EVALUATION OF GROUND-WATER RESOURCES EASTERN SOUTH DAKOTA AND UPPER BIG SIOUX RIVER, SOUTH DAKOTA AND IOWA

TASK 1: BEDROCK TOPGRAPHY AND DISTRIBUTION
TASK 2: EXTENT OF AQUIFERS
TASK 3: GROUND-WATER STORAGE
TASK 4: COMPUTERIZED DATA BASE

FINAL REPORT

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INTRODUCTION

This report is part of a series of studies being conducted by the U.S. Army Corps of Engineers to evaluate water resources in South Dakota and the Upper Big Sioux River in South Dakota and Iowa. The output contained in this report is restricted to that part of South Dakota east of the Missouri River and that part of the Big Sioux Basin located within South Dakota. The following listed Tasks are the output for this study.

TASK I - Prepare a map showing bedrock topography and distribution of bedrock beneath the glacial drift.

TASK II - Prepare a series of maps showing extent of all known bedrock, glacial, and alluvial aquifers.

Sub-Task IIA - Develop water level maps for aquifers where data are available.

TASK III - Estimate the total amount of water in storage by aquifer.

TASK IV - Develop a computer data base for ground-water analysis. The following items are to be included in the data base.

A. Well logs and test holes.

B. Geological sample logs.

C. Observation well data.

The output in this phase of the study is intended to provide a detailed ground-water resource inventory and to provide frame-work maps to serve as a base for more detailed technical studies. It will also serve as a tool for development and management of the ground-water resources based on data available at the present time.

DATA AVAILABILITY

The availability of data may vary considerably from county to county and from area to area within each county. In general, those counties which have a county water resource study completed have the most data available and therefore have the most reliable results in terms of output for this study. Figure 1 shows the counties of eastern South Dakota and a general classification for data availability.

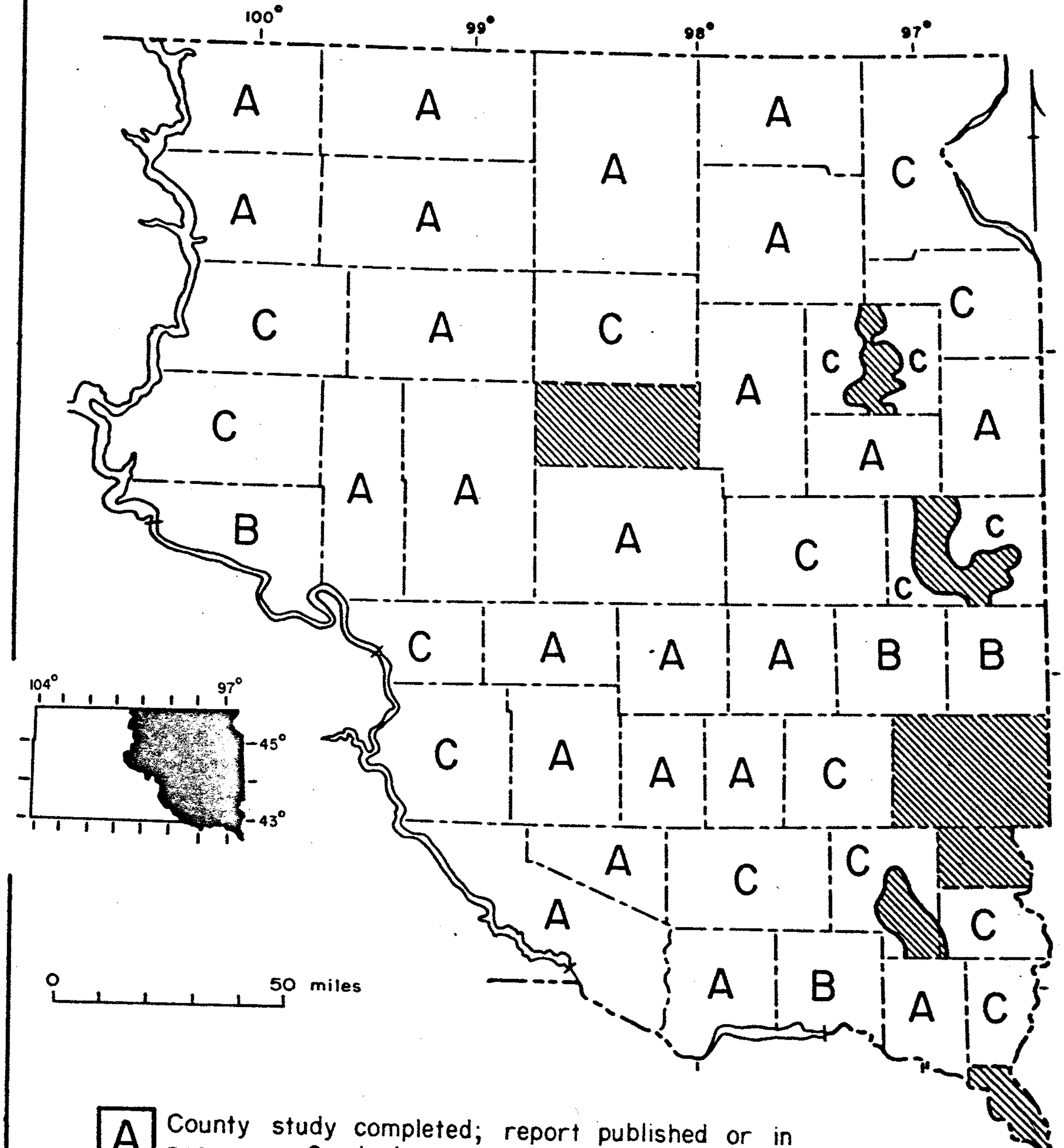
TASK I: BEDROCK MAPS

Plates 1 and 2 show the bedrock topography and distribution of bedrock units underlying the surficial deposits. Surficial deposits are defined as all unconsolidated glacial and non-glacial deposits of Pleistocene and Recent Age overlying bedrock.

The bedrock map is an important tool for ground-water resource studies because:

1. Used in conjunction with surface topographic maps it provides thickness of surficial deposits and depth to bedrock.

2. It shows the location of bedrock valleys; surficial



A County study completed; report published or in progress. Good data availability.

B County study in progress. Good data availability.

C No county study. Very limited data.

Areas which have no county study but data availability is good.

Figure 1. Map of eastern South Dakota showing relative data availability for surficial deposits.

deposits in these buried valleys generally are the major sources of ground water.

3. It can be used to identify areas where bedrock aquifers and aquifers in surficial deposits are in contact. These are potential areas for mixing of water from the two systems. This is important for recharge-discharge relationships and for water quality considerations.

TASK II: AQUIFER MAPS

Aquifers in Surficial Deposits

Surficial deposits are defined here as all unconsolidated glacial and non-glacial deposits of Pleistocene and Recent Age. This study has identified 98 aquifers and/or aquifer management units in the surficial deposits. In addition, several smaller areas have been identified which may be water bearing but there is too little data available to determine their aquifer potential. These are referred to as Miscellaneous Management Units or are unnamed on plates 3 through 7.

Plate 4 is a map showing the known distribution of all major aquifers in the surficial deposits. The major aquifers retain the common names already in use in the literature where possible, although the aquifer may be either more extensive or restricted than originally defined. An aquifer may be subdivided into management units. An example of an aquifer and management unit is Tulare-Hitchcock. Tulare is the major aquifer and Hitchcock is the management unit designation. This naming convention is consistently used throughout the report. Table 1 is a list of all identified aquifers and management units with the symbol designations that are used on figures, plates, and tables in this report.

The aquifer and management unit boundaries are chosen to coincide with hydrogeologic boundaries that are identifiable and which can be documented. Actual boundaries between units may be based on one or more of the following criteria:

1. Thinning and/or constriction of the aquifer or management unit.

2. Facies change from high to low permeability of aquifer material.

3. Change from water-table to artesian conditions and vice versa.

4. Ground-water divide.

5. Ground-water discharge point such as stream or lake.

6. Presence of streamflow gaging station.

This system of aquifer and management unit designation was designed to establish a bookkeeping framework of hydrologic data that is compatible with the basic data management system being developed as Task IV of this project. It is anticipated that all hydrologic data such as observation well data, water levels, aquifer source, water quality data, water-use data, and the Water

TABLE 1

List of Abbreviations used for Aquifers and Aquifer Management Units

A	Altamont
AV	Antelope Valley
BC	Bad Cheyenne
BS:A	Big Sioux : Aurora
BS:B	Big Sioux : Brookings
BS:MSC	Big Sioux : Middle Skunk Creek
BS:M	Big Sioux : Moody
BS:N	Big Sioux : North
BS:NDC	Big Sioux : North Deer Creek
BS:NSC	Big Sioux : Northern Skunk Creek
BS:SF	Big Sioux : Sioux Falls
BS:SMC	Big Sioux : Six Mile Creek
BS:S	Big Sioux : South
BS:SSC	Big Sioux : Southern Skunk Creek
BS:UC	Big Sioux : Unnamed Creek
B:E	Bowdle : Edmunds
B:HN	Bowdle : Hoven North
B:HS	Bowdle : Hoven South
B:L	Bowdle : Lebanon
BRC	Brule Creek
CHP	Chapelle Creek
CH:E	Choteau : East
CH:M	Choteau : Middle
CH:T	Choteau : Tyndall
CH:W	Choteau : West
CO	Corsica
COL	Coteau Lakes
COW	Cow Creek
CC	Crow Creek
CL	Crow Lake
DJ	Deep James
D	Delmont
EC	Elm Creek
E:I	Elm : Ipswich
E:NB	Elm : Northern Brown
E:SB	Elm : Southern Brown
ET	Ethan
FMT	Fairmount
F:A	Floyd : Alexandria
F:EJ	Floyd : East James
F:PC	Floyd : Pearl Creek

GE	Geddes
G	Grand
GG	Gray Goose
HA	Harrisburg
HB	Highmore Blunt
HV	Hillsview
HO	Howard
HU	Hubonmix
I	Intermediate
J	Java
L	Lennox
LT	Lesterville
LJM	Lower James Missouri
LJM:S	Lower James Missouri : Scotland
LVM	Lower Vermillion Missouri
MJ:A	Middle James : Aberdeen
MJ:C	Middle James : Columbia
M	Missouri
M:G	Missouri : Greenwood
M:PE	Missouri : Peoria
M:P	Missouri : Pierre
M:T	Missouri : Tower
NH	Newton Hills
OK	Okobojo Creek
O	Onaka
PAC	Parker Centerville
PC	Plum Creek
PCO	Prairie Coteau
SCH	Schindler
S	Selby
SC:A	Spring Creek : Artas
SC:H	Spring Creek : Herreid
SC:M	Spring Creek : McPherson
T	Tulare
T:EJ	Tulare : East James
T:HA	Tulare : Hand
T:H	Tulare : Hitchcock
T:HY	Tulare : Hyde
T:M	Tulare : Miller
T:RH	Tulare : Ree Heights
T:WS	Tulare : Western Spink
TL	Twin Lakes

UVM	Upper Vermillion Missouri
VEB	Veblen
VEF	Vermillion East Fork
VEF:AL	Vermillion East Fork : Antelope Lake
VEF:RL	Vermillion East Fork : Reid Lake
VEF:SL	Vermillion East Fork : Spirit Lake
VEF:WL	Vermillion East Fork : Willow Lake
VWF	Vermillion West Fork
WK	Wakonda
WAL	Wall Lake
W:MC	Warren : Morris Creek
W:WJ	Warren : West James
W:W	Warren : Wolsey
WL	White Lake
WIL	Wilmot

Rights permit system will be coded into the computer using the aquifer-management unit convention here defined. With only minor changes this bookkeeping system can also accommodate separation of hydrologic data on the basis of surface-water drainage basins.

This system of aquifer and management unit designations, along with the computerized basic data management system, will also provide a very useful tool for developing digital computer models of the hydrologic environments.

Aquifer Systems in Surficial Deposits

Aquifers within the surficial deposits can be subdivided into four general systems:

1. Deep James System and Fairmount Aquifer

2. Basal System

3. Intermediate System

4. Surface System.

It should be pointed out and emphasized that this four-fold sub-division is for descriptive purposes only and is not intended as a formal classification system.

The various physiographic divisions of eastern South Dakota and location of an idealized hydrogeologic cross section are shown in figure 2. Figure 3 is the idealized hydrogeologic cross section, from west to east, across eastern South Dakota and shows the general relationship between the Aquifer Systems. It can be

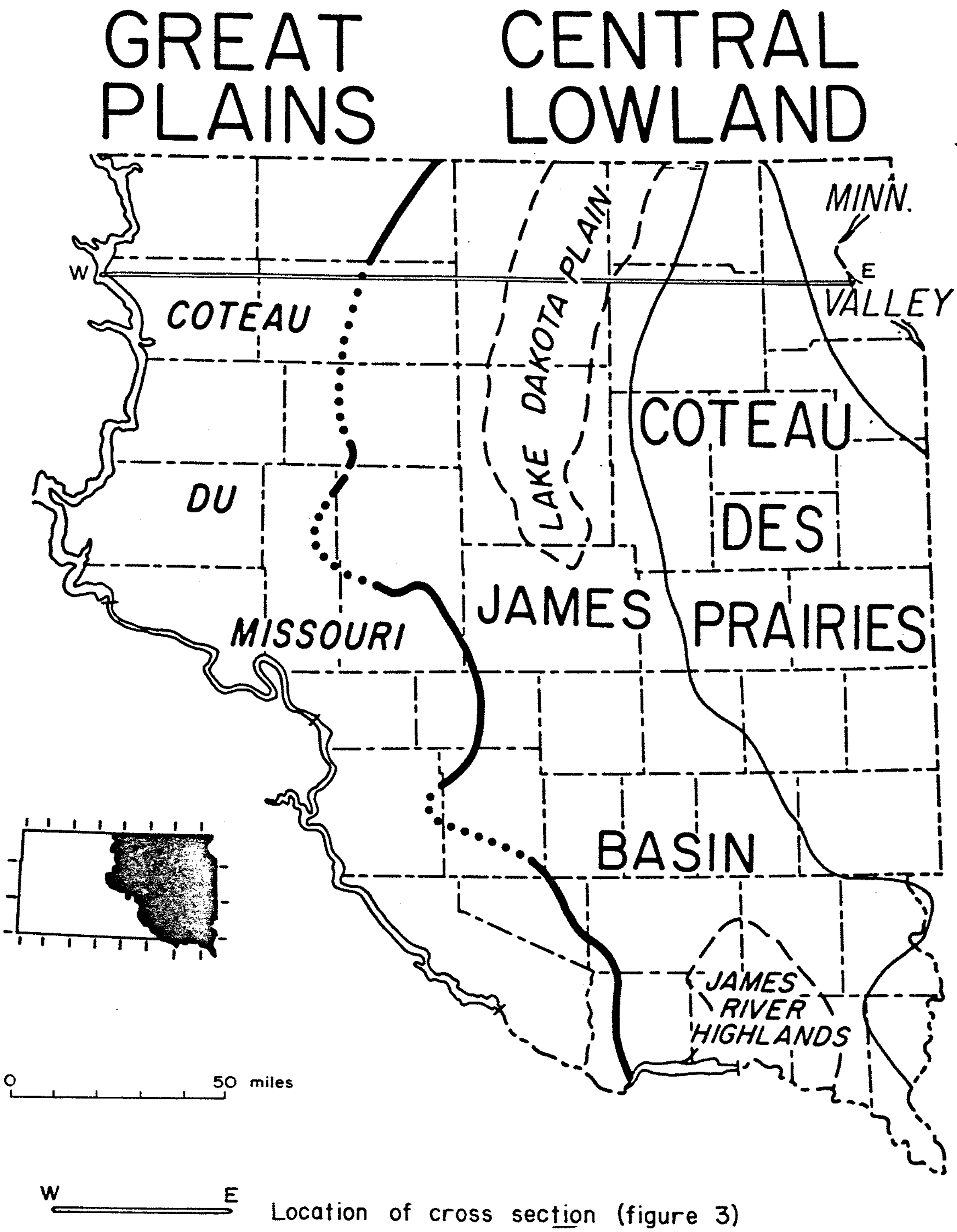
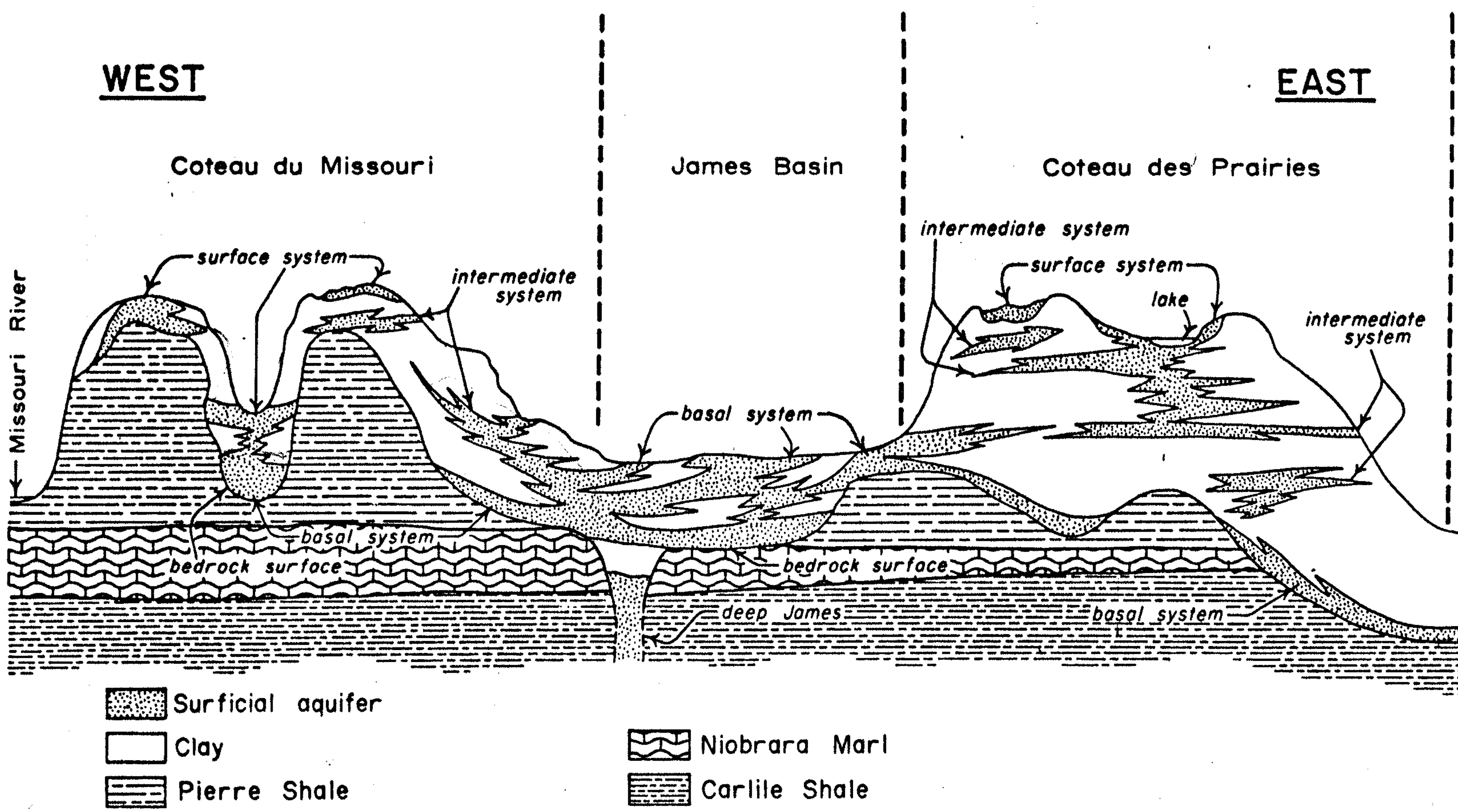


