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Non-Lignite Marker Beds in the Sentinel Butte Formation,
McKenzie and Dunn Counties, North Dakota

Steven G. Stancel

Introduction

Non-lignite marker beds in the Sentinel Butte Formation have been noted by several authors (Fisher, 1953; Meldahl, 1956; Clark, 1966; Royse, 1970; Cherven, 1973; Johnson, 1973). Five non-lignite marker beds are listed by Royse (1970): 1) basal sand bed, 2) blue bed, 3) lower yellow bed, 4) upper yellow bed, and 5) upper sand bed. These are shown in Figure 1.

The purpose of this study was to map the blue bed, the lower yellow bed, and the upper yellow bed, to determine their stratigraphic position, and to record the characteristics of the three beds.

Location

The research was conducted in the Badlands of the Little Missouri River trench between the western boundary of Theodore Roosevelt National Memorial Park, North Unit (R100W, T148N, Sec. 32), and the Lost Bridge across the Little Missouri River (R95W, T148N, Sec. 35) on North Dakota State Highway 22 north of Killdeer, North Dakota. The study area measured about 64 km. (40 mi.) along the course of the Little Missouri River or about 50 km (31 mi.) from west to east (see Plate I).

Methods of Field Work

Sixteen stratigraphic sections were measured and described. The horizontal distance between each ranged from 2 to 8 km. Most of the stratigraphic sections were measured on the north side of the river trench where the best exposures of strata usually occur. The marker beds were traced visually between sections and plotted on 7 1/2' topographic maps. The Geological Society of America Rock Color Chart was used to determine the color of the units. The classification of sedimentary structures used was that of Jacob (1973).

CHARACTERISTICS OF THE MARKER BEDS

The upper yellow bed, lower yellow bed, and blue bed in the Sentinel Butte Formation are readily identified and traced on the surface where they outcrop. The bright yellow-gray color of the two yellow beds contrasts with the dull grays and browns of the rest of the Sentinel Butte Formation and this contrast is especially conspicuous under the afternoon sun. The blue bed is a grayish-blue color and forms broad benches where it is thick.

The Upper and Lower Yellow Beds

The upper and lower yellow beds are quite similar and will be discussed together. The grain size, estimated in the field, ranges from very fine sand to silty clay and probably is mostly silt. No

textural analyses have been done as part of this study. Clark (1966, pg 22-23) did analyses on three samples of the lower yellow bed collected in the Theodore Roosevelt National Memorial Park, North Unit. These samples averaged 63% silt, 36% clay, and 1% sand. Grain size varies locally. The yellow beds are highly calcareous in all occurrences. The units are well sorted and lack cohesiveness except where moisture content is high. Calcareous concretions are common but not abundant and seldom are more than one meter thick in either the lower or upper yellow beds.

The color of the upper and lower yellow beds ranges from (5Y 8/4) grayish yellow to (5Y 8/1) yellowish gray. The yellow beds frequently form rather steep slopes. The thicker units usually exhibit a series of step-like benches each a meter or more high. Either of the two yellow beds, but especially the upper yellow bed, may form a cap on buttes, and the upper yellow bed is traceable at plains level for several miles in some places.

The most common sedimentary structure in the two yellow marker beds is small-scale, grouped sets of high-angle cross strata. Large-scale, solitary or grouped sets of high-angle cross strata also are found in both units along with planar bedding. The best exposures of sedimentary structures occur in large calcareous concretions. The upper and lower yellow beds tend to become finer upward. Dessication cracks are very large or absent in most outcrops of the

yellow beds.

The two yellow beds are well vegetated in most places, but to a lesser extent than outcropping lignitic beds. Fossils are not common in the two yellow beds but pelecypods, gastropods, and impressions of vegetation can be found within them.

Laterally, the two yellow beds remain quite similar in texture and appearance. The upper yellow bed becomes somewhat finer grained to the east and its thickness varies more than the lower yellow bed. The upper yellow bed tends to be comprised of a greater number of individual beds than the lower yellow bed, and this is especially true in the eastern half of the study area.

A white, powdery, surficial deposit is common on the yellow marker beds in the eastern half of the study area. This deposit caused the beds to appear white at a distance. Other strata have similar looking deposits so that in some places they may be confused with the yellow beds when viewed from a distance. The lower and upper yellow beds in the west half of the study area do not have these white, surficial deposits.

