SOUTH DAKOTA GEOLOGICAL SURVEY
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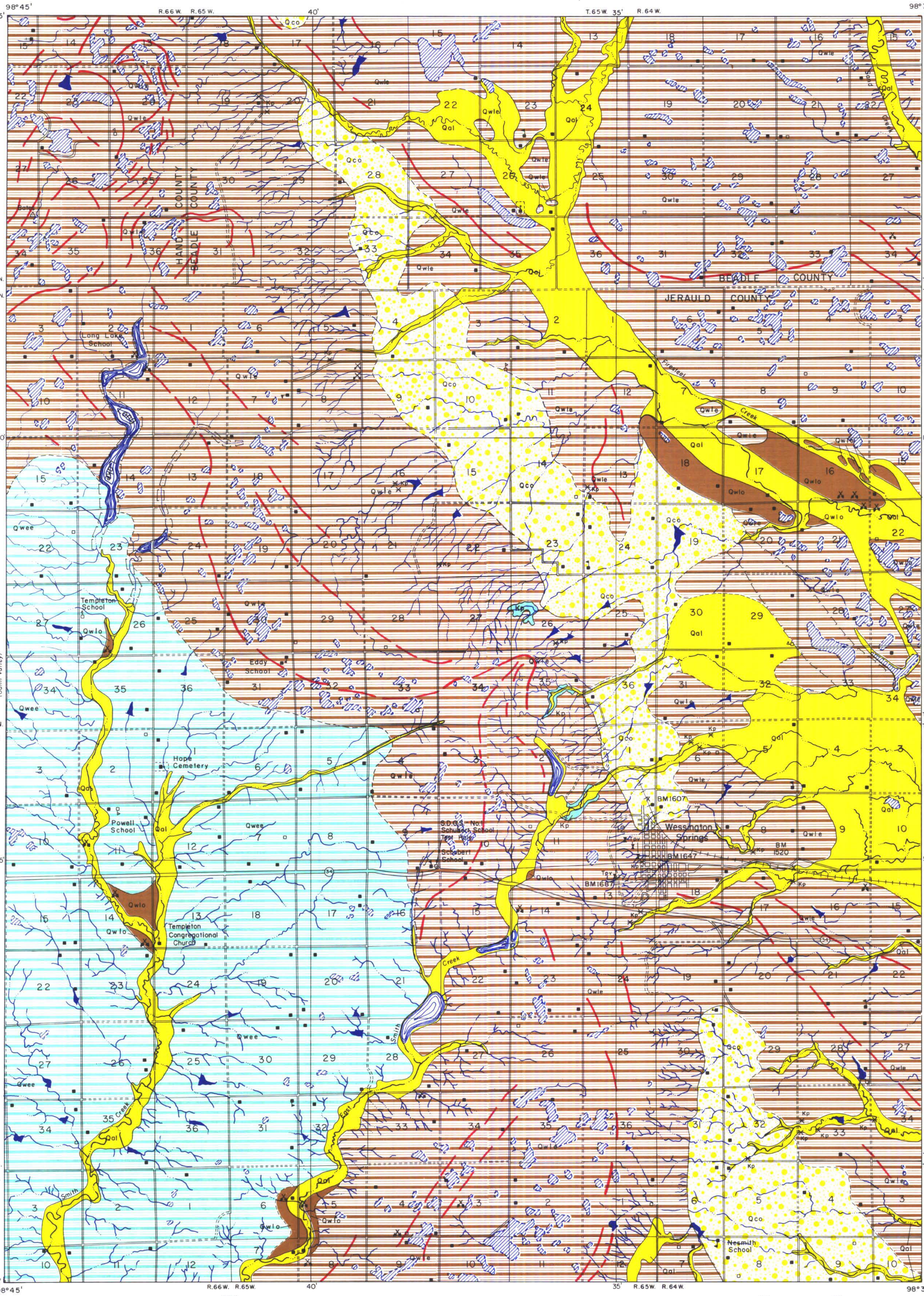
STATE OF SOUTH DAKOTA
NILS BOE, GOVERNOR

GEOLOGY of the WESSINGTON SPRINGS QUADRANGLE SOUTH DAKOTA



EXPLANATION

QUATERNARY

RECENT

Qal — Alluvium
Semistratified deposits of sand, silt, and clay, humic, brown to black, in stream flood plains, lakes and ponds; 0-6 feet thick.

Qco — Colluvium
Chiefly reworked till; consists of brown to dark-gray clay with rock fragments, partly stratified; forms plain at foot of Coteau; 0-6 feet thick.

PLEISTOCENE — Late Wisconsin

Qwlo — Outwash
Stratified deposits of poorly sorted sand and gravel; occurs as terrace levels; may also underlie Qal in Firesteel Creek valley; 0-54 feet thick.

Qwle — End Moraine
Boulder-clay till, olive-brown to olive-gray, calcareous, compact; mostly blocky; contains carbonized wood in places; characterized by rolling to rugged topography; 0-215 feet thick.

PLEISTOCENE — Early Wisc.

Qwee — End Moraine
Same as above but older (see text reverse side of this map for discussion)

UNCONFORMITY

TERTIARY — PLIOCENE

Tpv — Valentine Formation
Deposits of buff fossiliferous silt, sand, and clay; green siliceous sandstone; and green compact gravelly clay; crops out on eastern escarpment of Coteau; as much as 12 feet thick.

UNCONFORMITY

CRETACEOUS — UPPER CRETACEOUS

Kp — Pierre Shale
Gray to black, fissile to blocky mostly fossiliferous marine shale; crops out in deep ravines cut into Coteau escarpment and in small tributaries of Firesteel Creek; maximum exposed thickness about 90 feet.
X small outcrop.