Figure 2. Map of eastern South Dakota showing location of major physiographic features.



see figure 2 for location of physiographic divisions and idealized cross section

Figure 3. Idealized cross-section showing general relationship of aquifer systems.

seen that the systems, which are discreet entities on both the Coteau du Missouri and the Coteau des Prairies, are represented in the James Lowland by a single system, the Basal System. Since the aquifers in the James Lowland are hydrologically connected to the Basal System on both Coteaus and are confined to the bedrock low areas, they have been included as part of the Basal System.

Deep James Aquifer System and Fairmount Aquifer

The Deep James Aquifer System occupies a deep, narrow channel in the James Basin and is known to occur in northern Beadle County as well as throughout Brown County (pls. 3 and 4). It is also known to be present in Spink County although its distribution cannot be illustrated due to lack of data. Locally, the Deep James may be hydrologically connected to overlying aquifers. Confining walls of the deep channel are the Niobrara Marl and/or the Carlile Shale (which may contains the Codell Aquifer). Since any two or three of these aquifers may be in contact with each other co-mingling of the water is also likely to occur.

The Fairmount Aquifer in Grant and Roberts Counties (pls. 3 and 4) was first named and described in North Dakota. Like the Deep James Aquifer it is contained within a deep narrow bedrock channel below the Basal System, although it may locally be hydrologically connected to the Basal System aquifers. The confining valley walls for the Fairmount are Carlile Shale, which has low permeability and is not an aquifer. However, the Codell Sandstone has been reported in Roberts County at an elevation which could put it in contact with the Fairmount Aquifer.

Basal System

The Basal System is that series of deposits generally occupying the bedrock low areas (pl. 1) and is usually in direct contact with the underlying bedrock units. For the distribution of this system see plates 4 and 5. The Basal System is composed of materials of various Pleistocene and Recent Age deposits and includes glacial and non-glacial sediments although most of these sediments are glacially derived.

As illustrated on plate 5, there is probably some degree of hydrologic interconnection between all aquifers in the Basal System. Hydrologically the Basal System is diverse. On the two Coteaus the Basal System is normally a discreet unit and may be buried by as much as several hundred feet of glacial drift. Artesian head in the aquifer may also be several hundred feet.

Alternately, in topographic low areas on the Coteau du Missouri, in the James Basin and in the Minnesota Valley, the Basal System may occur from the land surface to the bedrock surface and be under either water-table or artesian conditions.

Intermediate System

Aquifers of the Intermediate System (pls. 4 and 6) are found primarily on the Coteau du Missouri and the Coteau des Prairies. They may be water-table aquifers or have water-table components, although they generally are under artesian conditions. On the Coteau du Missouri where the bedrock elevations are relatively high and surficial deposits are thin, aquifers of the Intermediate System may be lying on bedrock or be exposed at the surface. Stratigraphic and hydrologic continuity of these aquifers is commonly restricted from the aquifers and systems in the James Lowland.

On the Coteau des Prairies the glacial drift comprising the surficial deposits is as much as 800 feet thick. The aquifers of the Intermediate System contained within this thick sequence are neither in contact with the bedrock nor are they exposed at the surface, except where they may crop out along the flanks of the Coteau. However, aquifers of the Intermediate System may locally be in contact with aquifers of the Basal or Surface Systems.

In Marshall and Clark Counties individual aquifers have been identified within the Intermediate System, however data from the remainder of the Coteau des Prairies is too limited to allow differentiation and correlation of individual aquifers within the Intermediate System. To avoid confusion in this report and to prevent the introduction of miscorrelations for future investigators, it was concluded that all aquifers in the Intermediate System should be lumped under the Prairie Coteau Aquifer. Delineation of management units will be possible as more detailed information becomes available.

The Sioux Falls Aquifer underlies at least a portion of the City of Sioux Falls. Because its thickness and areal extent are unknown it has not been included on any of the maps and tables in this report. The Sioux Falls Aquifer underlies the Big Sioux Aquifer, is artesian, and has total dissolved solids values which are less than those from the Big Sioux Aquifer. Because of the good quality water further investigation of this aquifer would be desirable.

Surface System

Aquifers of the Surface System are found randomly distributed throughout eastern South Dakota (pl. 7). They are mostly exposed at the surface and are primarily water table although artesian segments may be present. Many of the Surface System aquifers are associated with or limited to present drainages such as the Big Sioux River. Others may occur as a "closed system" with no apparent relationship to surface drainages. An example of the latter is the Bowdle Aquifer in Potter, Walworth, Edmunds, and Faulk Counties. Aquifers of the Surface System may locally be hydrologically connected to aquifers of the Intermediate or Basal Systems.

Bedrock Aquifers

Bedrock aquifers include all sedimentary, igneous, and metamorphic rocks underlying the surficial deposits. Table 2 lists all the known bedrock units present in eastern South Dakota and indicates their respective aquifer potential. Plates 8 through 13 and figure 4 show the distribution and thickness of all bedrock units which are considered to have aquifer potential. These are denoted as "good," "limited," or "none" under the aquifer potential column in table 2.

TABLE 2

Bedrock units present in eastern South Dakota

	Maximum Thickness (feet)	Aquifer Potential
MESOZOIC		
Tertiary		
Ft. Randall Formation	120	None
Ogallala Undifferentiated	50	None
Cretaceous		
Fox Hills	200	None
Pierre Shale	1,300	None
Niobrara Marl	150	Good
Split Rock Creek Formation	300	Limited
Carlile Shale - Codell Sandstone Member	120	Good
Greenhorn Limestone	40	Limited
Graneros Shale	110	None
Dakota Sandstone	500	Good
Skull Creek Shale	150	None
Inyan Kara Group	300	Good
PALEOZOIC		
Pennsylvanian		
Minnelusa Formation	?	None
Mississippian		
Madison Group	600	Good
Ordovician		
Red River Formation	600	?
Winnipeg Formation	?	?
Cambrian-Ordovician		
Deadwood Formation	(?)	?
PRECAMBRIAN		
Sioux Quartzite	7,000?	Limited
Igneous and Metamorphic		Limited

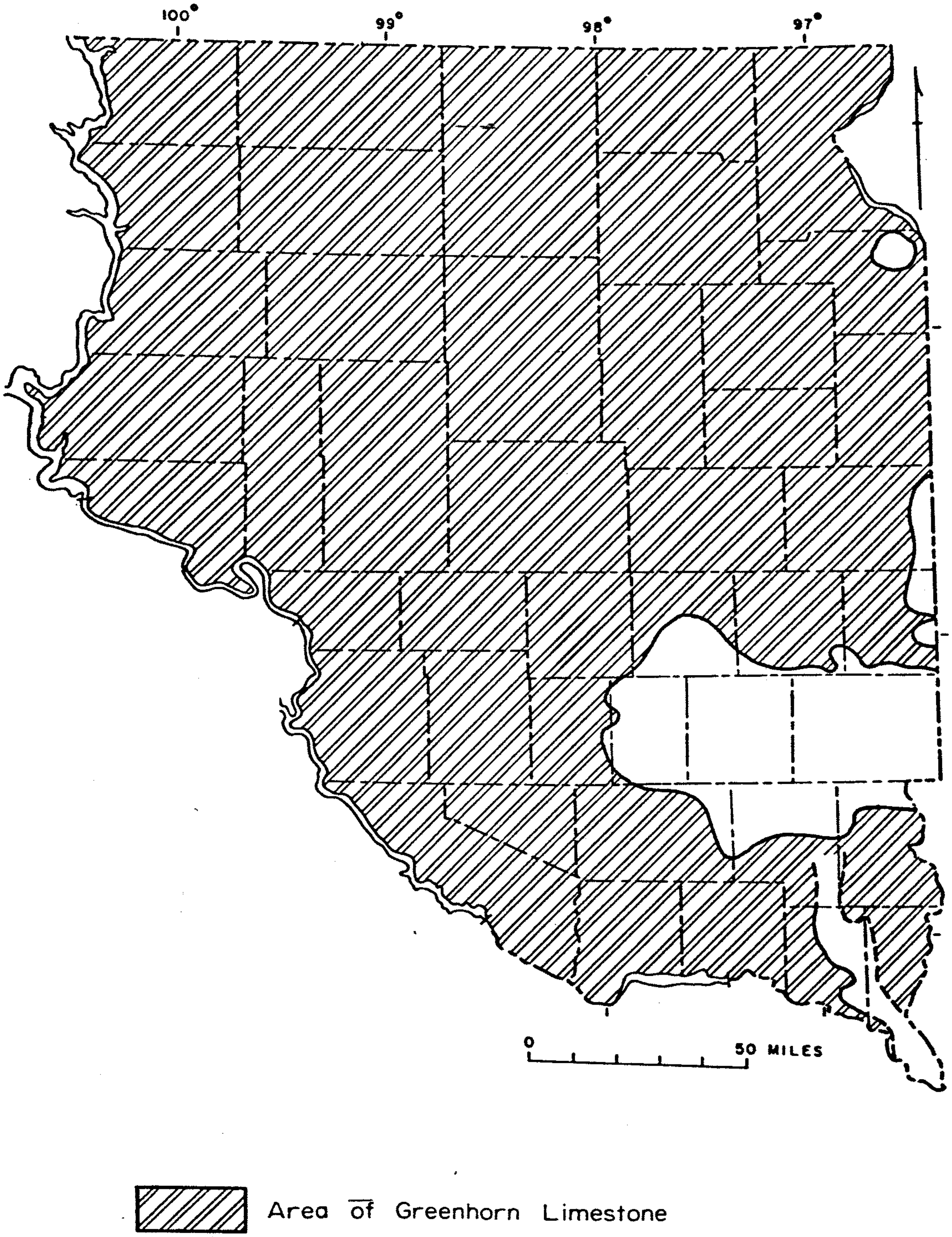


Figure 4. Map showing distribution of Greenhorn Limestone in eastern South Dakota.

Aquifers Having No Potential

The Fort Randall, Ogallala, Fox Hills, Pierre Shale, Graneros Shale, Skull Creek Shale, and Minnelusa Formations are considered to have no regional aquifer potential because they are either too thin, unsaturated, too impermeable, or there is no data available which would indicate that they are potential signficant aquifers in eastern South Dakota. Locally, they might yield enough water for low capacity wells.

Aquifers Having Limited Potential

The Split Rock Creek Formation, Greenhorn Limestone, Sioux Quartzite, and igneous and metamorphic rocks are aquifers of limited potential because of one or more of the following limiting factors:

1. Small areal extent
2. Low production capability
3. Poor water quality, or
4. Lack of data about the aquifers.

Locally, any of these aquifers could contain relatively good quality water and be capable of moderate productivity.

The Split Rock Creek Formation is present in eastern Minnehaha County (pl. 10). It consists of basal fine- to medium-grained sandstones overlain by organic claystones, opaline sediments, and massive cherts with a total known thickness of 300 feet. The basal sand which comprises the aquifer is as much as 237 feet thick, but it thins or pinches out rapidly. The meager data available show the water quality in the Split Rock Creek Formation is relatively good. The limiting factors of the Split Rock Creek Formation are its limited areal distribution and discontinuous nature of the water-bearing portion of the formation. In addition to the area shown on plate 10, there are several other known isolated occurrences of the formation in southeastern Lake County and southern Moody County.

The Greenhorn Limestone is present throughout eastern South Dakota except where truncated by the Sioux Ridge (see fig. 4). Poor water quality, low capacity wells, and availability of more preferable aquifers cause development of the Greenhorn to be limited.