The upper yellow bed averages 8.8 m thick in stratigraphic sections measured. Its actual average thickness is somewhat more. The lower yellow bed is an average of 6.9 m thick.

Blue Bed

X-ray diffraction analysis indicates that the blue bed is largely made up of the clay mineral montmorillonite along with a small quantity of vermiculite (Nels Forsman, 1974, personal communication). Clark (1966), working on samples taken from three locations in and near the west boundary of Theodore Roosevelt National Memorial Park, North Unit, determined that the clay-size material of the blue bed consists of 82% clay minerals, 90% of which is montmorillonite. Clark also found 16% quartz and small percentages of feldspar and calcareous minerals. Textural analyses show that the blue bed is 73% clay, 26% silt, and 1% sand (Clark, 1966, Table 3). Forsman examined samples from the North Unit of Roosevelt National Park and found that the sand fraction contained up to 60% unweathered volcanic glass shards.

A loose, crumbly, highly permeable, "popcorn" surface occurs on dry, weathered outcrops of the blue bed. Clark (1966, p. 16) attributed the "popcorn" surface to expansion and shrinkage of montmorillonite during wetting and drying.

The blue bed forms large benches capping the bluffs and covers lower slopes where it is being washed. The capping habit of the blue bed is especially pronounced along Squaw Creek in the North Unit of Roosevelt National Park (see Plate I).

The blue bed does not form benches to the east of the North Unit

of Roosevelt National Park. It's topographic expression is no different from other clay units and it can be distinguished only by color and stratigraphic position in the eastern half of the study area.

Another Conspicuous Bed

In stratigraphic sections 9, 11, and 13 (see Plate I) another conspicuous bed appears. It is similar to the upper yellow bed in many respects and occurs high in the stratigraphic sections, about 50 m above the upper yellow bed. This unit is a yellowish-gray (5Y 8/1), relatively non-calcareous, clayey silt. It averages about 6 m thick. This "yellow bed" can only be traced intermittantly because it usually occurs at the top of the bluffs at the level with the surrounding plains. Hickey (1972, p. 106) says the lower member of the Golden Valley Formation can be diagnosed by the kaolinitic composition, brilliant weathering colors of yellow, orange, or ash-gray, bare slopes and lateral persistence. Whether or not this "yellow bed" represents the lower member of the Golden Valley Formation is unknown.

EXTENT AND POSITION OF MARKER BEDS

The upper yellow bed, lower yellow bed, and the blue bed occupy the same relative position wherever they occur in the same stratigraphic section. The vertical interval between the lower yellow bed and upper

yellow bed increases from about 30 m in the western-most measured sections to 65 m in the eastern-most measured sections (see Plate I). Fisher (1953) gives an interval of 110 feet (33.5 m) between the "low yellow" (lower yellow bed) and the "high yellow" (upper yellow bed) in west-central McKenzie County. The interval between the two yellow beds increases continuously from west to east with minor variations.

The vertical interval between the blue bed and the lower yellow bed fluctuates between a maximum of 18 m and a minimum of 5.5 m. There is no consistent variation in the interval between these beds.

All three marker beds occur at progressively lower elevations from west to east. In stratigraphic section 1 (see Plate I) the base of the blue bed is 2240 feet above mean sea level (MSL), the bottom of the lower yellow bed is at 2300 feet above MSL, and the base of the upper yellow bed occurs at 2410 feet above MSL. In stratigraphic section 15, 48 km east of section 1, the base of the blue bed is at 2070 feet above MSL, the lower yellow bed is extrapolated to be at 2090 feet above MSL, and the base of the upper yellow bed appears at 2310 feet above MSL.

These data give a dip of 1.1 m/km (5.7 ft/mi) for the lower yellow bed, and a dip of .6 m/km (3.3 ft/mi) for the upper yellow bed.

Fisher (1953) gives a regional dip of strata in west-central McKenzie County, to the west of the area described here, of 10 to 40

feet per mile (2 to 8 meters per kilometer) to the east and northeast. The dips in the area described here are lower because the area is closer to the west flank of the Nesson Anticline than is Fisher's study area.

EXTENT

None of the three marker beds can be traced continuously throughout the study area. The upper yellow bed is the most extensive of the three and occurs in all but stratigraphic sections 10 and 11 (see Plate I). The upper yellow bed may be eroded or heavily vegetated locally.

The lower yellow bed is missing in stratigraphic sections 9 through 13, and the blue bed is missing in stratigraphic sections 8 through 12. Fluvial erosion probably removed the marker beds at these locations because thick sand bodies occur at the positions where the marker beds are expected.