Ice-Marginal Channel
Meltwater channel from which sand and gravel has been partly or wholly removed; locally occupied by alluvium

Major Morainal Crest

Gravel Pit

X BM 1900
Bench Mark
(monument showing exact altitude above sea level)

△ Bates
Triangulation Station
(monument marking exact geographic location)

House, School, Church

House, School, Church (abandoned)

⊙ Test hole

Cemetery

Intermittent stream

Intermittent lake

Lake

Geologic Contact
(dashed where approximately located)

Geology by Fred V. Steece, 1961-1962

Assisted by James A. McMeen, 1962
Richard Brown, 1961 Lynn Hedges, 1961

Vertical and horizontal control surveyed from triangulation and level lines of Federal surveys

Drafted by Elizabeth H. Garnos

True North — Magnetic North — 10°00' — Approximate Mean Declination, 1960

Scale 1:62 500
1 ½ 0 1 2 3 4 Miles

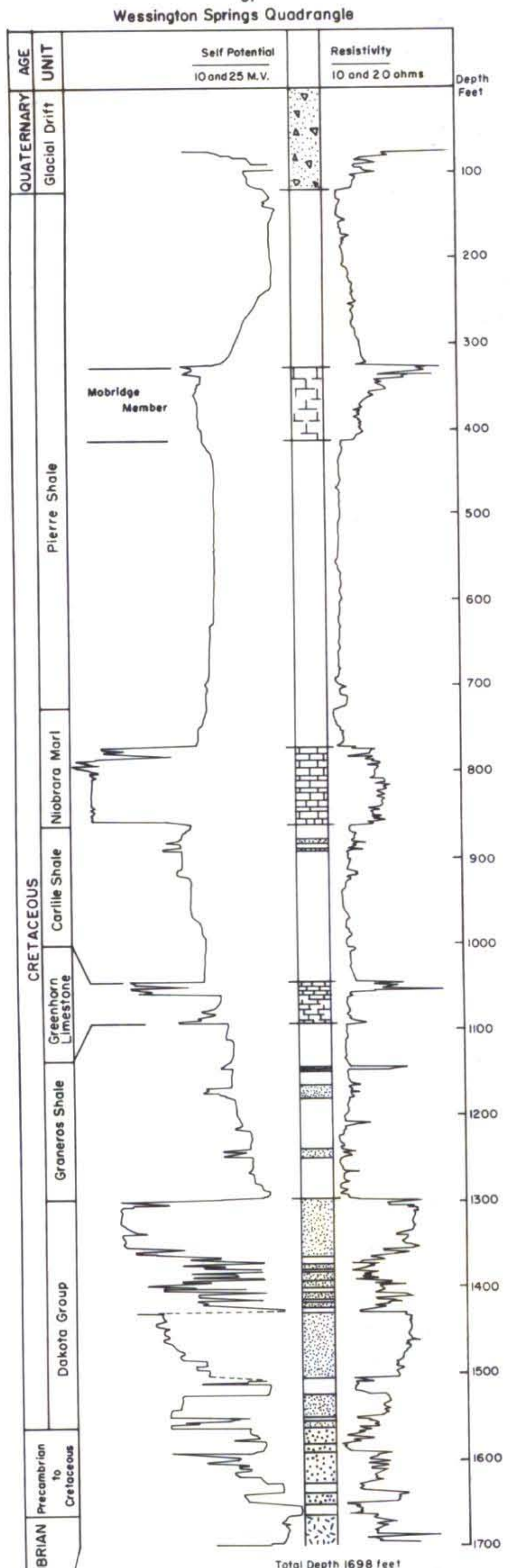
Vermillion, South Dakota
1967

104° 97° 46° 43°
Quadrangle Location

GEOLOGY OF THE WESSINGTON SPRINGS QUADRANGLE
SOUTH DAKOTA

by
Fred V. Steece

Figure 1
Geologic Column
of
Wessington Springs Quadrangle



(Lithologic and Electric log from Schubert School Stratigraphic test boring; drilled in 1960; S.W. Cor., Sec. 9, T.107N., R.65W.; Elevation=1910feet; Resistivity scale, 0-350feet=10 ohms, 350-1698ft.= 20 ohms; Self Potential, 0-350ft.=10 M.V., 350-1698 ft.=25 M.V.)

Explanation of Symbols

Glacial Drift; Shale; Marl; Limestone; Sandstone; Calcareous Shale; Siderite Pellets; Weathered Granite

INTRODUCTION

The Wessington Springs quadrangle includes about 215 square miles in Jerauld, Beadle, and Hand Counties, in east-central South Dakota.

The area is divided approximately in half by the steep east-facing escarpment of the Coteau du Missouri, locally known as the Wessington Hills, which is the eastern boundary of the Great Plains physiographic province. To the east of the escarpment, begins the James Basin division of the Central Lowlands physiographic province (Fenneman, 1946; Rothrock, 1943). The Coteau is made up of Cretaceous and Tertiary bedrock with a thin veneer of overlying glacial drift. Topographically, the Coteau escarpment is the most striking feature in the mapped area. The undrained younger drift atop the Coteau in many places forms high rugged morainic ridges, locally attaining remarkable proportions. This topography gives way to the smoother, slightly better drained topography of the older drift toward the southwest part of the quadrangle. The valleys of Smith and East Smith Creeks are major topographic features of the Coteau. Numerous deep narrow ravines cut the Coteau escarpment, providing many exposures of geologic materials as well as beautiful scenery.

At the foot of the Coteau is an apron of colluvium washed from the steep slopes of the escarpment, that in places forms a continual gentle sloping surface to the east. Locally this colluvial apron merges with alluvial fans derived from streams which contemporaneously eroded material from the Coteau escarpment. To the east of the Coteau the surface is typical of undrained glacial till, interrupted locally by alluvial valleys and several prominent morainic ridges.