The Sioux Quartzite underlies a substantial portion of southeastern South Dakota (see fig. 5). It serves as an aquifer primarily in areas where it directly underlies the surficial deposits in Minnehaha and McCook Counties and small portions of adjacent counties (fig. 5). Water is generally used from the Sioux Quartzite when there is no other suitable aquifer present. The Sioux Quartzite is impermeable except where joints and fractures are present. The location and magnitude of the joints and fractures are nearly impossible to predict. Therefore, its potential as a ground-water source is very difficult to predict. Some towns and many domestic wells do, however, obtain their water supply from the Sioux Quartzite where it directly underlies the

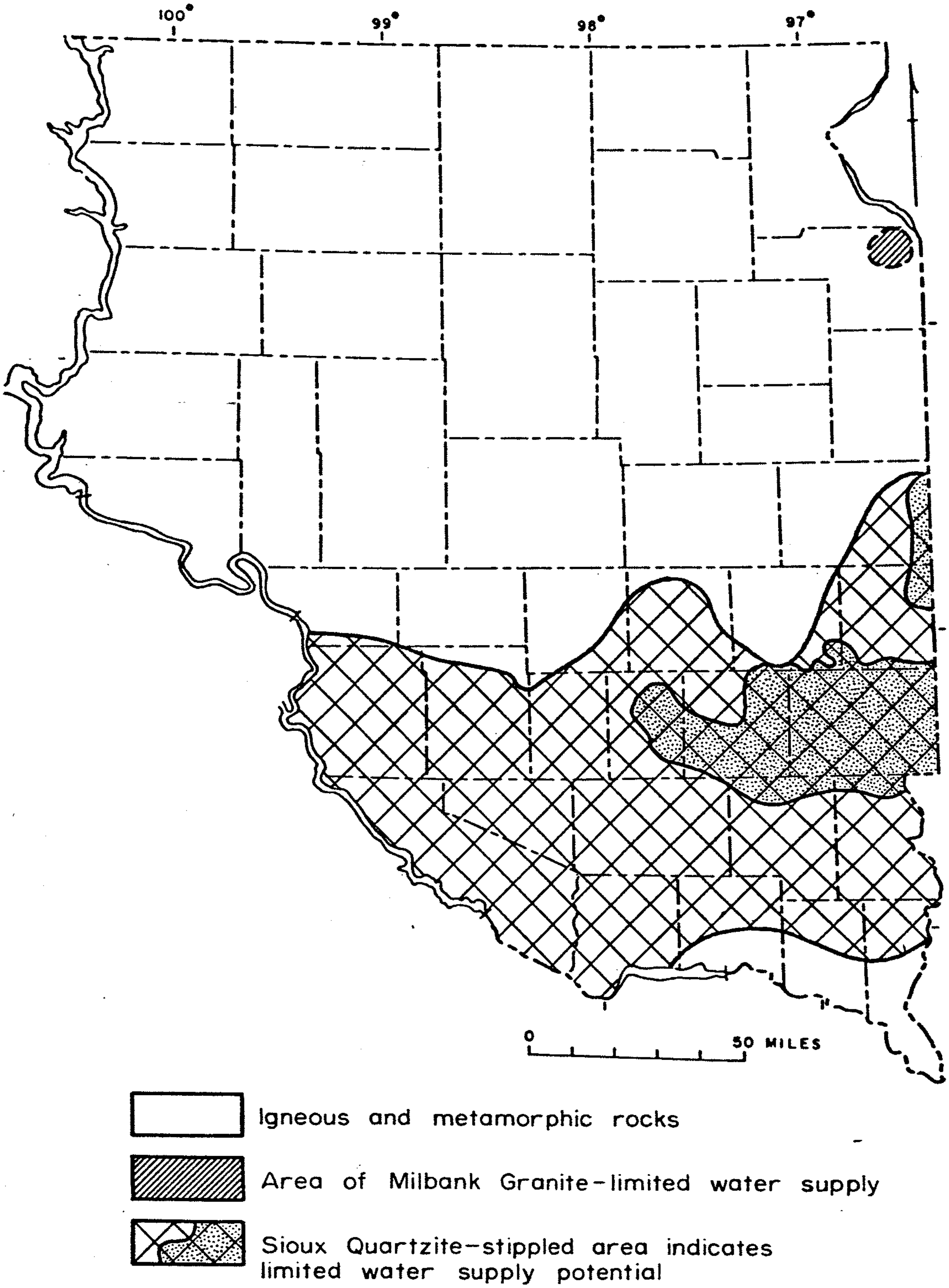


Figure 5. Map showing extent of Sioux Quartzite, igneous and metamorphic rocks and location of areas which have limited water supply potential.

surficial deposits. Therefore, locally it can be an important water source.

Igneous and metamorphic rocks in eastern South Dakota have even less potential for water development than does the Sioux Quartzite. Where used as a water source the water supply is obtained from joints and fractures, and possibly from the weathered upper surface of the rocks. Therefore, its potential as a water source is also very difficult to predict. The Milbank granite crops out or is at shallow depths in a small area around Milbank, in Grant County (see fig. 5). Here it does supply small amounts of water to domestic wells. Elsewhere in eastern South Dakota the igneous and metamorphic rocks are not used for water supplies and they are not considered as a potential water supply.

Aquifers Having Good Potential

The Niobrara Marl or "chalk rock" occurs over a large portion of eastern South Dakota (pl. 8). Where it directly underlies the glacial drift, (pl. 2) a portion of the upper Niobrara may have been eroded by a combination of sub-areal erosion and glacial activity. In the deeper bedrock channels the Niobrara has been completely removed exposing the older Cretaceous formations (pls. 1 and 2). In the central, south central, and southeastern part of the State, the Niobrara directly underlies the glacial drift (pl. 2). Over much of this area, the Basal Aquifer System of the surficial deposits is in direct contact with the Niobrara. Comingling of the waters occurs and affects hydraulic head, water quality, and recharge-discharge relationships in both the Niobrara Aquifer and the aquifers in the surficial deposits. The Niobrara Marl ranges in thickness from 40 feet in the northeast part of the State to 100 to 150 feet throughout much of the remainder of eastern South Dakota. It ranges in lithology from a light- to dark-gray speckled, well indurated limestone to a soft, white marl. Shaley zones can occur throughout the section. Water production from the Niobrara may be controlled by fractures and/or solution cavities. These are partially controlled by flexures and faults. Weathering and glacial activity may also contribute to higher productive zones in the Niobrara. Because these features are very difficult to predict in the subsurface, productivity of the Niobrara is also difficult to impossible to predict. The Niobrara can provide over 1,000 gallons per minute of water in areas such as northeastern Aurora County and southern Davison County where irrigation wells are developed in the Niobrara.

The minimum distribution of the Codell Sandstone Aquifer is shown on plate 9. The Codell consists of fine- to medium-grained sand, which can be either cemented or uncemented, with thin interbedded limestones. It has a maximum thickness of 120 feet but averages about 25 feet thick. At some locations it directly underlies the Niobrara Marl and if the basal Niobrara is permeable, then the two aquifers may function as one hydrologic unit. At other localities the Niobrara and Codell may be separated by a shale layer up to 20 feet thick. Where this relationship exists the two units probably function as separate hydrologic entities. Although the Codell commonly has total dissolved solids in excess of 1,500 parts per million, it is often preferred as a domestic water supply because it usually provides soft water. Well yields in the Codell probably could not exceed 200 gallons per minute and the average maximum yield is estimated to be 50 gallons per minute.

The Dakota Formation is present over the entire eastern portion of South Dakota except for the area surrounding the Sioux Ridge (pl. 10). Throughout the history of eastern South Dakota the Dakota Aquifer has played a major role in water development. Literally thousands of wells have tapped the Dakota since the late 1800's when the first "Dakota" well was drilled. Although in most areas the water was of poor quality, water from the Dakota was much desired because wells flowed. Early reports document flowing wells in excess of 3,000 gallons per minute. Unrestricted flow from these thousands of wells has reduced the head as much as 350 feet. Presently, wells flow only in portions of the James River Basin and along the Missouri River. The present flows are only a fraction of what was experienced in the late 1800's and early 1900's. Even now, it is estimated that as much as 100 million gallons per day are withdrawn from the Dakota through wells and much of this water flows to waste. It is estimated that natural discharge accounts for at least another 100 million gallons per day and that unknown but substantial quantities of water are recharging the overlying sedimentary and surficial aquifers through deteriorated well casings. This is probably particularly noticeable in the James Basin where there has long been extensive development from the Dakota.

The Dakota Formation consists primarily of fine- to medium-grained sand, sandstone, and interbedded shale. Wells with yields of several hundred gallons per minute are feasible with properly constructed wells in those areas where sufficient shale-free sand and/or sandstone is present.

The subsurface extent of the Inyan Kara Group in eastern South Dakota is shown on plate 11. The Inyan Kara Group in north central South Dakota has often been erroneously termed the Sundance Formation. Local terminology by well drillers perpetuates this misnomer. The Inyan Kara consists predominantly of white to light-gray, fine- to coarse-grained, friable sandstone as much as 300 feet thick in eastern South Dakota. Head pressures in the Inyan Kara normally are much higher than those in the Dakota Formation, causing wells to flow in the higher elevations and to have voluminous flows at lower elevations. The impermeable Skull Creek Shale separates the Inyan Kara Group from the overlying Dakota Formation except near the eastern boundary of the Inyan Kara Group where the Skull Creek pinches out. Here the water from the Inyan Kara recharges the Dakota Aquifer helping to maintain its artesian head. It also changes the chemical quality of water in the Dakota Formation. In this area large scale development of the Inyan Kara would undoubtedly be reflected in the Dakota Formation.

The Madison Group is present in north central South Dakota (pl. 12). The Madison consists mostly of indurated limestone with interbedded anhydrite and ranges up to 600 feet in thickness. Very little data are available concerning the quantity and quality of water that could be produced from this formation. In the western part of South Dakota the high production zones in the Madison are related to secondary porosity features whose presence and location are difficult to predict. The most productive zones in the Madison of eastern South Dakota, likewise, would probably be related to secondary porosity features. However, it is likely that there are locations in which wells could be drilled capable of producing several hundred gallons per minute.

Water quality of the Madison would probably make it unacceptable for irrigation or domestic uses but it could be satisfactory for stock watering or some industrial uses.

Data concerning water yielding characteristics, thickness, and water quality are not generally available for the Red River, Winnipeg, and Deadwood Formations so their actual aquifer potential is unknown. In terms of water quantity only, their potential may be limited to good, but water from all three formations is probably too highly mineralized to be considered for irrigation or domestic use. The extent and thickness of the Red River is shown on plate 13. The Winnipeg and Deadwood are probably present in eastern South Dakota but their actual extent is unknown. However, their extent would most likely be less than the extent of the Madison Group

Water from the aquifer in the Dakota Formation and water from all aquifers older than the Dakota may have potential for at least limited geothermal development.

Water Level Maps for Aquifers in Surficial Deposits

Water level maps have been constructed for those surficial aquifers for which adequate data are available and these are illustrated on plates 5 and 7. The number of observation wells in the intermediate aquifers (pl. 6) are not adequate to construct water level maps. Water level readings used in the construction of these plates were taken mostly during May, 1980. Where readings for this date were not available, estimates of the water levels were used.

Water Levels for Aquifers in Bedrock Formations

None of the aquifers in the bedrock formations have adequate numbers of well-monitoring sites from which data could be used to compile water-level maps for eastern South Dakota. Even the Dakota Formation, which has thousands of wells penetrating the aquifer, has too limited a distribution of regular measuring points to compile an accurate water level map.

TASK III: GROUND-WATER STORAGE

Aquifers in Surficial Deposits

There is very little data available about the water-yielding characteristics of aquifers in the unconsolidated Surficial Deposits in eastern South Dakota. Past published reports have provided data for total water available using porosity values which range from 0.15 to 0.35. Using this range of porosity values may be valid for computing total water in storage but these values do not provide an accurate total for that amount of water that can be practically recovered from an unconsolidated deposit. Furthermore, use of this wide range of porosity figures does not allow easy comparison of ground-water storage figures.

In order to provide a common basis for comparison and to provide a more realistic value for water availability, in terms of amount of water that could be recovered from wells by pumping, all ground-water storage figures from surficial deposits are calculated using a specific yield figure of 0.15. This value for specific yield falls within the range of 0.10 to 0.20 which is the general range of specific yields for unconsolidated deposits in eastern South Dakota as determined from aquifer test data. This value of 0.15 specific yield is used to calculate the "total recoverable ground water" in tables 3 and 4. Ongoing digital modeling studies in the Big Sioux Aquifer Study suggest that the specific yield is 0.20 for that aquifer. If this specific yield value is valid for the entire Big Sioux Aquifer then total recoverable water figures for the Big Sioux Aquifer (tables 3 and 4) should be increased by 25 percent. As more detailed information from aquifer test data and digital model studies becomes available, estimates of the recoverable ground-water can be revised accordingly.

Recoverable ground-water for each aquifer in the surficial deposits in eastern South Dakota was calculated in the following manner: the saturated thickness of aquifer material was planimetered to determine the total number of acres underlain by aqui-

TABLE 3

List of counties showing total recoverable ground water by aquifer from surficial deposits

NA = insufficient data available

Aquifer - Management Unit	Aquifer Symbol	Area of aquifer (acres)	Recoverable water (acre-feet)
AURORA			
Corsica	CO	74,500	391,130
Crow Lake	CL	5,100	19,000
White Lake	WL	24,300	55,000
TOTAL		103,900	465,130
BEADLE			
Altamont	A	9,000	29,000
Bad Cheyenne	BC	27,700	102,000
Deep James	DJ	NA	NA
Floyd : East James	F:EJ	146,600	700,000
Floyd : Pearl Creek	F:PC	11,000	45,000
Tulare : East James	T:EJ	23,200	132,000
Tulare : Hitchcock	T:H	53,800	333,000
Tulare : Western Spink	T:WS	57,000	162,000
Warren : West James	W:WJ	119,500	568,000
Warren : Wolsey	W:W	21,200	80,000
TOTAL		469,000	2,151,000
BON HOMME			
Choteau : Tyndall	CH:T	31,300	140,850
Choteau : West	CH:W	20,500	121,480
Hubonmix	HU	23,000	9,000
Lesterville	LT	NA	NA
Lower James Missouri : Scotland	LJM:S	33,300	249,750
TOTAL		108,100	521,080
BROOKINGS			
Altamont	A	NA	NA

Big Sioux : Aurora	BS:A	39,300	165,060
Big Sioux : Brookings	BS:B	74,500	245,850
Big Sioux : North Deer Creek	BS:NDC	5,700	6,840
Big Sioux : Six Mile Creek	BS:SMC	4,200	18,900
Big Sioux : Unnamed Creek	BS:UC	5,800	13,050
TOTAL		129,500	449,700

BROWN

Altamont	A	NA	NA
Deep James	DJ	160,000	720,000
Elm : Northern Brown	E:NB	187,200	702,000
Elm : Southern Brown	E:SB	62,400	234,000
Middle James : Aberdeen	MJ:A	118,800	356,000
Middle James : Columbia	MJ:C	220,500	661,000
TOTAL		748,900	2,673,000

BRULE

Corsica	CO	NA	NA
Geddes	GE	NA	NA
White Lake	WL	NA	NA
TOTAL		NA	NA

BUFFALO

Crow Creek	CC	NA	NA
Elm Creek	EC	NA	NA
TOTAL		NA	NA

CAMPBELL

Grand	G	97,900	1,469,000
Selby	S	128,000	480,000
Spring Creek : Artas	SC:A	9,200	13,560
Spring Creek : Herreid	SC:H	55,000	239,830
TOTAL		290,100	2,202,390

CHARLES MIX

Choteau : West	CH:W	169,600	1,225,370
Delmont	D	12,200	36,610
Geddes	GE	24,100	90,370
Hubonmix	HU	5,500	12,380
Intermediate	I	82,600	123,900
Missouri : Greenwood	M:G	7,400	111,000
Missouri : Tower	M:T	2,800	42,000
TOTAL		304,200	1,641,630

CLARK

Altamont	A	537,200	3,326,400
Prairie Coteau	PCO	217,600	825,600
Vermillion East Fork : Antelope Lake	VEF:AL	34,400	77,400
Vermillion East Fork : Reid Lake	VEF:RL	6,000	13,500
Vermillion East Fork : Spirit Lake	VEF:SL	4,700	4,940
Vermillion East Fork : Willow Lake	VEF:WL	13,100	29,480
TOTAL		813,000	4,277,320

CLAY

Brule Creek	BRC	1,800	4,050
Lower James Missouri	LJM	5,400	81,000
Lower Vermillion Missouri	LVM	100,800	1,512,000
Missouri	M	74,500	1,117,500
Parker Centerville	PAC	3,700	11,400
Upper Vermillion Missouri	UVM	11,200	168,000
Wakonda	WK	14,100	84,600
TOTAL		211,500	2,978,550

CODINGTON

Altamont	A	NA	NA
Antelope Valley	AV	6,800	15,300
Big Sioux : North	BS:N	67,300	151,430
Prairie Coteau	PCO	23,700+	71,100+
TOTAL		97,800	237,830

DAVISON

Ethan	ET	26,300	78,150
Warren:Morris Creek	W:MC	13,500	25,070
TOTAL		39,800	103,220

DAY

Altamont	A	565,100	847,970+
Coteau Lakes	COL	58,200	130,910+
Prairie Coteau	PCO	500,000	675,000+
TOTAL		1,123,300	1,653,880+

DEUEL

Altamont	A	305,900	1,605,900
Antelope Valley	AV	7,400	16,650
Big Sioux : Brookings	BS:B	26,400	59,400
Prairie Coteau	PCO	412,200	927,090
TOTAL		751,900	2,609,040

DOUGLAS

Choteau : Middle	CH:M	10,000	45,000
Choteau : West	CH:W	28,300	127,350
Corsica	CO	33,600	201,600
Delmont	D	15,700	35,320
Hubonmix	HU	400	900
Intermediate	I	40,500	60,750
TOTAL		128,500	470,920

EDMUNDS

Bowdle : Edmunds	B:E	36,000	108,000
Elm : Ipswich	E:I	35,800	108,000
Elm : Southern Brown	E:SB	3,700	11,000
Grand	G	112,000	840,000
Java	J	NA	NA
Onaka	O	5,800	26,000
TOTAL		192,500	1,093,000

FAULK

Bowdle : Edmunds	B:E	2,600	8,000
Elm : Ipswich	E:I	10,400	31,000
Elm : Southern Brown	E:SB	16,000	48,000
Grand	G	74,200	556,000
Onaka	O	13,400	60,000
TOTAL		116,600	703,000

