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LIGNITE GEOLOGY OF SOUTHEAST WILLIAMS COUNTY, NORTH DAKOTA

By

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(plates in pocket)

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To convert	Multiply by	To obtain
feet	0.3048	meters (m)
tons (short)	.907	metric tonnes (t)
Btu/lb	2.326	kilojoule/kilogram (kJ/kg)

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INTRODUCTION

The area of this study is in southeastern Williams County, North Dakota, between the city of Williston and the Mountrail County line (fig. 1). It is bounded on the south by Lake Sakakawea and on the west by the Little Muddy River. The Sentinel Butte and Tongue River Members of the Fort Union Formation of Paleocene age form the bedrock and contain numerous lignite beds. The four principal beds discussed herein (fig. 2) are, in ascending order, the Pittsley (Pt), Avoca (A), Williston (W), and Mormon (M), each of which is at least 5.0 ft (1.5 m) thick throughout most or all of the area.

Mining development in the area has been restricted to small operations, either shallow strip pits at the outcrop or underground mines. All underground mining has ceased. The only current surface mining is for leonardite (weathered lignite) in one small mine near Williston. The structure in the eastern half of the area is dominated by the oil-producing Nesson anticline (fig. 3).

PREVIOUS WORK

Herald (1913) published the principal work on the Williston lignite field (in the northwestern part of the area of this study). The Great Northern Railway (1966) published more detailed data for the same part of the area, based on drill and core holes. Collier (1918) and Leonard,

