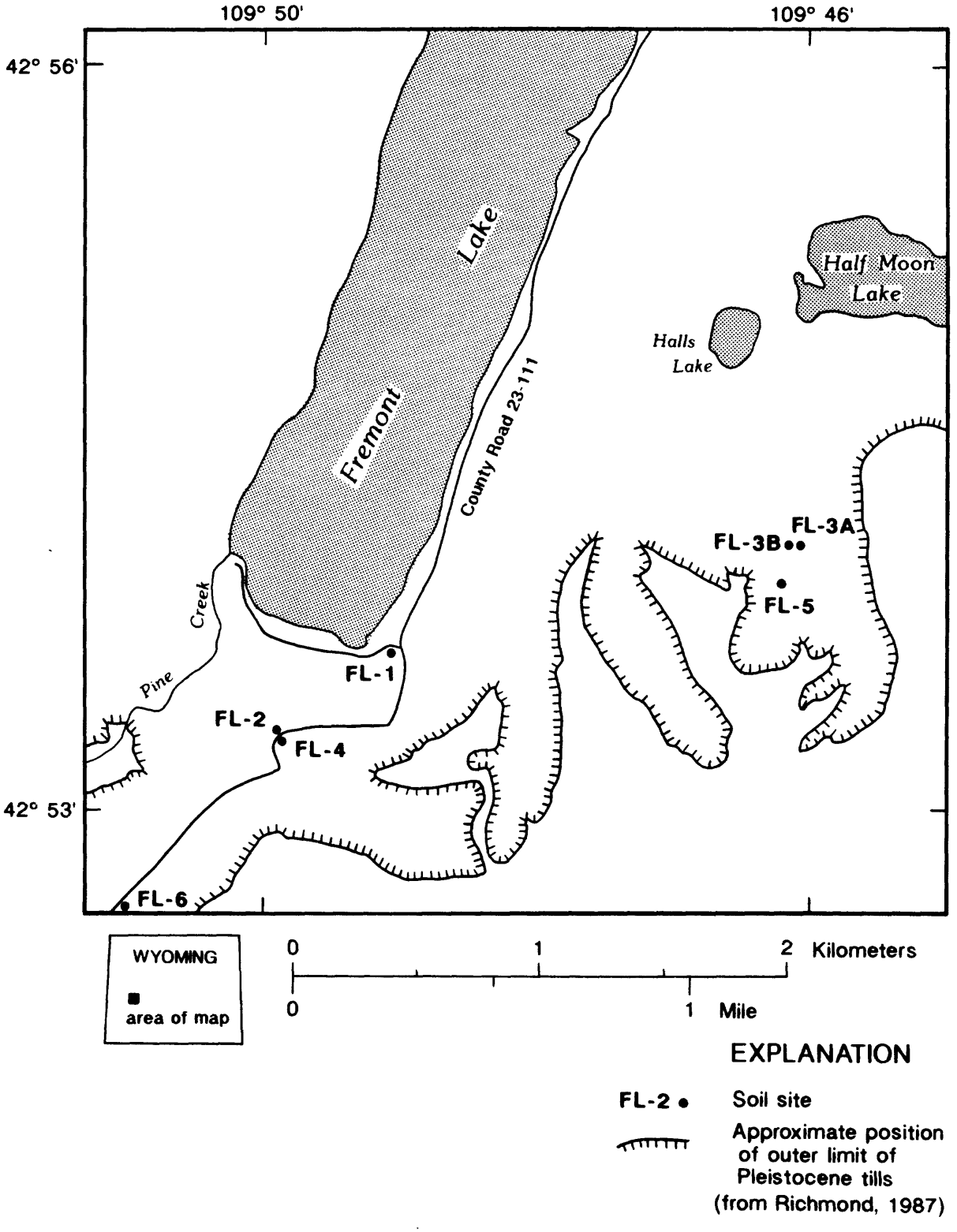

Figure 2.--Map showing the locations of soil sites at Fremont Lake, Sublette County, Wyoming