GRANT

Altamont	A	NA	NA
Antelope Valley	AV	14,500	32,630
Big Sioux : North	BS:N	9,400	21,150
Fairmount	FMT	2,000	9,000
Prairie Coteau	PCO	NA	NA
Veblen	VEB	70,600	211,800
Wilmot	WIL	66,600	149,850
TOTAL		163,100+	424,430+

HAMLIN

Altamont	A	205,400	1,078,790
Big Sioux : Brookings	BS:B	88,500	331,880
Big Sioux : North	BS:N	6,200	13,950
Prairie Coteau	PCO	345,600	778,000
TOTAL		645,700	2,202,620

HAND

Bad Cheyenne	BC	64,000	384,000
Crow Creek	CC	1,200	2,700
Elm Creek	EC	4,900	22,000
Grand	G	9,600	48,000
Highmore Blunt	HB	1,000	6,000
Tulare : Hand	T:HA	208,700	938,000
Tulare : Hyde	T:HY	34,600	156,000
Tulare : Miller	T:M	28,800	130,000
Tulare : Ree Heights	T:RH	11,700	53,000
Tulare : Western Spink	T:WS	9,600	86,400
Warren:Wolsey	W:W	1,300	2,030
TOTAL		375,400	1,828,130

HANSON

Floyd : Alexandria	F:A	19,800	44,930
Floyd : East James	F:EJ	53,800	322,800
Plum Creek	PC	28,400	76,880
TOTAL		102,000	444,610

HUGHES

Chapelle Creek	CHP	7,600	9,120
Gray Goose	GG	33,400	200,400
Highmore Blunt	HB	7,800	9,000
Missouri : Peoria	M:PE	1,600	7,200
Missouri : Pierre	M:P	5,700	25,650
TOTAL		56,100	251,370

HUTCHINSON

Choteau : East	CH:E	33,700	126,380
Choteau : Middle	CH:M	22,300	117,080
Ethan	ET	4,300	6,450
Hubonmix	HU	NA	NA
Lower James Missouri	LJM	93,800	633,150
Lower James Missouri : Scotland	LJM:S	1,800	13,500
Plum Creek	PC	NA	NA
TOTAL		155,900	896,560

HYDE

Bad Cheyenne	BC	64,000	384,000
Elm Creek	EC	11,200	50,000
Highmore Blunt	HB	44,300	109,380
Tulare	T	6,200	23,250
Tulare : Hyde	T:HY	39,000	176,000
TOTAL		164,700	742,630

JERAULD

Bad Cheyenne	BC	2,200	9,000
Crow Creek	CC	40,300	151,000
Crow Lake	CL	25,600	96,000
Warren : West James	W:WJ	28,200	106,150
TOTAL		96,300	362,150

KINGSBURY

Altamont	A	NA	NA
Big Sioux	BS	NA	NA
Floyd : East James	F:EJ	NA	NA
Howard	HO	NA	NA
Vermillion East Fork	VEF	NA	NA
Vermillion East Fork : Spirit Lake	VEF:SL	9,200	20,700
TOTAL		9,200	20,700

LAKE

Big Sioux : Northern Skunk Creek	BS:NSC	24,700	70,400
Howard	HO	NA	NA
Vermillion East Fork	VEF	NA	NA
TOTAL		24,700	70,400

LINCOLN

Big Sioux : South	BS:S	15,600	70,200
Brule Creek	BRC	33,200	99,600
Harrisburg	HA	43,200	105,170
Lennox	L	15,200	43,830
Newton Hills	NH	21,000	25,200
Parker Centerville	PAC	2,200	6,600
Schindler	SCH	31,200	124,590
Upper Vermillion Missouri	UVM	15,300	149,180
Wall Lake	WAL	25,100	70,400
TOTAL		202,000	694,770

McCOOK

Howard	HO	NA	NA
Floyd : Alexandria	F:A	NA	NA
Floyd : East James	F:EJ	NA	NA
Plum Creek	PC	NA	NA
Vermillion East Fork	VEF	NA	NA
Vermillion West Fork	VWF	NA	NA
TOTAL		NA	NA

McPHERSON

Grand	G	44,200	331,000

Hillsview	HV	51,200	230,000
Selby	S	30,100	90,000
Spring Creek : Artas	SC:A	1,000	1,560
Spring Creek : McPherson	SC:M	101,200	307,000
Twin Lakes	TL	19,200	86,000
TOTAL		246,900	1,045,560

MARSHALL

Altamont	A	39,000	292,500
Coteau Lakes	COL	32,000	120,000
Deep James	DJ	6,400	28,800
Middle James : Columbia	MJ:C	95,400	715,500
Prairie Coteau	PCO	492,800	1,478,400
Veblen	VEB	15,400	115,500
TOTAL		681,000	2,749,400

MINER

Floyd : East James	F:EJ	118,000	750,300
Howard	HO	110,100	210,040
Vermillion East Fork	VEF	NA	NA
Vermillion West Fork	VWF	NA	NA
TOTAL		228,100	960,340

MINNEHAHA

Big Sioux : Middle Skunk Creek	BS:MSC	17,300	38,930
Big Sioux : Moody	BS:M	2,400	9,000
Big Sioux : Sioux Falls	BS:SF	22,900	103,050
Big Sioux : South	BS:S	17,200	20,640
Big Sioux : Southern Skunk Creek	BS:SSC	9,700	32,010
Schindler	SCH	700	1,360
Wall Lake	WAL	17,300	75,690
TOTAL		87,500	280,680

MOODY

Big Sioux : Brookings	BS:B	1,700	5,100

Big Sioux : Middle Skunk Creek	BS:MSC	1,000	2,250
Big Sioux : Moody	BS:M	33,100	124,130
Big Sioux : Northern Skunk Creek	BS:NSC	700	2,000
TOTAL		36,500	133,480

POTTER

Bowdle : Edmunds	B:E	NA	NA
Bowdle : Hoven South	B:HS	11,900	23,000
Bowdle : Lebanon	B:L	10,100	22,000
Okobojo Creek	OK	NA	NA
Onaka	O	NA	NA
TOTAL		22,000	45,000

ROBERTS

Altamont	A	NA	NA
Big Sioux : North	BS:N	600	1,350
Coteau Lakes	COL	NA	NA
Fairmount	FMT	94,200	282,600
Prairie Coteau	PCO	NA	NA
Veblen	VEB	431,900	1,295,700
Wilmot	WIL	86,300	194,180
TOTAL		613,000	1,773,830

SANBORN

Floyd : East James	F:EJ	118,400	622,000
Warren : Morris Creek	W:MC	24,000	54,000
Warren : West James	W:WJ	121,000	730,000
TOTAL		263,400	1,406,000

SPINK

<u>Southern half:</u>

Altamont	A	11,200+	16,800+
Deep James	DJ	NA	NA
Tulare : East James	T:EJ	100,700	476,000
Tulare : Hand	T:HA	600	2,800
Tulare : Hitchcock	T:H	96,000	360,000
Tulare : Western Spink	T:WS	72,300	270,930

Northern half:

Deep James	DJ	NA	NA
Elm : Southern Brown	E:SB	NA	NA
Middle James : Aberdeen	MJ:A	NA	NA
Tulare : East James	T:EJ	NA	NA
Tulare : Hitchcock	T:H	NA	NA
TOTAL		280,800+	1,126,530+

SULLY

Bad Cheyenne	BC	NA	NA
Cow Creek	COW	3,600	8,100
Gray Goose	GG	NA	NA
Highmore Blunt	HB	20,300	30,450
Okobojo Creek	OK	13,800	16,620
Tulare	T	NA	NA
TOTAL		37,700	55,170

TURNER

Choteau : East	CH:E	5,000	7,500
Harrisburg	HA	300	220
Lennox	L	5,500	19,640
Parker Centerville	PAC	38,300	114,900
Upper Vermillion Missouri	UVM	106,400	1,037,400
Vermillion East Fork	VEF	3,400	5,100
Vermillion West Fork	VWF	6,800	10,200
Wakonda	WK	NA	NA
Wall Lake	WAL	28,600	66,370
TOTAL		194,300	1,261,330

UNION

Big Sioux : South	BS:S	16,200	72,900
Brule Creek	BRC	43,400	195,300
Lower Vermillion Missouri	LVM	24,800	372,000
Missouri	M	99,600	1,494,600
TOTAL		184,000	2,134,800

WALWORTH

Bowdle : Edmunds	B:E	8,300	19,000

Bowdle : Hoven North	B:HN	10,900	24,000
Grand	G	67,200	393,000
Java	J	55,000	182,000
Onaka	O	9,000	34,000
Selby	S	12,800	35,000
TOTAL		163,200	687,000

YANKTON

Lesterville	LT	5,800	17,400
Lower James Missouri	LJM	92,500	2,081,250
Lower James Missouri : Scotland	LJM:S	37,700	847,400
Missouri	M	45,000	675,000
TOTAL		181,000	3,621,050

TABLE 4

List of aquifers from surficial deposits showing total recoverable ground water by county.

NA = insufficient data available

Aquifer - Management Unit	County	Area of aquifer (acres)	Recoverable water (acre-feet)
Altamont	Beadle	9,000	29,000
	Brookings	NA	NA
	Brown	NA	NA
	Clark	537,200	3,326,400
	Codington	NA	NA
	Day	565,100	847,970+
	Deuel	305,900	1,605,900
	Grant	NA	NA
	Hamlin	205,400	1,078,790
	Kingsbury	NA	NA
	Marshall	39,000	292,500
	Roberts	NA	NA
	Spink	11,200+	16,800+
Total		1,672,800+	7,197,360+
Antelope Valley	Codington	6,800	15,300
	Deuel	7,400	16,650
	Grant	14,500	32,630
Total		28,700	64,580
Bad Cheyenne	Beadle	27,700	102,000
	Hand	64,000	384,000
	Hyde	64,000	384,000
	Jerauld	2,200	9,000
	Sully	NA	NA
Total		157,900	879,000
Big Sioux : Aurora	Brookings	39,300	165,060
Big Sioux : Brookings	Brookings	74,500	245,850
	Deuel	26,400	59,400
	Hamlin	88,500	331,880
	Kingsbury	NA	NA

	Moody	1,700	5,100
Total		191,100	642,230
Big Sioux : Middle Skunk Creek	Minnehaha	17,300	38,930
	Moody	1,000	2,250
Total		18,300	41,180
Big Sioux : Moody	Minnehaha	2,400	9,000
	Moody	33,100	124,130
Total		35,500	133,130
Big Sioux : North	Codington	67,300	151,430
	Grant	9,400	21,150
	Hamlin	6,200	13,950
	Roberts	600	1,350
Total		83,500	187,880
Big Sioux : North Deer Creek	Brookings	5,700	6,840
Big Sioux : Northern Skunk Creek	Lake	24,700	70,400
	Moody	700	2,000
Total		25,400	72,400
Big Sioux : Sioux Falls	Minnehaha	22,900	103,050
Big Sioux : Six Mile Creek	Brookings	4,200	18,900
Big Sioux : South	Lincoln	15,600	70,200
	Minnehaha	17,200	20,640
	Union	16,200	72,900
Total		49,000	163,740
Big Sioux : Southern Skunk Creek	Minnehaha	9,700	32,010

Big Sioux : Unnamed Creek	Brookings	5,800	13,050
BIG SIOUX (TOTAL)		490,400	1,579,470
Bowdle : Edmunds	Edmunds	36,000	108,000
	Faulk	2,600	8,000
	Potter	NA	NA
	Walworth	8,300	19,000
Total		46,900	135,000
Bowdle : Hoven North	Walworth	10,900	24,000
Bowdle : Hoven South	Potter	11,900	23,000
Bowdle : Lebanon	Potter	10,100	22,000
BOWDLE (TOTAL)		79,800	204,000
Brule Creek	Clay	1,800	4,050
	Lincoln	33,200	99,600
	Union	43,400	195,300
Total		78,400	298,950
Chapelle Creek	Hughes	7,600	9,120
Choteau : East	Hutchinson	33,700	126,380
	Turner	5,000	7,500
Total		38,700	133,880
Choteau : Middle	Douglas	10,000	45,000
	Hutchinson	22,300	117,080
Total		32,300	162,080
Choteau : Tyndall	Bon Homme	31,300	140,850
Choteau : West	Bon Homme	20,500	121,480
	Charles Mix	169,600	1,225,370
	Douglas	28,300	127,350

Total		218,400	1,474,200
CHOTEAU (TOTAL)		320,700	1,911,010
Corsica	Aurora	74,500	319,130
	Brule	NA	NA
	Douglas	33,600	201,600
Total		108,100	520,730
Coteau Lakes	Day	58,200	130,910+
	Marshall	32,000	120,000
	Roberts	NA	NA
Total		90,200	250,910+
Cow Creek	Sully	3,600	8,100
Crow Creek	Buffalo	NA	NA
	Hand	1,200	2,700
	Jerauld	40,300	151,000
Total		41,500	153,700
Crow Lake	Aurora	5,100	19,000
	Jerauld	25,600	96,000
Total		30,700	115,000
Deep James	Brown	160,000	720,000
	Marshall	6,400	28,800
	Spink	NA	NA
Total		166,400	748,800
Delmont	Charles Mix	12,200	36,610
	Douglas	15,700	35,320
Total		27,900	71,930
Elm Creek	Buffalo	NA	NA
	Hand	4,900	22,000
	Hyde	11,200	50,000
Total		16,100	72,000

Elm : Ipswich	Edmunds	35,800	108,000
	Faulk	10,400	31,000
Total		46,200	139,000
Elm : Northern Brown	Brown	187,200	702,000
Elm : Southern Brown	Brown	62,400	234,000
	Edmunds	3,700	11,000
	Faulk	16,000	48,000
	Spink	NA	NA
Total		82,100	293,000
ELM (TOTAL)		315,500	1,134,000
Ethan	Davison	26,300	78,150
	Hutchinson	4,300	6,450
Total		30,600	84,600
Fairmount	Grant	2,000	9,000
	Roberts	94,200	282,600
Total		96,200	291,600
Floyd : Alexandria	Hanson	19,800	44,930
	McCook	NA	NA
Floyd : East James	Beadle	146,600	700,000
	Hanson	53,800	322,800
	Kingsbury	NA	NA
	McCook	NA	NA
	Miner	118,000	750,300
	Sanborn	118,400	622,000
Total		436,800	2,395,100
Floyd : Pearl Creek	Beadle	11,000	45,000
FLOYD (TOTAL)		467,600	2,485,030
Geddes	Brule	NA	NA
	Charles Mix	24,100	90,370

Grand	Campbell	97,900	1,469,000
	Edmunds	112,000	840,000
	Faulk	74,200	556,000
	Hand	9,600	48,000
	McPherson	44,200	331,000
	Walworth	67,200	393,000
Total		405,100	3,637,000
Gray Goose	Hughes	33,400	200,400
	Sully	NA	NA
Harrisburg	Lincoln	43,200	105,170
	Turner	300	220
Total		43,500	105,390
Highmore Blunt	Hand	1,000	6,000
	Hughes	7,800	9,000
	Hyde	44,300	109,380
	Sully	20,300	30,450
Total		73,400	154,830
Hillsview	McPherson	51,200	230,000
Howard	Kingsbury	NA	NA
	Lake	NA	NA
	McCook	NA	NA
	Miner	110,100	210,040
Hubonmix	Bon Homme	23,000	69,000
	Charles Mix	5,500	12,380
	Douglas	400	900
	Hutchinson	NA	NA
Total		28,900	82,280
Intermediate	Charles Mix	82,600	123,900
	Douglas	40,500	60,750
Total		123,100	184,650
Java	Edmunds	NA	NA
	Walworth	55,000	182,000

Lennox	Lincoln	15,200	43,830
	Turner	5,500	19,640
Total		20,700	63,470
Lesterville	Bon Homme	NA	NA
	Yankton	5,800	17,400
Lower James Missouri	Clay	5,400	81,000
	Hutchinson	93,800	633,150
	Yankton	92,500	2,081,250
Total		191,700	2,795,400
Lower James Missouri : Scotland	Bon Homme	33,300	249,750
	Hutchinson	1,800	13,500
	Yankton	37,700	847,400
Total		72,800	1,110,650
LOWER JAMES MISSOURI (TOTAL)		264,500	3,906,050
Lower Vermillion Missouri	Clay	100,800	1,512,000
	Union	24,800	372,000
Total		125,600	1,884,000
Middle James : Aberdeen	Brown	118,800	356,000
	Spink	NA	NA
Middle James : Columbia	Brown	220,500	661,000
	Marshall	95,400	715,000
Total		315,900	1,376,000
MIDDLE JAMES (TOTAL)		434,700	1,732,000
Missouri	Clay	74,500	1,117,500
	Union	99,600	1,494,600
	Yankton	45,000	675,000
Total		219,100	3,287,100