This study did not proceed east of the Lost Bridge, but the lower yellow bed and blue bed can be traced in the bluffs above the Little Missouri Bay of Lake Sakawawea for an unknown distance to the east.

Fisher (1953) also traced the lower yellow bed and blue bed in McKenzie County. He traced these beds continuously from Sheep Butte in T148N, R103W, eastward to T148N, R95W, a distance of 45 miles. He also traced these markers northeastward along the preglacial valley of the Little Missouri River from the McKenzie County - Billings County line to 7 miles northeast of Watford City.

CONCLUSIONS

The consistent stratigraphic position of the blue bed, lower yellow bed, and upper yellow bed, the similarity in characteristics throughout the map area of the lower yellow bed and upper yellow bed, and the alignment of the lower yellow bed and the blue bed across a wide gap indicate the three marker beds were deposited as more or less continuous beds. Therefore, where one or all of the beds occur they can be used as stratigraphic markers in the Sentinel Butte Formation.

ACKNOWLEDGEMENTS

This study was supported by the National Science Foundation through Undergraduate Research Participation Grant G. Y. 11184 to the Department of Geology at the University of North Dakota. I wish to thank Dr. Art Jacob for his assistance and guidance in this project. I am also grateful to the National Park Service, the Supervisor of Parks, and Ralph Roye, Head Ranger, Theodore Roosevelt National Memorial Park, North Unit, for their assistance. A special thanks goes to the ranchers of McKenzie and Dunn Counties who allowed me access to their property.

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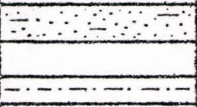
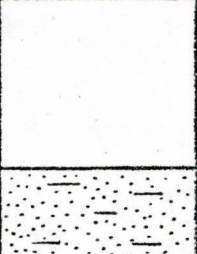
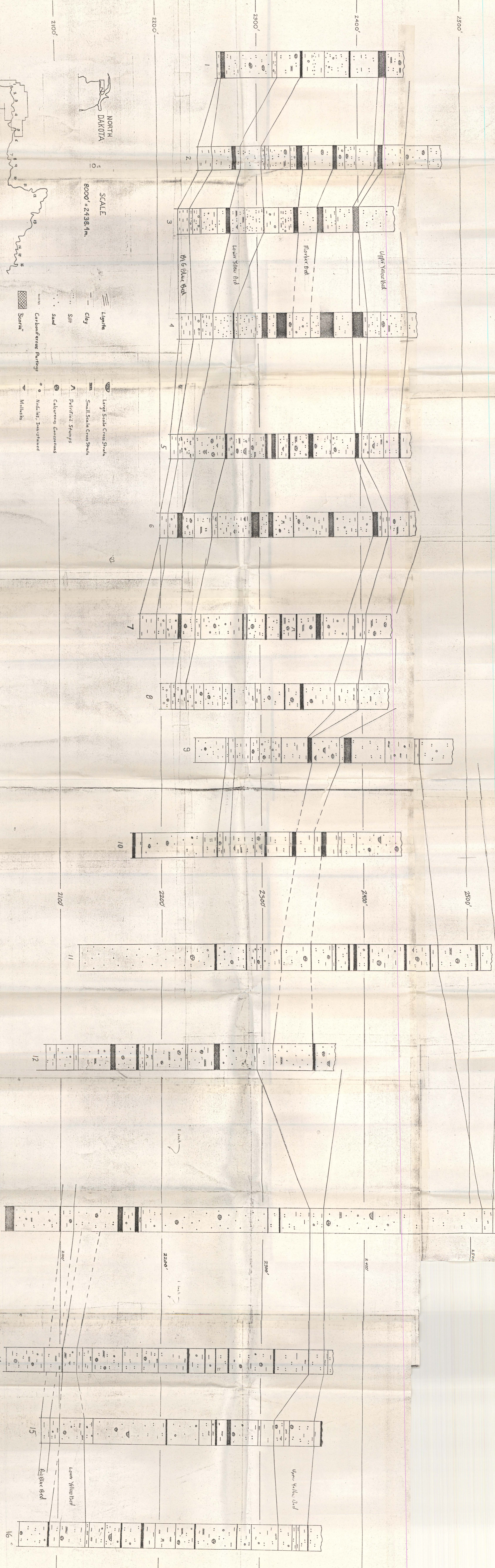
FORMATION	POSITION	MARKER BEDS
SENTINEL BUTTE FM.		UPPER SAND BED
		UPPER YELLOW BED
		LOWER YELLOW BED
		BLUE BED
		BASAL SAND BED

Figure 1. Marker beds in the Sentinel Butte Formation (modified from Royse, 1970, figure 4).