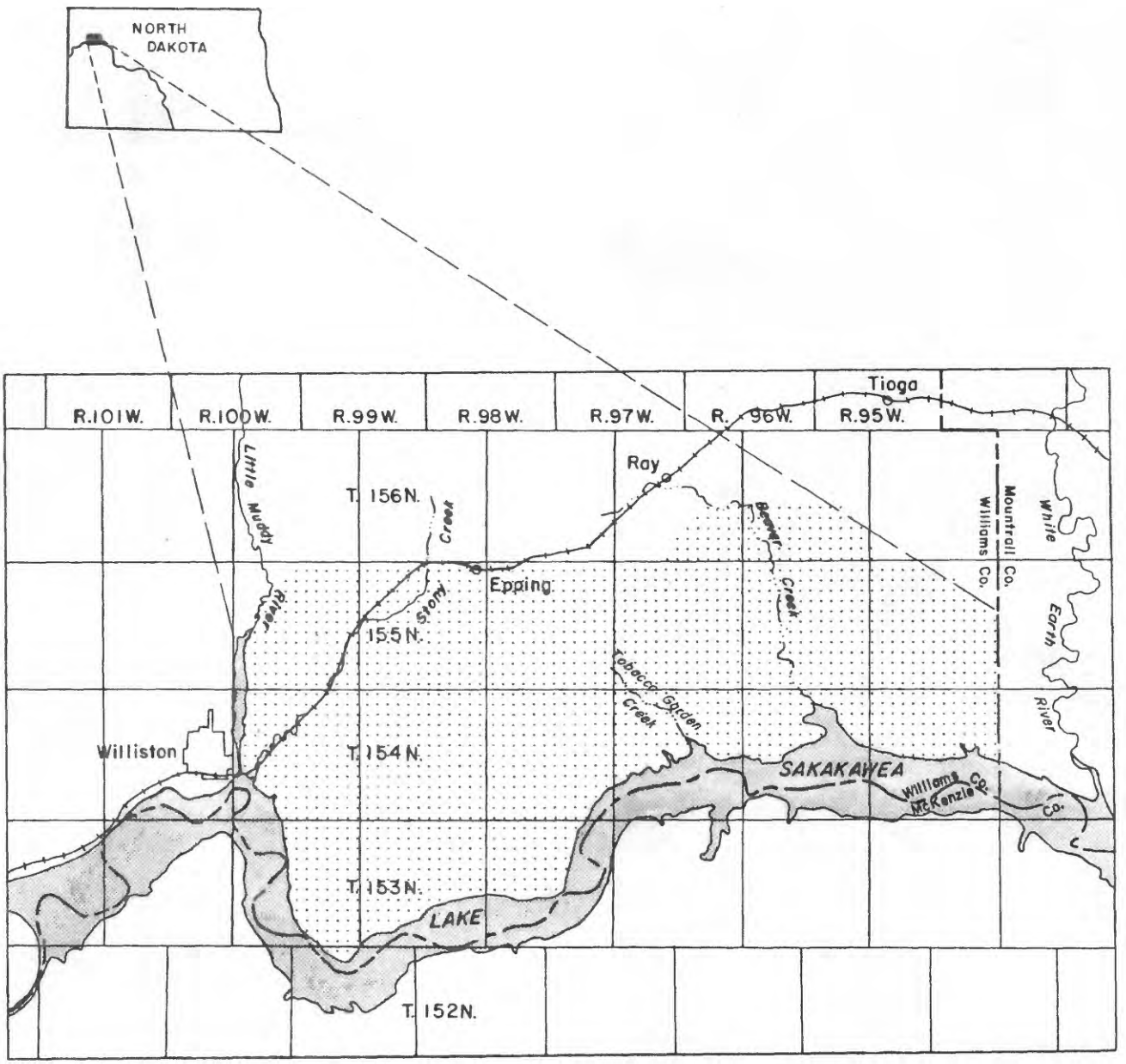

Figure 1. Location map of the southeast Williams County, North Dakota, study area (stippled).

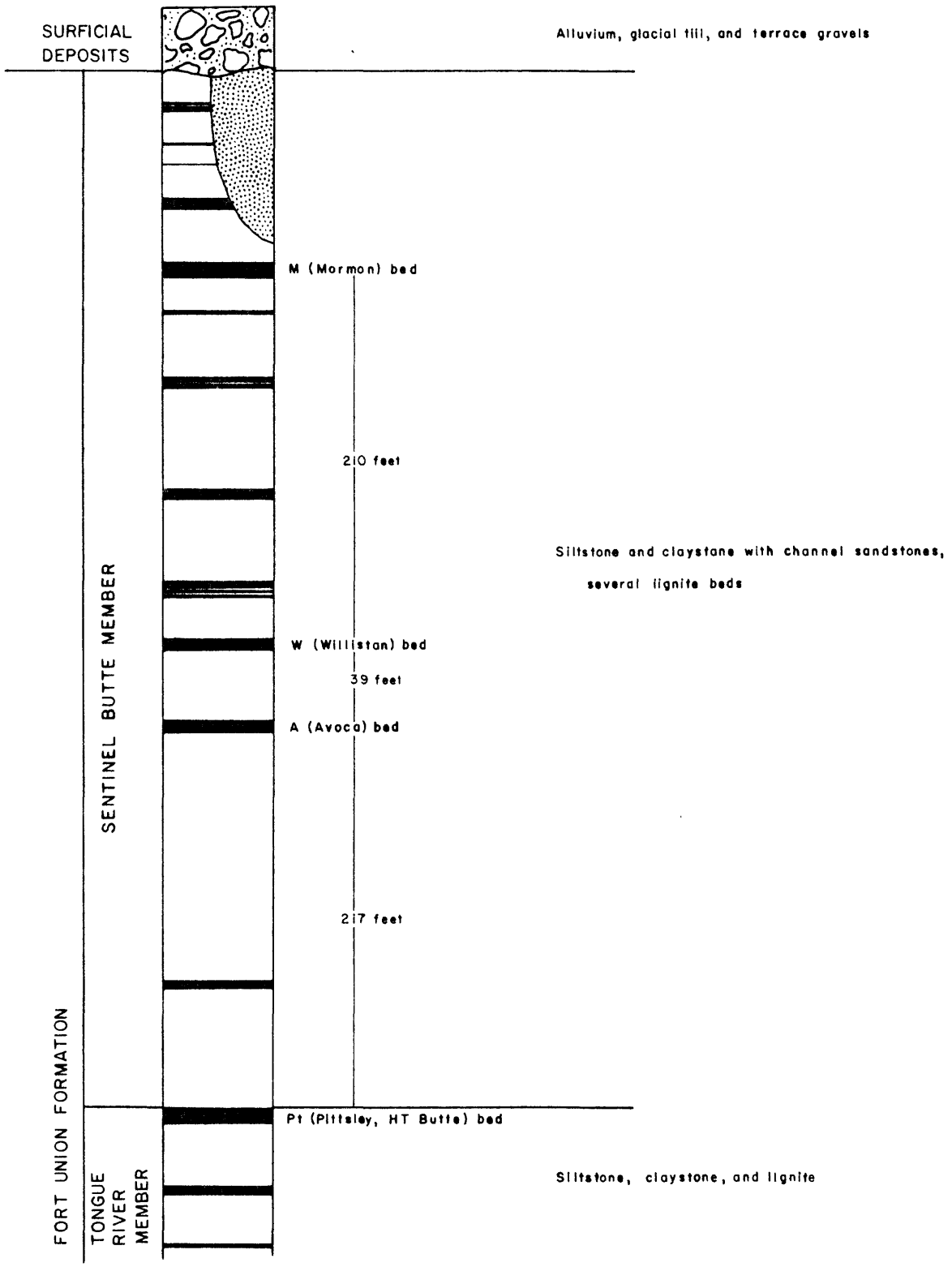

Figure 2. Generalized stratigraphic column for exposed bedrock in southeast Williams County, North Dakota. The four principal lignite beds are identified.