Missouri : Greenwood	Charles Mix	7,400	111,000
Missouri : Peoria	Hughes	1,600	7,200
Missouri : Pierre	Hughes	5,700	25,650
Missouri : Tower	Charles Mix	2,800	42,000
MISSOURI (TOTAL)		236,600	3,472,950
Newton Hills	Lincoln	21,000	25,200
Okobojo Creek	Potter	NA	NA
	Sully	13,800	16,620
Onaka	Edmunds	5,800	26,000
	Faulk	13,400	60,000
	Potter	NA	NA
	Walworth	9,000	34,000
Total		28,200	120,000
Parker Centerville	Clay	3,700	11,400
	Lincoln	2,200	6,600
	Turner	38,300	114,900
Total		44,200	132,900
Plum Creek	Hanson	28,400	76,880
	Hutchinson	NA	NA
	McCook	NA	NA
Prairie Coteau	Clark	217,600	825,600
	Codington	23,700+	71,000+
	Day	500,000	675,000+
	Deuel	412,000	927,090
	Grant	26,400+	79,200+
	Hamlin	345,600	778,000
	Marshall	492,800	1,478,400
	Roberts	NA	NA
Total		2,018,100+	4,834,290+
Schindler	Lincoln	31,200	124,590

	Minnehaha	700	1,360
Total		31,900	125,950
Selby	Campbell	128,000	480,000
	McPherson	30,100	90,000
	Walworth	12,800	35,000
Total		170,900	605,000
Spring Creek : Artas	Campbell	9,200	13,560
	McPherson	1,000	1,560
Total		10,200	15,120
Spring Creek : Herreid	Campbell	55,000	239,830
Spring Creek : McPherson	McPherson	101,200	307,000
SPRING CREEK (TOTAL)		166,400	561,950
Tulare	Hyde	6,200	23,250
	Sully	NA	NA
Tulare : East James	Beadle	23,200	132,000
	Spink	100,700+	476,000+
Total		123,900+	608,000+
Tulare : Hand	Hand	208,700	938,000
	Spink	600	2,800
Total		209,300	940,800
Tulare : Hitchcock	Beadle	53,800	333,000
	Spink	96,600+	360,000+
Total		150,400+	693,000+
Tulare : Hyde	Hand	34,600	156,000
	Hyde	39,000	176,000
Total		73,600	332,000

Tulare : Miller	Hand	28,800	130,000
Tulare : Ree Heights	Hand	11,700	53,000
Tulare : Western Spink	Beadle	57,000	162,000
	Hand	9,600	86,400
	Spink	72,300	270,930
Total		138,900	519,330
TULARE (TOTAL)		742,800+	3,299,380+
Twin Lakes	McPherson	19,200	86,000
Upper Vermillion Missouri	Clay	11,200	168,000
	Lincoln	15,300	149,180
	Turner	106,400	1,037,400
Total		132,900	1,354,580
Veblen	Grant	70,600	211,800
	Marshall	15,400	115,500
	Roberts	431,900	1,295,700
Total		517,900	1,623,000
Vermillion East Fork	Kingsbury	NA	NA
	Lake	NA	NA
	McCook	NA	NA
	Miner	NA	NA
	Turner	3,400	5,100
Vermillion East Fork : Antelope Lake	Clark	34,400	77,400
Vermillion East Fork : Reid Lake	Clark	6,000	13,500
Vermillion East Fork : Spirit Lake	Clark	4,700	4,940
	Kingsbury	9,200	20,700
Total		13,900	25,640

Vermillion East Fork : Willow Lake	Clark	13,100	29,480
VERMILLION EAST FORK (TOTAL)		70,800	151,120
Vermillion West Fork	McCook	NA	NA
	Miner	NA	NA
	Turner	6,800	10,200
Wakonda	Clay	14,100	84,600
	Turner	NA	NA
Wall Lake	Lincoln	25,100	70,400
	Minnehaha	17,300	75,690
	Turner	28,600	66,370
Total		71,000	212,460
Warren : Morris Creek	Davison	13,500	25,070
	Sanborn	24,000	54,000
Total		37,500	79,070
Warren : West James	Beadle	119,500	568,000
	Jerauld	28,200	106,150
	Sanborn	121,000	730,000
Total		268,700	1,404,150
Warren : Wolsey	Beadle	21,200	80,000
	Hand	1,300	2,030
Total		22,500	82,030
WARREN (TOTAL)		328,700	1,565,250
White Lake	Aurora	24,300	55,000
	Brule	NA	NA
Wilmot	Grant	66,600	149,850
	Roberts	86,300	194,180
Total		152,900	344,030

fer. Then, the average saturated thickness was determined by one of three methods:

1. Using published average saturated thickness
2. Estimating average saturated thickness, or
3. If enough detailed data were available an isopach map was constructed and each saturated thickness interval was planimetered.

Once the number of acres for each aquifer or each thickness increment within an aquifer were known, the value for saturated thickness was multiplied by the constant specific yield value of 0.15 to determine the total recoverable ground water.

Table 3 lists all of the counties in eastern South Dakota with the known aquifers and/or aquifer management units present in each county. Where data are available to calculate or make reasonable estimates, recoverable ground-water figures are provided. Table 3 also shows the number of acres underlain by each aquifer or aquifer management unit as well as the amount of recoverable water for each aquifer or aquifer management unit. In addition, table 3 provides total recoverable ground-water that is available in each county from the surficial deposits.

Table 4 is a list of all known aquifers or aquifer management units in eastern South Dakota. The listing provides numbers of acres and recoverable ground water by county for each aquifer as well as total area and total recoverable ground water for each aquifer or aquifer management unit.

The Big Sioux River contains many tributaries which may have substantial ground-water supplies but their presence has not been documented. The location of these major tributaries are shown on plates 4 and 7 by dashed lines and total acreages by county are listed on table 5.

Bedrock Aquifers

Porosity values, specific yields, and/or recoverable water data for bedrock aquifers in eastern South Dakota are nearly nonexistent. The following list will show the estimated values assumed for making storage figure calculations in this report.

Bedrock Aquifer	Assumed Porosity (percent)	Assumed Recoverable water (specific yield)
Niobrara Marl	NA	NA
Codell Sandstone	--	0.10
Dakota Formation	15	0.075
Inyan Kara	15	0.075
Madison	15	0.05
Red River	12	0.04

The values listed above have been applied uniformly over the entire area of each bedrock unit.

Table 6 lists the counties in eastern South Dakota along with recoverable ground-water totals for each bedrock aquifer present in the county. The total amount of recoverable water present in

TABLE 5

Additional acreage in Big Sioux Basin which may contain Big Sioux Aquifer potential

(These are identified on plates 4 and 7 by dashed lines and are unnamed aquifer management units of Big Sioux Aquifer)

COUNTY	ACRES
Brookings	53,506
Codington	33,379
Day	3,089
Deuel	498
Grant	9,366
Lake	10,064
Lincoln	7,274
Minnehaha	16,142
Moody	32,084
Roberts	996
Union	6,277
TOTAL	172,675

TABLE 6

List of counties showing total recoverable ground water from bedrock aquifers

Aquifer (by county)	Area of aquifer (square miles)	Recoverable water (acre-feet)
AURORA		
Niobrara Marl	700	NA
Codell Sandstone	707	905,000
Greenhorn Limestone	719	NA
Dakota Formation	719	10,526,200
TOTAL		11,431,200
BEADLE		
Niobrara Marl	1,249	NA
Codell Sandstone	986	1,262,000
Greenhorn Limestone	1,250	NA
Dakota Formation	1,250	18,000,000
TOTAL		19,262,000
BON HOMME		
Niobrara Marl	470	NA
Codell Sandstone	535	684,800
Greenhorn Limestone	573	NA
Dakota Formation	573	4,950,700
TOTAL		5,635,500
BROOKINGS		
Niobrara Marl	570	NA
Greenhorn Limestone	700	NA
Dakota Formation	700	3,796,800
TOTAL		3,796,800

BROWN

Niobrara Marl	1,700	NA
Greenhorn Limestone	1,750	NA
Dakota Formation	1,750	25,200,000
Inyan Kara Group	576	1,382,400
TOTAL		26,582,400

BRULE

Niobrara Marl	837	NA
Codell Sandstone	829	1,061,100
Greenhorn Limestone	837	NA
Dakota Formation	837	12,655,400
TOTAL		13,716,500

BUFFALO

Niobrara Marl	479	NA
Codell Sandstone	37	47,400
Greenhorn Limestone	479	NA
Dakota Formation	479	7,357,400
Inyan Kara Group	252	483,800
TOTAL		7,888,600

CAMPBELL

Niobrara Marl	774	NA
Greenhorn Limestone	774	NA
Dakota Formation	774	2,600,000
Inyan Kara Group	774	11,145,600
Madison Group	774	9,907,200
Red River	774	11,888,600
TOTAL		35,541,400

CHARLES MIX

Niobrara Marl	1,100	NA
Codell Sandstone	1,134	1,451,500
Greenhorn Limestone	1,134	NA
Dakota Formation	1,134	14,152,300
TOTAL		15,603,800

CLARK

Niobrara Marl	974	NA
Codell Sandstone	37	47,400
Greenhorn Limestone	974	NA
Dakota Formation	974	6,545,300
TOTAL		6,592,700

CLAY

Niobrara Marl	75	NA
Greenhorn Limestone	307	NA
Dakota Formation	403	5,803,200
TOTAL		5,803,200

CODINGTON

Niobrara Marl	701	NA
Greenhorn Limestone	701	NA
Dakota Formation	701	4,206,000
TOTAL		4,206,000

DAVISON

Niobrara Marl	400	NA
Codell Sandstone	423	541,400
Greenhorn Limestone	407	NA
Dakota Formation	407	2,442,000
TOTAL		2,983,400

DAY

Niobrara Marl	1,061	NA
Greenhorn Limestone	1,061	NA
Dakota Formation	1,061	10,185,600
TOTAL		10,185,600

DEUEL

Niobrara Marl	450	NA
Greenhorn Limestone	632	NA
Dakota Formation	632	3,033,600
TOTAL		3,033,600

DOUGLAS

Niobrara Marl	400	NA
Codell Sandstone	435	556,800
Greenhorn Limestone	435	NA
Dakota Formation	435	7,516,800
TOTAL		8,073,600

EDMUNDS

Niobrara Marl	1,158	NA
Greenhorn Limestone	1,158	NA
Dakota Formation	1,158	15,285,600
Inyan Kara Group	1,070	4,108,800
Madison Group	450	1,440,000
Red River	943	5,432,800
TOTAL		26,267,200

FAULK

Niobrara Marl	1,018	NA
Greenhorn Limestone	1,018	NA
Dakota Formation	1,018	14,659,200
Inyan Kara Group	882	3,175,200
Madison Group	360	864,000
Red River	864	3,538,900
TOTAL		22,237,300

GRANT

Niobrara Marl	260	NA
Greenhorn Limestone	688	NA
Dakota Formation	683	3,278,400
TOTAL		3,278,400

HAMLIN

Niobrara Marl	520	NA
Greenhorn Limestone	520	NA
Dakota Formation	520	3,744,000
TOTAL		3,744,000

HAND

Niobrara Marl	1,426	NA
Codell Sandstone	2	2,600
Greenhorn Limestone	1,426	NA
Dakota Formation	1,426	22,245,600
Inyan Kara Group	1,012	2,914,600
Red River	40	51,200
TOTAL		25,214,000

HANSON

Niobrara Marl	25	NA
Codell Sandstone	42	53,800
Greenhorn Limestone	22	NA
Dakota Formation	22	52,800
TOTAL		106,600

HUGHES

Niobrara Marl	759	NA
Greenhorn Limestone	759	NA
Dakota Formation	759	13,115,500
Inyan Kara Group	759	6,375,600
Madison Group	576	2,764,800
Red River	396	506,900
TOTAL		22,762,800

HUTCHINSON

Niobrara Marl	500	NA
Codell Sandstone	483	618,200
Greenhorn Limestone	684	NA
Dakota Formation	684	2,298,200
TOTAL		2,916,400

HYDE

Niobrara Marl	866	NA
Greenhorn Limestone	866	NA
Dakota Formation	866	15,795,800
Inyan Kara Group	866	6,235,200
Madison Group	324	414,700
Red River	378	967,700
TOTAL		23,413,400

JERAULD

Niobrara Marl	531	NA
Codell Sandstone	460	588,800
Greenhorn Limestone	531	NA
Dakota Formation	531	8,920,800
TOTAL		9,509,600

KINGSBURY

Niobrara Marl	814	NA
Codell Sandstone	602	770,600
Greenhorn Limestone	814	NA
Dakota Formation	814	8,595,800
TOTAL		9,366,400

LAKE

Split Rock Creek	NA	NA
Niobrara Marl	520	NA
Codell Sandstone	20	1,300
Greenhorn Limestone	487	NA
Dakota Formation	487	3,628,800
TOTAL		3,630,100

LINCOLN

Niobrara Marl	110	NA
Greenhorn Limestone	484	NA
Dakota Formation	484	4,297,900
TOTAL		4,297,900

McCOOK

Niobrara Marl	100	NA
TOTAL		NA

McPHERSON

Niobrara Marl	1,157	NA
Greenhorn Limestone	1,157	NA
Dakota Formation	1,157	13,884,000

Inyan Kara Group	1,157	6,109,000
Madison Group	180	144,000
Red River	846	4,873,000
TOTAL		25,010,000
MARSHALL		
Niobrara Marl	873	NA
Greenhorn Limestone	889	NA
Dakota Formation	889	9,387,800
TOTAL		9,387,800
MINER		
Niobrara Marl	510	NA
Codell Sandstone	398	509,400
Greenhorn Limestone	329	NA
Dakota Formation	329	7,776,000
TOTAL		8,285,400
MINNEHAHA		
Split Rock Creek Formation	69	99,400
Niobrara Marl	60	NA
TOTAL		99,400
MOODY		
Split Rock Creek Formation	NA	NA
Niobrara Marl	180	NA
Greenhorn Limestone	423	NA
Dakota Formation	423	1,982,900
TOTAL		1,982,900
POTTER		
Niobrara Marl	898	NA
Greenhorn Limestone	898	NA
Dakota Formation	898	12,069,100
Inyan Kara Group	898	7,543,200
Madison Group	898	10,057,600
Red River	898	6,896,600
TOTAL		36,566,500

ROBERTS

Niobrara Marl	440	NA
Greenhorn Limestone	1,111	NA
Dakota Formation	1,111	6,171,400
TOTAL		6,171,400

SANBORN

Niobrara Marl	530	NA
Codell Sandstone	560	716,800
Greenhorn Limestone	574	NA
Dakota Formation	574	8,678,900
TOTAL		9,395,700

SPINK

Niobrara Marl	1,509	NA
Codell Sandstone	60	76,800
Greenhorn Limestone	1,511	NA
Dakota Formation	1,511	19,219,900
TOTAL		19,296,700

SULLY

Niobrara Marl	1,058	NA
Greenhorn Limestone	1,058	NA
Dakota Formation	1,058	16,504,800
Inyan Kara Group	1,058	8,887,200
Madison Group	1,058	15,235,200
Red River	1,058	5,417,000
TOTAL		46,044,200

TURNER

Niobrara Marl	360	NA
Greenhorn Limestone	290	NA
Dakota Formation	325	933,100
TOTAL		933,100

UNION

Niobrara Marl	5	NA
Greenhorn Limestone	310	NA
Dakota Formation	452	7,810,600
TOTAL		7,810,600

WALWORTH

Niobrara Marl	742	NA
Greenhorn Limestone	742	NA
Dakota Formation	742	5,342,400
Inyan Kara Group	742	7,123,200
Madison Group	742	10,684,800
Red River	742	8,927,700
TOTAL		32,078,100

YANKTON

Niobrara Marl	210	NA
Greenhorn Limestone	523	NA
Dakota Formation	523	7,907,800
TOTAL		7,907,800

each bedrock aquifer is shown in table 7.

TASK IV: COMPUTERIZED DATA BASE SYSTEM FOR GROUND-WATER DATA

Task IV specified development of an ADABAS data base management system for storage and retrieval of certain geohydrologic records as listed below:

A. Well logs and test hole logs

B. Observation well data

Coding manuals for these data are included as appendices A and B, respectively, in this report. Anyone desiring information about the structure and operation of this data base, or anyone interested in obtaining data from this data base, should contact the head of Basic Data Section, South Dakota Geological Survey, Science Center, Vermillion, South Dakota. Phone (605)677-5227.