NORTH
DAKOTA

SCALE
8000' = 2438.4m.

- Large Scale Cross Strata
- Small Scale Cross Strata
- Peat/Fred Stumps
- Calcareous Concretions
- Nodules, Iron-stained
- Mollusks
- Lignite
- Clay
- Silt
- Sand
- Carboniferous Partings
- "Scoria"

High Blue Wash

Lower Yellow Bed

Upper Yellow Bed

Upper Yellow Bed

Lower Yellow Bed

High Blue Wash

2100'

2200'

2300'

2400'

2500'

2100'

2200'

2300'

2400'

2500'

13

14

16

15

10

8

7

6

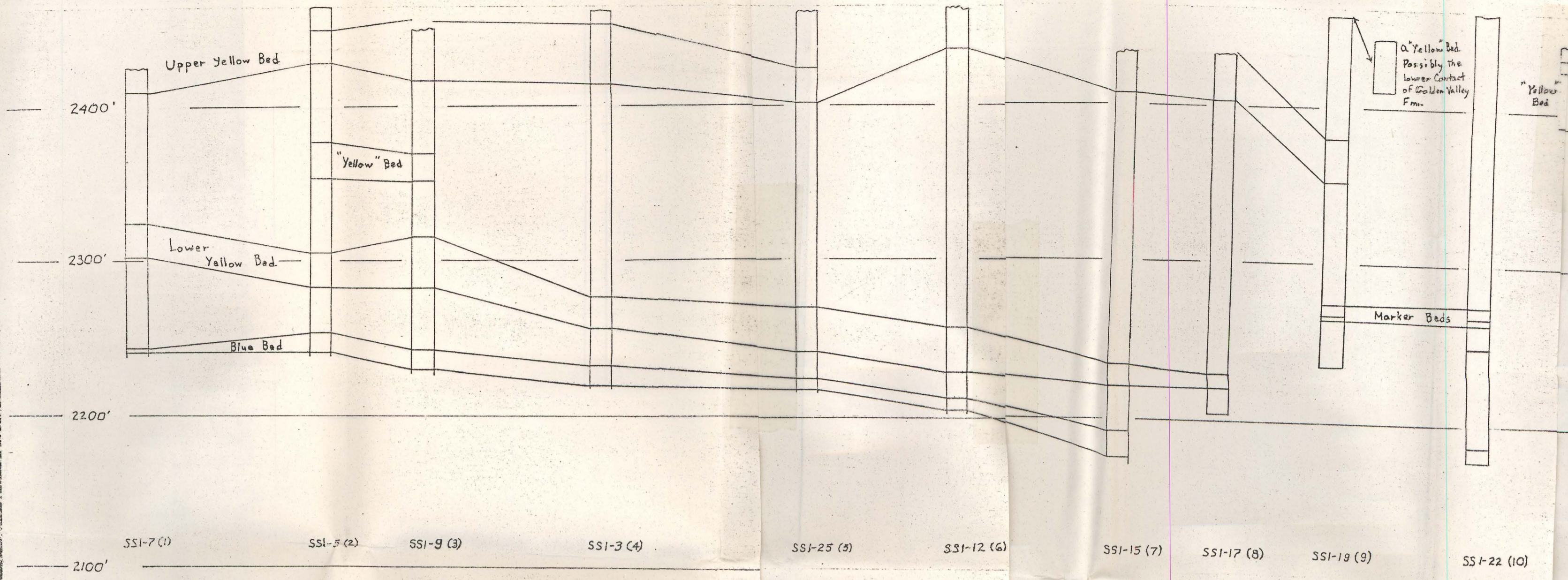
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4