West of the Coteau's summit, the drainage is toward the southwest and is controlled by the Missouri River about 40 miles west of the area. East of the summit, drainage is toward the southeast and ultimately reaches the James River, 25 miles east of the area. Maximum relief of the area is about 600 feet from 1990 feet on a peak locally known as "Turtle Mountain," 1½ miles northwest of Wessington Springs, to slightly less than 1400 feet in the valley of Firesteel Creek.

Wessington Springs, the county seat of Jerauld County (population 1488, census of 1960), is the only town in the quadrangle. The area is served by east-west State Highway 34, which passes just south of Wessington Springs. An all-weather north-south blacktop road connects Wessington Springs with the east-west Alpena road, one mile south of the Jerauld-Beadle county line. A single line of the Chicago, Milwaukee, St. Paul and Pacific Railroad entering the area from the east serves Wessington Springs where the road ends.

The climate of the area is sub-humid to semi-arid, with wide ranges and large daily fluctuations in temperature, and low precipitation. The mean annual rainfall at Wessington Springs from 1952-1963 was 20.35 inches, occurring mainly as rainfall in spring and early summer. The mean annual temperature for 1962 and 1963 was 46.9 degrees F. (U. S. Weather Bureau records).

This study, conducted in 1961 and 1962, is part of the State Geological Survey's continuing program of ground water, mineral resources, and Pleistocene investigations in South Dakota. That part of the area in Beadle County was mapped by L. S. Hedges and the writer in 1962 (Hedges, in preparation). The quadrangle has been included in regional studies by Todd (1896), Rothrock (1946), and Flint (1955).

The work was begun under the direction of Allen F. Agnew, former State Geologist, and was completed under Duncan J. McGregor, present State Geologist. The writer wishes to thank L. S. Hedges for assistance in 1961, and field consultation in 1962. The writer expresses his appreciation to the residents of the area, most of whom extended courtesy and permission to enter on their lands.

GEOLOGY

Glacial drift of the Pleistocene Epoch (the Great Ice Age) mantles the entire area except where it has locally been removed by erosion. Beneath the glacial deposits are Cretaceous marine sedimentary clay, shale and marl of the Pierre Shale formation and isolated remnants of Tertiary continental sediments. Information from wells and test holes in and near the quadrangle disclose about 1550 feet of Tertiary and Cretaceous sedimentary rocks beneath the glacial drift and overlying the Precambrian granite that makes up the basement of the area.

Surficial Deposits

The surficial deposits of the Wessington Springs quadrangle are of Pleistocene and Recent ages and include glacial drift (stratified and nonstratified), colluvium, alluvium, and small deposits of loess, and glacial lake sediments.

Pleistocene Deposits

Glacial drift comprises all the material transported and deposited directly or indirectly by glacial ice. Till (non-stratified drift), is an admixture of rock fragments in a clay-rich matrix that makes up the bulk of the glacial drift in the area. Outwash is stratified drift, chiefly sand and gravel, resulting from sorting and accumulation of glacial debris by the washing action of glacial meltwaters. Outwash deposits occur in valleys (valley trains), broad aprons (outwash plains), and interbedded with till and other glacial materials.

The glacial drift in the Wessington Springs quadrangle is of early and late Wisconsin ages (Steece, 1964a).

Early Wisconsin Deposits.--The glacial drift mapped in this quadrangle as early Wisconsin, probably is not as old as earliest Wisconsin, that is, Altonian, (Frye and Willman, 1960); Farmdale, (Leighton, 1965); Rockian, (Frye, Willman, and Black, 1965); and "Early" Wisconsin, (Goldthwait, 1958) but may be the equivalent of Tazewell (Ruhe, 1952). Though no radiocarbon dates are available for this drift, it is definitely older than the drift in this mapped area called late Wisconsin.[1]

[1] The terms Early, Middle and Late as used in this report, do not necessarily convey the same connotation as Leverett used in 1929.

Early Wisconsin glacial deposits make up the surface of about one-fourth of the quadrangle in the southwestern part of the mapped area. The surface of this drift is somewhat drained especially adjacent to Smith and East Smith Creeks. Numerous undrained depressions occur, however, on the interfluve between these drainages and in the uplands west of Smith Creek. The eastern drainage slope of Smith Creek has been smoothed not only by erosion, but also by the deposition of relatively thin discontinuous colluvium as much as 4 feet thick, and by even less continuous loess, as much as 6 feet thick.

The early Wisconsin drift is mainly gray to yellowish-brown calcareous clay-rich till with only small occurrences of interbedded stratified material.

This early Wisconsin drift is older than the drift mapped as late Wisconsin as shown by numerous facts, among which are: (1) the surface of the early Wisconsin drift is smoother and better drained than the late Wisconsin surface; (2) stratigraphic information shows more than one till present in the area; (3) East Smith Creek is an ice-marginal channel of the late Wisconsin ice. This stream has a more youthful profile and is about 50 feet higher than Smith Creek, which antedates the late Wisconsin drift; (4) the interfluve between these two creeks is closest to East Smith Creek, indicating that the eastern slope is younger than the western slope; (5) constriction of pre-existing valleys especially at the head of Smith Creek were produced by late Wisconsin ice; and (6) topographic discontinuities and major late Wisconsin moraines are aligned parallel to the late Wisconsin drift border. (For a more detailed discussion see Steece, 1964a.)

Outwash deposits, presumably of early Wisconsin age, crop out along the Coteau escarpment in several places in and adjacent to the quadrangle. In a gravel pit in NE¼NE¼SE¼ sec. 8, T. 108 N., R. 65 W., at least 15 feet of gravel with a thick silt cap is exposed beneath late Wisconsin till. A large cut bank west of the Wessington Springs city park in SE¼SE¼NE¼ sec. 13, T. 107 N., R. 65 W., reveals a similar situation. At this last locality at least 13 feet of sand and gravel is overlain by late Wisconsin till. The areal extent of these buried outwash bodies is unknown.