TABLE 7

List of bedrock aquifers showing total amount of recoverable ground water in eastern South Dakota

NA = data not available

Aquifer	Recoverable water (acre-feet)
Split Rock Creek Formation	99,400
Niobrara Marl	NA
Codell Sandstone	9,895,700
Greenhorn Limestone	NA
Dakota Formation	381,104,000
Inyan Kara Group	65,483,800
Madison Group	51,512,300
Red River	48,500,400
Winnipeg	NA
Deadwood	NA
Sioux Quartzite	NA
Igneous and Metamorphic	NA

APPENDIX A

South Dakota Geological Survey

Open-File Report No. 1-CR

STATE OF SOUTH DAKOTA
William J. Janklow, Governor

DEPARTMENT OF WATER AND NATURAL RESOURCES
Warren R. Neufeld, Secretary

GEOLOGICAL SURVEY
Duncan J. McGregor, State Geologist

Open-file Report No. 1-CR

DESCRIPTION OF FILE 'SDGS' AND INSTRUCTION MANUAL FOR OBSERVATION WELL AND TEST HOLE LOG FORMS

by

Rachel A. Barari

Science Center
University of South Dakota
Vermillion, South Dakota
1981

CONTENTS

RECORD TYPE L -- continued.

ILLUSTRATIONS

Figures

Figures -- continued.

APPENDICES

INTRODUCTION

The ADABAS data base management system has been chosen by the South Dakota Geological Survey for storage and retrieval of hydrologic data. The ADABAS file 'SDGS' is being created on the computer at the University of South Dakota for use by the Department of Water and Natural Resources.

Initially, the system is being designed to store and retrieve four types of data which are:

1. Observation well and test hole logs
2. Observation well level readings
3. Water quality data
4. Geologic sample logs

Communication with ADABAS such as data entry and manipulation will be accomplished by using COM-PLETE , a time sharing system, in conjunction with ADAMINT, a high-level data manipulation language. Information can be output by using COM-PLETE and ADAMINT or by using ADACOM, a report writer.

Figure 1 shows the general relationships among different steps in data management under ADABAS. First the needs of the user are evaluated and a dictionary of file descriptions and variables is built. Using the information provided by the dictionary, one can write application programs to input to the data base, modify it or output appropriate information. ADABAS also provides several query and output methods. Presently, ADACOM is being used with the data system.

Using the computer to store information has created the need for standardized data entry forms. The purpose of this manual is to provide the necessary documentation to correctly and efficiently fill out the data entry forms for the Observation Well and Test Hole Log Records that are being used by the Department of Water and Natural Resources.

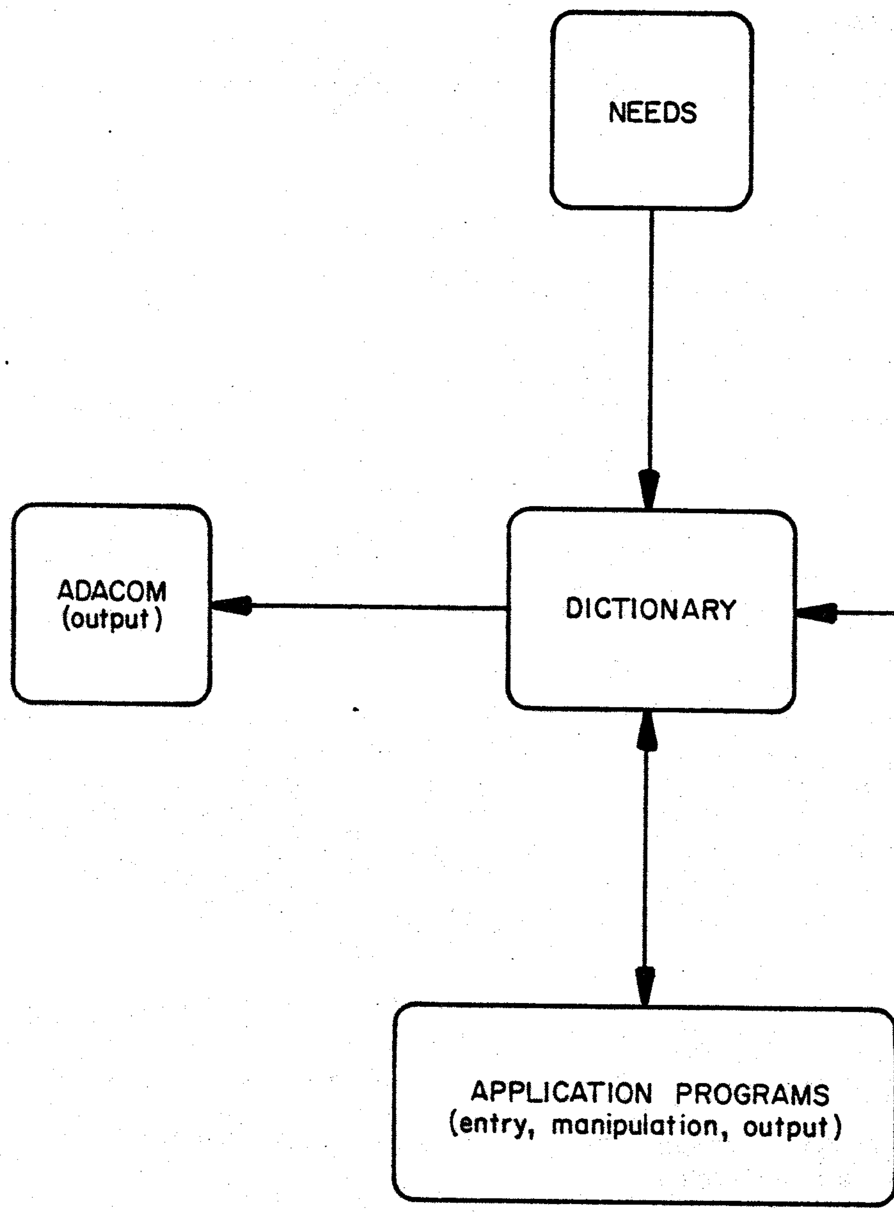


FIGURE I. SYSTEM FLOWCHART

DESCRIPTION OF THE FILE

The 'SDGS' file contains 158 variables that are distributed among five different record types. A complete alphabetical list of the variables is found in Appendix A, page 17.

Record types L and D contain observation well and test hole information. Record type P is for observation well level readings. Type W contains water quality analyses and type G is for geologic sample analyses.

DEFINITION OF TERMS

Numeric data is composed of the digits 0 - 9, decimal point and sign (+,-). The plus sign is implied and not usually written out.

Alphabetic data is any of the characters A - Z and the characters #, $ and @.

Alphanumeric data is an alphabetic character or digit. Alphabetic characters and digits can be combined to form alphanumeric data such as observation well names, i.e. UN-77V.

Special characters, such as the blank, ;, =, +, -, /, >, <, or ? may be used in text and in alphanumeric data.

Embedded blanks are those spaces found within a set of characters. An example of an observation well name with embedded blanks looks like 'UN - 77 V'. Without embedded blanks the observation well name looks like 'UN-77V'.

DATA ENTRY INFORMATION

Each record has its own data entry form. The records will be described in detail with examples to illustrate the proper way to fill out each variable. The variables are listed in the order that they appear on the forms.

Several rules apply to all record types. They are:

1. Slash all zeroes. Ø

2. Left-justify (begin in left-most column) all alphabetic and alphanumeric data unless otherwise specified.

3. Right-justify (end in the right-most column) all numeric data unless otherwise specified.

4. Print the information entered. You will not have to capitalize all text. If the keypuncher cannot read your record, you will then be required to capitalize all work submitted.

5. Use the individual variables. NOTES is only for information that will not fit anywhere else on the form.

Each appendix referred to in this manual is by no means complete. If the variable you need to use is not on the list please contact Rachel Barari or Lynn Hedges at the South Dakota Geological Survey, phone 677-5227 or Kathi Simon at the Department of Water and Natural Resources in Pierre, phone 773-4208.

FIG. 2. OBSERVATION WELL AND LITHOLOGIC LOG RECORD

DEPARTMENT OF WATER AND NATURAL RESOURCES

RECORD TYPE [L]

LOCATION ___ N/S ___ E/W ___ LATITUDE ___ LONGITUDE ___

COUNTY ___ R LAND OWNER ___

PROJECT ___ DATE ___

COMPANY ___ METHOD ___

DRILLER ___ DRILLERS LOG ___

GEOLOGIST ___ GEOLOGISTS LOG ___

AQUIFER ___ E-LOG ___ SAMPLES ___

MANAGEMENT UNIT ___

BASIN ___ WELL ___

TEST HOLE ___ OBSERVATION WELL ___

GROUND SURFACE ELEVATION ___ A/T/I CASING TOP ELEVATION ___ A/T/I

TOTAL DRILL HOLE DEPTH ___ TOTAL CASING AND SCREEN ___

CASING TYPE ___ CASING DIAMETER ___

SCREEN TYPE ___

SCREEN LENGTH ___ STICK-UP ___ WELL MAINTENANCE DATE ___

NOTES (1) ___

NOTES (2) ___

NOTES (3) ___

NOTES (4) ___

NOTES (5) ___

RECORD TYPE L

The Observation Well and Lithologic Log Record is the heading page for observation wells and test holes.

LOCATION - - - - - - - - - - - - 17 alphanumeric characters with the format IIID-RRD-SSABCD12 . I is the township number. R is the range number. D is the direction of the township or range number and S is the section number. ABCD is the subsection description and the last two columns contain a number that designates several logs at one location. The first 15 columns must be filled; the last two only when needed.

Examples:

|1Ø2N-54W-23AABC 1|

|Ø97N-53W-1ØAB |

|ØØ2S-Ø3E-Ø5DAC   2|

For data location system, see appendix G.

LATITUDE - - - - - - - - - - - - 6 digits plus decimal point. The format is DD.MMSS where D is degrees, M is minutes, and S is seconds.

Examples:

|45.2759|

|43.ØØØØ|

LONGITUDE- - - - - - - - - - - 7 digits plus decimal point. The format is DDD.MMSS where D is degrees, M is minutes, and S is seconds.

Examples:

|Ø99.1543|

|1ØØ.2ØØ1|

COUNTY - - - - - - - - - - - - - 20 characters. Write the county name in full. The B in the 20th column is to be used only when the site is located in the Sisseton Indian Reservation in Marshall, Day, Codington, Grant, or Roberts Counties.

Examples:

| Charles Mix |

| Roberts R |

LAND OWNER - - - - - - - - - - 20 characters. First initial and last name. If the owner is not a person, i.e., State of South Dakota, cross out the period and write in the name.

Examples:

| W. Kramer |

| South Dakota |

PROJECT- - - - - - - - - - - - - 25 characters. Write in the name of the project for which the log was recorded. The project name must be taken from the list in Appendix B, page 20.

Examples:

| Sioux Falls-Brandon Study |

| Day County Study |

DATE - - - - - - - - - - - - - - - 10 characters. All columns must be filled. The format is <u>MM-DD-YYYY</u> where <u>MM</u> is month, <u>DD</u> is day, and <u>YYYY</u> is year.

Examples:

| Ø6-26-1971 | | 11-ØØ-196Ø |

COMPANY- - - - - - - - - - - - - - 25 characters. Write in the drilling company name taken from Appendix C, page 22.

Examples:

| Panhandle Drilling |

| SDGS |

METHOD - - - - - - - - - - - - - - 10 characters. Write in the drilling method used. ROTARY, AUGER, CABLE TOOL, BORED, AIR DRILL, MIST DRILL, MUD DRILL, REVERSE ROTARY OR JETTED.

Examples:

| Rotary |

| Reverse |

DRILLER- - - - - - - - - - - - - - 25 characters. First initial and last name. If more than one driller use a slash between the names.

Examples:

| M. Thompson |

| L. Helseth/M. Thompson |

DRILLERS LOG - - - - - - - - - - 1 character. Put in an X if the log is an unedited drillers log.

GEOLOGIST- - - - - - - - - - - - 25 characters. Write in the name of the geologist responsible for the log. First initial and last name.

Examples:

S. Burch

G. Johnson

GEOLOGISTS LOG - - - - - - - - - 1 character. Put in an X if the log has been edited, rewritten or compiled by a geologist.

AQUIFER- - - - - - - - - - - - - 25 characters. Write in the name of the aquifer taken from Appendix D, page 25.

Examples:

Big Sioux

Tyndall-Scotland

E-LOG- - - - - - - - - - - - - - 1 character. Put in an X if an E-log has been taken. Indicate the type of log in NOTES at the bottom of the page. Geophysical or electrical/radioactive, etc.

SAMPLES- - - - - - - - - - - - - 1 character. Put in an X if a sample log was taken. Indicate the sampling interval (S) in the NOTES at the bottom of the page.

MANAGEMENT-UNIT- - - - - - - - 20 characters. Write in the name of the management unit from Appendix E, page 26.

Examples:

Cheyenne

Southern Brown

BASIN- - - - - - - - - - - - - - 20 characters. Write in the name of the drainage basin in which the log is located. The basins are listed in Appendix F, page 27.

Examples:

Little Missouri

Minnesota-Whetstone

WELL - - - - - - - - - - - - - - 10 characters. Write in the South Dakota Geological Survey's well identification or name for the log. No embedded blanks are allowed, although trailing blanks are acceptable. This name may or may not agree with the identification chosen by Water Rights which is given in the variable OBSERVATION WELL.

Examples:

BDS-77

SFB-1

TEST HOLE- - - - - - - - - - - - 10 characters. Write in the test hole number. No embedded blanks are allowed, although trailing blanks are acceptable.

Examples:

F-3A

A-1

OBSERVATION WELL - - - - - - - 10 alphanumeric characters. Write in the Water Rights observation well identification or name. No embedded blanks are allowed, although trailing blanks are acceptable. The format is CC-YYSS where CC is the county code, YY is the year, and SS is the sequence drilled within that county that year, A-Z, AA-ZZ, BA-BZ, etc.

The OBSERVATION WELL name may or may not agree with the identification chosen by the South Dakota Geological Survey which is given in the variable WELL.

Examples:

| B | D | - | 7 | 8 | A | A | | | |

| H | U | - | 8 | Ø | D | | | | |

GROUND SURFACE ELEVATION - - 6 digits plus decimal point. Write in the ground surface elevation as measured in feet. In the space after the elevation choose one of the following to indicate how the elevation was measured.

A - altimeter

T - topographic map

I - instrument

Examples:

| 1 | 6 | 3 | 5 | . | Ø | Ø | | T |

| 1 | 5 | 2 | 3 | . | 5 | 7 | | A |

CASING TOP ELEVATION - - - - 6 digits plus decimal point. Fill in the same way as GROUND SURFACE ELEVATION.

TOTAL DRILL HOLE DEPTH - - - 5 digits plus decimal point. Measured in feet.

Examples:

| | | 2 | 7 | . | 2 |

| 1 | 5 | 4 | 3 | . | Ø |

TOTAL CASING AND SCREEN- - - 5 digits plus decimal point. Total length of the casing and screen measured in feet.

Examples:

6.Ø

150.5

CASING TYPE- - - - - - - - - - 20 characters. Write in the type of casing installed.

Examples:

PVC

Stainless Steel

CASING DIAMETER- - - - - - - - 3 digits plus decimal point. Diameter of the casing measured in inches.

Examples:

2.Ø

1.5

SCREEN TYPE- - - - - - - - - - 30 characters. Enter the type of screen used. PLASTIC, STAINLESS STEEL, STEEL, PLEXIGLASS, FIBERGLASS, and MFG. for manufactured, or HM. for homemade.

Examples:

Stainless Steel, Hm.

PVC, MFG.

SCREEN LENGTH- - - - - - - - - - 5 digits plus decimal point. Length of the screen installed, measured in feet.

Examples:

2.6

5.Ø

STICK-UP - - - - - - - - - - - - - 5 digits plus decimal point. Casing, pipe length above ground level measured in feet.

Examples:

2.2

3.Ø

WELL MAINTENANCE DATE- - - - 10 characters. All columns must be filled. Contains the most recent well maintenance date. The format is <u>MM-DD-YYYY</u> where <u>MM</u> is month, <u>DD</u> is day and <u>YYYY</u> is year.

Examples:

Ø5-22-1977

1Ø-ØØ-1956

NOTES(1-5) - - - - - - - - - - - 5 variables of 50 characters each. Write in any comments appropriate to the record type. Always fill NOTES(1) before NOTES(2), NOTES(2) before NOTES(3), etc. NOTES(2), NOTES(3), NOTES(4), and NOTES(5) should be indented 2 spaces.