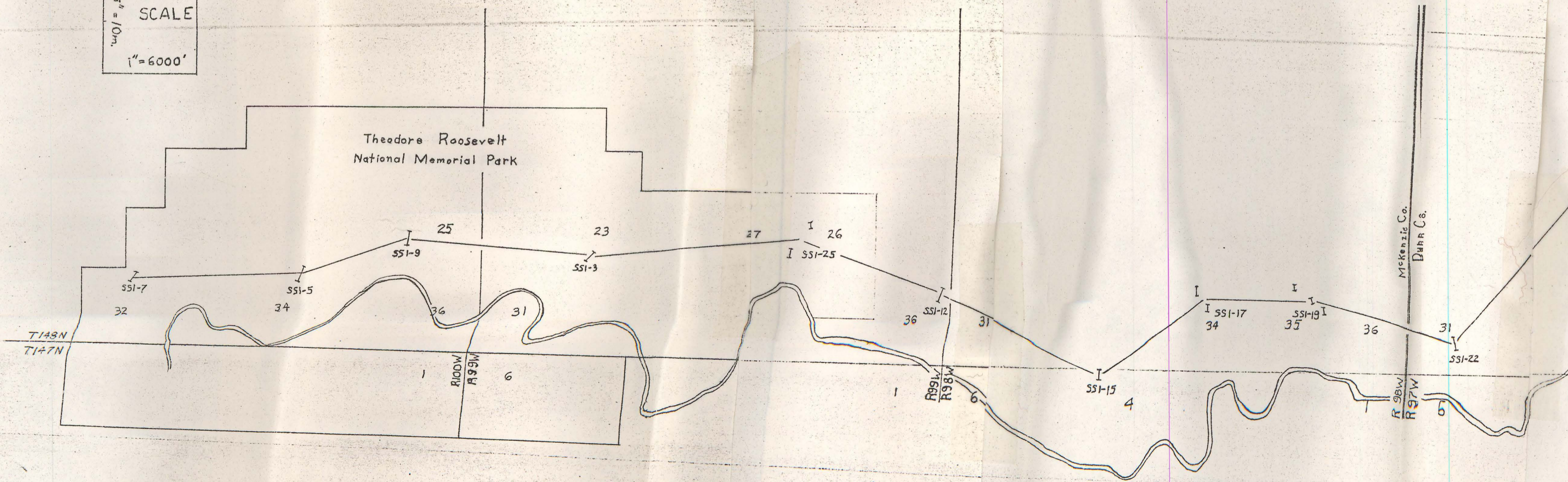
3

2

1



SCALE
 $\frac{1}{2}$ " = 100'
 1" = 6000'



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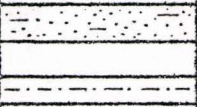
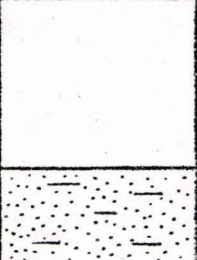
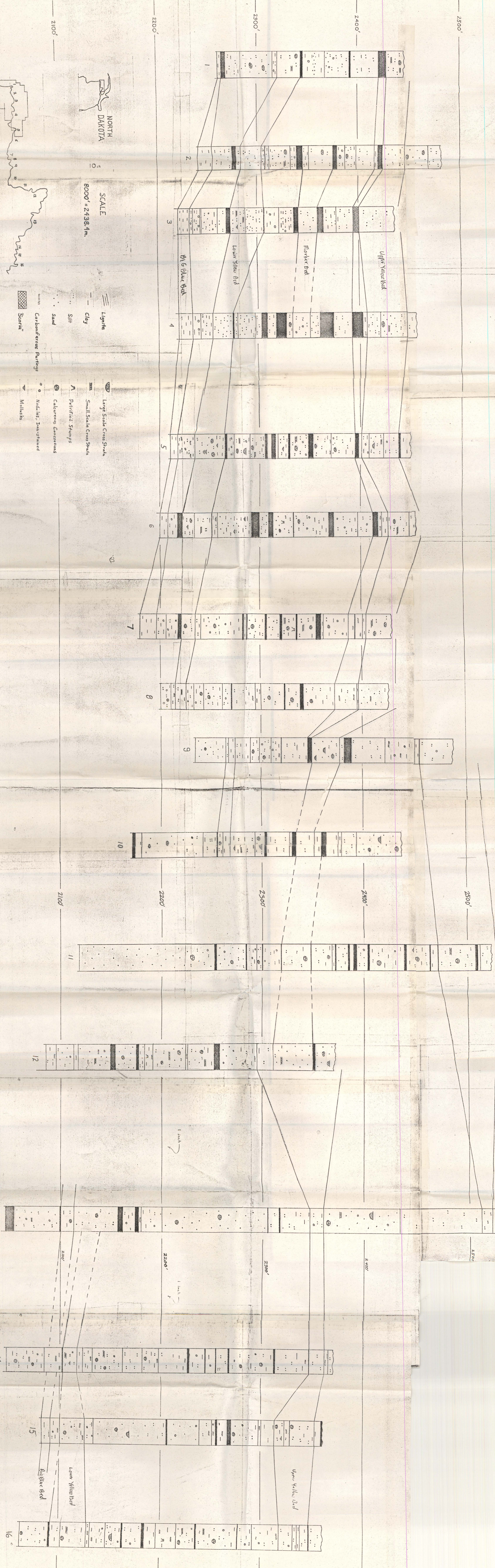
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		LOWER YELLOW BED
		BLUE BED
		BASAL SAND BED