These deposits of early Wisconsin buried outwash are probably isolated bodies with small areal extent (Steece, 1966). Five test holes drilled in the area of the early Wisconsin drift, reveal buried oxidized zones and possibly paleosols developed on a till that is even older than the early Wisconsin deposits. Material described as reddish-brown sandy clay (till ?) was penetrated in two test holes in NE cor. sec. 34, T. 107 N., R. 65 W. and SE cor. sec. 6, T. 106 N., R. 65 W. at depths of 60 feet and 15 feet respectively. In test holes in SW¼NE¼ sec. 13, T. 107 N., R. 65 W.; NE cor. sec. 20, T. 107 N., R. 65 W.; and SE cor. sec. 33, T. 108 N., R. 63 W. (just outside the west border of the quadrangle) brown zones in till were penetrated at depths of 54, 35, and 32 feet respectively. The age of this older till is not known, but since it underlies early Wisconsin deposits, it must be pre-early Wisconsin. Therefore this older till could date from one of the pre-Wisconsin ice advances. Since the youngest of the pre-Wisconsin advances is the Illinoian, this would be a reasonable age assignment for the till. An Illinoian age assignment is supported by the brown and reddish-brown weathering and/or paleosol horizons that may correlate with a pre-Wisconsin soil such as the Sangamon soil. Moderately well developed paleosols are developed on early Wisconsin deposits, (for example, see Forsyth and LaRocque, 1956), so the possibility exists that this lower till may also be early Wisconsin. Warren (1952) suggested that part of the Missouri River may be Illinoian in age. This fact implies that Illinoian ice once occupied the mapped area, and therefore any assignment of an older till to this glacial stage is a reasonable one. Positive identification of this drift must await further, more detailed evidence.

Late Wisconsin Deposits.--Nearly three-fourths of the quadrangle is occupied by drift of late Wisconsin age. The identification of this drift as late Wisconsin is based on evidence summarized by Steece and Howells (1965), and on a radiocarbon date in northeastern Jerauld County (sample W-987, 12,530±350, Ives and others, 1964). Several other radiocarbon dates are available in and around the mapped area. However, these dates are anomalously old (all dates are greater than 42,000 yr. B.P.) for late Wisconsin, and their true interpretation awaits further investigation (samples W-1623, NW¼ sec. 16, T. 107 N., R. 64 W.; W-1625, SE¼ sec. 8, T. 108 N., R. 65 W.; and W-1630, SE¼ sec. 12, T. 109 N., R. 66 W.).

The surface of the late Wisconsin drift is undrained, except on the Coteau escarpment and on some of the steep morainic ridges. The surface is characterized by numerous closed depressions and a number of prominent linear morainic ridges whose crests form the summit of the Coteau. These Coteau moraines parallel the late Wisconsin drift margin, except in the northwest corner of the area where their alignment becomes exceedingly complex (see map). It is probable that much of this drift in the northwestern part of the quadrangle is stagnation moraine, resulting from the dumping of debris from inactive or "dead" glacial ice.

Several other linear morainic ridges occur in the lowlands east of the Coteau; these represent successive halts of the late Wisconsin ice in its retreat from the area.

Like the early Wisconsin deposits, the late Wisconsin drift is mainly olive-gray to olive-brown clay-rich till. The till is commonly calcareous throughout, and oxidized to a depth of 20-30 feet. The till is compact to friable; it is usually pebbly and locally is sandy and sometimes contains cobbles and boulders. In some places the till contains a high proportion of shale where it is in close contact with the underlying Pierre Shale. The till contains some Tertiary sediments where it is in contact with Tertiary deposits.

A thin dark silt-loam to clay-loam soil is generally formed on the till, except on the steeper slopes which are actively eroding where soils are lacking.

Outwash deposits of late Wisconsin age occur at the surface in the quadrangle in the valleys of Smith, East Smith and Firesteel Creeks. These deposits owe their origin to meltwaters issuing from the late Wisconsin ice front during the shrinkage and northern retreat of the James ice lobe. Each still-stand is marked in the Wessington Springs quadrangle by moraines whose crests are shown as heavy red lines on the map.

All the outwash deposits are small in areal extent, are confined to valleys, and are thin, averaging about 20 feet in thickness. The gravel is usable for construction material.

Calcareous lacustrine marls and lake silts and clays, presumably of late Wisconsin age, commonly occur in the beds of many undrained depressions in the mapped area. Most of these depressions contain water during the spring and early summer months. Consequently, dark, humic accretionary clays have accumulated in the depressions and mask the lacustrine deposits. In addition, lacustrine deposits as much as 9 feet thick underlie alluvium and overlie glacial till in the late Wisconsin spillway channel near the brink of the Coteau, at the head of East Smith Creek, in sec. 11, T. 107 N., R. 65 W. The marls and calcareous clays commonly contain a rich assemblage of fossils including mollusks, charophytes, and ostracodes. Snail shells from a similar assemblage in marl overlying late Wisconsin outwash in Sanborn County about 15 miles east of Wessington Springs were dated at 10,060±300 (sample W-1033; Ives and others, 1964). Presumably the lacustrine deposits in this area are of approximately the same age because of similar stratigraphic position and comparatively the same fauna.

Loess, locally as much as 6 feet thick, sporadically mantles the early Wisconsin surface in the area roughly bounded by State Highway 34 on the south, the upper reaches of Smith Creek on the west, and the late Wisconsin drift border to the north and east. The loess is judged to be late Wisconsin in age because it is found east of Smith Creek valley from which the loess may have been derived when the valley contained late Wisconsin meltwaters.