FIG. 3. LITHOLOGIC LOG

RECORD TYPE D

LOCATION ____ N/S ____ E/W ____

COUNTY ____ R

LATITUDE ____

LONGITUDE ____

DESCRIPTION	BEGIN DEPTH	END DEPTH

NOTES (1)

NOTES (2)

NOTES (3)

NOTES (4)

NOTES (5)

RECORD TYPE D

Record type D contains the Lithologic Log for the observation well and/or test hole. Use as many pages as necessary to complete the log. NOTES should be filled in only on the last sheet.

LOCATION - - - - - - - - - - - Same as in Record Type L. See page 6.

COUNTY - - - - - - - - - - - - Same as in Record Type L. See page 7.

LATITUDE - - - - - - - - - - - Same as in Record Type L. See page 6.

LONGITUDE- - - - - - - - - - - Same as in Record Type L. See page 6.

DESCRIPTION- - - - - - - - - - Each line, is 41 characters long. You may use up to 5 lines to describe the lithology of each interval. Lines 2 - 5 should be indented 2 spaces.

BEGIN DEPTH- - - - - - - - - - 4 digits. Fill in the depth to the top of the logged interval. In most cases this will be 0. Measured in feet.

END DEPTH- - - - - - - - - - - 4 digits. Write in the lowest depth of the lithologic interval being described. Measured in feet.

NOTES(1-5) - - - - - - - - - - 5 variables of 50 characters each. Write in any comments appropriate to the record type. Fill in NOTES(1) before NOTES(2), NOTES(2) before NOTES(3), etc. NOTES(2), NOTES(3), NOTES(4), and NOTES(5) should be indented 2 spaces.

For examples of the variables explained above see Figure 4.

FIG. 4. LITHOLOGIC LOG

RECORD TYPE D

LOCATION 100N-52W-33CCDC 3

COUNTY Turner

LATITUDE 43.2554

LONGITUDE 097.0003

DESCRIPTION	BEGIN DEPTH	END DEPTH
Topsoil, black, silty	0	2
Clay, brown, sandy, pebbly (till)		51
Gravel, fine to coarse, and fine to		
coarse sand		80
Clay, light olive-gray to tan, sandy,		
with stringers of "western sand" below		
about 85 feet; mainly sand below		
90 feet; some gravelly zones		100

NOTES (1) Dry hole

NOTES (2)

NOTES (3)

NOTES (4)

NOTES (5)

APPENDIX A - VARIABLE LIST

VARIABLE	DESCRIPTOR*	RECORD TYPES	UNITS
Acidified		W	
Acidity		W	
ADJ-SAR		W	
Al2O3		G	%
Aluminum		W	PPM
Alunite		G	%
Anions		W	ME/L
Arsenic	DE	WG	PPM
Barium		WG	PPM
Bed, Basin		GLW	
Begin-depth, Field-TDS		DW	FT, PPM
Beryllium		WG	PPM
Bicarbonate		W	PPM
Boron, Reading		WGP	PPM, FT
Cadmium		WG	PPM
Calcite, Casing-screen		GL	%, FT
Calcite-mix, Stick-up		GL	%, FT
Calcium	DE	W	PPM
CaO		G	%
Carbonate		W	PPM
Casing-elevation		WL	FT
Casing-type		WL	
Cations		W	ME/L
Cerium, Field-Cond		GW	PPM, UMHOS
Cesium		WG	PPM
Chloride		WG	PPM
Chlorite		G	%
Chromium		WG	PPM
Clean-container		W	
Clinoptilolite		G	%
Cobalt		G	PPM
Code		WG	
Collector		WG	
Complete-location	DE	LWGD	
Copper		WG	PPM
County	DE	LWGD	
Cristobalite		G	%
CTE		LW	
Date	DE	LWGP	
Depth		D	FT
D-log		L	
Dolomite, Diameter		GL	%, IN
Driller		L	
Drilling-company		L	
Elevation		LW	FT
E-log, Office		LW	
Fe2O3		G	%

VARIABLE	DESCRIPTOR*	RECORD TYPES	UNITS
FeO		G	%
Field-PH		W	
Filtered		W	
Fluoride		W	PPM
Formalin-treated		W	
Formation, Aquifer	DE	WGL	
Geologist		L	
G-log		L	
Gold,Field-Temp		GW	PPM, DEG C
GSE		LW	
Gypsum		G	%
Hardness		W	PPM
Illite		G	%
Iron		W	PPM
Jarosite		G	%
K2O		G	%
Kaolinite		G	%
K-feldspar, Screen-length		GL	%, FT
Lake		W	
Lanthanum		G	PPM
Latitude		LWGD	
L-description, I<=5		D	
Lead		WG	PPM
Lithium		WG	PPM
Locate (super descriptor)	DE	PWGDL	
Location, M-unit		LW	
Log (super descriptor)	DE	LDGPW	
Longitude		LWG	
Magnesium	DE	W	PPM
Manganese		WG	PPM
M-description		G	
Member, W-M-Date		GL	
Mercury		WG	PPM
Method		L	
MgO		G	%
Mixed-layer-clay		G	%
Molybdenum, ALK-MO		GW	PPM
Na.		W	%
Na2O		G	%
Nickel		G	PPM
Nitrate	DE	W	PPM
Notes(I) I<=5		WGLD	
Obs-well	DE	LWP	
Optical-data		G	
Other, Screen-type		WGL	
Otheri		WG	
Owner		LW	
Phosphorous, ALK-P		GW	PPM
Plagioclase, TDH-Depth		GL	%, FT
Potassium		W	PPM

VARIABLE	DESCRIPTOR*	RECORD TYPES	UNITS
Project		LWG	
Pump		W	
Pyrite		G	%
Quartz		G	%
Record-type	DE	LWGDP	
Rhodochrosite		G	%
RSC		W	ME/L
Rubidium		WG	PPM
Sample-no.		WG	
Samples, Sample-type		LW	
SAR		W	
Screened		W	
Selenium	DE	WG	PPM
Siderite		G	%
Silicon		W	PPM
Silver		WG	PPM
SiO2		G	%
Smectite		G	%
Sodium	DE	W	PPM
Stibium, Antimony		WG	PPM
Stream		W	
Strontium		WG	PPM
Sulfate		W	PPM
Sulfur		G	PPM
Temperature		W	DEG C
Test-hole		L	
Thorium		G	PPM
TiO2		G	%
Total-clay		G	%
Total-conductivity		W	UMHOS
Total-percent		G	%
Total-solids	DE	W	PPM
Uranium		G	PPM
Usage, Group		WG	
Vanadium		G	PPM
Water-depth		W	FT
Water-elevation		W	FT
Well-depth	DE	WL	FT
Well-no.	DE	LW	
Where-collected		W	
Zinc		WG	PPM

* A descriptor is a primary search element in the ADABAS data base management system.

APPENDIX B - PROJECT NAMES

Aurora County Study
Beadle County Study
Bennett County Study
Bon Homme County Study
Brookings County Study
Brown County Study
Brule County Study
Buffalo County Study
Campbell County Study
Charles Mix County Study
Clark County Study
Clay County Study
Codington County Study
Davison County Study
Day County Study
Deuel County Study
Domestic Well
Douglas County Study
Edmunds County Study
Fairview City Study
Faulk County Study
Grant County Study
Gregory County Study
Hamlin County Study
Hand County Study
Hanson County Study
Hughes County Study
Hutchinson County Study
Hyde County Study
Iroquois City Study
Irrigation Test
Irrigation Well
Jerauld County Study
Kingsbury County Study
Lake County Study
Lincoln County Study
McCook County Study
McPherson County Study
Marshall County Study
Miner County Study
Minnehaha County Study
Moody County Study
Potter County Study
Roberts County Study
Sanborn County Study
Sioux Falls-Brandon Study
SE So. Dak. Water Project
Spink County Study
Turner County Study

Union County Study
Walworth County Study
Whitewood Creek Study
Yankton County Study

APPENDIX C - DRILLING COMPANIES

Information enclosed in parentheses is for your use only. Do not enter it on the coding sheet.

AAA Well Co.
Aberdeen Well Drilling
Aberle Well Co.
Tim Adair Drilling
Albrecht Well Works
Alexander Drilling
Anderson Well Co. (Robert J. Anderson)
Arts Well Drilling (Arthur D. Parsons)
Avon Well Co. (A.O. VanAsperen)
Barnett Drilling
Bergeleen Drilling
Bettenhausen Drilling
Bice Drilling
Boldt Well Drilling
Bonanza Valley Drilling
Buck's Drilling (John H. Smith)
Kenneth Callen
Chase Well Drilling
Coats Well Drilling
Coffield's Drilling
Dakota Boring Co. (Darrell Ooks)
Dakota Well Drilling (Dwayne Babby)
Byron Denke Drilling
Downen Drilling
Ellingson Well Drilling
Empire Irrigation
Falk Brothers
George's Drilling (George Eisenbraun)
Graf Drilling (Joe W. Graf)
Grass Drilling
Graves Well Drilling (Lynn Graves)
Grooms Drilling
Grosch Irrigation
Grosz Drilling
G.W.J. Well Drilling (Geo. Johnson)
Haag Well Drilling
Hamm Brothers
Harv's Well Drilling (Harvey L. Grafing)
Heaton Drillers
Hickey Drilling
Lloyd Hinker
Holwell Drilling
Huron Drilling
Hutmacher Brothers
Independent Drilling
Industrial Drilling
L.H. Johnson

Kaiser Well Works
Knuth's Drilling
Knutson Well Drilling
Komes Drilling
Koranda Well Co.
Dean Kuper
Lance Drilling (M.F. Eklund)
Caryl Larsen
Layne Minnesota Co.
Lee Well Drilling (Quentin Lee)
Leer Drilling
Lehr Drilling
Lemmon Well Drilling (Eddie Bierwagon)
Walter Lenius Drilling
M & R Drilling (Merle Bandy)
Mach Brothers
John Manikowski Drilling
Marquardt Drilling
Materi Exploration
Maxwell-Ness
McCarthy Well Co.
McGregor Drilling
Meginness Drilling
Vincent Mentele
Merriman Drilling
Mid-America Exploration
Minnehaha Waters (John H. Greenfield)
Minnesota Drillers (Walter Ervin)
Missouri Valley Irrig.
Joe Monger
Mueller Brothers
Nelson Irrigation (Glenn Nelson - Mitchell)
Nichols Well & Pump
Niobrara Valley Irrig. (J.B. Russell)
Nold Well Works
Oahe Well Drilling (Dwayne Martin)
O.S.T. Water Development (Oglala Sioux Tribes)
Okeson Well Boring
Charles Oleson
Oliver Well Drilling
Olson Drilling (Clarence Olson)
Olson Well Drilling (Maurice Olson - Groton)
Panhandle Drilling
Parks Well Drilling
Paulson Well Co.
Peckham Drilling
Penn Drilling
Peters Drilling
Pfeifer Drilling
Gerald Polt
Reimers Well Service
Riverside Well Drilling (Riverside Colony - Huron)
Rohrbach Bros. Drilling
Casper Rude Drilling

Rural Water Service
Russell Drilling (Roger Russell - Harvey, N.D.)
Sargent Irrigation
Sather Drilling
Floyd Sawvell
Scherle Drilling
Ben Schrag
Seidel Well Drilling
Russell Sharpe
Sioux Well Drilling (Burl T. Collins)
SDGS
Glen Stacks
Star Drilling
Ken Stevens
Summers Drilling
Susquehanna Western (G.A. Fluke)
Thorpe Well Co.
Torgrude Well Drilling
Triad Drilling (Geo. Y. Grant)
True Drilling
USBR
USCE
USGS
Venekamp Drilling
Venturia Well Drilling
Darryl Verley Drilling
Peter Volk
Wallace Warner
Walter Weichert
Water Rights Division
Weichert Drilling (William Weichert)
James Wetmore
W.W. Drilling (Raymond Zebroski)

APPENDIX D - AQUIFERS

The information in parentheses is for your use only. Do not enter it on the coding sheet.

Alluvial (West River on respective rivers and streams)
Altamont No. 2
Arikaree
Bad
Big Sioux
Bowdle
Choteau
Cobb
Codell
Corsica
Coteau
Coteau-Lakes
Crow Creek
Crow Lake
Dakota
Deadwood
Deep Glacial
Deep James
Delmont
Dry Choteau
Eden
Elm
Elm Creek
Faulkton
Floyd
Fort Union
Fox Hills
Gary
Geddes
Grand
Greenhorn
Greenwood
Hell Creek
Herrick
Hidewood
Highmore
Hillsview
Hubonmix
Inyan Kara
James
Java
Lake Dakota
Lower Vermillion-Missouri
Madison
Marday
Middle James
Minnelusa
Moreau Gravels
Newcastle-Muddy
Niobrara
North Andes
Ogallala
Onaka
Orton Gravels
Pease
Pierre
Platte
Pleistocene Series
Precambrian
Red River
Roslyn
Sand Hills
Selby
Skunk Creek-Lake Madison
Slaughter
Spring
Spring Creek
Sundance
Terrace Gravels (West River on respective rivers and streams)
Tower
Tulare
Twin Lakes
Tyndall-Scotland
Veblen
Wakonda
Warren
White Lake
White River
Winnipeg

APPENDIX E - MANAGEMENT UNITS

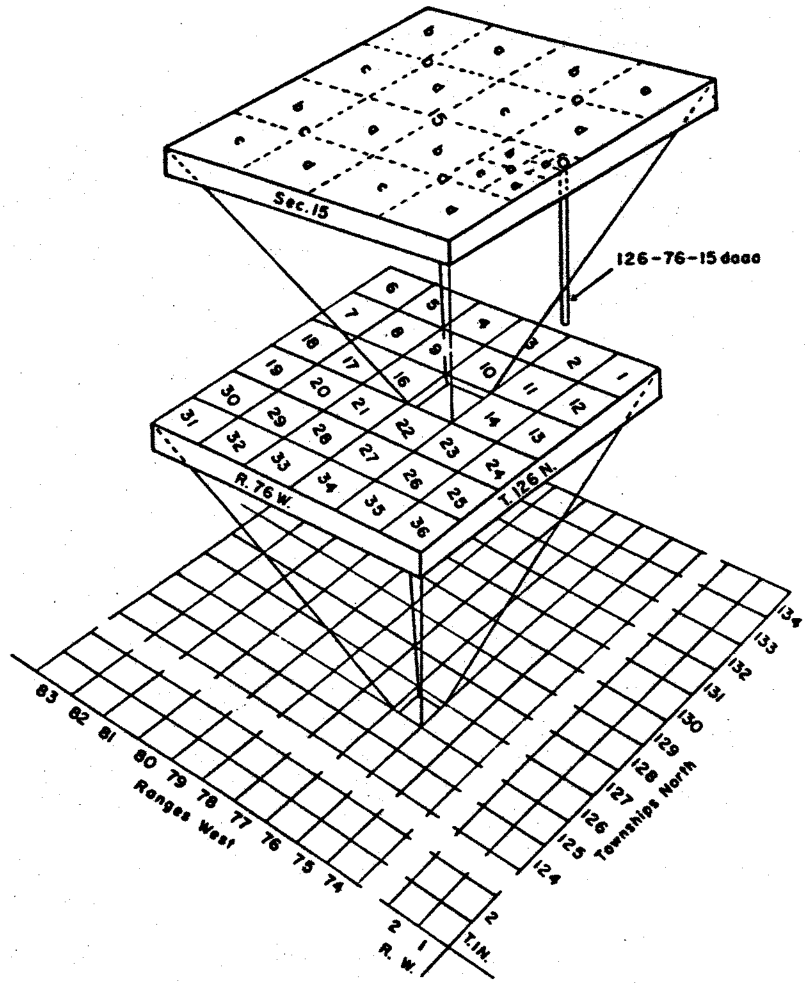
The aquifer name is listed only for reference. Do not enter it on the coding sheet.

AQUIFER	MANAGEMENT UNITS
Bad	Cheyenne
Bowdle	Hoven North
Bowdle	Hoven South
Bowdle	Lebanon
Elm	Ipswich
Elm	Northern Brown
Elm	Southern Brown
Middle James	Aberdeen
Middle James	Columbia
Tulare	East James
Tulare	Hand
Tulare	Hitchcock
Tulare	Hyde
Tulare	Miller
Tulare	Ree Heights
Tulare	Western Spink
Warren	West James
Warren	Wolsey

APPENDIX F - BASINS

Bad
Belle Fourche
Grand
James
Little Missouri
Lower Cheyenne
Minnesota/Whetstone
Missouri
Moreau
Niobrara Tributaries
Red/Rainy
Sioux
Upper Cheyenne
Vermillion
White

APPENDIX G - DATA LOCATION SYSTEM



Data Location System

Data points are located according to a numbering system based on the Federal land-survey system used in South Dakota. The location number consists of township, range, and section numbers separated by hyphens, followed by a maximum of four letters that indicate, respectively, the 160-, 40-, 10-, and 2 1/2-acre tract in which the well is located. A serial number following the last letter is used to distinguish between wells in the same tract. Thus, well 126-76-15daaa is in the NE 1/4 NE 1/4 NE 1/4 SE 1/4 sec. 15, T. 126 N., R. 76 W.