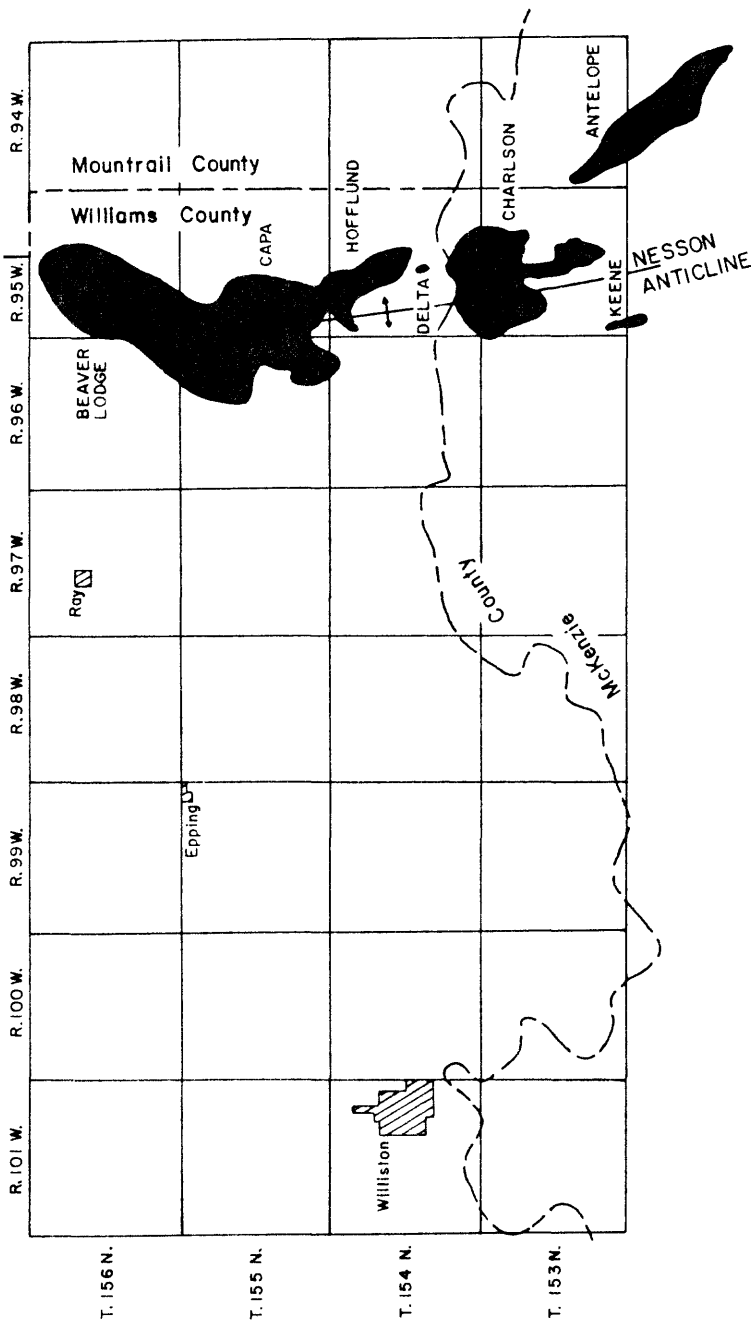

Figure 3. Index map of oil fields in southeast Williams County, North Dakota.

Dove, and Eaton (1925) identified the presence of lignite near Beaver Creek; however, the only substantial work on the deposit was done by the Great Northern Railway (1955) as a part of its Williston basin drilling program. Studies of the general geology of the county and water-well data were reported by Freers (1970) and Armstrong (1967, 1969). Federally funded drilling by the North Dakota Geological Survey (U.S. Geological Survey and North Dakota Geological Survey, 1976) and unpublished data from the U.S. Geological Survey provided additional information. Topographic map coverage is shown on plate 1A. Sources of outcrop data used in this report are indexed on plate 1B.

PHYSIOGRAPHY

The topography of the area is predominantly level uplands locally dissected near drainages. The majority of these upland surfaces are covered with glacial till, colluvial boulders, and gravel on the more gentle slopes. Southward toward Lake Sakakawea, dissection increases and badlands topography prevails along the shoreline. The badlands are most extensively developed in the southern part of T. 153 N., R. 99 W. Since completion of the reservoir in 1954, shoreline erosion has created near-vertical faces on the north-south ridges which extend into the lake.