Recent Colluvium

Colluvial deposits as much as 6 feet thick, derived from glacial till, mantle the eastern watershed of Smith Creek (deposits not shown on map). In addition, well developed colluvial deposits form a blanket on bedrock and glacial drift at the foot of the Coteau escarpment. The colluvium extends nearly the entire length of the escarpment in the mapped area except near Wessington Springs, and the extreme northern part of the quadrangle, where end moraine deposits are at the surface. The mantle averages about 1½ miles wide. In one area, about 3 miles north-northeast of Wessington Springs (secs. 29, 30, 31, 32, T. 102 N., R. 64 W.), the colluvium merges with a large alluvial fan that is derived from a small drainage off the Coteau escarpment.

The colluvium is composed of fine blocks of dark-gray, iron-stained clay derived mainly from glacial till and Pierre Shale which crop out on the face of the Coteau above the colluvial apron. Rarely does the colluvium contain gravel or rock fragments. In places, however, it is difficult to distinguish from glacial till, but can usually be identified by its darker color, fine texture and blocky structure.

The surface of the colluvial apron is relatively level and slopes gently eastward from the foot of the Coteau. The surface is broken by alluvial channels heading in the Coteau that are tributary to Firesteel Creek valley to the east.

Recent Alluvium

Alluvium underlies the flat bottoms of the main stream valleys in the quadrangle. Relatively narrow strips of alluvium follow Smith and East Smith Creeks, Firesteel Creek and the small segment of Sand Creek in the northeastern corner of the area. In addition, alluvial fans or coalescent alluvial fans occur east and northeast of Wessington Springs at the base of the Coteau, brought by runoff through deep narrow ravines cutting the Coteau escarpment. These deposits range in thickness from 2 to 10 feet and probably average about 3 or 4 feet. The alluvium is composed of dark humic clay that contains some silt, sand, and rarely gravel; it is commonly stratified and compact. The surface of the alluvial deposits is very level but occasionally exhibits undulatory topography, especially in the broader alluvial fans east of Wessington Springs.

Soils

Soils developed on the surficial deposits vary in their agricultural quality. In general, soils developed on deposits mapped as end moraine are productive except in stony or undrained areas. Soils developed on areas mapped as outwash and alluvium are less productive because of excessive and poor drainage, respectively. Colluvial soils are good to marginal for crop land. These last soils are poorly drained, contain excess soluble salts, and tend to develop clay pan structure. Heavy clay soils are developed in the hundreds of swales dotting the surface of much of the mapped area. These soils cannot be tilled because of standing water, or excessive soluble salts.

Bedrock Deposits

Sedimentary rocks of Tertiary and Cretaceous (and Paleozoic ?) ages, and Precambrian granite underlie the glacial drift. The sedimentary section has a maximum known thickness of about 1550 feet. A deep weathered zone is present on the Precambrian basement in the central part of the quadrangle. A test hole penetrating the entire sedimentary section was drilled in the summer of 1960 near Schubert School, 3 miles west of Wessington Springs in SE cor. sec. 9, T. 107 N., R. 65 W. (see fig. 1). The following stratigraphic information is based on the materials encountered in this test hole and other test holes and wells in and near the mapped area, and on supplementary information from bedrock exposures especially on the Coteau escarpment.

Tertiary Rocks

Unconsolidated sediments and quartzose sandstone of Tertiary age (Todd, 1894, p. 110) crop out on the Coteau escarpment at two localities immediately west of Wessington Springs.

Green conglomeratic sandstone that is siliceously cemented is exposed on the Wessington Hills west and slightly north of the Wessington Springs Junior College in NW¼SE¼ sec. 12, T. 107 N., R. 65 W. The sandstone is underlain by at least 4 feet of green clay, sand, and sandy silt that are locally calcareous. The green sediments may correlate with the Bijou Sandstone in central and south-central South Dakota (Stevenson, 1958). An artificial cut in SE cor. SW¼ sec. 12, T. 107 N., R. 65 W., exposes as much as 15 feet of tan to buff massive to bedded silt that contains numerous vertebrate fossils. The fauna was described by Green (1964) and on the basis of these fossils, Green suggests that this silt section be correlated with the Pliocene Valentine Formation of the south-central part of the State. The green sandstone exposure occurs at a slightly higher altitude than the tan silt exposure, and therefore may represent a resistant butte caprock that protected the Wessington Hills from severe erosion.

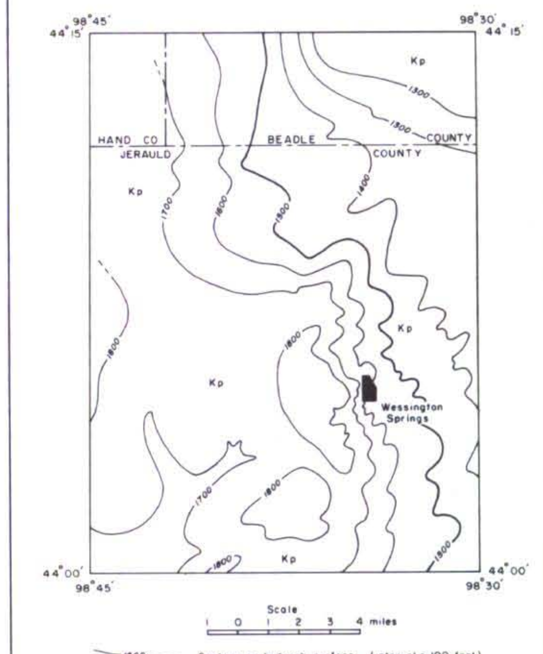
In the summer of 1965, during a ground-water investigation for the city of Wessington Springs, an auger test hole was drilled about 200 yards southwest of the fossiliferous silt. The hole penetrated 14 feet of oxidized glacial till, 35 feet of yellowish-gray Tertiary clay, and about 11 feet of dark-gray pebbly clay resting on Pierre Shale. If this dark-gray pebbly clay is glacial till, then the Tertiary beds are either reworked, misidentified, or stratigraphically misplaced. In addition to these two localities green sand, silt and clay were penetrated in hand auger borings at two locations on the Coteau escarpment, namely in NW¼SE¼ and SW¼NE¼ sec. 12, T. 107 N., R. 65 W. Although a search was made, no Tertiary sediments were found elsewhere in the quadrangle, except for silicified material in the glacial drift presumably of Tertiary age. An exposure of glacial silt surrounded with till in NE¼SE¼ sec. 35, T. 108 N., R. 67 W., four miles west of the quadrangle, was erroneously identified as a Tertiary age deposit by Green (1964).