APPENDIX B

South Dakota Geological Survey

Open-File Report No. 2-CR

STATE OF SOUTH DAKOTA
William J. Janklow, Governor

DEPARTMENT OF WATER AND NATURAL RESOURCES
Warren R. Neufeld, Secretary

GEOLOGICAL SURVEY
Merlin J. Tipton, Acting State Geologist

Open-file Report No. 2-CR

DESCRIPTION OF FILE 'SDGS' AND INSTRUCTION MANUAL FOR OBSERVATION WELL LEVEL READINGS

by

Rachel A. Barari

Science Center
University of South Dakota
Vermillion, South Dakota
1981

CONTENTS

ILLUSTRATIONS

APPENDIX

INTRODUCTION

The ADABAS data base management system has been chosen by the South Dakota Geological Survey for storage and retrieval of hydrologic data. The ADABAS file 'SDGS' is being created on the computer at the University of South Dakota for use by the Department of Water and Natural Resources.

Initially, the system is being designed to store and retrieve four types of data which are:

1. Observation well and test hole logs

2. Observation well level readings

3. Water quality data

4. Geologic sample logs

Communication with ADABAS such as data entry and manipulation will be accomplished by using COM-PLETE , a time sharing system, in conjunction with ADAMINT, a high-level data manipulation language. Information can be output by using COM-PLETE and ADAMINT or by using ADACOM, a report writer.

Figure 1 shows the general relationships among different steps in data management under ADABAS. First the needs of the user are evaluated and a dictionary of file descriptions and variables is built. Using the information provided by the dictionary, one can write application programs to input to the data base, modify it or output appropriate information. ADABAS also provides several query and output methods. Presently, ADACOM is being used with the data system.

Using the computer to store information has created the need for standardized data entry forms. The purpose of this manual is to provide the necessary documentation to correctly and efficiently fill out the data entry forms that are used by the Department of Water and Natural Resources.

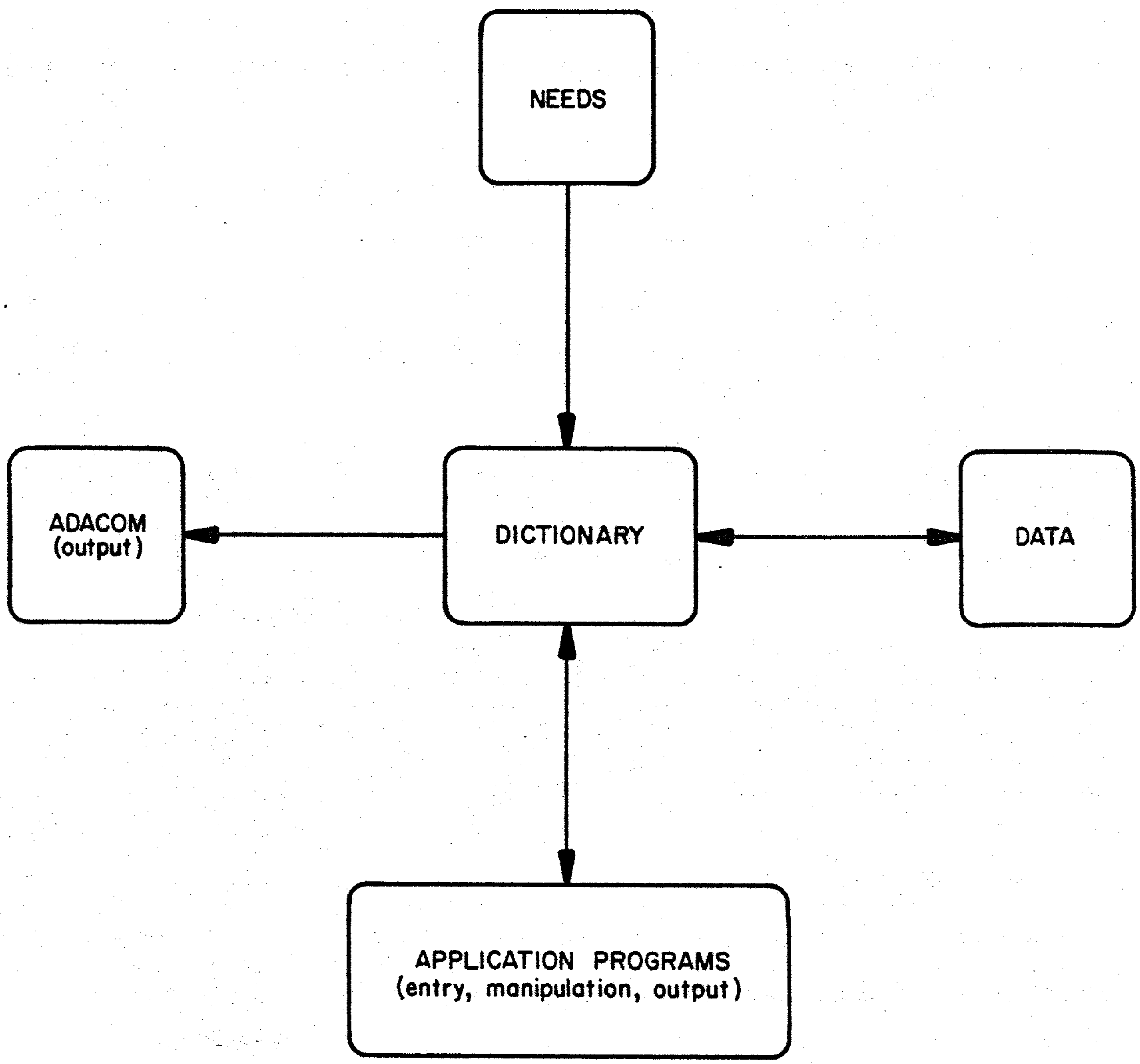


FIGURE I. SYSTEM FLOWCHART

DESCRIPTION OF THE FILE

The 'SDGS' file contains 158 variables that are distributed among five different record types. A complete alphabetical list of the variables is found in Appendix A, page 8.

Record types L and D contain observation well and test hole information. Record P is for observation well level readings. Type W contains water quality analyses and type G is for geologic sample analyses.

DEFINITION OF TERMS

Numeric data is composed of the digits 0 - 9, decimal point and sign (+,-). The plus sign is implied and not usually written out.

Alphabetic data is any of the characters A - Z and the characters ÷, $ and @.

Alphanumeric data is an alphabetic character or digit. Alphabetic characters and digits can be combined to form alphanumeric data such as observation well names, i.e. UN-77V.

Special characters, such as the blank, ;, =, +, -, /, >, <, or ? may be used in text and in alphanumeric data.

Embedded blanks are those spaces found within a set of characters. An example of an observation well name with embedded blanks looks like 'UN - 77 V'. Without embedded blanks the observation well name looks like 'UN-77V'.

DATA ENTRY INFORMATION

Each record has its own data entry form. The records will be described in detail with examples to illustrate the proper way to fill out each variable. The variables are listed in the order that they appear on the forms.

Several rules apply to all record types. They are:

1. Slash all zeroes. Ø

2. Left-justify (begin in left-most column) all alphabetic and alphanumeric data unless otherwise specified.

3. Right-justify (end in the right-most column) all numeric data unless otherwise specified.

4. Print the information entered. You will not have to capitalize all text. If the key-puncher cannot read your record, you will then be required to capitalize all work submitted.

FIG. 2. OBSERVATION WELL LEVEL READINGS

RECORD TYPE P

LOCATION	OBSERVATION WELL	DATE	READING

RECORD TYPE P

Record Type P is for Observation Well Level Readings.

LOCATION - - - - - - - - - - - 17 alphanumeric characters with the format IIID-RRD-SSABCD12. I is the township number. R is the range number. D is the direction of the township or range number and S is the section number. ABCD is the subsection description and the last two columns contain a number that designates several holes at one location. The first 15 columns must be filled; the last two only when needed.

For data location system, see appendix B.

OBSERVATION WELL - - - - - - - 10 alphanumeric characters. Fill in the observation well identification or name. No embedded blanks are allowed, although trailing blanks are acceptable.

DATE - - - - - - - - - - - - - - 10 alphanumeric characters. All columns must be filled.

READING- - - - - - - - - - - - - 6 digits plus decimal point. Fill in the well level reading (depth to water level from measuring point) as measured in feet.

For examples see Figure 3.

FIG. 3. OBSERVATION WELL LEVEL READINGS

RECORD TYPE [P]

LOCATION	OBSERVATION WELL	DATE	READING
11ØN-59W-Ø8AAAA 1	BD-76R	Ø5-14-1981	43.1Ø
1Ø9N-63W-21AAAA	BD-76H	Ø7-Ø7-1978	47.ØØ
1Ø5N-63W-36BBBB	AU-79C	Ø6-Ø4-198Ø	37.4Ø
1Ø1N-63W-23BA 2	AU-76A	Ø6-Ø5-1979	8.2Ø
1Ø4N-63W-Ø5BBCC	AU-77B	12-13-1977	42.4Ø

APPENDIX A - VARIABLE LIST

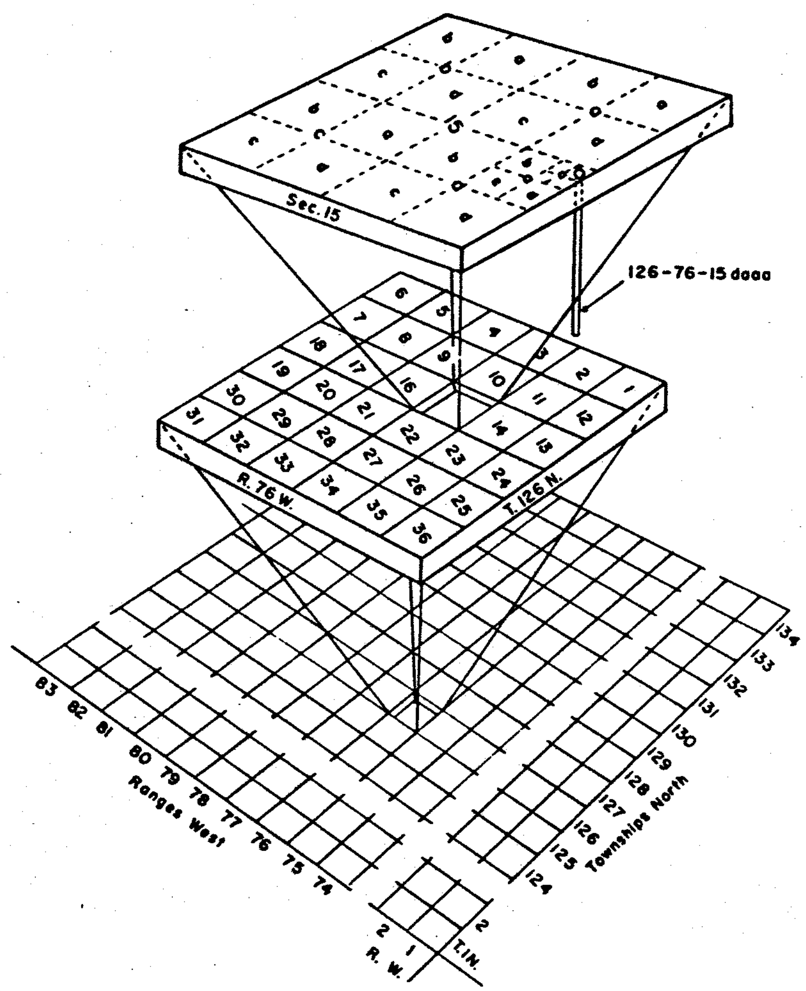
VARIABLE	DESCRIPTOR* VARIABLE	RECORD TYPES	UNITS
Acidified		W	
Acidity		W	
ADJ-SAR		W	
Al2O3		G	%
Aluminum		W	PPM
Alunite		G	%
Anions		W	ME/L
Arsenic	DE	WG	PPM
Barium		WG	PPM
Bed, Basin		GLW	
Begin-depth, Field-TDS		DW	FT, PPM
Beryllium		WG	PPM
Bicarbonate		W	PPM
Boron, Reading		WGP	PPM, FT
Cadmium		WG	PPM
Calcite, Casing-screen		GL	%, FT
Calcite-mix, Stick-up		GL	%, FT
Calcium	DE	W	PPM
CaO		G	%
Carbonate		W	PPM
Casing-elevation		WL	FT
Casing-type		WL	
Cations		W	ME/L
Cerium, Field-cond		GW	PPM
Cesium		WG	PPM
Chloride		WG	PPM
Chlorite		G	%
Chromium		WG	PPM
Clean-container		W	
Clinoptilolite		G	%
Cobalt		G	PPM
Code		WG	
Collector		WG	
Complete-location	DE	LWGD	
Copper		WG	PPM
County	DE	LWGD	
Cristobalite		G	%
CTE		L	
Date	DE	LWGP	
Depth		D	FT
D-log		L	
Dolomite, Diameter		GL	%, IN
Driller		L	
Drilling-company		L	
Elevation		LW	FT
E-log, Office		LW	
Fe2O3		G	%

VARIABLE	DESCRIPTOR* VARIABLE	RECORD TYPES	UNITS
FeO		G	%
Field-PH		W	
Filtered		W	
Fluoride		W	PPM
Formalin-treated		W	
Formation, Aquifer	DE	WGL	
Geologist		L	
G-log		L	
Gold, Field-temp		GW	PPM, DEG C
GSE		LW	
Gypsum		G	%
Hardness		W	PPM
Illite		G	%
Iron		W	PPM
Jarosite		G	%
K2O		G	%
Kaolinite		G	%
K-feldspar, Screen-length		GL	%, FT
Lake		W	
Lanthanum		G	PPM
Latitude		LWGD	
L-description, I<=5		D	
Lead		WG	PPM
Lithium		WG	PPM
Locate (super descriptor)	DE	PWDGL	
Location, M-unit		L	
Log (super descriptor)	DE	LDGPW	
Longitude		LWG	
Magnesium	DE	W	PPM
Manganese		WG	PPM
M-description		G	
Member, W-M-Date		GL	
Mercury		WG	PPM
Method		L	
MgO		G	%
Mixed-layer-clay		G	%
Molybdenum, ALK-MO		GW	PPM
Na.		W	%
Na2O		G	%
Nickel		G	PPM
Nitrate	DE	W	PPM
Notes(I) I<=5		WGLD	
Obs-well	DE	LWP	
Optical-data		G	
Other, Screen-type		WGL	
Otheri		WG	
Owner		LW	
Phosphorous, ALK-P		GW	PPM
Plagioclase, TDH-Depth		GL	%, FT
Potassium		W	PPM

VARIABLE	DESCRIPTOR* VARIABLE	RECORD TYPES	UNITS
Project		LWG	
Pump		W	
Pyrite		G	%
Quartz		G	%
Record-type	DE	LWGDP	
Rhodochrosite		G	%
RSC		W	ME/L
Rubidium		WG	PPM
Sample-no.		WG	
Samples, Sample-type		LW	
SAR		W	
Screened		W	
Selenium	DE	WG	PPM
Siderite		G	%
Silicon		W	PPM
Silver		WG	PPM
SiO2		G	%
Smectite		G	%
Sodium	DE	W	PPM
Stibium, Antimony		WG	PPM
Stream		W	
Strontium		WG	PPM
Sulfate		W	PPM
Sulfur		G	PPM
Temperature		W	DEG C
Test-hole		L	
Thorium		G	PPM
TiO2		G	%
Total-clay		G	%
Total-conductivity		W	UMHOS
Total-percent		G	%
Total-solids	DE	W	PPM
Uranium		G	PPM
Usage, Group		WG	
Vanadium		G	PPM
Water-depth		W	FT
Water-elevation		W	FT
Well-depth	DE	WL	FT
Well-no.	DE	LW	
Where-collected		W	
Zinc		WG	PPM

* A descriptor is a primary search element in the ADABAS data base management system.

APPENDIX B - DATA LOCATION SYSTEM



Data Location System

Data points are located according to a numbering system based on the Federal land-survey system used in South Dakota. The location number consists of township, range, and section numbers separated by hyphens, followed by a maximum of four letters that indicate, respectively, the 160-, 40-, 10-, and 2 1/2-acre tract in which the well is located. A serial number following the last letter is used to distinguish between wells in the same tract. Thus, well 126-76-15daaa is in the NE 1/4 NE 1/4 NE 1/4 SE 1/4 sec. 15, T. 126 N., R. 76 W.