Local relief in the area is as much as 500 ft (152 m). Total relief in the area is approximately 625 ft (191 m).

The preglacial course of the Yellowstone River was along the present-day Little Muddy River valley and the course of the Little Missouri was along Beaver Creek valley (Freers, 1970). The Little Muddy River and Beaver, Stony, and Tobacco Garden Creeks are the most prominent drainages within the study area (fig. 1); all empty directly into Lake Sakakawea.

STRUCTURE

Southeast Williams County is located on the northern flank of the Williston basin. The major structural feature is the Nesson anticline that trends north through the eastern half of the study area (fig. 3) where surface rocks dip 1/2 to 3/4°. Dips in the western half of the area are generally less than 1/4° (pls. 3 and 4). Other structural features include a depression centered on Stony Creek in T. 155 N., R. 100 W., and a high located in Tps. 154 and 155 N., R. 99 W. (pls. 5, 6, and 7).

STRATIGRAPHY

The bedrock of the area has been identified as the Fort Union Formation of Paleocene age (Herald, 1913; Collier, 1918; and Armstrong, 1967). Royse (1967, fig. 1) suggested that most of the exposed Fort Union is in the Sentinel Butte Member. Correlations using oil well logs in the area and studies farther south in west-central North Dakota (Rehbein, 1977) suggest that all exposures but a small area around Beaver Creek are of the Sentinel Butte Member (fig. 2). Both the Sentinel Butte and the underlying Tongue River are composed of interbedded siltstone, claystone, sandstone, and lignite.

Glacial till covers most of the upland surfaces of the area. The till deposits are as much as 100 ft (30 m) thick, but usually they are 10 ft (3 m) thick or less.

COAL

There are at least 15 lignite beds traceable throughout most of southeast Williams County (fig. 2). Of these, 4 consistently thick beds are considered: Pittsley (Pt), Avoca (A), Williston (W), and Mormon (M) (table 1). The other coal beds are of varying thickness and have less continuity.

Table 1.--Correlation of previous authors' names for the four principal lignite beds of southeast Williams County, North Dakota

[--, no information]

This report	Herald (1913)	Collier (1918)	Great Northern Railway (1955)	Great Northern Railway (1966)	Rehbein (written commun., 1976)
Mormon	--	12, Mormon	--	--	--
Williston	C	6, Williston	--	3	--
Avoca	B	5	--	4	--
Pittsley	--	1, Pittsley	1	--	HT Butte?

Collier (1918) identified the 1 or Pittsley bed near Beaver Creek in T. 155 N., R. 96 W. The Great Northern Railway (1955) located two beds with its drilling program. Bed 1, the higher of the two, corresponds to Collier's Pittsley bed. Studies of oil well logs suggest this bed may correlate to the HT Butte bed found in the southern counties of North Dakota (E. A. Rehbein, written commun., 1976). This is in general agreement with Royse (1967), who put the Sentinel Butte-Tongue River contact in about the same place.

Collier (1918, pl. 26) mapped the structure of the Nesson anticline, as reflected in his bed 6 (Williston bed). The mapped outcrop of the Pittsley bed is based on drill-hole data projection, reconnaissance mapping, and the interval between the Pittsley bed and the Williston bed subtracted from Collier's structure map. Freers (1970) indicated the presence of a buried valley roughly following the north edge of T. 154 N., R. 95 W. Apparently this valley cuts out the Pittsley bed (pl. 8). West of R. 96 W. the Pittsley bed presumably lies below the deepest drill holes. In secs. 7 and 18, T. 154 N., R. 95 W., and secs. 11, 12, and 13, T. 154 N., R. 96 W., the burning of the Pittsley bed in conjunction with at least one underlying lignite formed a large zone of baked and fused rock.

The Avoca bed is about 217 ft (66 m) above the Pittsley bed (pl. 9) and was mapped by Herald (1913) near Williston as the B bed. The Great Northern Railway (1966) designated it as bed 4. Reconnaissance mapping and unpublished quadrangle mapping (pl. 1B) of both the Avoca and Williston beds continue Herald's outcrop lines from the Williston area into R. 97 W. and along the eastern edge of the county. Freers (1970)

mapped a buried valley underlying the present valley of Beaver Creek that appears to cut out both the Williston and Avoca beds (pls. 10 and 11).

The Williston and Avoca beds are generally separated by about 39 ft (12 m) of interburden, but this separation ranges from 10 ft (3 m) to 98 ft (30 m) (pl. 12). The Williston bed is the most continuously traceable bed in outcrop and the most extensively mined.