Cretaceous Rocks

The Pierre Shale lies beneath the glacial drift except for the small areas where the Tertiary rocks are present. The configuration of the bedrock surface is shown on figure 2. The Pierre crops out at numerous localities on the Coteau escarpment, particularly in the walls of the many deep ravines which cut into the face of the Coteau. The largest single exposure of the Pierre Shale is immediately south of Wessington Springs in the wall of a ravine in NW¼SW¼ sec. 13, T. 107 N., R. 65 W. This exposure reveals 8 feet of brownish-gray weathered shale above 45 feet of light to dark olive-gray shale containing near the base a 4-inch bentonite bed that encloses numerous barite concretions. The slope above this cut is badly slumped, but there are indications that an additional 50 feet of gray shale lies above the cut bank, thus bringing the total shale section at this locality to slightly over 100 feet.

The only identifiable unit of the Pierre Shale exposed in the area probably correlates with the Mobridge Member that is extensively exposed in the Missouri River trench, 45 miles west of Wessington Springs. This unit is made up of gray calcareous marl, about 85 feet thick in the Schubert School test hole (fig. 1) on top of the Coteau The marl is exposed along the Coteau escarpment about 4 miles northwest of Wessington Springs in NW¼SW¼ sec. 26, T. 108 N., R. 65 W. This exposure reveals 20 feet of gray to brown massive to fissile calcareous marl. About one-fourth mile to the southeast, 50 feet of dark-gray massive to fissile noncalcareous shale occurs stratigraphically above the marl unit, and below the glacial drift. Numerous other exposures high on the Coteau escarpment throughout the northern part of the area reveal at least some part of this marl unit, as well as dark shales stratigraphically above and below. The Pierre Shale is 652 feet thick in the Schubert School test hole.

The Schubert School test boring penetrated the following Cretaceous strata in descending order beneath the Pierre Shale: Niobrara Marl, Carlile Shale, Greenhorn Limestone, Graneros Shale, and sand, shale, and sandstone of the Dakota Group.



Scale
1 0 1 2 3 4 miles

1800 Contour on bedrock surface (interval = 100 feet)

(Beadle County information from Hedges, in preparation; Bedrock beneath glacial drift is Pierre Shale, Small exposures of Tertiary deposits near Wessington Springs not shown.)

Figure 2. Bedrock Map of the Wessington Springs Quadrangle.

The Niobrara Marl is light to dark olive-gray speckled chalky marl and calcareous shale 90 feet thick. Shales of various shades of gray make up the Carlile Shale which is 182 feet thick. The Codell Sandstone Member of the Carlile Shale, if present, is only 15 feet thick in this test boring and occurs from 875 to 890 feet. The Codell is well developed only a short distance east and north in Sanborn, Beadle, and northeastern Jerauld Counties.

The Greenhorn Limestone is composed of 50 feet of medium to dark-gray compact speckled marl and calcareous shale, interbedded with thin dense fragmental limestone and calcitic sandstone layers. The Graneros Shale is mainly dark fissile shale containing thin brownish-gray dense fragmental limestone strata that closely resemble those in the Greenhorn Limestone, and sandstone layers. The Graneros Shale is 203 feet thick.

The Dakota Group consists of three distinct units in this area (see log), an upper sand unit, a middle sandy shale unit and a lower sand unit. Unconsolidated quartzose sand and thick dense fine sandstone layers compose the sand units of the Dakota Group in this area. The sand is subrounded fine to coarse and usually well-sorted; abundant pyrite and coal fragments occur with the sand. The middle sandy shale unit is mainly gray shale with interbedded sand layers. The Dakota Group sequence is 270 feet thick.

Precambrian to Cretaceous Weathered Zone

Beneath the sands of the Dakota Group in the Schubert School boring is a sequence of deposits 100 feet thick, composed of clays, shales and sands rich in relatively large red siderite pellets. A sample of moderate-red sericitic clay enclosing siderite pellets was recovered from the Schubert School boring, while changing bits. No other evidence of this material exists because the clay from the bit sample breaks down very readily when soaked in water. Therefore, when penetrated by the drill, the entire thickness of this clay very likely entered the circulation fluid undetected. The electric log shows, however, that there may be as much as 65 feet of clay interbedded with sands between depths of 1565 and 1665 feet.

The Precambrian to Cretaceous weathered zone is characterized by the abundant relatively large red siderite pellets (see fig. 1) as compared to the sparse occurrence of smaller brownish pellets in the Dakota Group.

Precambrian Rocks

At a depth of 1610 feet in the Schubert School boring, a small amount of pale-green sericite, white kaolinite (and some yellow vermiculite ?) begin to appear. These minerals increase in quantity downward and give way gradually to green chlorite, and corroded quartz and orthoclase at about 1640 to 1650 feet. The quartz, orthoclase, and chlorite persist in the section to near the bottom of the hole (1698 feet) where a little biotite and a few angular chips of pink granite begin to appear. This sequence might more properly be included in the Precambrian to Cretaceous weathered zone because it is doubtful if fresh unweathered Precambrian granite was penetrated in the boring. Still it is probably safe to assume that the Precambrian basement in the Wessington Springs quadrangle is pink biotite granite, like that composing much of the basement in South Dakota (Steece, 1961, 1962, 1964b).