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NORTH
DAKOTA

SCALE
8000' = 2438.4m.

- Lignite
- Clay
- Silt
- Sand
- Carbonaceous Partings
- Scoria
- Large Scale Cross Shafts
- Small Scale Cross Shafts
- Peat/Ford Stumps
- Calcareous Concretions
- Nodules, Iron-stained
- Mollusks

Upper Yellow Bed

Lower Yellow Bed

High Blue Bed

2500'

2400'

2300'

2200'

2100'

2500'

2400'

2300'

2200'

2100'

Upper Yellow Bed

Lower Yellow Bed

High Blue Bed

16

15

14

12

10

9

8

7

6

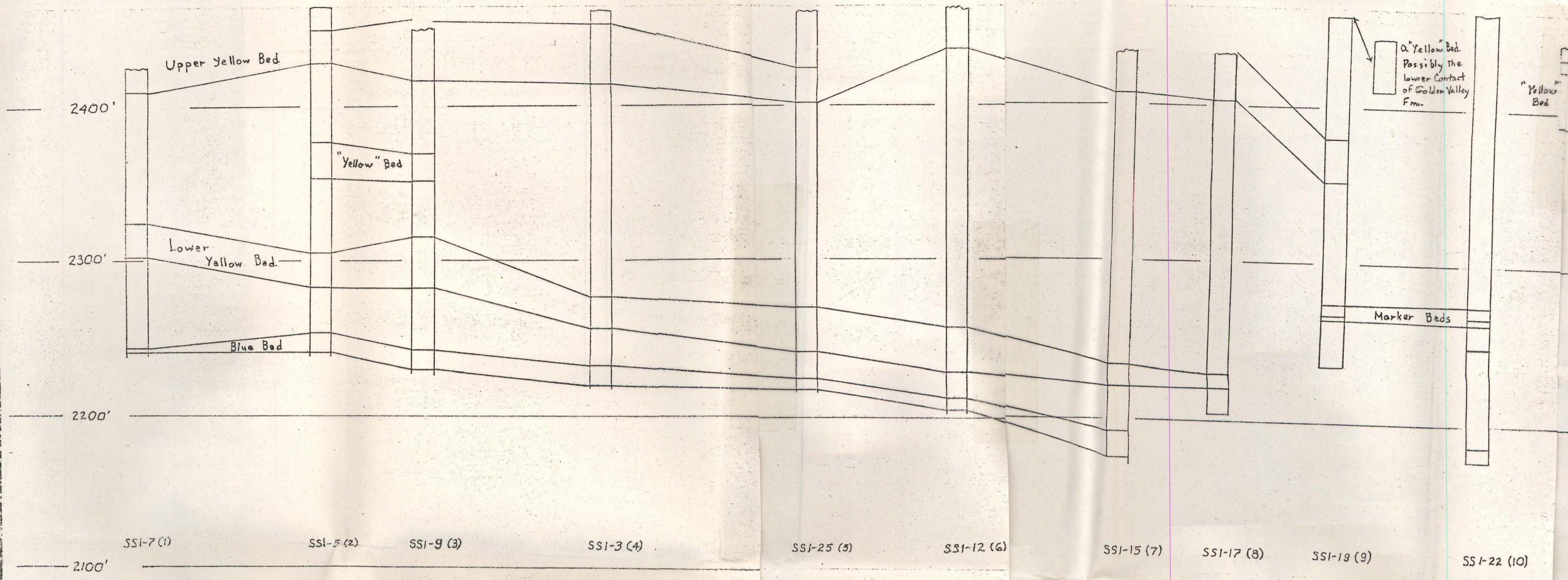
5

4

3

2

1



SCALE
 $\frac{1}{2}$ " = 100'
 1" = 6000'