The Mormon bed is about 210 ft (64 m) above the Williston bed (pl. 13). It has not been extensively mapped except in the Cussicks Spring 7½-minute quadrangle (pl. 1A). However, previously it was mined, particularly in T. 155 N., R. 97 W., but the locations of several of these mines are now unknown.

Each of the four named beds is consistently thick over most of the area (pls. 8, 10, and 11). The Pittsley bed ranges in thickness from 3.0-15.7 ft (0.9-4.8 m), averaging 8.9 ft (2.7 m) over the area where it is identified. The Avoca bed is 0-12.1 ft (0-3.7 m) thick, with the greatest thicknesses in Rs. 97 and 100 W. Incomplete topographic mapping of the area and insufficient drilling have hindered the complete mapping of the Avoca bed. Brief reconnaissance along the shoreline of Lake Sakakawea has shown the continuity of the Avoca bed from the eastern to the western part of the area. East of the center of T. 155 N., R. 96 W., the Avoca bed thins to less than 5.0 ft (1.5 m) and pinches out toward the north. The Williston bed usually has a thickness of 3.9-9.8 ft (1.2-3.0 m), but is as much as 12.1 ft (3.7 m) thick in T. 153 N., R. 100 W., and T. 155 N., R. 97 W. The Mormon bed is 5.9-13.1 ft (1.8-4.0 m) thick. A parting of 1.3 ft (0.4 m) in the western part of the area separates the bed into two benches, each of them about 3.4 ft (1.2 m) thick.

Brant's (1953) estimate of resources for beds more than 5.0 ft (1.5 m) thick in this area of Williams County is about 2.6×10^9 tons (2.4×10^9 t). The estimate from currently available data is 16.0×10^9 tons (14.5×10^9 t), broken down as follows:

	Tons	(metric tonnes)
Mormon bed	3.0×10^9	(2.7×10^9)
Williston bed	1.2×10^9	(1.1×10^9)
Avoca bed	1.4×10^9	(1.3×10^9)
Pittsley bed	1.0×10^9	(0.9×10^9)
Uncorrelated beds	9.4×10^9	(8.5×10^9)
Total	16.0×10^9	(14.5×10^9)

Lignite resources are not reported by overburden category, because the preliminary nature of this study and incomplete topographic coverage precluded detailed mapping of overburden thicknesses (pls. 9, 12, and 13).

Representative analyses from the four principal beds are presented in table 2. The average as-received heating value for all the samples from the Williston, Avoca, and Pittsley beds, as reported by the Great Northern Railway (1955, 1966) are: W, 6,202 Btu/lb; A, 6,759 Btu/lb; and Pt, 5,986 Btu/lb. The analysis for the Mormon bed shows a low heating value and high sulfur content, probably due to the shallowness of the bed at the coring site (pl. 2).

Table 2.--Analyses of lignite samples from core holes in southeast Williams County, North Dakota

[Analysis form: A, as received; B, moisture free; --, not applicable. Values in percent, except heating value. Coal bed: Pt, Pittsley; A, Avoca; W, Williston; M, Mormon]

Company core-hole No.	Hole No. this report (pl. 2)	Coal bed	Analysis form	Proximate				Ultimate	
				Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Btu/lb
[1]H-1	25	W	A	42.37	25.23	28.47	3.93	0.55	6,520
			B	-----	43.77	49.42	6.81	.96	11,310
	25	A	A	40.98	24.62	25.30	9.10	.43	6,130
			B	-----	41.72	42.87	15.41	.73	10,390
[1]D-1	32	W	A	42.62	23.54	25.94	7.90	.49	5,960
			B	-----	41.03	45.21	13.76	.85	10,390
	32	A	A	40.20	25.58	27.13	7.09	.40	6,360
			B	-----	42.77	45.38	11.85	.67	10,630
[2]13	48	Pt	A	37.51	27.61	28.97	5.91	.54	6,690
			B	-----	44.18	46.37	9.45	.87	11,137
[2]17	56	Pt	A	42.83	24.17	28.16	4.84	.28	6,368
			B	-----	42.27	49.26	8.47	.49	11,139
[2]14	59	Pt	A	46.55	25.09	19.33	9.03	.31	4,321
			B	-----	46.95	36.16	16.89	.58	8,084
[3]169-5	7	M	A	40.8	27.3	23.1	8.8	2.3	5,850
			B	-----	46.1	39.0	14.9	3.8	9,890

[1]Great Northern Railway (1966)
[2]Great Northern Railway (1955)
[3]U.S. Bureau of Mines (written commun., 1977)

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