Structure

The Wessington Springs quadrangle lies on the north flank of a buried highland known as the Sioux Ridge (Steece, 1962). The Precambrian surface from the mapped area northward dips steeply into a sharp narrow basin in central Beadle County (Hedges, in preparation), and thence northwestward into the broad deep Williston Basin of northwestern South Dakota and western North Dakota. From the mapped area south and southeastward, the basement rises onto the summit of the Sioux Ridge where the irregular surface of the Precambrian Sioux Quartzite is the basement rock. As the sedimentary sequence approaches the Sioux Ridge on all sides, the strata thin rapidly and pinch out on its flanks. Only the uppermost Cretaceous beds overlie the crest of the Sioux Ridge in the region to the east and southeast of Jerauld County. Thus, in this quadrangle, the Cretaceous rocks have a slight regional dip toward the northwest and a slight regional thinning toward the south and southeast.

MINERAL RESOURCES

The most important mineral resources of the area are ground water and sand and gravel. Clay is also available from the Pierre Shale.

Ground Water

Nearly all earth materials that lie below the water table contain varying amounts of interstitial water. The amount of water that is contained in a rock depends on the amount of pore space between the particles making up the rock. The size, shape, and arrangement of these particles control the permeability of the rock. Permeability in turn is a measure of the ability of a rock to allow the passage of water through interconnected pore spaces. Many rocks, such as clay and shale, are very porous and store large amounts of interstitial water. The pore spaces in these rocks are, however, extremely small or not interconnected and thus will not readily allow the passage of water. On the other hand, materials such as sand and gravel if well sorted as to size of the constituent particles, are highly permeable, as well as very porous, and easily allow water to flow through them.

The water table is present nearly everywhere beneath the earth's surface and represents the upper surface of the zone of saturation. Ground water is derived from precipitation that falls on the ground surface. This water is absorbed by earth materials, runs off as surface water, or is evaporated and transpired by plants. Absorbed water percolates downward to the water table and, in permeable material, moves down gradient and is then said to be in transient storage.

Permeable outwash sand and gravel deposits in the mapped area lie both at the surface and buried beneath younger glacial materials. The map shows the distribution of the outwash deposits that lie at the surface. In general these deposits are small and probably cannot be considered as major sources of shallow ground water, particularly where high capacity wells are desired. Buried outwash deposits lie beneath as much as 130 feet of glacial till in both the northeast and the southeast parts of the area (Steece, 1966). These outwash deposits locally are as much as 65 feet thick and lie well below the water table. In the parts of the buried outwash (Steece, 1966), slight artesian pressures have been reported and water in wells in this area may rise to within 60-80 feet of the ground surface; at the lowest elevations, such as in stream valleys, wells developed in this aquifer reportedly flow. Less information is available for the buried outwash deposits in the northeast part of the quadrangle, but they undoubtedly serve as good ground-water reservoirs under little or no artesian pressure. The buried gravels in this area are as much as 70 feet thick and lie below 100-130 feet of younger glacial drift. Basic data is insufficient to outline these buried outwash deposits, consequently no estimate of the ground water in storage can be made with any real meaning.

Water obtained from the buried glacial aquifers is generally of a sodium-calcium sulfate type, with high total solids content. Glacial drift water is hard, has a moderately high magnesium content, and has a wide range in nitrate, iron and manganese (see table 1). Excessive concentrations of sulfate, nitrate, and fluoride may have adverse physiological effects if water containing too much of these materials is consumed for prolonged periods. High concentrations of sulfate may produce a cathartic or laxative effect on humans. Water containing nitrate in amounts exceeding 10 parts per million (ppm) may contribute to the disease known as cyanosis or "blue baby" in infants whose feeding formulas contain this water. Fluoride in excess of the recommended limit may cause dental fluorosis, a dark mottling of tooth enamel, if water with this constituent in excess is used for drinking over prolonged periods of time. In addition, high sodium content may be undesirable for persons on salt-free diets.

The colluvial and alluvial deposits, while probably holding large amounts of absorbed water, contain too much clay and silt to be considered as aquifers, although sandy or gravelly zones may occur that would supply water to low-yield wells. Likewise, fine sand layers enclosed in glacial till are no doubt scattered through the area, but these usually are not large enough or coarse-grained enough to supply much water, nor is it possible to predict their locations.

Besides permeable materials in the glacial drift, ground water is stored in several of the bedrock formations in the area. Fractured, jointed, or cavernous zones in the Niobrara Marl render the formation sufficiently permeable to supply moderate amounts of water to wells. Water from the Niobrara is generally soft and of the sodium-bicarbonate type (bicarbonate not listed in table 1). The water is high in chloride and contains high total solids. The Niobrara Marl ranges from 120 feet below land surface east of Wessington Hills, to about 770 feet at higher points on top of the Hills.

Aquifers in the Greenhorn Limestone in adjacent areas (Steece and Howells, 1965) produce small amounts of water. The water is usually moderately mineralized and is of the sodium-sulfate type. The Greenhorn Limestone lies from 420-450 feet below land surface east of the Wessington Hills and about 1050 feet on top of the Hills.

The well-known Dakota Group sandstones produce mineralized water throughout central South Dakota. East of the Coteau escarpment in the Wessington Springs quadrangle, wells completed in the Dakota may flow at lower elevations than those west of the escarpment. The water level in wells west of the escarpment rises only to within 150-200 feet of the land surface. Dakota water in this area is very hard and is of the calcium-sodium sulfate type and is generally high in total solids. Water from the bedrock aquifers is not suited for irrigation use because of general poor quality and because they are not permeable enough to support high-capacity wells.

Sand and Gravel

Sand and gravel deposits occur as remnants of a former outwash valley train deposit along Firesteel Creek in the northeast part of the mapped area (mapped as Qwco, see map). Gravel is now or has been quarried from this deposit in secs. 16, 21, and 22, T. 108 N., R. 64 W. In this locality the gravel is at least 15-20 feet thick and can easily be quarried to a depth of 8-10 feet without encountering the water table. An estimated 20,000 acre-feet or approximately 32 million cubic yards of gravel is available from the outwash in Firesteel Creek valley.

In addition to the Firesteel Creek outwash deposits, sand and gravel occur along Smith Creek south of Highway 34, mainly in sec. 14, T. 107 N., R. 66 W. Other sand and gravel deposits are along East Smith Creek mainly in secs. 5 and 6, T. 106 N., R. 65 W.; in sec. 26, T. 108 N., R. 66 W.; in the meltwater channel associated with Long Lake in secs. 2 and 11, T. 108 N., R. 66 W.; along the Coteau escarpment in sec. 8, T. 108 N., R. 65 W.; and several very small deposits in the end moraine southwest of Wessington Springs, and in the extreme northeast part of the area.

The glacial gravels in the area are composed generally of igneous, metamorphic, and carbonate rocks with clay-ironstone, shale and chalk making up a minor part. In addition, the gravels at several localities contain a greater percentage of chert and other rocks of non-glacial origin than is usual in glacial gravels. Chert and soft particles such as shale, chalk, and clay-ironstone are deleterious constituents for concrete aggregate.

Clay

The Pierre Shale is composed almost wholly of clay. While many of the properties of the shale are unknown, it probably could be used satisfactorily in the manufacture of brick. Large supplies of Pierre Shale could be obtained along the Coteau escarpment where the glacial drift is thin or absent.

Table 1--Analyses of water from wells in the Wessington Springs quadrangle, and vicinity.

Well	Location	Depth (feet)	Source	Calcium	Sodium	Magnesium	Chloride	Sulfate	Iron	Manganese	Nitrate	Fluoride	pH	Hardness Ca CO_3	Total Solids	Analyst
U. S. Dept. of Health, recommended standards for drinking water				--	--	125	250	500[1]	.3	.05	10	.9 1.7[2]	--	--	1000[1]	
Edwin Reiner	SE¼SE¼ sec. 15, T. 107 N., R. 64 W.	32	Q	40	220	26	20	561	.08	0	0	.2	--	205	1064	CL
Gene Peterson	SE¼SE¼ sec. 7, T. 107 N., R. 65 W.	60-70	Q	179	820	158	351	1704	.02	0	55	.4	--	1096	4216	CL
North Spring City Well	SE¼NE¼ sec. 13, T. 107 N., R. 65 W.	12	Q	188	69[3]	41	11	344	.1	1.9	0	.2	7.1	643	958	DH
Gravel-pit City Well	SE¼NE¼ sec. 13, T. 107 N., R. 65 W.	20	Q	187	44[3]	42	10	319	.7	1.6	0	.2	7.0	645	945	DH
South Spring City Well	NE¼SE¼ sec. 13, T. 107 N., R. 65 W.	12	Q	202	65[3]	52	14	420	0	1.8	0	.2	7.2	720	1083	DH
George Hodgson	NE¼SE¼ sec. 22, T. 107 N., R. 66 W.	33	Q	1350	--	1080	113	2335	--	--	--	--	8.4	7700	7800	GS
Arent Weaver	NE¼NW¼ sec. 23, T. 107 N., R. 66 W.	125	Q	158	600	39	250	1150	2.17	--	4	.7	--	556	2340[4]	SB
(Abandoned Farm)	SE¼SW¼ sec. 24, T. 107 N., R. 66 W.	--	--	57	35	26	0	159	.08	.3	0	.2	--	251	498	CL
Douglas Flittie	SE¼SE¼ sec. 10, T. 108 N., R. 65 W.	18	Q	360	390	131	158	1894	.08	0	5.1	1.0	--	1438	3458	CL
Mrs. Cleo Pagel	NE¼NE¼ sec. 19, T. 107 N., R. 65 W.	208	Kp?	140	660	20	500	800	.52	--	0	.5	--	430	2535[4]	SB
E. Nelson	(Sanborn Co.) SE¼SE¼ sec. 10, T. 108 N., R. 62 W.	220	Kn	21	729	6.7	826	42	.10	.05	4.7	.9	7.7	80	1930	[5]
D. Fredericks	(Sanborn Co.) SE¼SW¼ sec. 28, T. 107 N., R. 61 W.	400	Kg	9.3	699	1.2	104	817	.94	0	3	3.4	7.8	28	2060	[5]
James Hinricks	NE¼NE¼ sec. 21, T. 106 N., R. 64 W.	890	Kd	332	140	75	70	1250	1.96	--	0	2.7	--	1140	1722[4]	SB
Maynard Shyrock	SW¼SW¼ sec. 4, T. 107 N., R. 65 W.	841	Kd	257	--	68	65	1217	.7	0	--	4.5	--	894	2076	CL
Dale Easton	NW¼NE¼ sec. 22, T. 107 N., R. 64 W.	900	Kd	288	180	63	60	1200	1.67	--	0	2.6	--	980	1690[4]	SB

1/ Modified for South Dakota by State Dept. Health, Pierre (written communications, Feb. 5, 1962)

2/ Optimum

3/ Reported as Sodium and Potassium

4/ Calculated

5/ See Steece and Howells, 1965

Source: Q, Quaternary; Kp, Pierre Shale; Kn, Niobrara Marl; Kg, Greenhorn Limestone; Kd, Dakota Group
Analyst: CL, State Chemical Laboratory; DH, S. Dak. Dept. Health; SB, Station Biochemistry; GS, S. Dak. Geological Survey

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